

Obesity Development During Adolescence in a Biracial Cohort: The NHLBI Growth and Health Study

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ABSTRACT. *Objective.* The National Heart, Lung, and Blood Institute Growth and Health Study (NGHS) is a 10-year study to investigate the development of obesity in black and white girls during adolescence and its environmental and psychosocial correlates. The purpose of this report was to examine changes in the annual prevalence rates of overweight and obesity in the NGHS cohort from ages 9 to 19 years.

Participants and Setting. A total of 2379 black and white girls, aged 9 to 10 years, were recruited from schools in Richmond, California, and Cincinnati, Ohio, and from families enrolled in a health maintenance organization in the Washington, DC area. Participant eligibility was limited to girls and their parents who declared themselves as being either black or white and who lived in racially concordant households.

Design and Statistical Analysis. The NGHS is a multicenter prospective study of a biracial cohort followed annually from ages 9 to 10 years through 18 to 19 years. The prevalence of overweight and obesity was based on age-specific ≥ 85 th and ≥ 95 th percentile values, respectively, for body mass index based on the 1960–1965 National Health Examination Survey reference population.

Main Outcome Measures. The main outcome measures were body mass index (weight in kilograms divided by height in meters, squared) and proportions of girls who were “overweight” and “obese” by age and race.

Results. The prevalence of overweight was 37% higher in blacks as compared with whites (30.6% vs 22.4%) even by age 9. The rate of overweight almost doubled in both groups during the 10-year period. By age 19, the rate of overweight was 56.9% in black and 41.3% in white girls. The prevalence of obesity was 17.7% in black and 7.7% in white girls at 9 years old, and the rates also doubled during the study period.

Conclusions. The doubling in the prevalence of overweight and obesity during adolescence in black and white NGHS girls was surprising. By age 19, more than

half of black girls were overweight and more than one third were obese. Almost half of white girls were overweight and almost 1 of 5 girls were obese. These findings should sound an alarm for all primary care physicians and public health professionals to take heed of what is happening to our youth. *Pediatrics* 2002;110(5). URL: <http://www.pediatrics.org/cgi/content/full/110/5/e54>; *race, adolescence, body mass index, obesity, overweight, prevalence rates, females.*

ABBREVIATIONS. NGHS, National Heart, Lung, and Blood Institute Growth and Health Study; HMO, health maintenance organization; BMI, body mass index; NHES, National Health Examination Survey; NHANES, National Health and Nutrition Examination Survey.

The prevalence of childhood obesity has been increasing in recent years with a greater increase in minority population groups.^{1–6} In the early 1960s, the prevalence of overweight was lower in black girls than in whites,⁵ but because of racial differences in the secular trend, the prevalence of obesity in black girls is now twice greater than in white girls of the same age.⁵

In general, prepubescent black girls are not fatter than comparable age white girls,^{7,8} although by early adulthood, black women are significantly heavier than white women.^{1,9,10} Thus, the racial disparity in adiposity appears some time during adolescence. The National Heart, Lung, and Blood Institute Growth and Health Study (NGHS) is a long-term multicenter research program to investigate the development of obesity and cardiovascular disease risk factors in a biracial cohort of girls during adolescence and their environmental and psychosocial correlates.^{11,12}

The purpose of this report was to describe the changes in the annual prevalence rate of overweight and obesity in the NGHS cohort of girls followed annually from ages 9 to 10 through 18 to 19 years.

