



# Growth and overweight of Navajo youth: secular changes from 1955 to 1997

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**OBJECTIVE:** To examine the growth status, prevalence of risk of overweight and of overweight, and secular changes in growth status in Navajo youth from 1955 to 1997.

**SUBJECTS:** 526 (256 males, 270 females) Navajo children 6–12 y of age.

**MEASUREMENTS:** Stature and mass were measured and the body mass index (BMI) was calculated.

**ANALYSIS:** All three variables were plotted relative to age- and sex-specific US reference data and the prevalence rates for risk of overweight and of overweight were estimated using the BMI as the criterion. The cut-off for the risk of overweight was the age- and sex-specific 85th and 95th percentiles of NHANES I, while the cut-off for overweight was a BMI  $\geq$  95th percentiles. Age-specific sex differences were compared using independent samples *t*-tests. Secular changes for body size were estimated by comparing age- and sex-specific means for stature, mass, and the BMI in the present study and two previous studies in 1955 and 1989.

**RESULTS:** No statistically significant differences were observed between sexes within age groups. In both sexes, mean age-specific stature appeared to be relatively stable around the 50th percentile of US reference values. Mean age-specific mass appeared to be relatively stable between the 50th and 90th percentiles of the reference values, while the mean BMI tended to fluctuate about the 85th percentile. Approximately 41% of the Navajo boys and girls 6–12 y of age had BMIs  $\geq$  85th percentiles of US reference data. Compared to corresponding data on Navajo youth in 1955 and 1989, the current sample was larger in mass and the BMI. The estimated rate of secular change in mass was about 1.5 kg/decade in younger boys and girls, and about 3 kg/decade in older boys and girls between 1955 and 1997. The estimated rate of secular change in the BMI was about 0.5–1.0 units/decade between 1955 and 1997, while that for stature was about 2 cm/decade between 1955 and 1997.

**CONCLUSIONS:** The results are consistent with recent findings on the Navajo Health and Nutrition Survey that overweight is a serious public health concern across the lifespan in the Navajo, and that the problem begins in childhood. Furthermore, Navajo children appear to be heavier than about a decade ago.

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**Keywords:** children; nutrition; BMI; overweight; obesity; Native Americans

## Introduction

The early study of Darby and colleagues<sup>1</sup> on the 'nutriture of the Navajo' noted the traditional diet and subsistent lifestyle of this southwestern US Native American tribe. At that time, malnutrition, more specifically undernutrition, was a concern among the Navajo. Subsequently, a secular increase in the stature and mass and in the prevalence of overweight of Navajo schoolchildren has been observed.<sup>2</sup>

Recent evidence for a secular increase in the prevalence of overweight in US children, adolescents, and adults has drawn considerable attention, since obesity is associated with several chronic diseases.<sup>3</sup> Among ethnic groups in which data is available, Native Americans display higher prevalence rates of overweight than any other group in the US.<sup>4–8</sup> The

causes of the higher prevalence of overweight among Native Americans are unknown, but many authors have indicated the need to begin preventive measures during childhood.<sup>4,8–12</sup>

The Navajo Health and Nutrition Survey recently published a series of papers examining several issues related to chronic disease in Navajo adolescents and adults.<sup>13</sup> About 35% of Navajo boys and 40% of Navajo girls ages 12–19 y are overweight.<sup>4</sup> This study extends these findings to childhood by examining the growth status and prevalence of overweight in Navajo children 6–12 y of age. Secular changes in body size are also considered.

## Subjects and methods

Participants were volunteers enrolled in three boarding schools and one public school from various regions (Northeast, Southeast, Central and West) of the Navajo Reservation in northeastern Arizona. Boarding schools were selected from approximately

