Obesity, Levels of Lipids and Glucose, and Smoking among Navajo Adolescents[1]

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ABSTRACT Although there is a high prevalence of overweight among Navajo children and adolescents, other risk factors for chronic disease in this population have received little attention. We therefore examined the distribution and interrelationships of overweight, cigarette smoking, blood pressure and plasma levels of lipids and glucose among 160 Navajo 12- to 19-y-olds. In agreement with previous reports, participants were ~2 kg/m^2 heavier than adolescents in the general U.S. population, and the prevalence of overweight (>85th percentile) was 35–40%. Levels of total cholesterol and blood pressure were similar to those in the general U.S. population, but Navajo adolescents had a 5–10 mg/dL lower median level of HDL cholesterol, and a 30 mg/dL higher median triglyceride level. Eight percent of the adolescents examined had either impaired glucose tolerance or diabetes mellitus as assessed through an oral glucose tolerance test (n = 10) or self-report (n = 1). Relative weight (kg/m^2) was associated with adverse levels of lipids, lipoproteins and glucose, with overweight adolescents having a fivefold greater risk for elevated triglyceride levels than other adolescents. Tobacco use was fairly prevalent among boys (24% cigarettes, 23% smokeless tobacco), but not girls (9% cigarettes, 3% smokeless tobacco). Because of its associations with other risk factors and with various chronic diseases in later life, it may be beneficial to focus on the primary prevention of obesity among Navajo children and adolescents. J. Nutr. 127: 2120S–2127S, 1997.

KEY WORDS: • *adolescents* • *American Indians* • *lipids* • *glucose* • *diabetes mellitus* • *body weight*

Over the last few decades, obesity, diabetes and hypertension have become important health problems in American Indian communities (Welty 1991). Furthermore, it is likely that various characteristics among children are predictive of these chronic diseases. Childhood obesity is associated with adverse levels of lipids and blood pressure (Dietz 1987) and increases the risk of diabetes mellitus, coronary heart disease (CHD)[3] and all-cause mortality in later life (Johnston 1985, McCance et al. 1994, Must et al. 1992, Nieto et al. 1992). Obesity has increased in the general U.S. population over the last few decades (Kuczmarski et al. 1994, Troiano et al. 1995), but its prevalence is two- to threefold higher among American Indian children from various tribes than among other children (Broussard et al. 1991, Gilbert et al. 1992, Jackson 1993, Strauss 1993).

In addition to obesity, other characteristics of children and adolescents may influence the risk of subsequent disease. The initial stages of atherosclerosis are associated with adverse levels of lipids and blood pressure in children and adolescents (Newman et al. 1986), and levels of total cholesterol among young men are predictive of CHD in later adulthood (Klag et al. 1993). Furthermore, a high plasma glucose level among adolescents, independent of relative weight, increases the risk of noninsulin-dependent diabetes mellitus (McCance et al. 1994). Some evidence also suggests that the risk of lung cancer is inversely associated with the age of smoking initiation (Hegmann et al. 1993).

Several large studies of chronic disease risk factors in early life have been conducted (Berenson 1986, Lauer et al. 1975). However, despite the high prevalence of obesity among American Indian children (Broussard et al. 1991, Gilbert et al. 1992, Jackson 1993, Strauss 1993), there have been few studies (Freedman et al. 1992, Savage et al. 1976) of other risk factors in this population. This study of Navajo adolescents describes

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[3] Abbreviations used: BMI, body mass index; CHD, coronary heart disease; HDL, high-density lipoprotein; IGT, impaired glucose tolerance; LDL, low-density lipoprotein; NHANES II, Second National Health and Nutrition Examination Survey; VLDL, very low-density lipoprotein.

TABLE 1

Levels of anthropometric characteristics by sex and age, Navajo Health and Nutrition Survey, 1991–92

	Age, y	*n*	Weight: Median, kg	Weight: >85th percentile,[1] %	Height: Median, cm	Height: >85th percentile,[1] %	Body mass index: Median, kg/m2	Body mass index: >85th percentile,[1] (%)	Percentage trying to lose weight, %
Boys	12–13	20	51	28	156	5	22.3	55	44
	14–15	22	65	38	168	16	22.6	44	39
	16–17	21	67	16	174	17	21.8	16	39
	18–19	25	71	25	173	40	23.7	27	44
	Overall	88	66	27	170	21	22.9	35	41
Girls	12–13	22	48	15	157	19	19.2	26	15
	14–15	11	62	47	162	9	23.0	67	64
	16–17	22	63	19	162	24	23.2	32	35
	18–19	17	62	36	162	8	24.5	50	78
	Overall	72	59	26	161	16	23.0	40	44

1 Percentiles for weight, height and body mass index are based on data collected in NHANES II [see Materials and Methods, and Najjar and Rowland (1987)].

the distributions and interrelationships of relative weight, cigarette smoking, lipids, lipoproteins, glucose levels and blood pressure.

