Adolescent Obesity Increases Significantly in Second and Third Generation U.S. Immigrants: The National Longitudinal Study of Adolescent Health[1,2]

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ABSTRACT Little is known concerning obesity patterns of ethnic subpopulations in the U.S. and the effects of acculturation on these patterns. Adolescent obesity, a major public health problem, has important health, social and economic consequences for the adolescent. The National Longitudinal Study of Adolescent Health survey is unique in the size of the adolescent sample and in its ability to provide large representative samples of Anglo, African-American, Hispanic and Asian-American adolescents. A nationally representative sample of 13,783 adolescents was studied. Measurements of weight and height collected in the second wave of the survey were used to study adolescent obesity. Multivariate logit techniques were used to provide an understanding of the ethnic, age, gender and intergenerational patterns of adolescent obesity. Comparisons are presented between the NHANES III results and those from the Adolescent Health Survey. The smoothed version of the NHANES I 85th percentile cut-off was used for the measure of obesity in this paper. For the total sample, 26.5% were obese. The rates were as follows: white non-Hispanics, 24.2%; black non-Hispanics, 30.9%; all Hispanics, 30.4%; and all Asian-Americans, 20.6%. Important variations within the Hispanic and Asian-American subpopulations are presented. The Chinese (15.3%) and Filipino (18.5%) samples showed substantially lower obesity than non-Hispanic whites. All groups showed more obesity among males than among females, except for blacks (27.4% for males and 34.0% for females). Asian-American and Hispanic adolescents born in the U.S. are more than twice as likely to be obese as are first generation residents of the 50 states. J. Nutr. 128: 701–706, 1998.

KEY WORDS: • *adolescent obesity* • *acculturation* • *international migration* • *humans*

Childhood obesity is a major public health problem affecting nearly 25% of all North American children (Gortmaker et al. 1987, Troiano et al. 1995, USDHHS 1997). Its effects on health during childhood and adulthood and its related social and economic consequences are becoming clearer. What is less clear is the way in which patterns of adolescent obesity vary by race, age and sex. This study introduces a new survey, the National Longitudinal Study of Adolescent Health survey,[4] which offers a wide set of opportunities for understanding more about the health of U.S. adolescents. Add Health is unique in the size of the adolescent sample and in its ability to provide large representative samples of Anglo, African-American, Hispanic and Asian-American adolescents.

Childhood obesity has important health consequences for children and is a major antecedent of adult obesity (NIH 1995). Several studies have demonstrated the persistence of childhood obesity into adulthood (Rolland-Cachera et al. 1987, Serdula et al. 1993, Siervogel et al. 1991). The likelihood of adult obesity is greater for obese adolescents (Guo et al. 1994). Obesity is the most important risk factor for hypertension; it is associated with abnormal lipid profiles during childhood and adolescence. Other early stages of chronic diseases also relate to obesity, as do increased morbidity and mortality (Must et al. 1992). The consequences of childhood obesity extend beyond its health effects. Gortmaker et al. (1993) used a prospective analysis as evidence that adolescent obesity affects later socioeconomic status (SES) and has other consequences such as reduced chances for marriage (Stunkard and Sorensen 1993) and subjection to a range of discriminatory behaviors. Among U.S. adolescents aged 12–17 y, the level of obesity was relatively constant throughout the 1960s and 1970s but has shifted upward

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[4] Hereafter this survey is termed Add Health.

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since then. Troiano et al. (1995) showed that, between the years 1976–1980 and the years 1988–1991,[5] the proportion of adolescents above the 95th percentile more than doubled. More recent results showed that there was a significant increase in the obesity pattern for adolescents between the first phase of NHANES III (1988–1991) and the second phase (1991–1994) and that Hispanic males and females and Black non-Hispanic females were the groups most likely to be overweight (14–16.3% overweight compared with 9.6–12.5% for the other groups) (USDHHS 1997). The increase between the 1976–1980 period and these more recent patterns of obesity was greater among boys than girls. These most recent NHANES III data were based on a sample of <2000 adolescents; thus, ethnic, age and sex relationships could not be examined in detail. The large representative sample of youth from each ethnic group in the Add Health survey provided a basis for clarifying current patterns of adolescent obesity.