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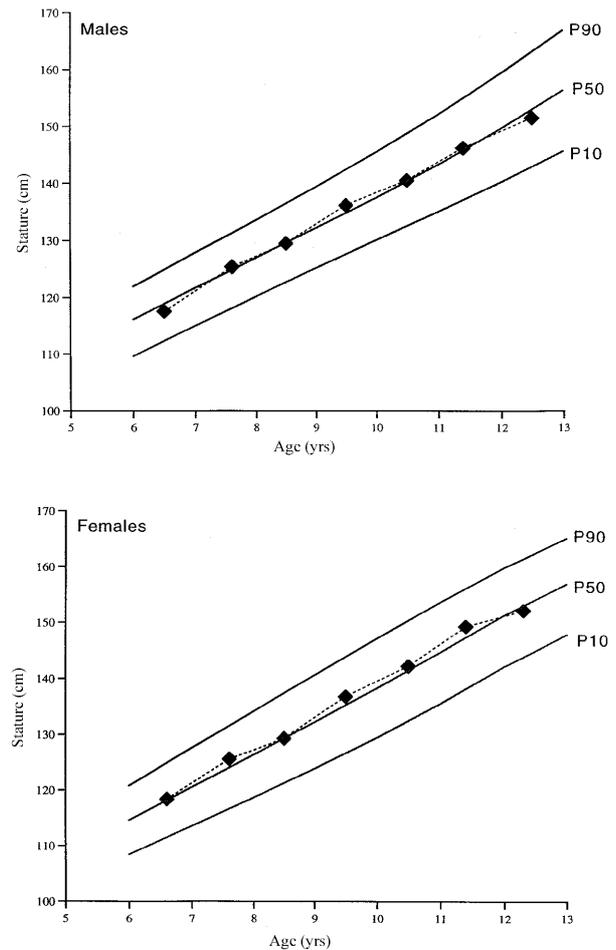
50 boarding schools on the Navajo Reservation based on regional location and willingness to participate in the study. The public school was selected because it served a large area and was distantly removed from the other school locations. The sampling procedure included all children attending school at the selected site as part of a pulmonary function screening. It is unknown whether school attendance was random. Sampling children throughout various regions of the reservation from boarding schools in which enrollment consists of students from various locations on the reservation and a public school that serves a large area would seem to identify a reasonably representative sample of Navajo youth. The sample included 526 males ( $n = 256$ ) and females ( $n = 270$ ) 6–12 y of age. The total sample represents about 3% of the children in this age range on the Navajo Reservation in Arizona (approximately 18,000 5–12 y).<sup>14</sup> Informed consent was obtained according to school policy. The protocol for the data collection was approved by the Northern Arizona University Human Subjects Committee and the Navajo Institutional Review Board.

Data were collected between March 1996 and May 1997. Measurements of stature and body mass were obtained without shoes and excess clothing and accessories. Stature was measured to the nearest 1/4 inch with the subject standing erect and the head placed in the Frankfort horizontal plane. Body mass was measured to the nearest pound using a standard physician scale. Both measures were converted to SI units. The body mass index (BMI) was calculated ( $\text{kg}/\text{m}^2$ ).

Stature, mass and BMI were plotted relative to age- and sex-specific reference data for the US.<sup>15,16</sup> The BMI was used to estimate the prevalence rates for risk of overweight and of obesity.<sup>17</sup> Subjects with a BMI  $\geq 85$ th and  $< 95$ th for age- and sex-specific percentiles of NHANES I (1971–1974) were considered at risk of overweight.<sup>16</sup> Subjects with a BMI  $\geq 95$ th percentile for age and sex were considered overweight.<sup>16</sup> Age-specific sex differences were compared using independent sample *t*-tests.

Secular changes in body size were estimated by comparing age- and sex-specific means for stature, mass and BMI in the present study and two previous studies of Navajo children in 1955<sup>1</sup> and 1989.<sup>2</sup> The

1955 study was conducted to examine the dietary habits and nutritional status of the Navajo population. Data were collected in the summer of 1955 around the areas of Ganado and Pinon, AZ. Subjects were recruited by radio broadcasts in the Navajo language, posters at trading posts, and contact by staff members. The response rate is unknown. The sample included 261 (105 males and 156 females) Navajo youth 6–12 y of age. Stature and body mass were measured by one of four physicians. Mean values from the 1955 study



**Figure 1** Stature of Navajo Native American boys and girls 6–12 y of age. Age-specific means are plotted relative to the 10th, 50th, and 90th percentiles of US reference values (Hamill et al, 1977).<sup>15</sup>

