Predictors of overweight and overfatness in a multiethnic pediatric population1–3

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ABSTRACT The goal of the study was to determine whether overweight or overfatness were predicted from sex, race or ethnicity, school site, and intervention or control status for children who were 9 y old at the outset of the Child and Adolescent Trial for Cardiovascular Health (CATCH). In this ethnically and geographically diverse group of 5106 students, height, weight, and triceps skinfold thickness were measured at 9 (baseline) and 11 y (follow-up) of age. The strongest predictors of status at follow-up were baseline overweight (odds ratio: 69.0; 95% CI: 54.9, 96.3) and overfatness (odds ratio: 27.4; 95% CI: 22.4, 33.4); site, African American race or ethnicity, and male sex were also significant independent associations. Children in the overweight (> 85th percentile for body mass index) group had significantly higher adjusted means for total blood cholesterol, higher apolipoprotein B concentrations, lower mean HDL-cholesterol concentrations, and lower performance on the 9-min run than those in other groups (<15th, 15–49th, or 50–85th body mass index percentiles). Similar results were found for these factors for those subjects with greater triceps skinfold-thickness measurements. Groups of children who were overweight and overfat at baseline were more likely to be overweight and overfat at follow-up and to have more cardiovascular risk factors than their peers. Am J Clin Nutr 1998;67:602–10.

KEYWORDS Obesity, overweight, fatness, body mass index, triceps skinfold thickness, children, Child and Adolescent Trial for Cardiovascular Health, CATCH, African Americans

INTRODUCTION Obesity, hyperlipidemia, hypertension, smoking, and a sedentary lifestyle in childhood influence the development of cardiovascular and other diseases in adulthood (1, 2). Obesity is a critically important risk factor because of its increased prevalence in the United States today and its development early in childhood, when primary preventive measures could be instituted. Knowledge of the characteristics of children who become obese is a matter of public health importance because it may aid both in identifying high-risk children and in targeting primary prevention strategies. This contribution supplements the limited data available on minority racial and ethnic groups of predictors of overweight and obesity from preadolescence into early adolescence (3).

The Child and Adolescent Trial for Cardiovascular Health (CATCH) was a randomized, controlled, school-based intervention field trial sponsored by the National Heart, Lung and Blood Institute in elementary school children to test a program to reduce risk factors for heart disease. CATCH provided the opportunity to examine changes in overweight and overweight in the cohort in relation to other risk factors, physical activity, and energy intake (4). The design and results for CATCH were published elsewhere (5–11). CATCH consisted of a behaviorally oriented classroom curriculum coupled with school environment and family-oriented interventions. They were all based on health promotion and behavior change theory and aimed at reducing fat and sodium intakes, increasing physical activity, and preventing initiation of smoking (6). The CATCH behavioral intervention was not designed to reduce weight.

The study involved 96 elementary schools located at four sites. They were randomly assigned to be 40 control and 56 intervention schools; these received either the school-based or school- and family-based intervention program (5). Baseline (third grade) and follow-up measurements (fifth grade) at the student level included height, weight, blood pressure, serum lipids, a 24-h dietary recall from a sample of children, a 9-min run, and a self-administered physical activity checklist.

This paper presents data on overweight and overfatness among CATCH children at follow-up (fifth grade), and identifies child characteristics that predict overweight and overfatness, such as sex, race or ethnicity, school site, and study group. It describes how indicators of cardiovascular disease risk including diet, physical activity levels, serum cholesterol, and blood pressure varied cross-sectionally in...
children categorized by their weight and fatness. Finally, it identifies cardiovascular disease risk factor changes in children who became heavier or fatter over the course of the 2.5-y study.

SUBJECTS AND METHODS

Study participants were 5106 students (51.8% males and 48.2% females) with a mean age of 8.8 y who were in the third grade at the outset of the CATCH study (fall 1991) in 96 public schools located in California, Louisiana, Minnesota, and Texas. They were from ethnically diverse backgrounds (69.1% white, 13.2% African American, 13.9% Hispanic, 1.9% Asian, 0.5% Native American, and 1.4% other). Some 4019 of these students (79%) were measured during the baseline (prerandomization) period and also 2.5 y later (spring 1994) at the completion of the intervention. Participation rates at follow-up were highest for white (79.6%) and Hispanic (79.8%) children, and only slightly lower for African American (75.1%), Asian (76.8%), and Native American (64.0%) children. For certain measurements, such as the 24-h dietary recalls, HDL cholesterol, and apolipoprotein (apo) B, sample sizes are somewhat smaller because only selected random samples of the cohort were measured; details are provided below. All measures were described in detail elsewhere (4, 8). Human subjects committees at each university filed the study protocol and received approval.