Little information has been published on comparative patterns of obesity among adolescents of various ethnic and racial backgrounds. The Hispanic HANES survey collected data for over a thousand Hispanic adolescents with full anthropometry (Pawson et al. 1991). The survey found that among Hispanic adolescents aged 12–18 y, obesity patterns were greater among Puerto Ricans than among Mexican-Americans and Cubans. Studies on Hispanic adolescents showed increased obesity rates over time and greater probability of a higher waist-hip ratio (Kaplowitz et al. 1989). There are no comparable large-scale studies of Asian-Americans and no surveys that allow us to explore obesity across and within the full set of ethnic groupings for U.S. adolescents as has been reported for adults by Kumanyika (1993).

It is important to note that there is great heterogeneity among ethnic subpopulations, especially as it relates to the length of time of residence in the U.S. This paper takes advantage of the large samples of Hispanics and Asian-Americans to explore the effect of generation of residence in the U.S.

SUBJECTS AND METHODS

Survey. The collection of the data followed informed consent procedures established by the institutional review board of the University of North Carolina at Chapel Hill. The Add Health is a study of a nationally representative sample of adolescents in grades 7–12 in the United States. The study was designed to help explain the underlying conditions of adolescent health and health behavior with special emphasis on the effects of the multiple contexts of adolescent life. Data were gathered from adolescents themselves, from their parents, siblings, friends, romantic partners and fellow students, and from school administrators. The Add Health study was longitudinal, with adolescents interviewed for a second time after a 1-y interval. This analysis focuses primarily on the first wave but will present some second wave information. The first wave of data from the youth was obtained between April and December, 1995. We term this the 1995 or Add Health Wave I sample. The Add Health Wave II sample was collected between April and December, 1996.

The primary sampling frame was a list of all high schools in the United States. From this frame, a stratified sample of 80 high schools was selected, with probability proportional to size. A high school was defined as such if it included an 11th grade and an enrollment of >30 students. The sample was stratified by region, degree of urbanization (urban/suburban/rural), school type (public/private/parochial), ethnic mix and size. More than 70% of the original sample of high schools were recruited. If a high school refused to participate, a replacement school within the stratum was selected. For each high school, one of its feeder schools was selected with probability proportional to its student contribution to the high school.

A roster of students enrolled in each school was obtained. From the rosters, a sample of 16,000 was randomly selected for a 1.5-h home interview. Approximately 200 students were selected from each school pair, irrespective of size, thus creating a self-weighting sample.

In addition, special subsamples were drawn. Eligibility for these samples was determined by an adolescent's responses on the in-school questionnaire. Adolescents could qualify for more than one sample. The core sample consisted of the nationally representative sample of 12,105 adolescents, representative of adolescents in grades 7–12 during the 1994–1995 school year in the United States. A wide range of additional subsamples was drawn to provide meaningful samples of children who were disabled, blacks from well-educated families, Chinese, Cuban, Puerto Rican, adolescents residing together, siblings of various levels of relationship (twins, full siblings, half-siblings, nonrelated adolescents residing together, siblings of twins). These subsamples added up to a survey of over 20,000 youth in Add Health Wave I. The overall interview participation rate was ~80%. All eligible adolescents who would have been in school during 1996 were reinterviewed. This included dropouts from school and excluded only those who were seniors in high school in 1995. The follow-up rate was 88%, that is, of the eligible sample of adolescents, we were able to collect data for 88%. Others had moved, died, could not be found or refused to be interviewed.