MATERIALS AND METHODS

Sample. The survey design and methods have been described elsewhere in this issue (White et al. 1997). A representative sample of residents (≥12 y of age) from households in each of the eight Indian Health Service units comprising the Navajo Nation was selected by using a three-stage cluster design. Within each service unit, enumeration districts were selected with probability proportional to the population. One segment within each enumeration district was chosen at random, and 10 housing units within each segment were then selected. About 60% of the 760 identified households participated in the survey, and a total of 985 subjects were examined from October 1991 to December 1992. The current analyses include 160 subjects who ranged in age from 12 to 19 y.

Interviews, medical examinations and laboratory methods. Participants were contacted the previous evening as a reminder to fast, and venipuncture was performed at the beginning of the 2.5- to 3-h interview. As described elsewhere in this issue (Will et al. 1997), subjects were then given a 75-g oral glucose load, and additional blood samples were drawn at 1 and 2 h postload.

Standardized questionnaires, administered in Navajo or English by trained interviewers, were used to obtain information about diabetes mellitus, cigarette smoking, smokeless tobacco use and weight loss practices. Height and weight were measured with respondents wearing light clothing without shoes, and body mass index (BMI) (kg/m^2) was calculated as a measure of relative weight. (Weight or height was not available for 2 of 162 adolescents examined, and they have been excluded from all analyses.) Three blood pressure measurements were taken by using a random-digit sphygmomanometer, and the mean of the last two values was used in the analyses. Persons were considered to be cigarette smokers, irrespective of the number of cigarettes smoked daily, if they responded positively to a question about current cigarette smoking.

All laboratory determinations were performed in a single laboratory (Corning Clinical Laboratories, El Paso, TX) that participates in the proficiency survey operated by the College of American Pathologists. Specimens were transported to the laboratory on a daily basis, and levels of total cholesterol and triglycerides were measured with a Technicon SMAC-III (Technicon Instrument Corporation, Tarrytown, NY); a Technicon RAXT was used for determinations of high-density lipoprotein (HDL) cholesterol and plasma glucose. Levels of low-density lipoprotein (LDL) cholesterol were estimated by subtracting the sum of HDL cholesterol and (triglycerides/5) from the total cholesterol level (Friedewald et al. 1972).

Subjects with missing laboratory determinations have been excluded only from analyses involving that characteristic. The fasting status was either unknown or <10 h for six subjects, and their levels of triglycerides and glucose were not used in the analyses. Because glucose levels from the 2-h postload samples were used only if they were drawn between 105 and 135 min, 13 subjects were excluded from these analyses. The level of LDL cholesterol was not calculated for one subject whose triglyceride level was >400 mg/dL.[4]

Classification of risk-factor levels. Because of the small number of adolescents ($n = 11$) who had either impaired glucose tolerance (IGT) or diabetes mellitus, these two groups are combined in the analyses. Nine met the WHO criterion (WHO Study Group 1985) of a 2-h plasma glucose level of 140–199 mg/dL[5], and one had a level of 225 mg/dL. One additional subject reported being told by a physician that she had diabetes mellitus. All fasting glucose values were ≤140 mg/dL.

Reference data for weight and height were obtained from the Second National Health and Nutrition Examination Survey (NHANES II) (Najjar and Rowland 1987); the 85th sex- and age-specific percentile of BMI was used as the cutpoint for overweight. Classification of LDL cholesterol values into borderline-high (110–129 mg/dL) and high (≥30 mg/dL) categories followed the guidelines of the National Cholesterol Education Program (1991); an HDL cholesterol level <35 mg/dL was also considered to increase the risk of CHD. [The recommended cutpoints for LDL cholesterol levels correspond to approximately the 75th (110 mg/dL) and 90th percentiles (130 mg/dL) among adolescents.] Triglyceride levels above the sex- and age-sex specific 95th percentiles for adolescents examined in the Lipids Research Clinics Prevalence Study (National Cholesterol Education Program 1991) were considered high.

