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Secular Increases in Relative Weight and Adiposity Among Children Over Two Decades: The Bogalusa Heart Study

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ABSTRACT. ***Objective.*** **To examine trends in relative weight and obesity among 5- to 24-year-olds between 1973 and 1994.**

Design. **A panel design consisting of seven cross-sectional surveys of schoolchildren and three surveys of post-high-school subjects. Anthropometric measurements included height, weight, and subscapular and triceps skinfolds.**

Study Population. **All schoolchildren residing in Ward 4 of Washington Parish, Louisiana, a biracial community, were considered eligible; participation rates were >80%. Young adults were eligible if they had participated previously as schoolchildren. A total of 26 371 examinations were performed on 11 564 persons.**

Results. **During the study period, substantial increases in mean levels of weight (0.2 kg/y) and skinfold thickness (0.15 mm/y) were observed; these changes were independent of height, age, and other covariates. The prevalence of overweight, defined by the 85th percentile of weight-for-height in 1973 to 1974, increased approximately twofold by 1994. Although secular increases were seen both among boys and girls and among blacks and whites, the largest increases were seen among 19- to 24-year-olds. Furthermore, the yearly increases in relative weight and obesity during the latter part of the study period (1983 through 1994) were ~50% greater than those between 1973 and 1982.**

Conclusions. **The increasing prevalence of obesity in early life indicates a need for primary prevention. Additional study is needed to determine whether these trends are continuing to accelerate and to examine possible explanations, such as diet and physical activity, for these changes.** ***Pediatrics*** **1997;99:420–426;** ***child, obesity, body weight, secular trends, blacks, longitudinal studies.***

ABBREVIATIONS. GEE, generalized estimating equations; NHANES, National Health and Nutrition Examination Survey.

The 30 million adults in the United States who are ≥20% desirable weight[1] are at increased risk for diabetes, coronary heart disease, hypertension, and certain cancers.[2] Furthermore, the prevalence of overweight is rising, and the mean weight of adults increased by an estimated 3.6 kg from 1976 through 1991.[3] Because substantial weight loss is difficult to maintain,[4] several studies have focussed on its development and consequences in early life.

Overweight children tend to remain overweight during follow-up periods of up to 20 years[5,6] and, in general, have a 1.5- to twofold increased risk for being overweight as adults.[7] Obesity in early life is associated cross-sectionally with respiratory conditions and several risk factors for coronary heart disease[7,8] and is predictive of hypertension,[9] diabetes,[9] coronary heart disease,[10,11] and all-cause mortality[10,12] in adulthood. Some evidence[11] suggests that these longitudinal associations may exist independently of weight status in adulthood.

Despite the widespread attempts at weight loss,[13] the prevalence of overweight among adults[3] and children[14–17] in the United States has increased over the last few decades. We have previously documented secular increases in relative weight among 5- to 14-year-olds in Bogalusa, Louisiana, between 1973 and 1988.[16,17] The current analyses extend our observations to 1994 and broaden our study to include persons up to 24 years of age, as well as skinfold thickness measurements.

METHODS

Population and Study Sample

The Bogalusa Heart Study is a community-based study of cardiovascular disease risk factors in early life.[18] The eligible population consists of all children and young adults living in Ward 4 of Washington Parish, Louisiana, which includes the city of Bogalusa; the 1980 population of this biracial (70% white, 30% black) community was ~20 000. Children and young adults who were examined in any of the cross-sectional surveys conducted between 1973 and 1994 are included in the current analyses (Table 1). Measurements obtained in specialized substudies, in which selection was based on previous risk-factor levels, are excluded.

During this 21-year period, there were seven cross-sectional examinations of schoolchildren, each with a participation rate of >80%;[19] these surveys began near the start of the school year and lasted 6 to 12 months. The initial screening (1973 through 1974) was restricted to 5- to 14-year-olds, but 15- to 17-year-olds were included in all subsequent surveys. Subjects who participated in these school-based surveys were eligible to be rescreened as young adults. The first of three post-high-school surveys, which had a participation rate of 54%,[20] was conducted in 1982; each of these screenings lasted ~1.5 to 3 years. Because 18-year-olds were not examined in the 1988 through 1991 survey, this age group is limited to 19- to 24-year-olds. (The 5-year-olds examined in 1974 would have been 19 years of age in 1988.)