Anthropometry. The Add Health survey collected both self-reported and measured weight and height data. In Add Health Wave I, weight and height were collected by asking each respondent to recall these measures. In Add Health Wave II, similar self-reported data were collected and subsequently the respondents' weight and height were measured. We focus on the measured weight and height data from Add Health Wave II for this analysis.[6]

There is little agreement about the method of measuring excess body fatness in youth, in particular in large surveys. The approach recommended by scholars in the field as well as major scientific advisory groups that have reviewed this topic is that the best measure of adolescent adiposity is body mass index (BMI, kg/m^2) (Cole 1991, Himes and Dietz 1994, WHO 1995). One must compare BMI for an age-sex standard. This study uses the BMI standard developed by an international expert committee (WHO 1995). The recommendation is that BMI is the most practical measure for adolescents and that the best standard to use is the HANES I standard that was smoothed by Must et al. (1991). The 85th percentile was selected as the cut-off for indepth analysis of overweight patterns in this paper. The reference data used by this international group were based on the NHANES I (National Health and Examination Survey) of the U.S. National Center for Health Statistics. These data were collected between 1971 and 1974. Some researchers have referred to the 95th percentile as delineating the superobese. This analysis does not separate the superobese from the obese because unreported research found consistently that in most age-sex-ethnic groupings, the proportion of obese to superobese was similar. Use of this cut-off appeared to overestimate the obesity of girls relative to boys.[7] This study uses the 85th percentile for most of the analysis. Many refer to this as obesity; others consider it to represent overweight status. There is no consensus on the measurement of adiposity among adolescents. Many feel that this 85th percentile cut-off represents only an approximation of the true population prevalence of obesity or overweight status. Use of the WHO-recommended BMI cut-offs ignores racial-ethnic-group specific cut-off points. Research is emerging that justifies use of exten-

[5] Use of skinfolds rather than weight and height data seems to indicate that the increase in adolescent obesity rates occurred earlier (see Gortmaker et al. 1987).

[6] Adolescent girls systematically underreported their weight; thus we do not use the Add Health Wave I results for this study, which is essentially a focus on prevalence.

[7] There appears to be a potential that use of the Must el al. (1991) percentiles will lead to an overestimation of female obesity. "If you compare the smoothed NHANES I percentiles from Must et al. to the actual percentiles from NHANES I for ages 6–17, you can see that especially for girls, the smoothed 85th percentile values almost all lie below the empirical 85th percentile values and are lower on average by 0.6 BMI units. Using the Must et al. percentiles results in a higher estimated prevalence of overweight particularly for girls ages 6–17 y." (Personal communication, Katherine Flegal, National Center of Health Statistics, Hyattsville, MD, November 19, 1997).

TABLE 1

The National Longitudinal Study of Adolescent Health: sample characteristics[1]

	1996 Wave II	
	%	*n*
Male	49.1	7120
Female	50.9	7384
Age, *y*		
12–15	33.3	4809
16–22	66.7	9629
Ethnicity		
White non-Hispanic	53.5	7726
Black non-Hispanic	21.8	3154
American Indian non-Hispanic	0.8	118
Hispanics	15.7	2277
Mexican	8.8	1269
Cuban	2.5	354
Puerto Rican	3.0	433
Central/Southern American	1.5	221
Other Hispanic	1.3	183
Asian	6.8	980
Filipino non-Hispanic	2.8	399
Chinese non-Hispanic	1.8	262
Asian other non-Hispanic	2.2	319
Total sample size		14,438

[1] Adolescents in the analysis sample for this study.

sive measurement of body composition to predict body fatness more precisely (Lohmann et al. 1997) and points to the potential need for ethnic-group specific cut-offs.

Other measures. Add Health collected separate race and ethnic identification from each adolescent and from parents. Race reports of adolescents were used, except in the few cases in which the adolescent reported "other" or declined to answer. In these cases, interviewer or parent reports of race were substituted. Ethnicity was determined from adolescent reports only.