Statistical analyses. All proportions, means, and correlations were calculated by using sample weights; SUDAAN (Shah 1991) was used in the estimation of standard errors and *P*-values to account for the sampling design. Because several distributions were skewed and a few data points were found to strongly influence the results of parametric statistical procedures, the relation

4 To convert levels of cholesterol to SI units, multiply by 0.02586.
5 To convert levels of glucose to SI units, multiply by 0.05551.

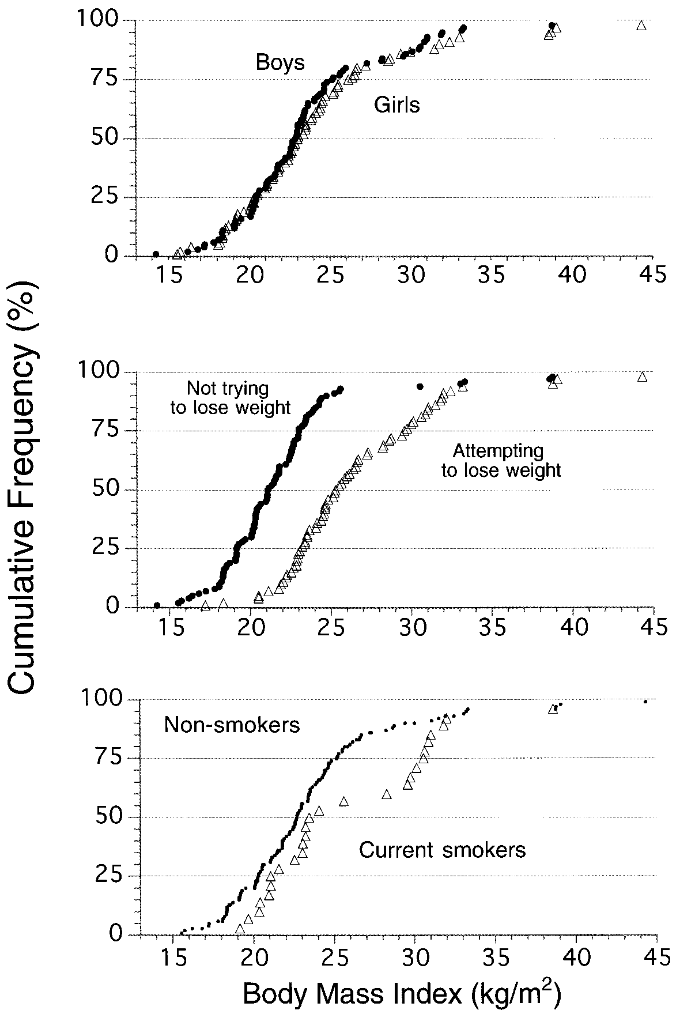

FIGURE 1 Cumulative frequency distribution of body mass index by sex (*top*), attempting to lose weight (*middle*) and current cigarette smoking (*bottom*).

of these risk factors to age and BMI were summarized using medians and Spearman correlation coefficients. The statistical significance of differences in levels of risk factors across categories (e.g., current cigarette smoking) was assessed with the use of linear regression (using the ranks of continuous variables) or logistic regression (for dichotomous variables) to adjust for sex and age differences.

The importance of nonlinear effects was assessed by using generalized additive models (Venables and Ripley 1994) and locally weighted scatterplot smoother (LOWESS) curves. This smoothing technique, which relies only on the data to specify the form of the model, uses weighted least-squares regression on a subset (75% of the data in the current analyses) to fit each value of a smoothed curve; outliers are subsequently identified and down-weighted in an iterative process (Cleveland 1979).