This panel design, based on repeated cross-sectional examinations, resulted in a total of 26 371 examinations performed on

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TABLE 1. Number of Examinations (×100), by Age and Year*

Year	Age Group (y)			
	5–9	10–14	15–17	19–24
1973	8†	8		
1974	8	12		
1975				
1976	8	4	3	
1977	8	12	7	
1978	9	2	<1	
1979	5	12	7	
1980				
1981	8	2	1	
1982	6	12	5	4
1983	6			
1984	3	2	4	
1985	3	12	3	4
1986				3
1987	5	4	2	
1988	9	9	4	1
1989				5
1990				1
1991				<1
1992		1	3	
1993	3	10	2	
1994	8	4	<1	

* There were seven examinations of school-aged children, and three examinations of post-high-school subjects.
† Numbers have been rounded to the nearest 100; 804 5- to 9-year-olds, for example, were examined in 1973. Between 1973 and 1994, there were 9687 examinations of 5- to 9-year-olds, 10 425 of 10- to 14-year-olds, 3961 of 15- to 17-year-olds, and 2298 of 19- to 24-year-olds. The 26 731 examinations represent data from 11 564 different persons.

11 564 different persons. Of these subjects, 4600 were examined once, 2645 twice, 1990 three times, and 2329 four or more times. Forty-nine percent of the children were girls, and 36% were black; the mean age at examination was 12 years.

Anthropometric Examinations

Height was measured to the nearest .1 cm with an Iowa Height Board, and weight to the nearest .1 kg using a balance beam metric scale (Detecto Scales, Inc).[21] These instruments were calibrated monthly, and the mean of two measurements were used in all analyses; data were verified with automatic measurements. Schoolchildren were examined while wearing underpants, an examination gown, and socks; post-high-school subjects wore street clothes (excluding sweaters, jackets, belts, and shoes). Triceps and subscapular skinfolds were each measured three times to the nearest millimeter with Lange Skinfold Calipers, and we used the mean thickness at each site in the analyses.

Two measures of relative weight were calculated: the Rohrer (kg/m^3) and Quetelet (kg/m^2) indices.[22] These indices are highly correlated with each other ($r \sim .9$) and with the two skinfolds ($r \sim .7$ to .8),[5] but the Quetelet index is less strongly correlated with height among 5- to 17-year-olds than is the Rohrer index ($r = -.04$ vs .57 in these analyses). However, because the Quetelet index is widely used in studies of adults and in many studies of children, levels of both indices are presented in the analyses. (Almost identical results were obtained using either the Rohrer or Quetelet index.) Several regression analyses also used weight as the dependent variable and year of examination as an independent variable, and included height and height^2 as covariates.

The reproducibility of the anthropometric measures was assessed in a 10% random sample from each survey,[23] and based on 1978 through 1979 data, intraclass (within-observer) correlation coefficients were ≥.99 for height, weight, and both skinfolds. Intraclass correlation coefficients for the Quetelet and Rohrer indices were .97 and .93, respectively.

Although technical errors in skinfold measurements performed over several decades could confound secular trends,[24] skinfold thicknesses are more direct measures of adiposity than are weight/height indices. Thus, we used the subscapular and triceps skinfolds in several analyses and have used the mean of these two skinfolds as a global measure of adiposity. (The subscapular skinfold was first measured in the third (1978 through 1979) cross-sectional survey.) Overweight or obese children were defined as those with a relative weight or skinfold thickness, respectively, above various percentiles; both the 85th and the 95th percentiles were used in these analyses.

Statistical Analyses

Survey-specific mean and median values of the anthropometric measures were calculated as an initial summary of the data. Regression models were then used to adjust for possible differences in height and other covariates across surveys and to examine differences in trends by race, sex, age, or time period. Distributions of the anthropometric measures at the initial and final examinations were examined in percentile comparison plots.[25] Because of the large sample size and the numerous analyses performed, a P value < .001 was used to assess statistical significance.