Measures

Anthropometric measurements

Height was measured to the nearest 0.1 cm and weight to the nearest 0.1 kg for the entire cohort. The mean of two measurements for each was used in the analyses. Body mass index (BMI), which measures weight adjusted for height, was calculated as weight (kg) divided by height (m) squared.

Triceps skinfold thickness was measured three times each at baseline and follow-up as a measure of fatness of all children in the cohort. Triceps skinfold thickness was measured with Lange calipers (Cambridge, MD) to the nearest 1.0 mm over the triceps muscle at the midpoint between the acromion and the olecranon according to established guidelines (12).

Total serum cholesterol, HDL cholesterol, and apo B

Nonfasting venipuncture samples were drawn for lipid determinations (9). The serum samples were sent to a central laboratory (Miriam Hospital, Providence, RI) for analysis. Total cholesterol values were available for 5106 children at baseline and 3936 (77%) at follow-up. HDL cholesterol and apo B were measured in a randomly selected subsample (45%); 2332 children provided samples for HDL cholesterol at baseline and 1742 (75%) at follow-up; for apo B, 2337 measurements were available at baseline and 1739 (74%) at follow-up.

Briefly, serum total cholesterol was determined by enzymatic methods in a Beckman CX4 autoanalyzer (Beckman Instruments, Inc, Fullerton, CA). HDL cholesterol was determined after precipitation with heparin and manganese chloride, and apo B was assayed by nephelometry with a Behring nephelometer (Behring Diagnostics, Inc, Westwood, MA) with antisera raised in goats to isolated protein flow-density lipoprotein in the central laboratory (13). The central laboratory has successfully participated in the Centers for Disease Control Lipid Standardization Program and is in phase III monitoring.

Blood pressure

Arm size was measured and the appropriate cuff size selected for measurement of blood pressure while the participant was seated for 5 min in a quiet room. Five recordings of systolic and diastolic pressure were taken at 1-min intervals (Dinamap Automated Device, model 8100XT; Critikon, Inc, Tampa, FL). The average of the last three readings was used for analysis.

24-h recalls of dietary intake

A 24-h dietary recall assessed total daily food intake in a random subsample of 30 students per school selected at baseline and was repeated in the same children at follow-up (14). One thousand eight hundred seventy-four recalls were available at baseline and 1182 (63%) at follow-up. Students completed a nonquantified food record on the previous day, and this was used as a prompt for the interviewer, who conducted the 24-h recall. This method has been shown to be reliable and valid (14–16). Total energy and percentage of energy from fat were calculated from each child’s intake by using the University of Minnesota’s Nutrient Data System software, developed by the Nutrition Coordinating Center, University of Minnesota, Minneapolis (food database version 4A, nutrient database version 19).

Reports of physical and sedentary activity

The Self-Administered Physical Activity Checklist (SAPAC) was developed and validated during CATCH (17). SAPAC was administered to all children (n = 3239) in grade 5 only to assess type, duration, and intensity of selected leisure time physical activities, television watching, and video game use. Children reported the number of minutes they had spent during the previous day in various common physical activities and selected sedentary activities (18). The total minutes of all daily physical activity, vigorous physical activity, and sedentary leisure time activities (television and computer game viewing), were computed from these measures. Most children (n = 3214) completed a 9-min run at follow-up, and the distance covered was recorded (11).

Statistical analysis

Descriptive statistics

Overweight was defined for the purposes of this analysis as weight > 85th percentile of BMI and overfat as triceps skinfold thickness above the 85th percentile of the first National Health and Nutrition Examination Survey (NHANES I; 1971–1973) age-, sex-, and race- and ethnicity-specific reference population for whites and African Americans, and for the total population for Hispanics, Native Americans, and Asians (19).