The adolescents were also classified by the generation of their birth in the U.S. Generation one defines "immigrant children," or those children who were not born in the United States or to U.S. citizens abroad, and thus migrated to the U.S. as children (in most cases with their immigrant parents). Generation two are the "children of immigrants" or children born in the United States (and thus U.S. citizens) but who have at least one parent who is foreign born. Generation three or higher are children who were born in the United States to native-born parents. Generation three+ children may have grandparents or great-grandparents who were immigrants, but because the immigration is much farther removed from the social context of their childhood and adolescent development, this category is considered the native population and the fundamental comparison group for immigrant children and the children of immigrants. For both the Asian children (other than Chinese) and the Hispanic children from Cuba and Central and South America, there were few children in the third generation grouping or beyond. In addition, Puerto Ricans are really not immigrants in that they are all born as U.S. citizens. But we followed an acculturation-based approach with Puerto Ricans and designated those born in Puerto Rico as first generation for this study.

Age is based on age at the time of each survey.

RESULTS

Add Health Wave II sample characteristics are presented in **Table 1**. The sample size for each ethnic subpopulation group examined in the subsequent multivariate analysis is $\geq$980.

The Wave II Add Health results are compared with the NHANES III data in **Table 2**. Note that the much smaller size of the NHANES III sample might limit its ability to measure the prevalence of obesity and obesity for subpopulation groups. Sample weights were available and were used for both the core Add Health sample and the NHANES III sample. Post-stratification sample weights were used to allow these results to be comparable with the U.S. population. In addition, both surveys are based on complex sample designs, and it is appropriate to control for the design effects of multiple stages of sampling as is done for Table 2 for the prevalence results. It is important for the reader to remember that obesity levels have risen from the 1988–1991 NHANES III Phase I results to the 1991–1994 Phase II results (USDHHS 1997). This means that we might expect the Add Health results for 1996 (Wave 2) to be somewhat higher than the NHANES III results.

There are a few interesting issues to point out in this comparison. Gender results were perplexing. The NHANES III weighted results at the 85th percentile were slightly higher for females than males, whereas for the Add Health Wave 2 weighted results, females had a slightly lower level of obesity than did males. At the 95th percentile, these patterns were the same for both surveys—both NHANES III and Add Health males had a higher prevalence of obesity. The gender differences were not significant. In addition, the large confidence intervals of NHANES, in particular, indicate that the differences between the two surveys were not significant.

A second issue relates to a comparison of the results for each ethnic subpopulation. The difference for black non-Hispanics for the two samples was striking, whereas the results for the other ethnic groups were very similar. What might explain this difference? Is it some quirk of sample weights and loss-to-follow-up in the two surveys or is it some other issue related to the differences in sampling between the two surveys? Could this represent a real increase in black non-Hispanic obesity between 1988–1994 and 1996?

Is this a result of the differences in the design of the two sampling frames? For example, Add Health started with a school cohort; however, for the second wave, all persons interviewed in Wave I were followed. Dropout rates in U.S. schools are very small until the last year or two of school, but there is a very small likelihood of a bias related to this school-based Wave I sample. We studied the Wave I obesity patterns of those lost-to-follow-up in Wave II of Add Health compared with those retained. Of the black non-Hispanics who were resurveyed, 31.5% were obese; among those lost-to-follow-up, 25.9% were obese. This was a small number, but their inclusion would have reduced slightly the Wave II obesity prevalence for black non-Hispanics.

We do not have adequate information to study the representativeness of the NHANES III sample or its differential refusal rate at each stage of the analysis.

Based on the NHANES III results, the concern was that all Hispanic youth and black females had very high levels of obesity. The results presented in **Table 3** indicate that the highest levels of adolescent obesity were found among black non-Hispanic females and Hispanic males; 31% of both subpopulations were obese. Remarkably, Asian-Americans who were neither Chinese nor Filipino were also at this level. The Native American subsample was very small but demonstrated a much higher level of obesity as has been found in special studies of Native Americans of many age groups (e.g., Lohmann et al. 1997).