METHODS

Study Design

The NGHS is a multicenter cohort study of black and white girls on whom longitudinal observations were made at annual visits. The study participants were ages 9 to 10 years at first visit (1987–1988) and 18 to 19 years (1996–1997) at the tenth annual visit. A complete description of the study design and protocol has been reported previously.^{11,12}

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Study Sites and Population

NGHS is a collaborative program that involved 3 field centers, a data coordinating center, and the National Heart, Lung, and Blood Institute project office. Study eligibility was limited to girls and their parents who declared themselves as being either "black" or "white" and who lived in racially concordant households. The recruitment strategies involved schools at 2 NGHS field sites and via a large health maintenance organization (HMO) at another site. Selection of potential schools was based on census tract data that showed approximately equal percentages of black and white children and the least disparity in income and education between black and white residents. The recruitment schema involved approaching a whole class of potentially age-eligible girls with very few restrictive eligibility criteria. This inclusive strategy was to help assemble a study population that would reflect, as closely as possible for volunteer participants, normal free-living 9- to 10-year-old black and white girls living in the community where the clinical sites are located. The majority of the cohort selected via the HMO was randomly drawn from a membership list of potentially eligible families with 9- to 10-year-old girls. A small percentage was recruited from a Girl Scout troop situated in the same geographical area as the HMO population. Informed consent was obtained from all participants and their parents. The NGHS protocol was approved by the institutional review board at all participating centers.

Clinical Measurements and Data Collection

A detailed description of the data collection methods for the NGHS have been previously reported.^{11,12} All clinical assessments including anthropometric measures and stage of pubertal maturation were obtained annually by centrally trained examiners using a common protocol. Height was measured to the nearest 0.1 cm with the girls wearing socks, using custom-made stadiometers. Weight was measured to the nearest 0.1 kg with calibrated Health-o-meter electronic scales (Sunbeam Products, Inc, Maitland, FL) and with the participant wearing only a large NGHS standard T-shirt. Sexual maturation was assessed by trained registered nurses using criteria developed by Garn and Falkner, based on Tanner staging principles, but modified for the study of obesity in a biracial population.¹³ Specific staging plates were developed for evaluation of both pubic hair and areolar development. Girls were queried annually on menstrual periods to ascertain the age at menarche.

Statistical Methods and Data Analysis

Body mass index (BMI; weight in kg/height in m²) was used to examine the prevalence rate of overweight based on the age-specific ≥85th percentile value of BMI for girls from the 1960–1965 National Health Examination Survey (NHES) reference population (unpublished data).^{1,14} The prevalence of obesity was based on the age-specific ≥95th percentile value for girls from the same NHES reference population. The percentage of girls at each sexual maturation stage was calculated by race and age at last birthday. Within each age, comparisons of the mean height, weight, and BMI between black and white girls were made using a standard *t* test with the appropriate adjustment as needed for unequal variances.¹⁵

RESULTS

A total of 2379 black (1213, 51%) and white (1166, 49%) girls, aged 9 to 10 years, were enrolled in NGHS. The follow-up rate at the tenth visit was 91% for black participants and 88% for white girls.

Mean height, weight, and BMI at each age are presented by race in Table 1. Although black girls were significantly taller than white girls at age 9 ($P < .001$), by age 19, white girls were significantly taller than black girls ($P = .002$). Body weights and BMI were significantly higher for black girls at all ages ($P < .001$ for all years).

In general, black girls underwent pubertal maturation earlier than did white girls. Even at 9 years old, almost half of the black cohort was pubertal, whereas less than one fourth of white girls had entered puberty (Table 2). At age 11 years, 28% of black girls had achieved menarche compared with 10.5% of white girls. At 12 years of age, 62% of black compared with 40% of white girls had achieved menarche. By 14 years old, however, >90% of both groups had achieved menarche. At age 16, 100% of the cohort had achieved menarche with the average number of years postmenarche ranging from 3.8 years for white girls and 4.5 years for black girls. At

TABLE 1. Mean ± Standard Deviation Height, Weight, and BMI by Age, Race, and Sample Size