For both BMI and triceps skinfold measurements, the number and percentage of individuals who were “maintainers” (ie, who remained in the category of weight-for-height or fatness status from baseline to follow-up), “gainers” (with measures < 85th percentile at baseline and > 85th at follow-up), and “losers” (with > 85th percentile at baseline and < 85th percentile at follow-up) were also identified.

Multivariate analysis

Logistic regression analyses were carried out to assess indicator variables that might be predictors of weight and fatness status at follow-up. The dependent variables were weight (BMI) or triceps-skinfold-thickness category at follow-up. The independent variables were participation in the CATCH intervention (intervention or control group), site (California, Louisiana, Minnesota, or...
Texans), sex, race or ethnicity (white, African American, Hispanic, Native American, Asian, and other), and weight or fatness category at baseline. Odds ratios (ORs) and 95% CIs were calculated.

To assess the associations of weight (BMI) or fatness (triceps skinfold thickness) status with other physiologic and behavioral characteristics related to cardiovascular risk, CATCH participants were categorized into four groups (<15th, 15–49th, 50–85th, and >85th percentile) at both baseline and follow-up on the basis of their BMI or triceps skinfold thickness compared with the appropriate age-, sex-, and race- and ethnicity-specific percentile, by using the NHANES I reference standards. Means and SEs from an analysis of variance (ANOVA) model that adjusted for race and ethnicity, sex, intervention assignment, and site were computed for each group for the following variables of interest: physiologic measurements (total serum cholesterol, apo B, HDL cholesterol, and blood pressure), indicators of physical activity level (total reported minutes spent on physical activity and sedentary behaviors such as video games and television watching) from SAPAC, performance on the 9-min run, and dietary intakes (total energy and percentage of energy from fat) from 24-h recalls. Adjusted group means were compared by using Scheffé’s method for multiple comparison procedures.

The percentage change in various cardiovascular risk-related characteristics in CATCH participants categorized as maintainers, gainers, and losers from baseline to follow-up were examined by using age-, sex-, race- and ethnicity-, or population-specific definitions for overweight (>85th percentile) and not overweight (<85th percentile) or triceps skinfold thickness > or <85th percentile of the NHANES I standards. Percentage change from baseline was calculated for each of these. Adjusted group means were again computed and compared by using Scheffé’s method.

CATCH was not designed to alter weight or fatness. The CATCH intervention and control group distributions were similar and the two groups did not change in either BMI or triceps skinfold status over the course of the intervention (8). Therefore, data from the two groups were pooled for further analyses.

RESULTS

Distributions of BMI and triceps skinfold thickness

The number and percentage of CATCH participants at baseline and follow-up in each BMI and triceps-skinfold-thickness category compared with the NHANES I reference population are presented in Table 1 (19–21). Compared with these standards, the distributions were shifted to the right; ie, a larger proportion of both males and females were in the overweight and overfat categories than was expected. These findings were evident both at baseline (=9 y of age) and at follow-up (=11 y of age). Differences from standards were especially pronounced in the upper weight percentiles (20, 21).

The prevalence of overweight in the CATCH population was 28.2% in males and 29.8% in females at baseline (Table 1). At follow-up, 34.1% of the males and 30.1% of the females were overweight. The prevalence of overfatness (triceps skinfold thickness >85th percentile) was 24.3% for males and 24.0% for females at baseline, compared with 34.1% for males and 26.5% for females at follow-up. The prevalence of overweight was 38.6% for African Americans and 25.5% for whites. For triceps skinfold thickness above the 85th percentile, the prevalence was 36.0% for African Americans and 21.9% for whites (data not shown).

Predictors of overweight and overfatness

Demographic variables associated with overweight in CATCH participants obtained from a multiple logistic regression analysis of BMI status at follow-up (>85th percentile compared with <85th percentile) are presented in Table 2. Baseline weight status was the most powerful positive predictor of overweight at follow-up (OR: 69.0; 95% CI: 54.9, 86.7). Other factors that predicted overweight at follow-up were site (weights in Minnesota were lower than other sites), African American and “other” race or ethnicity, and male sex (data not shown for sex). No effects of the intervention were evident.