Because serial measurements from an individual are not independent, possibly leading to biased results using standard regression techniques, we used generalized estimating equations (GEE)[26] to compute all regression coefficients and P values. These iterative procedures were implemented in SAS using the GEE1 macro of Karim (Technical Report #674, Department of Biostatistics, Johns Hopkins University, 1989) and in the Statistical Package for Interactive Data Analysis (SPIDA), version 6. The GEE regression coefficients (which account for within-person correlations) typically differed by <10% from those of standard regression analyses. All presented results are based on the assumption that correlations among observations at different times are identical (ie, an exchangeable correlation structure). However, other possible correlation structures, such as m-dependence and autoregressive, yielded very similar results.

RESULTS

The distribution of the 26 371 weight and height measurements by age group and year of examination are shown in Table 1. (All numbers have been rounded to the nearest 100; in 1973, for example, there were 804 children examined between 5 and 9 years of age and 777 between the ages of 10 and 14.) Because the cross-sectional surveys focused on different ages, the intervals between the initial and final examinations differed across age groups. There were ~20 years (1973 through 1974 to 1992 through 1994) of data for the 5- to 14-year-old children, but ~16 years (1976 through 77 to 1992 through 1994) for the 15- to 17-year-olds, and 7 years for the 19- to 24-year-olds.

Levels of several anthropometric variables increased substantially over time (Table 2). Among the 5- to 14-year-olds, there were increases in weight (+3.4 kg), Rohrer index (+1.1 kg/m^3), Quetelet index (+1.5 kg/m^2), and skinfold thickness (+2.2 mm); these changes were independent of any differences in race, sex, height, and age across the study period. (Slightly smaller, but consistent, increases over time were also seen in median levels of the anthropometric variables, although the data are not shown.) Similar trends were seen among older subjects, with the mean weight increasing by 5.6 kg among 15- to 17-year-olds and by 3.8 kg among 19- to 24-year-olds. Although the mean skinfold thickness also increased among the 15- to 17-year-olds, only a small (and nonsignificant) increase in the mean skinfold thickness was seen among the 19- to 24-year-olds. Secular trends in height differed across age groups, with a 1.6-cm increase among 5- to 14-year-olds, but a small decrease among older subjects. Additional adjust-

TABLE 2. Mean Levels of Anthropometric Variables by Age Group and Year of Examination

Age Group (y)	Study Years*	Weight (kg)	Rohrer Index (kg/m³)	Quetelet Index (kg/m²)	Mean Skinfold (mm)†	Height (cm)	Age (y)
5–14	1973–1974	35.9	12.7	17.6	. . .	140	10.3
	1976–1977	35.3	13.0	17.8	. . .	138	10.0
	1978–1979	35.5	13.0	17.9	11.9	138	10.0
	1981–1982	35.8	13.1	18.0	12.5	138	9.9
	1983–1985	38.2	13.3	18.5	12.0	140	10.2
	1987–1988	37.1	13.5	18.6	12.2	138	9.9
	1992–1994	41.0	13.7	19.5	14.6	142	10.4
Adjusted‡ change: Final—initial exam		+3.4	+1.1	+1.5	+2.2	+1.6	
15–17	1976–1977	60.3	12.7	21.3	. . .	168	16.3
	1978–1979	60.5	12.8	21.4	13.5	168	16.4
	1981–1982	61.4	13.0	21.8	13.8	168	16.3
	1983–1985	62.8	13.3	22.3	15.3	168	16.3
	1987–1988	65.8	13.8	23.2	15.9	168	16.4
	1992–1994	65.2	14.0	23.3	16.7	167	16.3
Adjusted‡ change: Final—initial exam		+5.6	+1.2	+2.0	+2.8	−0.2§	
19–24	1982–1983	68.2	13.9	23.6	16.4	170	21.5
	1985–1986	67.8	14.1	23.7	16.7	169	22.3
	1988–1991	70.9	14.9	25.0	17.2	168	22.5
Adjusted‡ change: Final—initial exam		+3.8	+0.8	+1.4	+0.5§	−1.0§	

* Number of measurements for each survey among the 5- to 14-year-olds ranged from 2604 (1983–85) to 3508 (1973–74); for the 15- to 17-year-olds, from 534 (1992–94) to 992 (1976–77); and for the 19- to 24-year-olds, from 709 (1985–86) to 823 (1988–91).
† Mean of triceps and subscapular skinfolds.
‡ Differences were calculated using generalized estimating equations in which the (n) study years were represented using (n-1) indicator variables. Changes in weight, Rohrer index, and skinfold thickness have been adjusted for height, age, race, and sex. Changes in height have been adjusted for age, race, and sex.
All differences between the first and last examinations were statistically significant at the .001 level except where noted: § $P > .001$.

ment for cigarette smoking did not alter any of these trends (data not shown).