Age (Years)	Height (cm)		Weight (kg)		BMI (kg/m ²)	
	Black	White	Black	White	Black	White
9	139.4 ± 7.0 (542)*	137.1 ± 6.0† (634)	36.3 ± 9.45 (543)	33.3 ± 7.3† (634)	18.5 ± 3.8 (542)	17.6 ± 3.1† (634)
10	146.0 ± 7.6 (1205)	143.0 ± 6.9† (1144)	42.4 ± 11.7 (1206)	38.0 ± 9.3† (1142)	19.7 ± 4.4 (1211)	18.4 ± 3.5† (1141)
11	152.7 ± 7.5 (1107)	149.6 ± 7.3† (1030)	49.0 ± 13.2 (1103)	43.5 ± 10.7† (1031)	20.9 ± 4.7 (1110)	19.3 ± 3.8† (1040)
12	157.8 ± 6.7 (1119)	155.8 ± 7.2† (1049)	55.5 ± 14.4 (1116)	49.5 ± 12.4† (1046)	22.1 ± 5.1 (1153)	20.3 ± 4.2† (1058)
13	160.9 ± 6.2 (1087)	160.5 ± 6.6 (961)	60.2 ± 15.5 (1087)	54.9 ± 12.8† (962)	23.2 ± 5.5 (1115)	21.2 ± 4.3† (982)
14	162.1 ± 6.1 (994)	163.0 ± 6.3† (860)	63.6 ± 17.0 (992)	58.5 ± 12.4† (856)	24.1 ± 6.1 (1000)	22.0 ± 4.3† (880)
15	162.7 ± 6.2 (968)	164.0 ± 6.2† (844)	65.5 ± 17.3 (965)	60.8 ± 13.4† (842)	24.7 ± 6.2 (968)	22.5 ± 4.6† (854)
16	163.2 ± 6.2 (1015)	164.5 ± 6.4† (898)	67.5 ± 18.5 (1009)	62.1 ± 13.7† (890)	25.3 ± 6.6 (999)	22.9 ± 4.7† (891)
17	163.2 ± 6.3 (1015)	165.0 ± 6.3† (1001)	70.0 ± 19.8 (1020)	63.8 ± 14.6† (984)	26.2 ± 7.1 (998)	23.4 ± 5.0† (983)
18	163.5 ± 6.2 (947)	165.0 ± 6.4† (926)	71.1 ± 20.6 (941)	64.5 ± 14.8† (917)	26.6 ± 7.4 (933)	23.6 ± 5.2† (917)
19	164.0 ± 6.1 (552)	165.2 ± 6.0† (460)	74.4 ± 22.1 (551)	66.4 ± 15.3† (460)	27.7 ± 8.0 (550)	24.3 ± 5.4† (460)

* Sample size.

† $P < .001$ between the races.

TABLE 2. Prevalence (%) of Pubertal Maturation Stage by Age and Race

Age Interval*	Prepubertal		Pubertal		Postmenarcheal		Mean Years Postmenarche	
	Black	White	Black	White	Black	White	Black	White
9	51.4	77.2	47.6	22.3	0.9	0.5	0.5	0.4
10	20.4	46.9	71.9	51.6	7.7	1.6	0.5	0.6
11	3.5	12.4	68.5	77.0	28.0	10.5	0.8	0.6
12	0.5	1.7	37.4	58.6	62.2	39.7	1.1	0.9
13	0.1	0.2	11.1	24.7	88.8	75.1	1.7	1.3
14	0.0	0.1	2.2	7.7	97.8	92.2	2.5	2.0
15			0.2	1.3	99.8	98.7	3.4	2.9
16					100.0	100.0	4.5	3.8

* Age interval, eg, 9 = 9.0 to 9.9 years.

TABLE 3. Prevalence of Overweight and Obesity by Age and Race

Age (Years)	% Overweight*		% Obesity†	
	Black	White	Black	White
9	30.6	22.4	17.7	7.7
10	34.2	23.0	18.5	9.4
11	34.4	22.6	20.0	10.2
12	37.3	23.4	20.6	9.6
13	39.4	25.3	21.7	10.7
14	36.1	22.4‡	26.3	12.8
15	37.8	22.1‡	19.6	8.0‡
16	39.3	24.1‡	20.8	8.4‡
17	48.6	30.8	29.9	14.1
18	51.3	33.3	32.3	14.9
19	56.9	41.3	36.9	18.0

* Age-specific 85th percentile for BMI from National Center for Health Statistics/Centers for Disease Control and Prevention; Cycles 2 and 3, NHES (1963-1965 and 1966-1970) (Unpublished data, courtesy of Dr R.J. Kuczmarski at the National Center for Health Statistics, Hyattsville, MD).