The logistic regression analysis of triceps-skinfold-thickness status at follow-up also showed no intervention effects, although, as expected, baseline overfatness status strongly predicted overfatness at follow-up (OR: 27.4; 95% CI: 22.5, 33.4). Sex and race or ethnicity interactions were significant; the overall P value was <0.048 for the interactive term. Certain race-sex combinations, such as status as an African American (OR: 3.39; 95% CI: 2.30, 4.98), white (OR: 1.67; 95% CI: 1.34, 2.07), Hispanic (OR: 2.0; 95% CI: 1.35, 2.92), or other, and being male were strong predictors of relative overfatness. The other race-sex combinations were heterogeneous, some groups being at higher and some at lower risk, but none of the other groups were sig-

### Table 1

| % | Total (n) | 15th | 15–49th | 50–85th | >85th percentile | Total (n) | 15th | 15–49th | 50–85th | >85th percentile |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BMI Males | 2626 | 4.4 | 23.0 | 44.4 | 28.2 | 2024 | 6.4 | 22.8 | 36.7 | 34.1 |
| Females | 2434 | 6.9 | 22.4 | 41.0 | 29.8 | 1938 | 9.5 | 24.7 | 35.6 | 30.1 |
| Triceps skinfolds thickness | 2626 | 8.9 | 28.7 | 38.0 | 24.3 | 2024 | 3.0 | 19.2 | 43.7 | 34.1 |
| Females | 2434 | 7.8 | 32.9 | 35.2 | 24.0 | 1938 | 8.5 | 30.0 | 35.9 | 25.6 |
**TABLE 2**
Predictors of overweight at follow-up in CATCH participants

<table>
<thead>
<tr>
<th>Predictors Subgroup at follow-up</th>
<th>Odds ratio (of overweight at follow-up)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BMI &gt; 85th percentile of NHANES I reference population</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>1.11 (0.89, 1.40)</td>
<td></td>
</tr>
<tr>
<td>Intervention</td>
<td>2335 (32)</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>1628 (32)</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Site</strong></td>
<td></td>
<td>Reference</td>
</tr>
<tr>
<td>California</td>
<td>1002 (28)</td>
<td>0.81 (0.59, 1.10)</td>
</tr>
<tr>
<td>Louisiana</td>
<td>989 (37)</td>
<td>0.93 (0.67, 1.27)</td>
</tr>
<tr>
<td>Minnesota</td>
<td>996 (26)</td>
<td>0.68 (0.49, 0.95)</td>
</tr>
<tr>
<td>Texas</td>
<td>976 (38)</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Sex and race or ethnicity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>2025 (34)</td>
<td>1.65 (1.33, 2.04)</td>
</tr>
<tr>
<td>Females</td>
<td>1938 (30)</td>
<td>1.0</td>
</tr>
<tr>
<td>White</td>
<td>2774 (28)</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>African American</strong></td>
<td></td>
<td>Reference</td>
</tr>
<tr>
<td>Hispanic</td>
<td>498 (41)</td>
<td>1.49 (1.08, 2.06)</td>
</tr>
<tr>
<td>Native American</td>
<td>556 (43)</td>
<td>1.33 (0.96, 1.86)</td>
</tr>
<tr>
<td>Asian</td>
<td>74 (26)</td>
<td>0.70 (0.31, 1.57)</td>
</tr>
<tr>
<td>Other</td>
<td>46 (43)</td>
<td>3.18 (1.29, 7.27)</td>
</tr>
<tr>
<td><strong>Baseline status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overweight</td>
<td>1273 (3%)</td>
<td>69.0 (54.94, 86.63)</td>
</tr>
<tr>
<td>Not overweight</td>
<td>3962 (68%)</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**Notes:**

1. CATCH, Child and Adolescent Trial for Cardiovascular Health; NHANES I, First National Health and Nutrition Examination Survey.
2. Each variable was simultaneously controlled for the other variables.
3. The number of Native Americans, Asians, and others was very small. Interaction terms for race and sex with treatment or race with sex were not significant.

**FIGURE I.** Mean physiologic measures (cholesterol, apolipoprotein B, and HDL) by weight status groups based on BMI percentiles at follow-up in the Child and Adolescent Trial of Cardiovascular Health. Let- ers indicate whether adjusted group means from mixed ANOVAs with covariates of site, race, sex, and intervention status were different from one another; bars with different letters are significantly different, $P < 0.05$; whiskers indicate 95% CIs.