**Table 1** Means (M), medians (MD) and standard deviations (SD) of body size of Navajo Native American youth

Age (y)	n	Males									Females									
		Stature (cm)			Mass (kg)			BMI ( $\text{kg}/\text{m}^2$ )			Stature (cm)			Mass (kg)			BMI ( $\text{kg}/\text{m}^2$ )			
		M	MD	SD	M	MD	SD	M	MD	SD	n	M	MD	SD	M	MD	SD	M	MD	SD
6	29	117.1	116.4	5.6	23.3	22.5	4.2	16.9	16.5	2.01	28	117.9	119.2	4.3	24.0	24.5	3.7	17.2	17.0	1.90
7	44	125.4	125.7	5.2	28.2	26.9	6.7	17.7	17.1	2.87	42	125.6	126.0	7.3	27.7	26.4	4.8	17.5	17.2	2.32
8	42	129.5	128.3	6.2	30.4	28.2	7.9	18.0	17.0	3.12	55	129.3	129.5	5.3	31.1	29.5	6.8	18.5	17.6	3.09
9	47	136.2	134.6	6.4	36.9	35.1	8.0	19.8	19.3	3.60	33	136.8	135.9	5.9	38.5	38.1	9.7	20.4	18.3	4.24
10	45	140.6	140.3	6.8	38.5	34.9	9.6	19.3	18.3	3.48	58	142.3	142.2	6.9	41.0	39.0	10.8	20.1	19.4	4.33
11	26	146.3	145.1	6.4	46.2	44.7	10.9	21.4	21.1	3.55	37	149.4	149.9	7.0	48.6	45.8	14.2	21.5	19.9	4.93
12	23	151.6	152.4	6.9	48.8	45.3	12.9	21.0	20.1	4.42	17	152.8	153.0	4.9	47.8	46.0	13.8	20.4	18.8	5.36

Age refers to age at last birthday (ie 7 = 7.00–7.99 y). None of the differences between the sexes are significant.

were taken from the original paper (Table 17, p. 42, Darby *et al*<sup>1</sup>) and converted to SI units. Only stature and mass will be reported here since the calculation of BMI from mean statures and masses may distort the ‘true’ mean BMI. The 1989 sample was chosen from schools on the reservation. The sampling procedure included selecting at least one class for every grade among schools that serve Navajo students. Thus, the sample was representative of Navajo schoolchildren residing on the reservation. Stature and mass were measured by Indian Health Service nutritionists and dieticians in most schools; some school officials assisted in other schools. Stature was measured to the nearest 1/4 inch with the subject standing erect and the head placed in the Frankfort horizontal plane. Body mass was measured to the nearest 1/2 pound using a standard physician scale. Both measures were converted to SI units. Mean values from the 1989 study were made available by the authors.

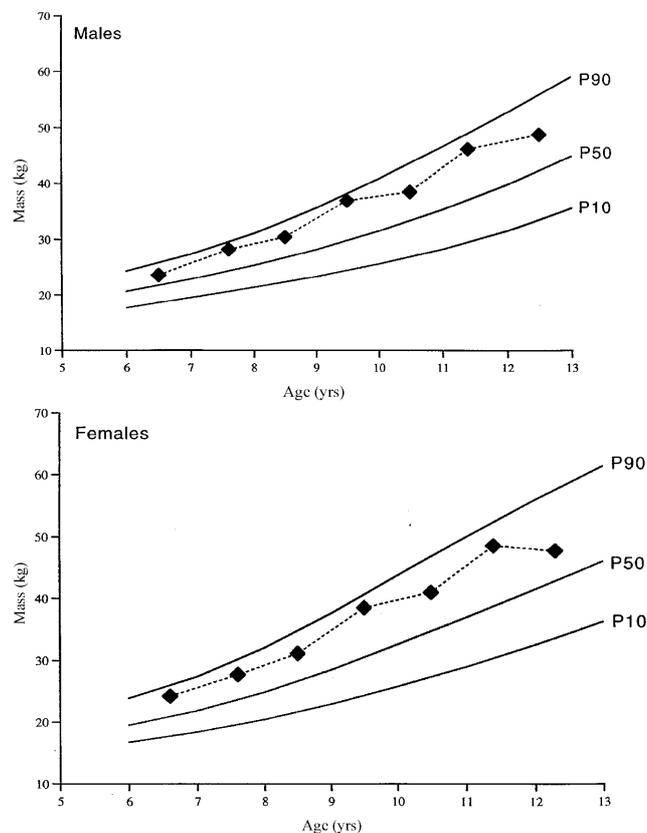
## Results

Descriptive statistics by age and sex are shown in Table 1. There were no statistically significant differences between sexes within age groups. Mean stature