RESULTS

Sex- and age-specific levels of various anthropometric measures among the 88 boys and 72 girls are shown in **Table 1**. Although BMI was moderately correlated (r = 0.2–0.4) with age, increasing by 1.4 kg/m^2 (boys) to 5.3 kg/m^2 (girls) across the four age categories, 35–40% of all adolescents examined were overweight (>85th percentile for BMI). There was little difference in the distribution of BMI between boys and girls, but four girls (vs. one boy) had a value >35 kg/m^2 (**Fig. 1**). Although the high prevalence of overweight was primarily due to high weights, the prevalence of heights below the 15th percentile tended to increase with age among boys, reaching a maximum of 40% among 18- to 19-y-olds. (Among girls, the median height among 18- to 19-y-olds (162 cm) was identical to that among 14- to 15-y-olds.) The 67 adolescents who reported trying to lose weight had a median BMI 4.2 kg/m^2 higher than that of other subjects (Fig. 1), but 5 (of 47) subjects with a BMI <21 kg/m^2 were trying to lose weight, whereas 16 (of 61) overweight persons were not. Of those trying to lose weight, 83% were eating less and exercising, 22% fasted for >24 h and 7% (4 boys and 2 girls) vomited after eating (data not shown).

About 25% (22 boys and 5 girls) of the adolescents currently smoked cigarettes, and a slightly smaller number (19 boys and 3 girls) currently used smokeless tobacco (**Table 2**). Although six cigarette smokers did not provide information on smoking intensity, the median number of daily cigarettes among the remaining 21 smokers was only two. Smokeless tobacco was more likely to have been tried by cigarette smokers than by nonsmokers, but its duration and intensity were also low; six adolescents reported using more than one pouch weekly and only three had used it for more than 3 y. Compared with nonsmokers, current cigarette smokers had a higher median BMI and a higher prevalence (57 vs. 33%) of overweight (Fig. 1, *bottom*). Smokeless tobacco use, in contrast, was only weakly associated with relative weight. Although fairly similar proportions of smokers and nonsmokers reported trying to lose weight, current smokers were more likely to fast for over 24 h than were nonsmokers (47 vs. 17%).

TABLE 2

Levels of selected characteristics, by current smoking status, Navajo Health and Nutrition Survey, 1991–92

	Current cigarette smoker[1]	
	No	Yes
n	130	27
Girls	65 (51%)[2]	5 (25%)
Age, *y*	16	17
Regular use of smokeless tobacco		
Ever	17 (12%)	9 (31%)
Current	16 (12%)	6 (20%)
Body mass index, *kg/m*^{2}	22.6*	23.5*
Body mass index ≥85th percentile	44 (33%)**	15 (57%)**
Perceived as overweight	50 (38%)	9 (31%)
Trying to lose weight	54 (40%)	13 (51%)
Eating less/exercising more[3]	44 (83%)	10 (82%)
Vomiting[3]	4 (7%)	2 (8%)
Fasting >24 hours[3]	8 (17%)*	5 (47%)*

1 Three of the 160 subjects did not report current smoking status and are not included in the table. *P*-values have been adjusted for sex and age differences between smoking categories using logistic or linear regression.

2 For dichotomous variables, values are number (percentage of smoking category); for continuous variables, median values are shown.

3 Percentages represent the proportion of those trying to lose weight who reported using the specified method.

* $P < 0.05$; ** $P < 0.01$; *P*-values were calculated using linear or logistic regression to adjust for differences in sex and age between smokers and nonsmoker.

TABLE 3

Levels of selected risk factors, by sex and age, Navajo Health and Nutrition Survey, 1991–92

Characteristic	Sex	Overall	Age group, *y* 12–13	14–15	16–17	18–19	Spearman correlation with age
n[1]	Boys	88	20	22	21	25	
	Girls	72	22	11	22	17	
Current cigarette smoker, %	Boys	24[b]	14	19	22	37	
	Girls	9	10	11	5	12	
Current smokeless tobacco user, %	Boys	23	24	8	24	33	
	Girls	3	2	5	5	0	
Systolic blood pressure, *mm Hg*	Boys	109	101	108	109	116	0.47**
	Girls	106	106	101	108	105	0.05
Diastolic blood pressure, *mm Hg*	Boys	67	62	65	66	71	0.38**
	Girls	64	57	66	65	66	0.29*
Total cholesterol, *mg/dL*	Boys	157	162	144	146	164	0.08
	Girls	154	137	148	162	176	0.48**
HDL cholesterol, *mg/dL*	Boys	44	47	43	44	39	−0.26**
	Girls	44	41	41	46	44	0.21
Total/HDL cholesterol	Boys	3.5	3.3	3.2	3.4	3.8	0.27**
	Girls	3.5	3.4	3.4	3.5	3.7	0.21
Triglycerides, *mg/dL*	Boys	90	75	82	114	90	0.13
	Girls	104	94	104	100	120	0.03
2-h plasma glucose, *mg/dL*	Boys	88	99	90	86	79	−0.17
	Girls	94	107	93	91	90	−0.25**
Impaired glucose tolerance or diabetes mellitus,[3] %	Boys	3	0	8	5	0	
	Girls	13	15	29	9	3	

[1] Levels of total cholesterol, HDL cholesterol, systolic blood pressure and diastolic blood pressure were available for all subjects. The 2-h glucose level and the classification of impaired glucose tolerance or diabetes, the characteristics with the largest number of missing values, were unavailable for 10 boys and 9 girls.