**FIGURE 2.** The adjusted means for systolic blood pressure and performance on the 9-min run for the four BMI status groups are shown in Figure 1. Blood pressure rose as BMI increased and differences in means between all groups were significant. The 9-min run was lowest for the overweight group but no other differences between the other groups were apparent. Significant differences were not evident for total minutes of physical activity reported per day, minutes spent in vigorous physical activity, or for minutes spent viewing television and playing video games (Figure 3). Differences between groups in total energy per day and percentage of energy from fat were not apparent (data not shown).

**ASSOCIATIONS OF BMI WITH CARDIOVASCULAR RISK FACTORS**

Means of various cardiovascular disease risk factors at follow-up in the four groups of CATCH participants based on BMI percentiles at follow-up are shown in **Figure 1**. Means and SEs were computed from an ANOVA model with covariates of race, sex, intervention group, and site. The overweight group (> 85th percentile of BMI) had significantly higher total blood cholesterol and apo B concentrations than the two middle groups (ie, $P < 0.01$ using Scheffé’s method for multiple comparisons), whereas the means were not significantly different from the lowest BMI group. Mean HDL-cholesterol concentrations were lower for the overweight group than for all the other groups.

**ASSOCIATIONS OF FATNESS WITH CARDIOVASCULAR RISK FACTORS**

Mean total serum cholesterol, HDL cholesterol, and apo B concentrations for groups of CATCH participants categorized by their triceps skinfold thicknesses are shown in **Figure 4**. Means for total cholesterol and apo B concentrations were highest and HDL-cholesterol concentrations were lowest for the overfat (> 85th percentile) group. For total cholesterol and HDL cholesterol, the overfat group differed from the two next lower fatness groups; the overfat group was different from the leanest group for apo B and HDL.

The associations with both systolic blood pressure and 9-min run results are shown in **Figure 5**. As fatness increased, systolic blood pressure increased, and the mean differences were significant between each group. With increasing fatness, the number of yards run in 9 min decreased, with the two groups above the 50th percentile having the poorest performance, and these differences were significant. No significant differences in group means were found for reported minutes of physical activity, minutes spent in sedentary behavior (television watching and playing video games), total energy per day, or percentage of energy from fat (data not shown).
Characteristics of groups whose relative status changed

It was of interest to determine whether changes in cardiovascular risk factors and dietary measures differed in groups of children whose relative weights or fatness status changed over the course of the intervention. Selected risk factor changes based on BMI for each factor expressed as a percentage of the baseline characteristic are shown in Table 3. Each factor was analyzed separately by using a mixed-model ANOVA, which adjusted for race, sex, and intervention group. Baseline data were not available on television watching, total physical activity, and 9-min run, so these values are not included. Values with different superscript letters are significantly different, P < 0.0125.

### TABLE 3
Percentage change in various characteristics from baseline to follow-up in groups of CATCH participants by weight status assessed by unadjusted BMI

<table>
<thead>
<tr>
<th>Factor</th>
<th>Never overweight (n = 2523)</th>
<th>Overweight and lost (n = 138)</th>
<th>Always overweight (n = 994)</th>
<th>Not overweight and gained (n = 275)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food energy (kJ)</td>
<td>7.3 ± 6.2a</td>
<td>-11.8 ± 10.2b,c</td>
<td>0.1 ± 6.5b</td>
<td>16.4 ± 8.0b</td>
</tr>
<tr>
<td>Percentage energy from fat (%)</td>
<td>-0.6 ± 3.5a</td>
<td>-10.1 ± 5.8a</td>
<td>-0.2 ± 3.8a</td>
<td>-0.1 ± 4.6a</td>
</tr>
<tr>
<td>HDL cholesterol (mmol/L)</td>
<td>-1.1 ± 1.3a</td>
<td>0.8 ± 2.3bc</td>
<td>-6.5 ± 1.4b</td>
<td>-6.4 ± 0.8b</td>
</tr>
<tr>
<td>Apolipoprotein B cholesterol (g/L)</td>
<td>-0.7 ± 1.3a</td>
<td>0.2 ± 2.2a</td>
<td>3.1 ± 1.3b</td>
<td>6.5 ± 1.7c</td>
</tr>
<tr>
<td>Total cholesterol (mmol/L)</td>
<td>0.9 ± 0.7a</td>
<td>-1.4 ± 1.2b</td>
<td>2.1 ± 0.7b</td>
<td>5.8 ± 1.0d</td>
</tr>
<tr>
<td>Blood pressure (mm Hg)</td>
<td>5.0 ± 0.4a</td>
<td>3.4 ± 0.7b</td>
<td>3.6 ± 0.4b</td>
<td>7.4 ± 0.6c</td>
</tr>
</tbody>
</table>