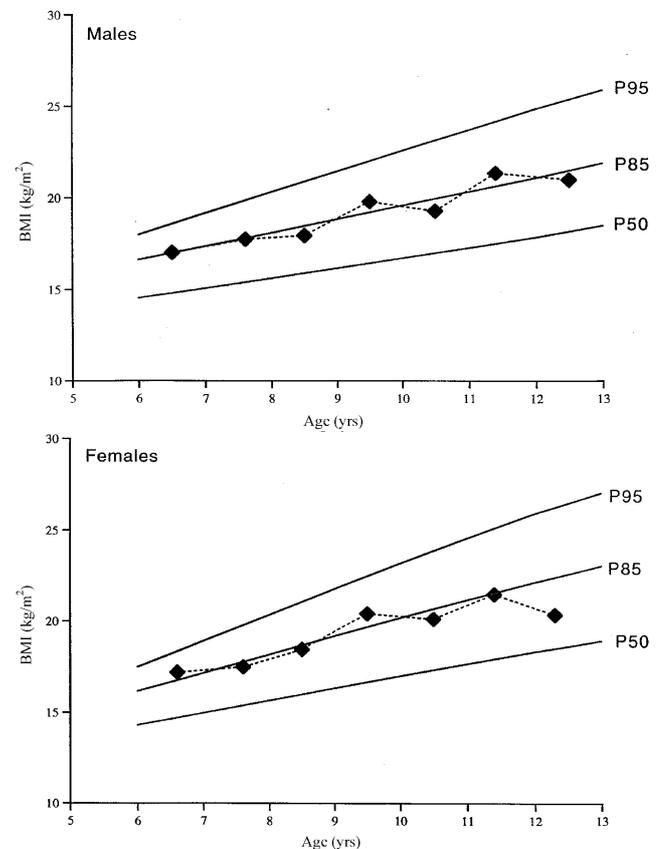
was slightly greater (1.2–1.7 cm) in girls between 10 and 12 y, and mean mass was slightly greater (1.6–2.5 kg) in girls between 9 and 11 y compared with boys in the same age groups. The BMI was similar between sexes at all ages.

Mean stature, mass and BMI are plotted relative to US reference values in Figures 1–3. Mean statures were rather stable about the 50th percentiles of the reference (Figure 1). Mean mass was consistently above the reference medians (Figure 2). As a result, age-specific means for the BMI tend to fluctuate about the 85th percentiles of the reference in both sexes (Figure 3). Approximately, 41% of Navajo boys of girls had a BMI  $\geq$  85th percentile (Table 2). Younger girls (6–9 y) had a slightly higher prevalence of risk of overweight and of overweight than older girls (10+ y) (44.3% vs 36.6%), while there was only a small difference in the prevalence of risk of overweight and of overweight between younger and older boys (39.5% vs 43.6%).

Secular changes in the body size of Navajo children are shown in Figures 4–6. Age-specific means for stature and mass were greater in the current Navajo sample compared with those in 1955. There were small differences in stature between the two most recent surveys, but the current sample appears to be heavier at many ages.



**Figure 2** Body mass of Navajo Native American boys and girls 6–12 y of age. Age-specific means are plotted relative to the 10th, 50th, and 90th percentiles of US reference values (Hamill *et al*, 1977).<sup>15</sup>

