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Nutrient intake over time in a multi-ethnic sample of youth

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Abstract

Objectives: The purpose of this paper is to present longitudinal data on nutrient intakes of youth with emphases on differences by sex and race/ethnicity. Nutrients selected for examination are those implicated in chronic disease.

Design: 24-hour dietary recalls were collected from a cohort of third, fifth and eighth graders ($n = 1874$).

Setting and subjects: The sample is drawn from the Child and Adolescent Trial for Cardiovascular Health and includes students from California, Louisiana, Minnesota and Texas.

Results: Across the total sample, nutrient intakes met recommended levels except that total fat, saturated fat and sodium consistently exceeded recommendations and calcium and iron intake of girls consistently fell short of recommended levels. Nutrient consumption between third and eighth grade differed by sex and race/ethnicity for a number of nutrients. In particular, females' intake of energy from total fat, calcium, iron, folic acid, vitamin A and vitamin D decreased over time relative to males' intakes, controlling for overall energy intake. Compared with the other ethnic/racial groups, African-American students increased their intake of energy from total fat and saturated fat over time.

Conclusions: Our results suggest that the diets of youth change over time, and negative trends are more common in females than in males and in African-American and Hispanics compared with Caucasian students. Nutrition education and intervention are needed throughout childhood and adolescence with an emphasis on choosing healthful foods. In addition, greater attention to differential opportunities and reinforcements for females and males, and Caucasian, Hispanic and African-American students is warranted.

Keywords
Adolescents
Dietary recommendations
Longitudinal study

Poor diet is recognised as a risk factor for many chronic diseases including cardiovascular disease, cancer, hypertension, osteoporosis and anaemia[1–4]. Dietary habits and preferences are believed to form in childhood and become habituated over time[5–7]. National nutritional surveillance data and other nutritional surveys suggest that children's diets are high in total fat, saturated fat and sodium, and low in fruit and vegetables, calcium and iron, which may predispose them to diet-related disease[8–13].

The burden of disease is not shared equally by all segments of our population and there is some evidence that dietary risk factors differ by race/ethnicity and sex. In adults, Caucasians have lower risk for mortality from diseases with diet-related aetiologies such as heart disease, cancer and hypertension than do African-Americans[14,15] and women are at greater risk for osteoporosis and iron-deficiency anaemia than are men[1].

Evidence from cross-sectional, national data suggests that the diets of children may differ by race/ethnicity and sex[8,15–19]. A limitation of the available data is that they are cross-sectional, constraining our ability to examine developmental trends over time. This limitation is particularly concerning when we study the diets of children, since food and nutrient intakes may change with

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physical, social and psychological maturation. Longitudinal data describing change in students' diets are available for a cohort of Minnesota students using 24-hour recalls taken in third, fifth and eighth grade. The data indicate that students' intakes of fruit, vegetables and milk decreased as they became older while their intake of soft drinks increased[20]. However, these data represent primarily Caucasian children. We are aware of no recently published longitudinal cohort studies reporting nutrient intakes of male and female youth from diverse racial and ethnic backgrounds.

The purpose of this paper is to present longitudinal data on selected nutrient intake of youth, specifically examining how diets compare with recommended intakes and also examining differential trends over time in intake by sex and ethnicity. The sample is drawn from the Child and Adolescent Trial for Cardiovascular Health (CATCH)[21,22], with nutrient data available from the cohort in third, fifth and eighth grades and spanning the ages of approximately 8 to 14 years. Nutrients selected for examination are those most often implicated in chronic diseases such as cardiovascular disease, cancer, osteoporosis, hypertension and anaemia.

Methods

Study design

CATCH was a group-randomised trial, conducted at four field centres: University of California at San Diego, La Jolla; University of Minnesota, Minneapolis; University of Texas, Austin; and Tulane University, New Orleans, LA. The trial was co-ordinated by New England Research Institutes, Watertown, MA and directed from the programme office at the National Heart, Lung, and Blood Institute, Bethesda, MD[21].