The obesity patterns of the Hispanic and Asian-American subpopulations are explored in some greater detail in Table 3 and also in unreported logit regressions. The obesity patterns

TABLE 2

Comparison of obesity patterns, NHANES III and National Longitudinal Study of Adolescent Health for Adolescents ages 13–18 y

	Add Health Wave 2 core sample		NHANES III[1]	
	Percentage	95% confidence interval[2]	Percentage	95% confidence interval[2]
		BMI ≥85th percentile, %		
Gender				
Male	27.8	(26.1–29.5)	24.6	(20.6–28.7)
Female	25.9	(24.0–27.8)	26.6	(22.8–30.4)
Ethnic Group				
White non-Hispanic	24.9	(23.1–26.6)	24.3	(20.5–28.1)
Black non-Hispanic	34.2	(30.4–38.1)	29.8	(26.3–33.3)
Hispanic	31.0	(27.4–34.8)	31.0	(27.3–34.6)
Total sample	26.9	(25.5–28.3)	25.6	(22.8–28.4)
		BMI ≥95th percentile, %		
Gender				
Male	12.0	(10.7–13.3)	10.7	(7.8–13.7)
Female	11.6	(10.2–13.0)	9.7	(7.6–11.9)
Ethnic Group				
White non-Hispanic	10.9	(9.7–12.2)	9.5	(7.0–12.0)
Black non-Hispanic	16.3	(13.5–19.0)	12.7	(10.3–15.1)
Hispanic	12.1	(10.6–12.9)	13.3	(10.7–15.9)
Total sample	11.8	(10.6–12.8)	10.2	(8.4–12.1)
(Sample size for comparison)	(8646)		(2387)	

[1] Sample weights based on medical examination only.
[2] Adjusted for complex design effects.
BMI, body mass index.

for Mexican-Americans and Puerto Ricans were the highest among the Hispanics. Of equal interest was the much lower rate of obesity among Cuban-American females and Central and South American adolescents.

Most important is the acculturation or assimilation effect that we have found. Little exists in the nutrition literature concerning the effects of immigrant assimilation and adaptation to American culture on adolescent nutrition. Our prevalence results indicated a significant and important acculturation effect, namely, that second and third generation Hispanics are more likely to be obese.

TABLE 3

The National Longitudinal Study of Adolescent Health: obesity categorized by racial and ethnic groupings, 1996 Wave II sample

	Body mass index ≥85th percentile			
	n	% Male	% Female	% Total
White non-Hispanic	10,645	25.8	22.6	24.2
Black non-Hispanic	4449	27.4	34.0	30.9
American Indian non-Hispanic	173	44.4	40.0	42.4
Hispanic-American (total)		31.6	29.1	30.4
Mexican-American	1731	32.2	32.0	32.1
Cuban-American	524	33.1	21.4	27.1
Puerto Rican	574	32.3	28.0	30.3
Central/South Americans	323	25.7	26.9	26.2
Other	240	20.0	22.5	21.3
First generation	735	26.0	23.1	24.5
Second generation	1310	33.7	30.6	32.1
Third generation	1090	32.4	31.0	31.7
Asian-American (total)		25.7	15.0	20.6
Filipino	586	22.6	12.8	18.5
Chinese	349	18.9	10.9	15.3
Other	486	35.9	20.6	28.2
First generation	622	15.6	8.3	11.6
Second generation	576	30.8	22.0	27.2
Third generation	220	34.6	20.3	28.0
Total sample		27.2	25.9	26.5

Among Asian-American, there were marked sex and generational effects. Females were considerably less likely to be obese as were those who were born in another country and represent first generation Asian-Americans. The other Asians—a combination of Koreans, Japanese, Southeast Asian, and Indian-American youth—were the most likely to be overweight; Chinese-American youth were the least likely. The obesity level more than doubled between the first and second generation Asian-Americans.