The mean Quetelet index increased from ~16 kg/m² among 5-year-olds to 24 kg/m² among 19- to 24-year-olds (Fig 1), but in almost all race, sex, and age categories, the mean value was higher at the final examination than at the initial examination. The overall increase in the mean Quetelet index was ~1.5 kg/m.²

After adjusting for covariates, it was estimated that over each 10-year period, weight increased by 2.0 kg, the mean skinfold thickness increased by 1.5 mm, and height increased by .47 cm (Table 3). (Increases were also seen in the Rohrer index [+.6 kg/m³ per 10 years] and Quetelet index [+.9 kg/m² per 10 years]). Several of these estimates, however, varied somewhat across subgroups. The increase in weight, along with its proportional increase, was largest (+6.2 kg

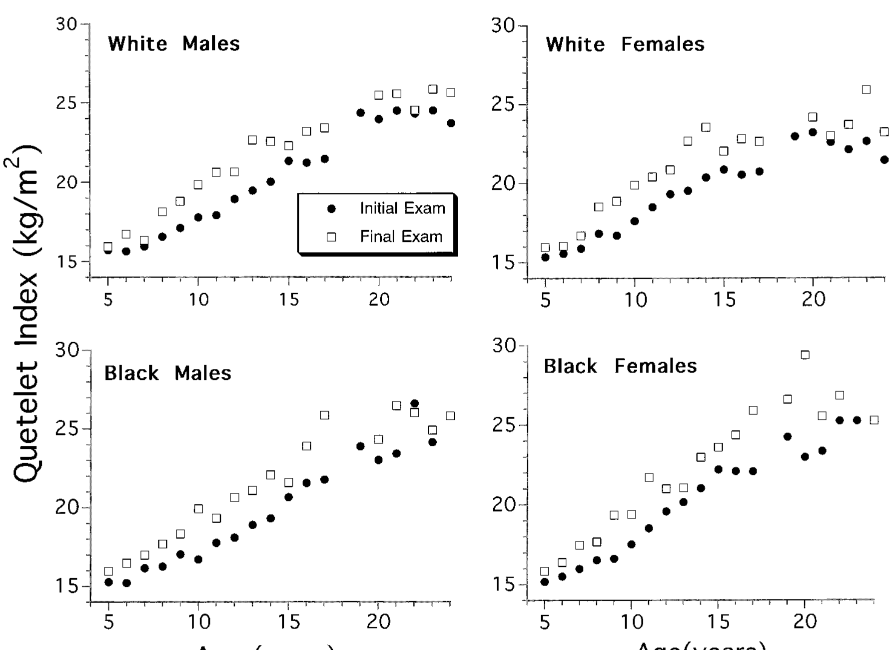

Fig 1. Mean levels of the Quetelet index by race, sex, age, and survey. The initial examination was conducted in 1973 through 1974 (5- to 14-year-olds), 1976 through 1977 (15- to 17-year-olds), or 1982 through 1983 (19- to 24-year-olds). The final examination was conducted in 1992 through 1994 (5- to 17-year-olds) or 1988 through 1991 (19- to 24-year-olds). Each mean Quetelet index is based on an average of 60 measurements; 5 mean values based on fewer than 10 measurements have been omitted.