† Age-specific 95th percentile for BMI from National Center for Health Statistics/Centers for Disease Control and Prevention; Cycles 2 and 3, NHES (1963-1965 and 1966-1970) (Unpublished data, courtesy of Dr R.J. Kuczmarski at the National Center for Health Statistics, Hyattsville, MD).

‡ Although the prevalence of overweight and of obesity seemed to decrease, this is attributable to the higher cutpoints for the 85th and 95th percentile from the NHES reference values, most likely a result of the relatively small sample sizes in NHES for each race-specific age group.

age 19, the average number of postmenarche years was 7.4 years for black girls and 6.7 years for white girls.

Table 3 presents the prevalence of overweight and obesity by age and race. At age 9, the prevalence of overweight in NGHS black girls was 37% higher than that in white girls, 30.6% versus 22.4%. The prevalence of overweight almost doubled during the course of NGHS for both groups so that by 19 years old, 56.9% of black and 41.3% of white girls were overweight with the rate for black girls still 37% higher.

The prevalence rate of obesity (BMI \geq 95th percentile of the NHES reference population) at age 9 was 17.7% for black girls and 7.7% for whites with the rate in blacks more than twofold higher than that in whites, or 129% more. This rate more than doubled in both racial groups between ages 9 to 19 years, from 17.7% to 36.9% in blacks and from 7.7% to 18.0% in whites. The increases became greater after 16 years old. However, the relative racial difference

in the prevalence of obesity remained relatively stable with age.

DISCUSSION

The NGHS is a large biracial cohort study to longitudinally track changes in adiposity and obesity development during adolescence, a critical time of pubertal maturation and increase in body size. A previous NGHS report showed that even at age 9, the mean BMI of black girls was higher than that of white girls at the 85th percentile.¹² There were, however, no racial differences among the lean girls (15th percentile).¹² Although the prevalence of overweight in black girls was more than a third greater than white girls even at age 9, there was a greater racial disparity in obesity with the prevalence more than twofold higher among black girls as compared with white girls. The prevalence of overweight and obesity continued to increase with age but because the increases were similar in both groups, the black-white ratio of the prevalence remained the same during the 10 years of NGHS. This doubling of the prevalence of both conditions resulted in approximately half of the NGHS cohort being overweight by age 19 and about a third of the black participants and one fifth of white participants being obese.

Pubertal maturation is known to impact on obesity development. Girls of both races who mature early have higher levels of BMI and sum of skinfolds during their teenage years than girls who mature later.^{16,17} Because black girls undergo pubertal maturation earlier than do white girls, differences in pubertal maturation stage can account for racial differences in obesity during adolescence. A previous NGHS report noted that at age 9 and 10, racial differences in BMI or sum of skinfolds were completely accounted for by black girls' more advanced pubertal maturation levels.⁸ However, after menarche when girls of both races are sexually mature, pubertal maturation can no longer account for racial differences in obesity.¹² Thus, adolescence, a time during which body fat accumulates naturally in girls, may be a vulnerable period for the development of obesity in girls.

What is the reason behind this startling increase in obesity during adolescence? Could this increase be solely attributable to changes in lifestyle during the teen years? During the 10-year study period, there was a 35% decrease in the average daily level of physical activity in the NGHS cohort.¹⁸ During the

same period, there was no appreciable change in the self-reported average daily intake of energy (data not shown). The average daily energy intake increased by ~17 kcal/d for white girls, but this increase was not statistically significant ($P = .90$). The increase in the caloric intake was somewhat greater for black girls, by 129 kcal/d ($P = .002$). However, the rates of overweight and obesity increased similarly for the 2 racial groups by twofold.