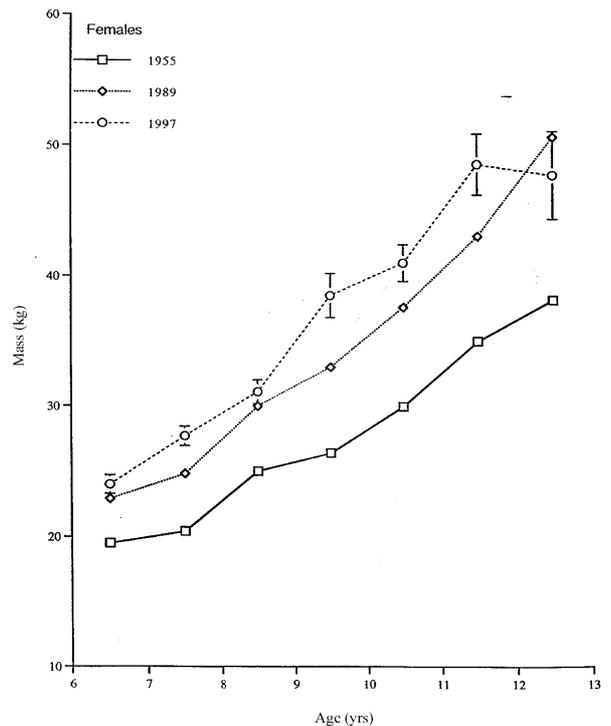
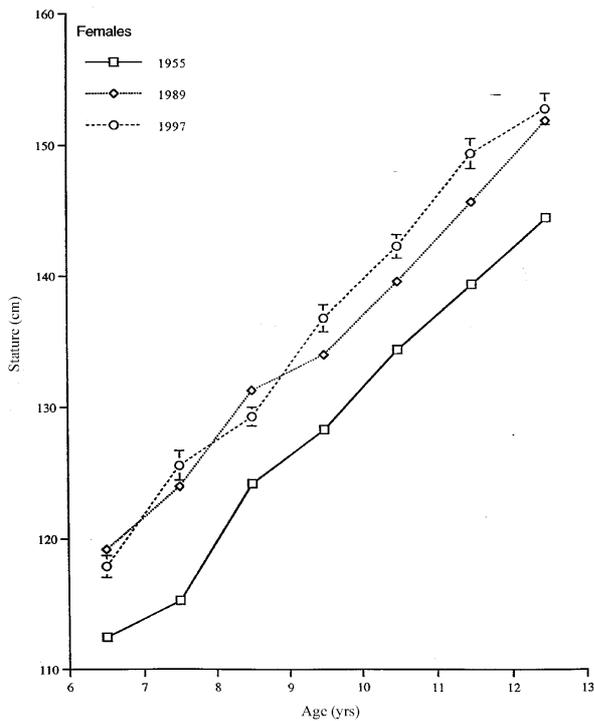
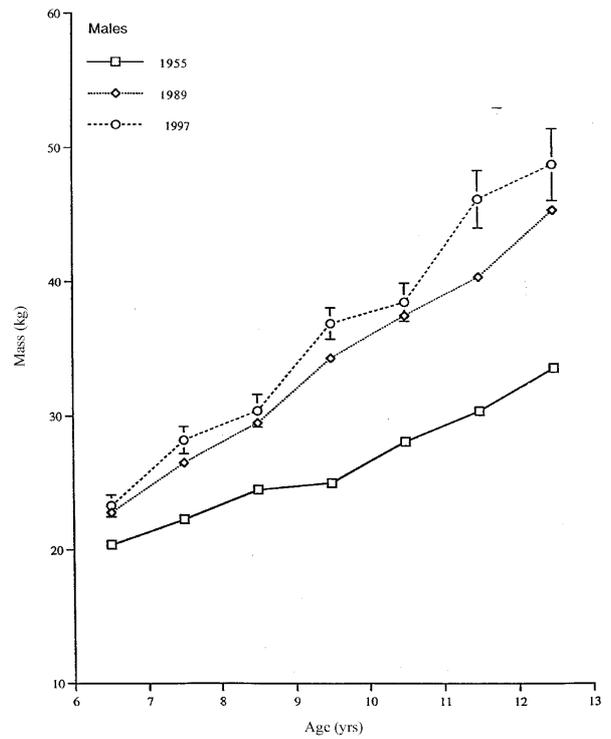
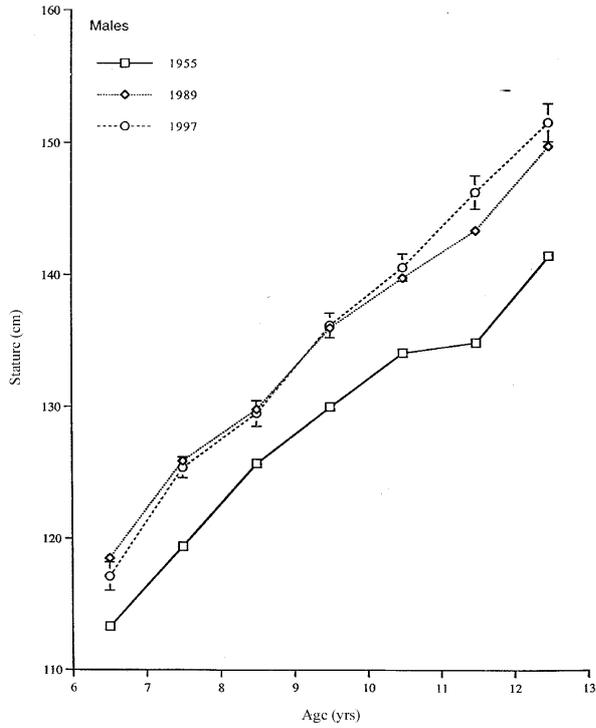


**Figure 3** Body mass index (BMI) of Navajo Native American boys and girls 6–12 y of age. Age-specific means are plotted relative to the 50th, 85th, and 95th percentiles of US reference values (Must *et al*, 1991).<sup>16</sup>

**Table 2** Prevalence of at risk for overweight and overweight of Navajo Native American youth

	Males			Females				
	At risk <i>n</i> ( $\geq 85$ th–95th percentile)	Overweight ( $\geq 95$ th percentile)	Total ( $\geq 85$ th percentile)	At risk <i>n</i> ( $\geq 85$ th–95th percentile)	Overweight ( $\geq 95$ th percentile)	Total ( $\geq 85$ th percentile)		
6–9 y	162	40 (24.7%)	24 (14.8%)	64 (39.5%)	158	34 (21.5%)	36 (22.8%)	70 (44.3%)
10+y	94	26 (27.7%)	15 (16.0%)	41 (43.6%)	112	20 (17.9%)	21 (18.7%)	41 (36.6%)
Total	256	66 (25.8%)	39 (15.2%)	105 (41.0%)	270	54 (20.0%)	57 (21.1%)	111 (41.1%)

Prevalence in parentheses.