TABLE 3. Estimated Change* (per 10 Years) in Mean Levels of Weight, Skinfold Thickness, and Height

	N	Weight (kg)	Mean Skinfold† (mm)	Height (cm)
Overall	26 371	2.0	1.5	0.47
Age Group, y				
5–9	9 687	0.7	0.4§	0.53
10–14	10 425	2.4	2.2	1.01
15–17	3 961	4.0	2.2	0.05§
19–24	2 298	6.2	1.0§	−1.37§
Time period‡				
1973–82	14 455	1.4	1.7	0.20§
1983–94	9 618	2.0	2.4	0.54§
Race-sex				
White males	8 292	2.0	1.2	0.30
White females	8 177	2.2	1.6	0.24
Black males	4 883	2.1	1.4	0.97
Black females	5 019	1.9	1.8	0.60

* Estimated changes were calculated using generalized estimating equations; year of examination was the predictor variable of interest, and age, race, and sex were included as covariates. Values in the table represent the estimated regression coefficients for the yearly change multiplied by 10. Height was included as a covariate in models in which weight or the mean skinfold was the dependent variable.
† Mean of subscapular and triceps skinfolds; because of missing measurements, the sample size is 18 767. The subscapular skinfold was first measured in 1978.
‡ Analyses involving the two time periods are restricted to 5- to 17-year-olds; 19- to 24-year-olds were first examined in 1982–1983.
All changes are statistically significant at the .001 level except where noted: § $P > .001$.

or 8.6% of its initial value) among 19- to 24-year-olds and was smallest among 5- to 9-year-olds; the largest increase in skinfold thickness, however, was seen among 10- to 17-year-olds. Nevertheless, increases in both weight and skinfold thickness were larger during the 1983 through 1994 period than during the 1973 through 1982 period (eg, +2.0 kg vs +1.4 kg for weight, $P < .001$ for difference between periods). Trends did not differ by race or sex.

The secular trends in the anthropometric measures also varied according to the initial level, with the largest increases seen at the upper ends of the distribution. A comparison of percentiles of the Rohrer index between the initial and final examinations (Fig 2), for example, indicated that among 5- to 17-year-olds (top), the median value increased by .8 kg/m^3 (12.3 to 13.1 kg/m^3) over the study period, but the 90th percentile increased by 2.4 kg/m.^{3} Similar changes across relative weight percentiles were also seen among 19- to 24-year-olds (bottom). The skinfold thicknesses showed somewhat larger differences, with the median increasing by 1 mm (11 to 12 mm) and the 90th percentile increasing by 8 mm (22 to 30 mm) (data not shown).

The prevalences of overweight and obesity, as defined by various percentiles of the Quetelet index and skinfold thickness, respectively, increased substantially over time (Table 4). Among the 5- to 14-year-olds, 31% to 37% of those examined in 1992 to 1994 would have been considered overweight or obese based on the 85th percentile of values obtained in 1973 through 1974; corresponding percentages based on the 95th percentile ranged from 11% (Quetelet index) to 22% (triceps skinfold thickness).

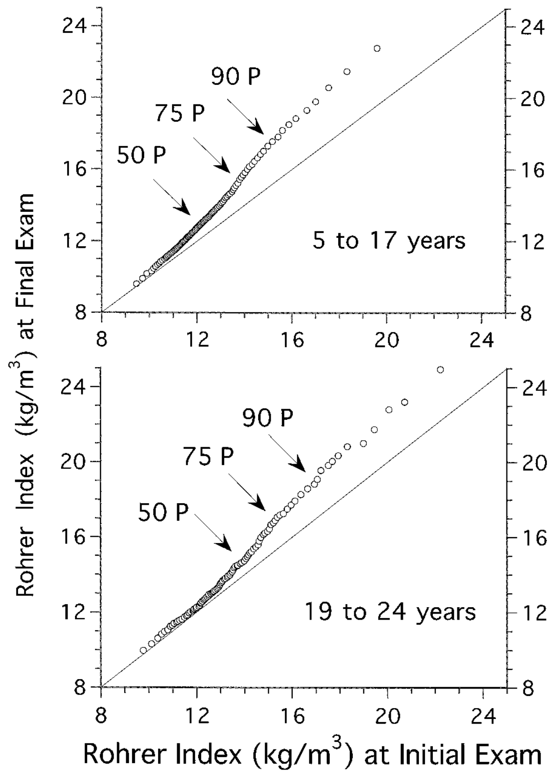

Fig 2. Percentile comparison plot for the Rohrer index between initial and final examination for 5- to 17-year-olds (top) and 19- to 24-year-olds (bottom). The 1st through 99th percentiles of the Rohrer index at the final examination (y-axis) are plotted against the corresponding percentiles at the initial examination. The diagonal line represents the expected value if there had been no secular change, and the distance above the line represents the secular increase in Rohrer index at each percentile. The mean intervals between the two examinations were 16 to 20 years (for 5- to 17-year-olds) and 7 years (for 19- to 24-year-olds).