1, x ± SE from the mixed ANOVA, which adjusted for race, sex, and group intervention. Never overweight, ≤ 85th percentile at BMI at baseline and ≤ 85th percentile at follow-up; overweight and lost, > 85th percentile for BMI at baseline and ≤ 85th percentile at follow-up; always overweight, > 85th percentile for BMI at baseline and > 85th percentile at follow-up; not overweight and gained, ≤ 85th percentile for BMI at baseline and > 85th percentile at follow-up. Follow-up data only are available for television watching, total physical activity, and 9-min run, so these values are not included. Values with different superscript letters are significantly different, P < 0.0125.

### DISCUSSION

Neither the prevalence of overweight and overfatness nor means for BMI and triceps skinfold thicknesses as reported in an earlier publication were influenced appreciably by the CATCH intervention and therefore did not account for changes at follow-up at age 11 y (8). When we examined whether site, sex, race or ethnicity, or baseline status predicted overweight or overfatness at follow-up, the most powerful determinant of overweight and overfatness was a child’s status at baseline. In addition, male sex and African American race or ethnicity combinations were also strong predictors. Over the 2.5 y of the study, many more children became heavy (n = 275) and fat (n = 425) than returned to more desirable weight (n = 138) and fatness (n = 193). A substantial percentage of the children became overweight (7%) or remained so (25%). Similarly, many children became overweight (10%) or remained so (21%) over the duration of the study. In contrast, only 5% of children who were overweight or overfat attained normal status over the course of the study. These findings suggest that the prediction of future obesity begins by 6–9 y of age (22).

Another study found that both a high BMI and a high triceps skinfold thickness are associated with high cardiovascular disease indicators in adulthood (23). Tracking coefficients for 9-y-old children in the Muscatine study ranged from 0.59 to 0.76 for BMI and from 0.44 to 0.58 for triceps skinfold thickness in adulthood (24). Most other studies show similar associations (25, 26). The possibility that overweight or overfatness may persist into adulthood is, therefore, of particular concern (27).

### Race and ethnicity associations with overweight and overfatness

A limitation of our study was that overfatness was measured only by triceps skinfold thickness. Nevertheless, racial and ethnic associations were apparent. Hispanic adults had high degrees of overweight and obesity in the Hispanic Health and Nutrition Examination Survey of 1982–1984 (28) as did Hispanic males in our study. Hispanic ethnicity and male sex were predictive of later fatness as measured by triceps skinfold thickness, but not of a higher BMI. African Americans were more likely to be heavy and fat than whites in the Bogalusa Heart Study and the Brooks County Study (29). We also observed associations between African American race or ethnicity and both BMI and skinfold thicknesses, but only in males. In other large multietnic studies, BMI and triceps skinfold thickness were lower in school-aged...
Asian children than in other ethnic groups (30). In CATCH, the number of Asian children was small, and although trends were in a protective direction for this race, they were not significant. Race and ethnicity, weight, and fatness are related, and these factors affect many cardiovascular disease risk factors (31). In other studies, the correlations among BMI, tricep skinfold thicknesses, and HDL vary by race and ethnic group, suggesting that excessive weight and fatness may be especially pernicious for some ethnic groups (29). Unfortunately, data on family income and urbanization, which are also associated with weight and fatness, were not available to the investigators for the CATCH children, so it is not possible to assess the relative effects of these factors on measures of weight and fatness (32, 33).

Associations of weight and fatness with cardiovascular disease risk factors

Measures of many of the cardiovascular disease risk factors, both physiologic and behavioral, covaried with increasing weight and fatness. Note also that the triceps skinfold thickness was highly correlated with BMI in our study population ($n = 3962; r = 0.81, P < 0.0001$).

Overweight and obesity confer immediate psychosocial risks, such as social isolation, distorted body image, and social rejection in childhood. However, the most serious problems associated with them are heightened risk of persistent overweight and associated long-term health risks (2, 27). The associations of both excess weight and fatness with adverse lipoprotein profiles, including increased total and apo B cholesterol and decreased HDL cholesterol in the CATCH population, were described previously in other populations (29, 30).