[2] For dichotomous variables, values are percent of sex- and age-category with the specified characteristic; for continuous variables, median values are shown.

[3] Defined as a 2-h glucose level ≥140 mg/dL or self-reported diabetes mellitus. Of the 11 adolescents in this category, nine had a 2-h glucose level between 140 and 199 mg/dL, one had a 2-h glucose level of 225 mg/dL and one reported having been told by a physician that she had diabetes mellitus.

* $P < 0.05$; ** $P < 0.01$.

Among boys, the prevalence of cigarette smoking tended to increase with age, but use of smokeless tobacco showed no consistent trend with age (**Table 3**). Several other characteristics were also moderately associated with age, but unexpectedly, levels of systolic blood pressure did not increase with age among girls. (As assessed in stratified analyses, the lack of association between age and systolic blood pressure among girls was largely attributable to the constant median heights among 14- to 19-y-old girls, data not shown.) Overall, median levels of total and HDL cholesterol were similar among boys and girls; however, HDL cholesterol levels decreased by about 8 mg/dL during adolescence among boys, whereas girls showed an increase. These differing trends were reflected in 12- to 13-y-old boys having higher HDL cholesterol levels than similarly aged girls, whereas among older subjects, levels were higher among girls. About 10% of the adolescents had an HDL cholesterol level <35 mg/dL, and about 20% of the adolescents had a triglyceride level above the 95th percentile for the general U.S. population; median levels of triglycerides were 90 (boys) and 104 (girls) mg/dL.[6] Compared with boys, girls had higher 2-h glucose levels and a higher prevalence of IGT/diabetes (13 vs. 3%). In general, these sex- and age-differences were independent of relative weight (data not shown).

BMI was related to adverse levels of the risk factors examined (**Table 4**), with median levels of triglycerides showing the largest proportional difference between persons with a BMI <20 kg/m^2 and those ≥27 kg/m^2 (e.g., 73 vs. 151 mg/dL among boys). Associations with levels of total/HDL cholesterol and systolic blood pressure were also strong, with correlation coefficients of 0.5 to 0.6. As seen in **Figure 2**, however, several of the associations were curvilinear, with the maximum (predicted) level of total cholesterol and the lowest HDL cholesterol level occurring at a BMI of ~30 kg/m^2. Although associations between BMI and 2-h glucose levels were relatively weak (r = 0.1–0.3), all 11 adolescents with IGT/diabetes had a BMI >23.5 kg/m^2, about the 60th percentile among other adolescents.

Using cutpoints suggested by the National Cholesterol Education Program, we found that 6% of the adolescents had a high (≥130 mg/dL) level of LDL cholesterol (**Table 5**). These 11 subjects tended to have a lower (−6 mg/dL) HDL cholesterol level and higher median levels of triglycerides (+161 mg/dL) and total/HDL cholesterol (+2.0 units), as well as a higher prevalence of IGT/diabetes (27%) than did adolescents with an LDL cholesterol level <110 mg/dL. About two thirds of the subjects with a high LDL cholesterol level were also overweight, but most adolescents with a high BMI did not have an elevated LDL cholesterol level (positive predictive value = 14%).

DISCUSSION

Our results are consistent with recent reports (Gilbert et al. 1992, Sugarman et al. 1990b) that found a high

[6] To convert levels of triglycerides to SI units, multiply by 0.01129.