The study proceeded in three phases. CATCH-I was a feasibility study performed in two elementary schools at each field centre. CATCH-II was a three-year intervention trial implemented in 14 elementary schools at each centre, with 10 additional schools serving as controls. The overall sample was thus 96 schools with 56 randomly chosen for intervention and 40 for control[23].

The target population for CATCH-II was students enrolled in Grade 3 in the first year of the trial (1991–92). The intervention was directed largely towards the school environment and included materials and programmes designed to intensify energy expenditure during physical education classes, improve nutrition inside and outside school, and discourage smoking[24–26]. The classroom curricula for Grades 3–5 included specific information and skill development with regard to healthful eating and physical activity[27,28].

The CATCH-II intervention was evaluated at the end of three years, when the cohort was completing Grade 5 (1993–94). Among other results, CATCH-II demonstrated a significant reduction in intake of total fat and saturated fat, while maintaining adequate levels of micronutrient intakes as reported by 24-hour food recall in a randomly chosen sub-sample of the cohort[13,29].

CATCH-III was designed to follow the original cohort as they progressed beyond elementary school, without further intervention, and to determine whether children from intervention schools maintained the improvements seen at the end of Grade 5. Among the individual-level measures repeated at Grade 8 (1996–97) was a single 24-hour diet recall, the results of which are discussed in detail in this paper. The primary CATCH-III intervention results for nutrition, physical activity, knowledge and behaviour and physiological risk factors have been reported elsewhere[22].

Sample

The CATCH cohort, defined by participation in risk-factor screening in Grade 3, consisted of 5106 students, mean age 8.76 years at baseline. Of 3486 students randomly chosen for 24-hour diet recall, 1920 consented and provided baseline data, representing 60% of those selected and 38% of the whole cohort. Participation was slightly higher among Caucasian students (61%) than among African-American (54%) or Hispanic students (58%).

After exclusion of implausible responses and unverifiable outliers, the baseline sample size was 1874. Follow-up data were collected from 1360 students at Grade 5 and 1493 at Grade 8. Participation in the two waves of follow-up did not differ significantly by site, sex or ethnicity (Table 1).

Data collection

The methodology for the 24-hour diet recall was developed and validated during the CATCH pilot phase[30]. Each student selected for a 24-hour recall was instructed to keep a non-quantitative food record the day before the scheduled interview. At school the next day, the student participated in an individual 30–40 minute interview with a trained CATCH staff member, assisted by the food record. Interviewers were trained and certified for direct data entry into a laptop computer with Minnesota Nutrition Data Systems (NDS).

Table 1 Sample characteristics by ethnicity and sex

	Grade		
Total sample	3	5	8
Mean age (years)	8.8	11.1	14.1
	n (%)	*n* (%)	*n* (%)
African-American	226 (12)	145 (11)	183 (12)
Caucasian	1297 (69)	958 (70)	1043 (70)
Hispanic	284 (15)	209 (15)	215 (14)
Other	67 (4)	48 (4)	52 (4)
Female	941 (50)	685 (50)	757 (51)
Male	933 (50)	675 (50)	736 (49)
Total sample	1874	1360	1493

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The NDS Food Database Version 12A and Nutrient Database 27 were employed in the Grade 8 interviews and appropriate earlier versions for Grade 3 and Grade 5 data. Since one intervention component involved changing the content of school meals and recipes, school-specific recipes and vendor product information were used to create a supplemental database of nutrient values applicable to any reported consumption of school breakfast and lunch during the intervention phase of CATCH[31]. For the eighth grade data, school-specific recipes were not used since school-level interventions affecting recipes and vendor products were not implemented.