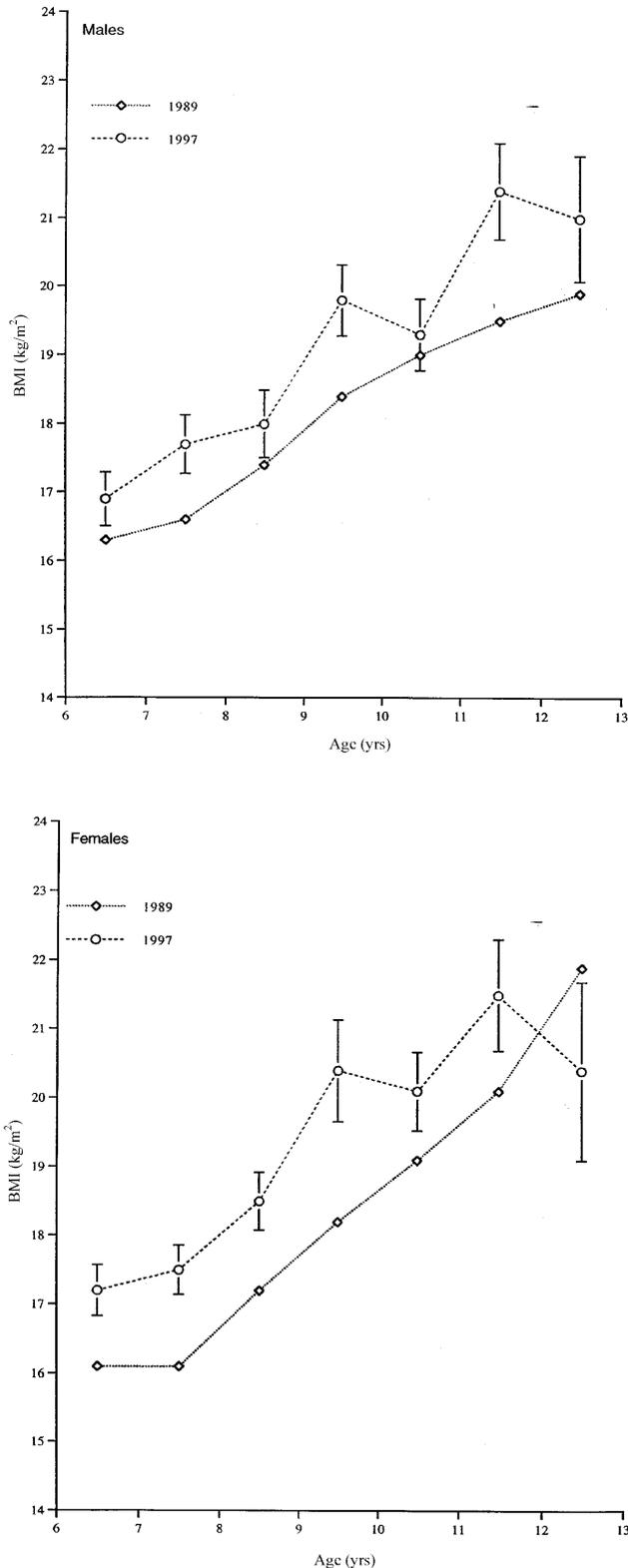


**Figure 4** Secular trend for stature of Navajo Native American boys and girls. 1955 data from Darby *et al*<sup>1</sup> and 1989 data from Sugarman *et al*.<sup>2</sup>