TABLE 4

Levels of selected risk factors, by sex and body mass index (BMI), Navajo Health and Nutrition Survey, 1991–92

Characteristic	Sex	BMI, kg/m²				Spearman correlation (adjusted for age)[1]
		<20	20–22.9	23–26.9	≥27.0	
n[2]	Boys	15	33	24	16	
	Girls	15	22	22	13	
Current smokers, %	Boys	8[3]	13	26	59	
	Girls	14	2	6	20	
Systolic blood pressure, *mm Hg*	Boys	96	107	113	121	0.56**
	Girls	104	98	104	120	0.50**
Diastolic blood pressure, *mm Hg*	Boys	62	65	68	73	0.26**
	Girls	56	64	64	72	0.36**
Total cholesterol, *mg/dL*	Boys	147	160	150	166	0.24**
	Girls	134	163	151	180	0.20
LDL cholesterol, *mg/dL*	Boys	76	86	92	99	0.25**
	Girls	77	96	86	107	0.24
HDL cholesterol, *mg/dL*	Boys	49	47	40	36	−0.42**
	Girls	43	49	42	39	−0.55**
Total/HDL cholesterol	Boys	2.9	3.1	3.7	4.6	0.51**
	Girls	3.1	3.4	3.6	4.5	0.65**
Triglycerides, *mg/dL*	Boys	73	71	91	151	0.49**
	Girls	86	95	110	128	0.47**
2-h plasma glucose, *mg/dL*	Boys	84	96	79	91	0.10
	Girls	98	88	89	99	0.30**
Impaired glucose tolerance or diabetes mellitus,[4] %	Boys	0	0	5	11	
	Girls	0	0	21	30	

1 Spearman correlation coefficients between BMI and specified characteristic have been adjusted for age by using indicator variables for the four age categories.
2 Levels of total cholesterol, HDL cholesterol, systolic blood pressure and diastolic blood pressure were available for all subjects. The 2-h glucose level and the classification of impaired glucose tolerance or diabetes, the characteristics with the largest number of missing values, were unavailable for 10 boys and 9 girls.
3 Values are medians unless otherwise noted.
4 Defined as a 2-h glucose level ≥140 mg/dL or self-reported diabetes mellitus. Of the 11 adolescents in this category, nine had a 2-h glucose level between 140 and 199 mg/dL, one had a 2-h glucose level of 225 mg/dL and one reported having been told by a physician that she had diabetes mellitus.
* $P < 0.05$; ** $P < 0.01$.

prevalence of overweight among Navajo adolescents; we found that the median BMI in this group was about 2 kg/m^2 higher than levels in the general population, and ~35% (boys) to 40% (girls) of the 12- to 19-y-olds had a BMI above the 85th percentile. Furthermore, compared with other adolescents (Berenson 1986, National Heart Lung and Blood Institute 1980), we found a 5–10 mg/dL lower median HDL cholesterol level, a 30 mg/dL higher median triglyceride level, and a very high prevalence of IGT. BMI was associated with adverse levels of the risk factors, and almost one half of the subjects examined reported trying to lose weight.

Although malnutrition was seen among Navajo preschool children as late as the 1960s (Van Duzen et al. 1969), the secular increase in the weight of Navajo adolescents over the last few decades (Sugarman et al. 1990b) parallels the trend seen nationally (Troiano et al. 1995). The magnitude of the observed secular increases in relative weight over a short time period suggests changes in behavioral or environmental characteristics such as diet or physical activity. On a population level, trends in overweight and inactivity are highly correlated (Prentice and Jebb 1995), but energy intake and expenditure have been very difficult to quantify on an individual level (Bingham 1987).

Lipid levels among Navajo adults (Howard et al. 1983, Sievers 1968) and other American Indian tribes (Howard et al. 1983, Mendlein et al. 1997, Savage et al. 1976, Sugarman et al. 1992a) have been described, but levels among adolescents have received less attention. In the 1960s, the mean level of total cholesterol was 30–50 mg/dL lower among Navajo 15- to 29-y-olds than in other population groups (Sievers 1968), but more recent studies have found that levels among Navajo 25- to 34-y-olds are comparable to those in the general population (Sugarman et al. 1992a). Our results for levels of total cholesterol among Navajo adolescents agree with these more recent findings, and it is likely that any comparisons of lipid levels between the Navajo and other groups would be strongly influenced by the marked secular trends in obesity over the last few decades.