Similar increases in overweight and obesity were seen among 15- to 17-year-olds, and despite the shorter time interval, 19- to 24-year-olds showed an ~twofold increase in the prevalence of overweight based on the 95th percentile (from 5% to 12%). The proportion of 19- to 24-year-olds with a high (≥85th or ≥95th percentile) triceps skinfold thickness, however, showed little change despite increases in the subscapular skinfold thickness.

DISCUSSION

These results document a substantial increase in the prevalence of obesity among schoolchildren and young adults in Bogalusa, Louisiana. Between 1973 and 1994, the mean weight increased by .2 kg/y, and the mean skinfold thickness increased by .15 mm/y; based on the initial 85th and 95th percentiles of the Quetelet index, the prevalence of overweight approximately doubled. These changes were independent of the relatively small changes observed in height (+.05 cm/y) and other covariates. Furthermore, these secular trends appear to be accelerating, with larger increases seen during the latter part (1983 through 1994) of the study period than during 1973 through 1983.

Although there are exceptions,[27] several recent reports have documented an increase in overweight

TABLE 4. Prevalence of Overweight and Obesity Based on Selected Percentiles* of the Quetelet Index and Skinfolds at Initial Examination

Year	Age Group (years)											
	5–14				15–17				19–24			
	N	Quetelet Index	Skinfolds		N	Quetelet Index	Skinfolds		N	Quetelet Index	Skinfolds	
			Triceps	Subscapular			Triceps	Subscapular			Triceps	Subscapular
1973–1974	3508	15 (5)†	15 (5)	. . .	. . .			. . .				
1976–1977	3073	20 (7)	27 (11)	. . .	992	15 (5)	15 (5)	. . .	. . .			
1978–1979	2908	21 (8)	34 (16)	15 (5)	671	15 (5)	19 (7)	15 (5)	. . .			
1981–1983	2749	22 (9)	37 (19)	20 (8)	554	19 (6)	19 (9)	20 (7)	766	15 (5)	15 (5)	15 (5)
1983–1986	2604	23 (10)	25 (11)	22 (9)	662	23 (10)	20 (9)	33 (14)	709	19 (6)	16 (7)	16 (7)
1987–1991	2688	27 (12)	27 (12)	24 (9)	548	30 (12)	22 (10)	38 (15)	823	26 (12)	13 (7)	24 (10)
1992–1994	2582	32 (11)	37 (22)	31 (17)	534	30 (15)	28 (16)	37 (21)	. . .			

* Cutpoints were calculated within each year of age using the 85th or 95th percentiles of each anthropometric measure at the initial examination; these cutpoints were then applied to values at subsequent examinations. Linear regression was used to adjust levels for race, sex, and height.

† Values represent proportion of participants above the 85th (95th) percentile-based values obtained at the initial examination for each age group.

among schoolchildren in the United States.[14,15,28] Data collected in the National Health and Nutrition Examination Surveys (NHANES),[15] for example, indicate that the prevalence of overweight (based on the 95th percentile of the Quetelet index) doubled between 1963 and 1991, with most of the increase occurring after 1980. (Secular trends in the Quetelet index among adults also appear to be accelerating, with larger increases seen from 1976 to 1991 than between 1960 and 1976.[3]) However, although some evidence suggests that childhood trends in overweight may be most pronounced among blacks,[15] we found little difference across race–sex groups. It is possible that trends in overweight (or differences in these trends by race–sex group) may differ by geographic region.

Obese children tend to undergo sexual maturation at a relatively young age,[29] and earlier-maturing children generally have a large adolescent growth spurt.[30] These interrelationships may account for some of the small increase in height (primarily attributable to results from the 1992 through 1994 survey) that we observed among 5- to 14-year-olds. However, because the age at which the growth spurt occurs is not related to attained height,[30] little or no trend would be expected among older subjects; the small decrease in height we observed among 19- to 24-year-olds may be attributable to chance.