What was seen in the NGHS during the 10-year period may be, in part, parallel to a societal trend in the United States during the late 1980s to 1990s. The first phase of the third National Health and Nutrition Examination Survey (NHANES III) was conducted during 1988–1991, and corresponded to the period spanning ages 10–11 to 14–15 years of the NGHS cohort. However, the greatest increase in obesity prevalence in the NGHS cohort was seen after age 17, corresponding to the years after 1995. Recent reports from NHANES, 1999, show an increase in the prevalence of obesity in children, ages 6 to 19 years, from that of NHANES III.¹⁹

There are several reasons to believe that the NGHS findings may be mirroring what was taking place in the United States in the 1990s. First, this large (over 2300) cohort is not confined to 1 geographic region as it was assembled from 3 separate geographical regions—Cincinnati, Ohio; the greater Washington, DC, area; and West Contra Costa County, California. The selection of the sampling frames (ie, schools at 2 of 3 NGHS sites) was based on census tract data to ensure a wide range of household income and education and also the least disparity in these measures between the 2 races. Whole classes of age-eligible girls were approached for recruitment to help assemble a study population to reflect as closely as possible healthy free-living 9- to 10-year-old black and white girls residing in that community.

Second, empirical analyses reveal that the variables of interest, ie, BMI and the prevalence of obesity, are quite equivalent between the NGHS cohort and the NHANES III sample. For instance, the mean BMI of 10-year-old NGHS white girls (around 1988–1989) was 18.4 kg/m², and the mean BMI of 10-year-old NHANES III (1988–1991) sample of white girls was 18.4 kg/m². The mean BMI of 10-year-old black girls was 19.7 kg/m² in NGHS as compared with 19.5 kg/m² of the NHANES III 10-year-old black girls. The prevalence of overweight among the 9- to 11-year-old NGHS cohort was 29.3% versus 27.7% in the NHANES III sample of 9- to 11-year-old girls. Similarly, the prevalence of obesity among 9- to 11-year-old NGHS girls was 15.5% as compared with 13.9% of the NHANES III sample.

Additional empirical analyses support the observation that the doubling of obesity in the NGHS cohort is a part of the overall national trend. As noted above, the prevalence of overweight and obesity in the NGHS 9- to 11-year-old cohort was similar to the rates in the same age NHANES III sample. However, for older NGHS girls, there is a wider gap in the prevalence rates of overweight and obesity between the NGHS and NHANES III. The data for the older age NHANES III sample were collected

earlier (1988–1991), whereas the data for the older NGHS age groups were collected ~5 years later. Hence, despite the equivalent prevalence rates at the outset, ie, ages 9 to 11, the rate in the older NGHS group whose data were collected later show a deviation from the time-fixed NHANES sample. This suggests that there may be a continuing trend toward increasing obesity in more recent years after the NHANES III survey period, and the doubling of the rate seen in the NGHS cohort is more likely not only the result of the lifestyle changes that invariably occur during adolescence but also compounded by the broader societal changes taking place in the recent years.

The dramatic doubling of the rate of overweight and obesity in the NGHS cohort between late childhood and young adulthood should sound an alarm for primary care physicians and public health professionals. Because obesity is usually “asymptomatic” and traditionally viewed as a temporary phenomenon from which a child is expected to outgrow, the magnitude of the problem, which is of a marked epidemic proportion, has not been accompanied by the usual societal outcry that would have been raised had obesity been a classic infectious disease. Until recently, the issue of excessive body weight has not garnered much attention from researchers, clinicians, and policymakers. These findings should serve as an urgent reminder that a greater effort needs to be directed to the understanding of the causal web of this epidemic and to developing public health and clinical strategies to combat this mass disease plaguing about half of US children and adolescents.

PARTICIPATING NGHS CENTERS

Clinical Centers

Children’s Hospital Medical Center (Cincinnati, OH); University of California at Berkeley (Berkeley, CA); and Westat, Inc (Rockville, MD).

Coordinating Center

Maryland Medical Research Institute (Baltimore, MD).

National Institutes of Health Program Office

Division of Epidemiology and Clinical Applications, National Heart, Lung, and Blood Institute (Bethesda, MD).

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