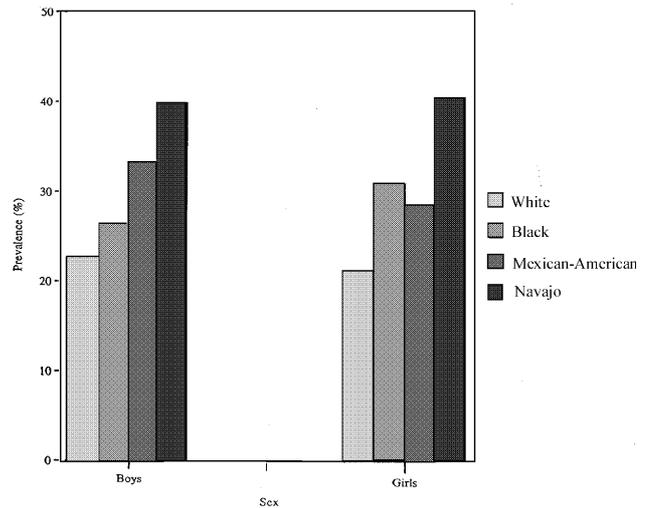
**Figure 5** Secular trend for body mass of Navajo Native American boys and girls. 1955 data from Darby *et al*<sup>1</sup> and 1989 data from Sugarman *et al*.<sup>2</sup>

## Discussion

The stature of Navajo youth approximates US reference values, but mass and the BMI were higher when compared to the general population. These results



**Figure 6** Secular trend for BMI of Navajo Native American boys and girls. 1955 data from Darby *et al*<sup>1</sup> and 1989 data from Sugarman *et al*.<sup>2</sup>



**Figure 7** Ethnic group differences in the estimated prevalence of overweight in US youth 6–11 y of age. Data are from Troiano *et al*<sup>11</sup> and the present study.

probably reflect the improved nutritional status of Navajo youth over the past 30 y. In 1969, 65% and 35% of 4–7 y olds were below the 25th percentiles of reference values for stature and mass, respectively, as undernutrition or malnutrition was evident.<sup>18</sup> More recently, low stature-for-age based on Z scores was reported,  $-0.22$  and  $-0.21$ , for 5–17 y old boys and girls, respectively;<sup>2</sup> however, in another report mean stature of 14–18 y old Navajo youth did not differ from US reference data.<sup>19</sup>

The secular increase in stature in Navajo youth appears to be slowing (Figure 4). It has been reported that the secular increase in stature has stopped in the US as no evident changes have occurred across national surveys since the early 1960s.<sup>20</sup> It is common in auxology to express secular changes in body size as an estimated change in body size per decade (e.g. 3 cm/decade).<sup>21</sup> The rate of secular change can be estimated by subtracting the means at different observations (i.e. 1997 minus 1955) and dividing the difference by the elapsed time expressed in decades (i.e. 1997 minus 1955 equals 4.2 decades). Since 1955, mass has increased about 1.5 kg/decade in younger children (6–9 y) and about 3 kg/decade in older children (10–12 y), while the BMI has increased about 0.5 units/decade in younger children and 1.0 units/decade in older children. The secular increase in body mass and the BMI between 1989 and 1997 was equal to or greater than the increase between 1955 and 1989.

It is important to consider sampling and methodological limitations in the analysis of secular trends. Sample size and representativeness, and intra- and inter-observer measurement variability may limit the interpretation of the comparison of historical data sets. The elapsed time between studies should also be considered since it is not known if changes in body size over time are linear. For example, in the present study stature may have increased only between 1955

and 1965 and then remained unchanged. Nevertheless, allowing for these limitations, such comparisons provide insights into secular trends.

The findings for mass and the BMI warrant attention. The secular trend for increasing pediatric overweight is well documented.<sup>12</sup> In the present study, 26% of boys and 20% of girls were at risk for overweight and 15% of boys and 21% of girls were overweight. The prevalence rate in this sample of Navajo youth was substantially greater than in other ethnic groups of US youth 6–11 y of age (Figure 7). Results from Phase I of NHANES III (1988–1991) indicated that the prevalence of at risk of and of overweight were 11.1% and 10.9%, respectively.<sup>11</sup> Complete results from NHANES III (1988–1994) indicated that approximately 11% of US youth were overweight (i.e. BMI  $\geq$  95th percentile), and an additional 14% had a BMI between the 85th and 95th percentiles.<sup>12</sup> The findings of the present study were similar to those for Navajo adolescents 12–17 y of age in the Navajo Health and Nutrition Survey (35% for boys and 40% for girls),<sup>4</sup> and were slightly greater than those reported by Gilbert *et al*<sup>19</sup> (25% for boys and 33% for girls) for 14–18 y old Navajo youth. Recent information indicates high prevalence rates (30.6–78.3%) of overweight among various North American Indians.<sup>5,7,8,22</sup> It is important to recognize that a direct comparison of the prevalence rates of overweight between studies should be made with caution due to the use of different reference groups (i.e. NHANES I vs National Health Examination Survey (NHES Cycle II, 1963–1965)),<sup>23</sup> although the general trend remains (i.e. the prevalence of overweight is greater in Navajo youth compared with other US ethnic groups). The reference data used in the current study were chosen since they have been recommended in the guidelines for overweight in the pediatric population.<sup>17</sup>