Although adipose tissue is probably the component of overweight that confers an increased disease risk, most studies of secular trends have focused solely on indices of weight and height. These measures of relative weight, although easily obtained, reflect bone and muscle mass as well as adipose tissue; additionally, the Quetelet index is moderately correlated with height during growth.[31] In contrast, skinfolds more closely reflect the amount of adipose tissue, but are subject to large measurement errors.[24] Furthermore, because of the interrelationships among energy intake, growth, and fat storage, there may be more discordance between overweight and obesity among children than among adults. Griffiths et al,[32] for example, found that <50% of 4-year-old boys with a weight-for-height value above the 90th percentile were also above the 75th percentile for triceps skinfold thickness.

Analyses based on relative weight or skinfold thicknesses have led to conflicting conclusions. Using NHANES data, Gortmaker et al[33] found that the prevalence of obesity (85th percentile for triceps skinfolds) among 12- to 17-year-olds increased by 40% from 1960 to 1980. Other analyses, however, showed no change in the mean Quetelet index of these subjects over the same period.[34] These findings may indicate that either (1) the errors involved in skinfold measurements over time may negate their usefulness in assessing secular trends,[24] or (2) increases in adipose tissue were accompanied by decreases in lean body mass.[33] The similarity of our findings for both relative weight and skinfold thicknesses suggests that adiposity has increased. We found, however, that the trend in relative weight was more closely paralleled by changes in the subscapular rather than triceps skinfold.

Although other studies have also reported increases in overweight among children[35,36] and adults,[37,38] the underlying reasons remain unclear. The magnitude of these trends over short periods, however, implicate a behavioral/environmental characteristic, such as diet or physical activity. Although these components of energy balance are difficult to quantify,[39] most studies have found that total energy intake in the United States has remained fairly stable over the last few decades[37,40–42] and that fat intake has decreased.[41,42] However, the potentially large underreporting of total energy intake by obese adolescents[43] and adults[44] may obscure any secular trends. Although total energy intake was found to increase by ≈200 kcal between the 1976 through 1980 and 1988 through 1991 NHANES surveys,[45] the use of different protocols to obtain 24 dietary recalls makes this comparison problematic.

Physical activity may play an important role in the trends observed in relative weight and obesity. Low levels of physical activity are predictive of subsequent weight gain in some[46] (but not all[47]) studies, and secular trends in overweight are highly correlated with changes in several surrogate measures of inactivity.[48] Adolescents have shown decreased enrollment in physical education classes[49] and participation in vigorous physical activity;[50] the effects of these changes may be accentuated by increased television viewing.[51] However, among adults in the Minnesota Heart Health Study, changes in relative weight were independent of exercise and food intake.[37]

The possible effects of nonparticipation, which could influence all studies of secular trends, should be considered when interpreting our findings. If participation (which was ~50% to 60% among post-high-school subjects[20]) was associated with obesity, then our prevalence estimates of obesity could be biased; this effect could be magnified by the ~15% decrease in the population of Bogalusa that occurred during the 1980s. However, in contrast to the estimate of individual prevalence estimates, the secular trend in obesity would be expected to be biased only if the association between participation and obesity changed during the time frame of the study. For example, if thin persons were more likely to participate during the initial phase of the study than during the latter part, a spurious increase in obesity would be observed.

Although a participation bias cannot be ruled out, we found little evidence to support this possibility. Baseline levels of various anthropometric variables were not related with continued participation in the Bogalusa Heart Study,[20] and mean levels of relative weight and skinfolds were similar between new examinees and subjects who had been examined previously. Furthermore, although it might be expected that any bias would increase as participation decreases, we observed secular increases among school-aged children, for whom participation rates were >80%, and young adults.

We have previously observed trends in lipid and lipoprotein levels that are consistent with secular increases in obesity,[52] and some evidence suggests that childhood body weight may be a better predictor of various diseases than is adult weight status.[11] Although the shape of the relation of obesity to various diseases remains uncertain,[53] there is little doubt that marked obesity is detrimental. The large increases in the proportion of children and young adults at the upper end of the distributions for relative weight and adiposity may, therefore, be particularly relevant. Additional study is needed to elucidate future trends in obesity among children and young adults and to explain these changes. Because substantial weight loss is difficult to maintain,[4] the prevention of obesity should be given additional emphasis.

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