We undertook further analysis on the ethnicity-gender relationships. Adolescent obesity patterns for the Add Health Wave I adolescents in which we used logit analysis to control for age, gender, ethnic difference, and generation of birth effects are presented in **Figure 1**. We also studied generation-ethnic subpopulation interactions. Differences presented in this graph were all significant ($P < 0.05$). Analyses were generated both for all Asian and Hispanic subpopulation groupings and for the total Asian and Hispanic samples. We focus here on the total Asian-American and Hispanic groups. There were significant effects between the first and second generation obesity levels for each grouping. The third generation effects were not significantly different than those of the second generation. We also examined (data not presented) the effects of membership in the Hispanic and Asian subpopulation groups presented in Table 3. Except for Chinese-Americans, there were large and significant changes in the level of obesity for children born in the second or third generation compared with the first generation in all of these groups. Age relationships to obesity

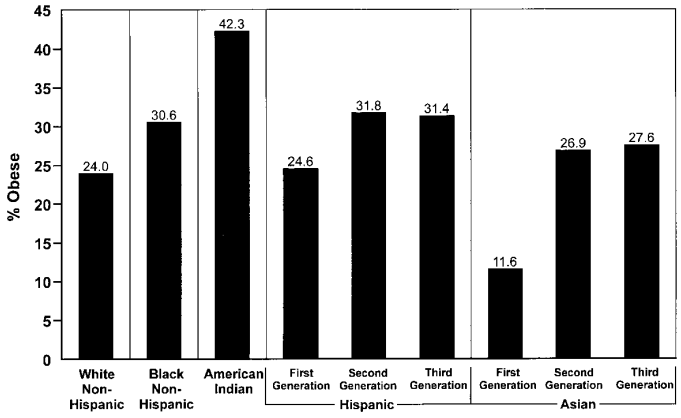

FIGURE 1 Proportion of adolescent obesity, categorized by ethnicity and generation of birth. The solid columns represent the proportion of adolescents whose body mass index (BMI) is above the 85th percentile based on the 1995 WHO standard. The ethnicity and ethnicity-generation effects are significant at the 0.05 level in the logit analysis. Source: National Longitudinal Study of Adolescent Health, Wave 2. The results are adjusted for gender and age.

are shown by sex in **Figure 2**. The proportion of obese males was fairly constant at 29% from age 13–15 y, declining to ~25% for ages 16–18 y. For females, the levels were fairly constant at close to 28% for ages 13–15, declining to ~24% for ages 16–18 y. The interpretations of these age trends by sex is complicated by sex differences in the timing and pattern of physical maturation. Males continue to add height across the adolescent years, whereas most females have reached adult height by age 13 y. BMI standards as well as other studies presenting national data on U.S. adolescents have ignored the issue of sexual maturation. For that reason, we do not attempt to create any type of sexual maturity adjustment because no standard procedures exist for such adjustments. In addition, statistics reported in earlier research on the prevalence of obesity were not presented with corrections for sexual maturity. We have no clear explanation for this age-related drop in obesity.

DISCUSSION

The Add Health data indicated that the obesity status of U.S. adolescents continues to increase. Over 25% of our adolescents belong to the obese category. The much greater size of the Add Health sample for adolescents compared with NHANES III allowed us to expand on previous knowledge of obesity by race, sex and ethnicity. Add Health showed that all race and ethnic categories except Chinese and Filipino had higher obesity levels than non-Hispanic whites. The Add Health Chinese and Filipino samples showed substantially lower obesity than non-Hispanic whites. In most groups, there was more obesity among males than among females. The large exception noted was black non-Hispanics, a group in which significantly more females were obese (34 vs. 27.4% for males). When comparing gender differences by age, males have a slightly higher level of obesity at all ages.