The limitations of the BMI as a proxy for overweight has previously been addressed.<sup>24</sup> Since the BMI is a measure of not only fat tissue but also fat-free mass (i.e. bone and muscle), this proxy for overweight assumes that at a given stature, variation in body mass is due to variation in body fat content. During childhood and adolescence, changes associated with normal growth and maturation confound this indicator, especially rates of growth in stature and mass during the adolescent spurt. Using the triceps skinfold and estimated percentage fat as the criteria for adiposity, Malina and Katzmarzyk<sup>25</sup> found that BMI had high specificity (86–100%) but variable sensitivity (4–75%). Thus, almost all adolescents who are not at risk for overweight or who are not overweight are correctly classified, while many adolescents who are at risk for overweight or who are overweight may be incorrectly identified. An important role with regards to the utility of BMI in this study is that Navajo children have greater skinfold thicknesses than other US youth.<sup>19,26</sup> In addition, preliminary results from the Pathways study of 11 y

old Native Americans found that estimated body fat was 36% in boys and 39% in girls.<sup>26</sup> These results suggest a greater contribution of subcutaneous fat to overall mass in the Native American pediatric population.

Although the burden of mortality is low for childhood obesity (i.e. children rarely die from obesity), adult health may be impacted by childhood obesity, although more information is required from long term studies.<sup>27</sup> Additionally, the manifestation of adult obesity and its co-morbidities presents a burden of morbidity early in life. Relationships between childhood and adult obesity vary considerably and depend upon which approach is used. Correlations between anthropometric status (BMI, skinfold thickness) in childhood and adulthood range from  $-0.04$  to  $0.84$ .<sup>10</sup> Furthermore, about 26–63% of obese children become obese adults, and conversely, 5–44% of obese adults were obese children.<sup>10</sup> Evidence is reasonably consistent that risk of adult obesity increases with obesity in childhood with a relative risk (RR) of 3.8–7.0.<sup>27</sup> These associations suggest an influence of genetic and modifiable environmental factors on the development and treatment of obesity. The prevalence of overweight in Navajo adults is also high, 35% for men and 62% for women.<sup>6,28</sup> Thus preventive measures are an important strategy in the Navajo community, especially among young Navajo females.<sup>8</sup> The advocacy of policies regarding general nutrition and physical education should be the primary focus of such efforts.<sup>29</sup>

Obesity is associated with other co-morbidities, most commonly cardiovascular disease and diabetes mellitus. In the Bogalusa Heart Study, 5–18 y old boys with 25% or greater body fatness also had the highest percentage of subjects in the highest quintile for blood pressure, total cholesterol, and serum lipoprotein ratios.<sup>30</sup> The RR for subjects in the upper tertile (more obese) showed a greater clustering (RR = 3.1) of systolic blood pressure, fasting insulin, and serum cholesterol ratios.<sup>31</sup> Results are similar for elevated blood pressure and triglycerides, and impaired glucose tolerance among overweight Navajo adolescents and adults.<sup>4,19,28,32,33</sup>

The high prevalence of overweight in Navajo youth may be influenced by several factors including genetic susceptibility, socioeconomic status, dietary habits, and physical inactivity.<sup>8</sup> Although a significant role for physical inactivity or sedentary lifestyle has been postulated in the etiology of obesity among youth, data dealing with habitual physical activity or energy expenditure in Navajo youth are limited. However, evidence suggests that estimated energy intake is less in Navajo boys and girls in the upper tertile of the BMI distribution compared to youth in the lower and middle tertiles.<sup>19</sup> If this is so, it would imply a significant role for physical inactivity as an important factor in the development of obesity among Navajo youth. The increasing prevalence of obesity in Navajo youth indicates a need for study of the epidemiology

of physical activity and/or physical inactivity within the context of cultural perceptions of obesity, diet, and energy balance.<sup>34</sup> Future studies should also include an assessment of motor abilities since obese youth have generally poorer levels of both health-related and motor fitness.<sup>35</sup> Proficiency in motor tasks may facilitate or place constraints on access to physical activities, on the level of activity that can be sustained, as well as the enjoyment of physical activity.

The results of this study were consistent with recent findings of the Navajo Health and Nutrition Survey that overweight is a serious public health concern across the lifespan in this ethnic group. Navajo children also appear to be heavier than about a decade ago. Therefore, it is important to establish primary prevention of obesity and associated risk factors during childhood.

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