Data analysis

Each macronutrient and micronutrient variable derived from the 24-hour recall was analysed as a separate dependent variable, according to a uniform statistical modelling procedure described below. Total fat and saturated fat were expressed as percentages of total energy intake for analysis. All other nutrients were expressed in mass units. Iron, folacin, vitamin A and vitamin C had severely skewed distributions and, consequently, were transformed for analysis to a quasi-Gaussian distribution by the Blom method[32,33], then re-transformed to original units for presentation.

Nearly half of the total sample (933, 45%) provided data for all three grades; the remainder had at least one missing time point. Incomplete cases were included in the analysis on the assumption that missing data points were unrelated to study variables. Analysis was restricted to the three major ethnic groups (Caucasian, African-American and Hispanic) to avoid numerical instability from sparse data cells for other racial/ethnic groups.

Mixed-model, repeated-measures analysis of variance (ANOVA) was used, in a single comprehensive statistical model, to account for changes in intakes of each macronutrient and micronutrient intake over time, while controlling for random variation among schools and individual students as well as systematic differences attributable to sex, ethnicity, CATCH intervention and field site. Including a student random effect was equivalent to assuming compound-symmetric covariance for the three-item observation vector (Grades 3, 5, 8) or uniform pairwise correlation between grades within a given student. To test the assumption of compound symmetry for the covariance matrix, we repeated the analysis with an unstructured covariance matrix for the Grade 3, 5 and 8 measures. Doing so changed the outcomes only negligibly; results of the compound-symmetric model are presented here.

In addition to main effects, a sex/ethnicity interaction term was included to allow for variation in the male–female difference according to ethnicity. Sex/grade and ethnicity/grade interaction terms were included to allow the trend in nutrient intake over time to vary by sex and ethnicity. Finally, an intervention/grade interaction was included to test the hypothesis that the CATCH intervention had an impact on the overall pattern of nutrient intake, spanning the baseline, intervention and post-intervention phases. Adjusted subgroup means were constructed from the fitted model to estimate the mean nutrient intake at each grade, by sex and by ethnicity. All computations were performed with SAS software, including the MIXED procedure for the primary analysis[34].

To control inferential error in the presence of multiple endpoints and independent variables, the Type I error rate was set at 5% for each pairing of dependent variable and main effect in ANOVA[35]. For interaction terms, the criterion employed was a more stringent 1%. The expected number of Type I errors for the variables reported in Table 3 was thus $12 \times 5 \times 0.05 = 3$ for main effects and $12 \times 4 \times 0.01 = 0.48$ for interactions.

Results

Table 2 shows the recommended nutrient levels and mean, unadjusted nutrient levels by grade. Mean intakes for both males and females are included if recommended intakes differ by sex. Energy intake was slightly below recommended levels[36] at all grades (except eighth grade males), with males increasing their energy intake over time and females decreasing their intake. The percentage energy from total fat and saturated fat was above recommended levels[37] at all grades but showed a slight decrease over time. Dietary cholesterol intake was consistently within the recommended intake[36] of less than 300 mg, while dietary sodium (which did not include salt added at the table) ranged from about 3000 mg in Grade 3 to over 3300 mg in Grade 8, exceeding the recommended level[38] of 2400 mg. Mean levels of vitamins and minerals exceeded Recommended Dietary Allowances or the Dietary Reference Intakes (DRIs) (1999) for both males and females for folic acid, vitamin D and vitamin C[36,39]. (The DRIs for folate were not used as the recommended level because the DRI for folate (300 μg for 9–13 year olds) represents Dietary Folate Equivalents, an adjusted value based on folic acid fortification in foods. This fortification occurred in January 1998, after the eighth grade data collection period.) Using the guideline of age plus five grams for recommended levels of total fibre[40], students met the fibre recommendation only in third grade. Calcium intake was low at all three grade levels for both sexes; females' intake of iron did not meet recommended levels at any grade, and intake of vitamin A was not met in eighth grade for either sex[36,39].