These results of an increase in adolescent obesity confirm points raised in two recent publications of the National Center for Health Statistics group that carried out the NHANES. As the NHANES III results indicate, there was an increase in obesity between the first and second phase of NHANES III (Troiano et al. 1995, USDHHS 1997).

The age and gender relationships have been the subject of numerous growth studies; thus, these are not unique. This study does not address a related issue of age-gender-ethnic adiposity patterns. The National Heart, Lung, and Blood Institute Growth and Health Study is conducting a study of over 2000 girls in the following three areas: schools in Richmond, CA, Cincinnati, OH and a Group Practice in Washington, DC (Crawford et al. 1994, Morrison et al. 1994). Subjects entered the cohort at age 9 y and will be followed until age 16 y. The focus is on the role of diet and physical maturation in affecting the onset of obesity. Important black-white differences in sexual maturation and adiposity relationships have been found.

The unique results concern the effects that we found for the acculturation process for two major subpopulations, Hispanics and Asian-Americans. For both the Hispanic and Asian groups, children born outside the U.S. (first generation Americans or in the case of Puerto Ricans, first generation residents of the contiguous 48 states) showed less obesity than those born in the U.S. of immigrant parents. This acculturation effect was especially strong for Asians.

There is a large literature that examines the process of immigrant assimilation to U.S. culture, but little in the literature speaks to questions we face in studying obesity. That literature finds narrowing gaps in education and socioeconomic status as immigrants go from first to second generation when they are compared with native U.S. citizens (Hirschman 1996). Further analyses are required to determine whether socioeconomic status might explain the findings noted in this paper. First generation children and their native-born parents are less well educated than are those of the second generation (Hernandez and Darke 1998). The immigrant populations are so diverse that we are finding many paradoxes in the classic assimilation model for immigrant adjustment (Park 1950, Portes 1996). For instance, second generation Mexicans might have poorer health outcomes than first generation ones (Guendelman, 1988, Guendelman and Abrams 1995, Scribner and Dwyer 1989, Scribner 1996). Parental backgrounds differ widely among the immigrant groups, particularly in the comparison of Asian with Latin American and Caribbean groups (e.g., Landale et al. 1998).

When studying adolescent obesity we face a more complex set of issues. First, one would need to integrate these issues of assimilation with all of the issues related to adolescence, a period often marked by rebellion from transitional constraints linked to the family and adults and by greater peer and other

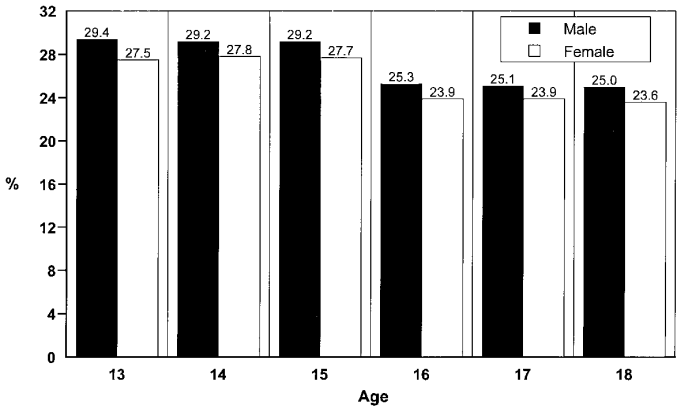

FIGURE 2 Proportion of youth categorized by age and gender whose body mass index (BMI) is above the 85th percentile based on the 1995 WHO standard. Source: National Longitudinal Study of Adolescent Health, Wave 2.

effects. In addition, we must consider effects on both of the key shifts in diet and physical activity that promote obesity. This analysis cannot unravel any of these issues but points out one important direction for future research. These results are most important due to the increased proportion of first generation Asian-Americans and Hispanic-Americans who are moving into the child-bearing ages.

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