We found, as have studies in other populations (Beaglehole et al. 1980, Berenson 1986), that levels of HDL cholesterol decrease during adolescence among boys. However, compared with these previous reports, levels of HDL cholesterol in the current study were relatively low, whereas triglyceride levels were relatively high; similar differences have also been seen among young adults from several American Indian populations (Welty et al. 1995). It is likely that these adverse lipid levels are, at least in part, attributable to the high prevalence of overweight and the truncal distribution of body fat among Navajo adolescents (Gilbert et al. 1992). Studies of other American Indians suggest that, although the production of very low-density lipoprotein (VLDL) among the obese is high, levels of LDL cholesterol tend to remain normal because of the

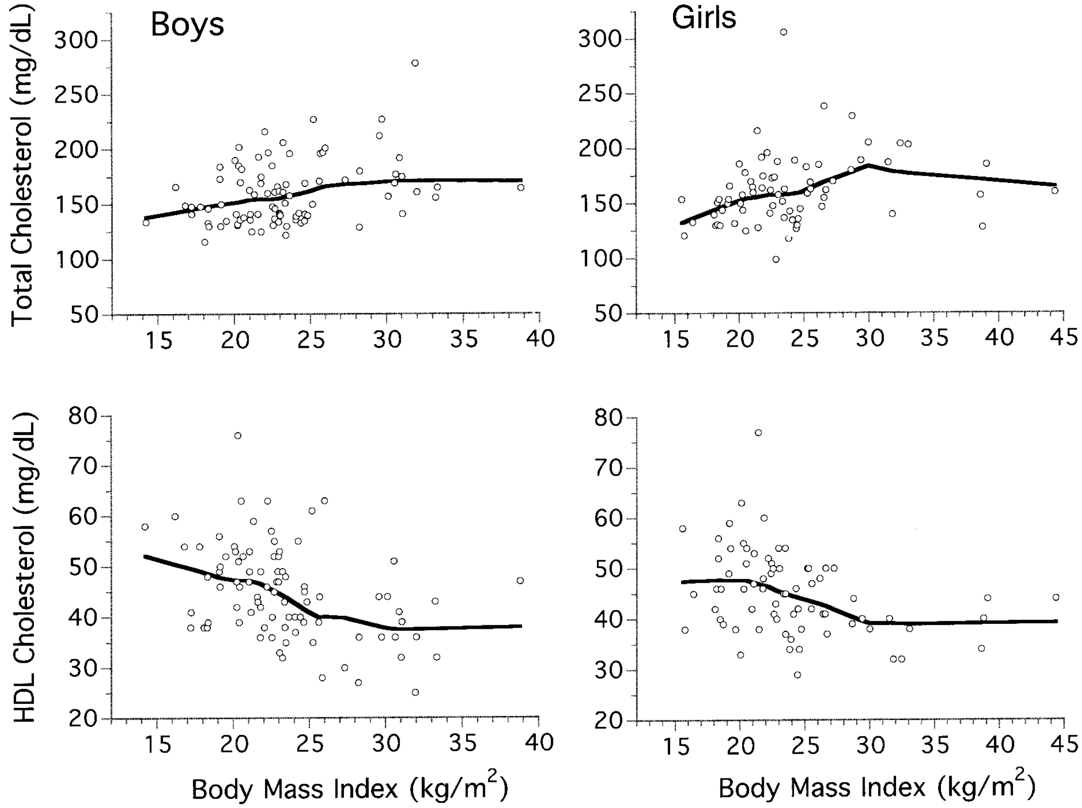

FIGURE 2 Scatterplots and locally weighted scatterplot smoother (LOWESS) curves showing the relation of body mass index to levels of total cholesterol (*top*) and HDL cholesterol (*bottom*); separate plots are shown for boys (left) and girls (*right*). Each subject is represented by an open circle, and each point along the fitted LOWESS curve represents the predicted level on the basis of a weighted least-squares regression using 75% of the data (see Materials and Methods for additional information).

removal of the precursor from the circulation (Egusa et al. 1985).

The very high prevalence (8, 95% confidence interval: 4–12%) of IGT and diabetes mellitus, respectively, in the current study may also be the result of obesity; the 11 adolescents with IGT or diabetes mellitus had a mean BMI that was ~7 kg/m^2 higher than that of other subjects. Comparisons of prevalence rates of diabetes mellitus across populations can be strongly influenced by differences in medical-record ascertainment and disease classification, and confounding by age. However, the prevalence of IGT and diabetes mellitus (8%) among the 12- to 19-y-olds in this study appears to be roughly comparable to that seen among young and middle-aged adults in the general U.S. population (Kenney et al. 1995), but is lower than the very high rates among some American Indian tribes (Bennet et al. 1976). The prevalence of diabetes mellitus among Navajo adults is 2.5- (Sugarman et al. 1992b) to fourfold (Will et al. 1997) higher than that in the general U.S. population.