Adjusted mean nutrient levels by sex and racial/ethnic group are shown in Table 3. Figures 1 and 2 present graphic illustrations for only those nutrients for which the trend over Grade 3–5–8 differed significantly ($P < 0.05$) between sex (Fig. 1) or ethnicity (Fig. 2) as assessed by the sex/grade or ethnicity/grade interaction term in the model.

Table 2 Unadjusted mean (standard deviation, SD) nutrient intakes by grade

		Grade		
Nutrient	Recommended level	3 ($n = 1874$)	5 ($n = 1360$)	8 ($n = 1493$)
Energy (kcal)*	2500 (male)	2109 (713)	2227 (834)	2562 (1070)
	2200 (female)	1955 (624)	2001 (671)	1888 (747)
Energy from total fat (%)†	30% or less of total calories	32.6 (7.0)	31.1 (7.0)	31.0 (8.2)
Energy from saturated fat (%)†	Less than 10%	12.7 (3.5)	11.7 (3.5)	11.5 (3.8)
Dietary cholesterol (mg)*	Less than 300	220 (150)	214 (156)	211 (174)
Sodium (mg)‡	2400	2972 (1248)	3135 (1361)	3363 (1743)
Calcium (mg)§	1300	1082 (488)	1056 (525)	1134 (733)
Iron (mg)*‖	12 (male)	13.0 (7.3)	13.8 (7.9)	15.5 (9.0)
	15 (female)	11.0 (6.3)	12.1 (5.8)	11.1 (7.0)
Folic acid (μg)*‖	150	253 (173)	255 (186)	231 (208)
Vitamin A (IU)*‖	1000 (male)	1110 (924)	1041 (909)	874 (891)
	800 (female)	1030 (881)	880 (770)	623 (640)
Vitamin D (μg)§	5	7.4 (3.8)	6.9 (4.1)	6.7 (5.4)
Vitamin C (mg)§‖	45–75 (male)	82.6 (98.8)	92.0 (117.3)	94.2 (122.1)
	45–65 (female)	78.0 (99.0)	82.6 (112)	67.6 (96.4)
Total fibre (g)¶	5 g plus age	14.5 (6.8)	14.8 (7.4)	15.1 (8.6)

Nutrient recommendation is based on:
* Recommended Dietary Allowances[36].
† Dietary Guidelines for Americans[37].
‡ National High Blood Pressure Education Program[38].
§ Dietary Reference Intakes[39].
¶ Williams[40].
‖ Due to the skewed distribution of these nutrients, medians and interquartile ranges are presented rather than means and standard deviations.

The trend in nutrient consumption between third and eighth grade showed statistically significant differences ($P < 0.05$) between males and females for total energy, percentage energy from total fat, calcium, iron, folic acid, vitamin A, vitamin D, total fibre and fat. Our results show a steady increase in energy intake over time for males, while females' energy intake increased slightly between Grades 3 and 5 and then fell to its lowest level in Grade 8. Percentage energy from total fat fell from third to eighth grade for both sexes but to a greater degree for females. Between Grades 3 and 8, females' calcium and iron intake dropped by 10% and 9%, respectively, while males' calcium and iron intakes both fell by 3%. Both sexes experienced marked and consistent decreases in folic acid, vitamin A and vitamin D over time, with females consistently showing greater reductions over time compared with males. From the third to eighth grade, folic acid intake dropped by 15% in males and 23% in females. Intakes of vitamin A dropped 39% in males and 47% in females while vitamin D dropped 16% in males and 28% in females. Females' intake of fibre showed a significantly different trend from that of males, increasing in Grade 5, then decreasing in Grade 8. Sodium intake remained stable for females while males' intakes increased over time.