Associations between overweight, as measured by high BMI, excessive fatness, and high blood pressure have also been reported by others (34). Their associations with other cardiovascular risk factors in children and their effects on young adults were also evident in Bogalusa (29, 31). In the Bogalusa Heart Study, body fatness in both white and African American children was significantly associated with cardiovascular disease risk factors, including elevated blood pressure, total cholesterol, and serum lipoprotein ratios when predictive equations including triceps and subscapular skinfold thicknesses were used. Moreover, these differences persisted after the data had been adjusted for age, fat patterns, and fasting blood sugar status (29).

In the Muscatine Study, increased familial cardiovascular mortality was evident in overweight children, as assessed from causes of death in first- and second-degree adult relatives. The heavier children in the fifth quintile of relative weight were more likely to have relatives who...
died of cardiovascular disease. Heavy children with high blood pressure had relatives with the highest mortality risks of all (35).

Other investigators also found that food energy intakes and the percentage of energy from fat were only weakly associated with weight, skinfold thicknesses, and height in 10-y-old children in the Bogalusa Heart Study (36). This is not surprising because overweight children do not necessarily have higher energy intakes than normal-weight children (37). Underreporting may also contribute to the low association of energy intakes with BMI because obese adolescents tend to underreport their energy intakes to a greater extent than do their nonobese peers (38).

BMI and overweight are often (31, 39–42), but not always (43, 44), negatively associated with physical activity in cross-sectional studies of children. One recent longitudinal study found an inverse relation between physical activity and BMI (45), another with triceps skinfold thickness (46), and a third with percentage body fat in boys but not in girls (47). The strongest correlations appear to be between high BMI and low levels of physical activity and cardiovascular fitness (46).

Time spent viewing television was associated with the incidence and prevalence of obesity in NHANES I (48) and in most other studies of primary school children (49, 50). Television viewing has also been linked to decreased physical fitness and obesity (51). Higher levels of physical activity were evident in a town not having television service as compared with one that did (52). However, some studies of teenage females failed to find associations between physical activity levels and either BMI or skinfold thicknesses (53). In older children (grade nine) weekly hours of television viewing were not strongly associated with BMI (50).

Although we found a weak positive correlation between time spent watching television and playing video games and both BMI and triceps skinfold thickness, mean time spent in these activities was not significantly different between overfat and nonoverfat children. The results confirm those of the National Heart, Lung and Blood Institute’s Growth and Health Study of 9-y-olds; neither BMI nor skinfold thicknesses were highly associated with television viewing (42). However, racial and ethnic differences in dietary intakes and physical activity may also influence the relation between television viewing, weight, and fatness. In one large study of girls 9–10 y of age, whites were more physically active and spent more time watching television than African Americans, whereas African American girls had higher energy and fat intakes than whites (54). In CATCH, however, white children reported spending less time watching television and playing video games than did African American and Hispanic children.

Characteristics of groups whose relative status with respect to BMI or fatness changed over the course of the intervention

The changes in cardiovascular risk factors were most striking in children whose BMIs or fatness were greatest at baseline or who had become heavier or fatter. In contrast, those whose rela-
tive weight or fatness decreased from third to fifth grade achieved more favorable risk factor status. There is a need for early intervention to prevent overweight and obesity and for treatment when high BMIs or fatness are noted. These children appear to be on a track that not only predicts future overweight but that has a notably negative effect on cardiovascular risk factors even during childhood.

Conclusions

The strongest predictors of overweight and overweight in CATCH fifth graders were their prior status in third grade. Several indicators of cardiovascular disease risk varied strikingly by BMI and triceps skinfold thickness. The cross-sectional associations were strongest for increases in total and apo B cholesterol and systolic blood pressure and decreases in HDL cholesterol. As BMI and fatness increased, performance on the 9-min run decreased. Adverse changes in cardiovascular risk factors were most striking in those who were already overweight or overfat, or who became so over time. It is possible, even in primary school, to identify a group of children at high risk with respect to both later overweight and fatness and who are likely to have other cardiovascular risk factors. These findings underscore the importance of continued efforts at population-based interventions in children to prevent overweight and fatness by promotion of physical activity and healthy eating patterns.

REFERENCES