Our finding that cigarette smokers were heavier than nonsmokers is in contrast to the inverse association that is typically observed between smoking and weight (Klesges et al. 1989). It is possible that some adolescents may have started smoking to lose weight, but that the low intensity of smoking limited its metabolic effects (Perkins 1992). Questions concerning smoking as a weight-loss technique were not included in the interview, but other studies have found that about 40% of adolescent girls use smoking to control appetite and weight (Camp et al. 1993), and that intent to smoke and overweight are associated among boys (Tucker 1983). Although the prevalence of smokeless tobacco use in the current study (23%, boys; 3%, girls) was lower than in previous reports, these differences may be due to the phrasing of the questions. We asked subjects about current use only if they had used smokeless tobacco on a *regular basis*, whereas others have asked about current use only (Backinger et al. 1993) or have grouped occasional with daily users (Davis et al. 1995).

Various limitations of the current study should be also considered. Because of the relatively small sample size, our estimates are not very precise; the 95% confidence interval for the estimated 38% prevalence of overweight, for example, ranges from 31 to 46%. In addition, BMI was used as a surrogate for obesity, and although it is possible that associations between relative weight and adiposity may be nonlinear or differ across racial/ethnic groups, overweight Navajo adolescents have thick subscapular skinfolds (Gilbert et al. 1992). Although all persons who *reported* fasting for <10 h were excluded from these analyses, it is possible that the high levels of triglycerides in this study may be due in part to the to the inclusion of some subjects who did not actually fast. However, the high prevalence of overweight, along with its strong relation to various risk factors, suggests that the adverse triglyceride levels are due primarily to the prevalence of overweight. We found that overweight adolescents were about five times as likely to have an elevated triglyceride level (>95th percentile) as were other adolescents.

The observed relation of relative weight to adverse levels of lipids, lipoproteins and blood pressure suggests that

TABLE 5

Levels of selected risk factors, by LDL cholesterol categories, Navajo Health and Nutrition Survey, 1991–92

	LDL cholesterol (mg/dL)[1]		
	<110	110–129	≥130
n, %	120 (79)	22 (15)	11 (6)
LDL cholesterol, *mg/dL*	82[2]	117	147
Total cholesterol, *mg/dL*	148	189	215
Female, %	47	53	56
Age, *y*	16	18**	17
Body mass index, *kg/m²*	22.6	23.2	27.2**
Body mass index >85th percentile, %	34	39	66*
HDL cholesterol, *mg/dL*	44	45	38*
Total/HDL cholesterol	3.3	4.1**	5.3**
Triglycerides, *mg/dL*	90	113	151**
2-h plasma glucose, *mg/dL*	89	97	98
Impaired glucose tolerance (IGT) or diabetes mellitus,[3] %	7	0	27*
Systolic blood pressure, *mm Hg*	106	107	115*

[1] The three LDL cholesterol categories correspond to the National Cholesterol Education Program categories (acceptable, borderline-high, and high) for children and adolescents (National Cholesterol Education Program 1991). The LDL cholesterol level, which was estimated using the Friedewald equation, was not calculated for seven persons: three did not report duration of fast, three fasted for <10 h and one had a triglyceride level of 474 mg/dL.

[2] For continuous variables, the median value is shown; for dichotomous variables, the proportion of subjects in LDL cholesterol category with specified characteristic is shown.

[3] Defined as a 2-h glucose level ≥140 mg/dL or self-reported diabetes mellitus. Of the 11 adolescents in this category, nine had a 2-h glucose level between 140 and 199 mg/dL, one had a 2-h glucose level of 225 mg/dL, and one reported having been told by a physician that she had diabetes mellitus.

* $P < 0.05$; ** $P < 0.01$; *P*-values contrast levels between persons with an LDL cholesterol level of <110 mg/dL with other categories; linear regression or logistic regression was used to adjust for sex and age differences. Because of small numbers, *P*-values for IGT/diabetes were calculated using Fisher's Exact Test and do not account for the sampling design.

the recent increases in CHD (Klain et al. 1988) and diabetes mellitus (Sugarman et al. 1990a) among the Navajo may continue. Because obesity among these adolescents is strongly related to levels of various risk factors for CHD and may influence subsequent morbidity and mortality, it is important to focus on the primary prevention of obesity in early life among the Navajo.

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