Figure 2 illustrates the trends seen across the grades for nutrients for which there were statistically significant differences ($P < 0.05$) among the three racial/ethnic groups studied. Percentage energy from total fat declined steadily across the grades for Caucasian and Hispanic students (5% and 8%, respectively) while African-American students decreased their intake in fifth grade and then increased it in eighth grade to a level 2% higher than the third grade intake. Intake of percentage energy from saturated fat decreased for Caucasian and Hispanic students at each grade level while African-American students' intakes decreased between third and fifth grade and then increased in eighth grade. Hispanic students had the largest decrease in energy from saturated fat between third and eighth grade (14%) followed by a decrease in 8% in Caucasian students and a 3% decrease in African-American students.

Calcium intake remained fairly constant for the Caucasian students over time while intakes dropped at each grade level for both African-American and Hispanic students. Between third and eighth grade, African-American students reduced calcium intake by 14% while Hispanic students' calcium intake decreased by 7%. Folic acid intakes declined over time for Caucasian, African-American and Hispanic students. Between Grade 3 and Grade 8, African-American and Hispanic students' folic acid intake decreased by 27% and 17%, respectively, while Caucasian students' intakes declined by 11%. Vitamin A levels declined in all groups over time, with the largest decrease occurring between Grades 5 and 8. African-American students' vitamin A intakes decreased the most over time, with a 56% decrease in mean intake between Grade 3 and Grade 8. Hispanic and Caucasian students experienced declines in intake of 41% and 29%, respectively, between Grades 3 and 8. Vitamin D intake showed similar trends over time, with the largest decline in intake seen in African-American students (28% decrease between Grade 3 and Grade 8) and Hispanic students (27% decrease between Grades 3 and 8).

Table 3 Adjusted mean (standard error, SE) intake by grade, sex and race/ethnicity

		Mean (SE)				
	Grade	Male	Female	Caucasian	African-American	Hispanic
n	3	899	908	1297	226	284
	5	655	657	958	145	209
	8	713	728	1043	183	215
Energy (kcal)*	3	2068 (34)	1983 (32)	2031 (22)	2134 (53)	1912 (49)
	5	2198 (40)	2037 (37)	2139 (26)	2238 (66)	1977 (56)
	8	2521 (38)	1913 (35)	2231 (25)	2275 (59)	2144 (55)
% Fat*†	3	32.6 (0.3)	32.9 (0.3)	32.6 (0.2)	32.4 (0.5)	33.4 (0.5)
	5	31.2 (0.4)	31.3 (0.4)	31.4 (0.3)	31.1 (0.6)	31.2 (0.5)
	8	32.2 (0.4)	31.1 (0.3)	31.0 (0.2)	33.1 (0.6)	30.8 (0.5)
% Saturated fat†	3	12.8 (0.2)	12.7 (0.1)	12.6 (0.1)	12.5 (0.2)	13.2 (0.2)
	5	12.0 (0.2)	11.5 (0.2)	11.9 (0.1)	11.6 (0.3)	11.9 (0.3)
	8	12.0 (0.2)	11.4 (0.2)	11.6 (0.1)	12.1 (0.3)	11.4 (0.3)
Dietary cholesterol (mg)	3	237 (6)	231 (6)	226 (4)	231 (9)	245 (8)
	5	234 (7)	209 (6)	214 (5)	230 (11)	221 (10)
	8	215 (7)	198 (6)	199 (4)	202 (10)	217 (9)
Sodium (mg)*	3	3044 (43)	3100 (41)	3109 (30)	3055 (67)	3051 (62)
	5	3113 (50)	3116 (47)	3136 (34)	3068 (82)	3138 (71)
	8	3346 (48)	3111 (45)	3247 (33)	3187 (74)	3252 (69)
Calcium (mg)*†	3	1092 (20)	1061 (19)	1151 (14)	1025 (32)	1053 (29)
	5	1050 (24)	958 (22)	1092 (16)	902 (39)	1018 (33)
	8	1059 (23)	952 (21)	1158 (15)	882 (35)	977 (33)
Iron (mg)*	3	13.0 (0.2)	12.8 (0.2)	13.0 (0.1)	13.3 (0.3)	12.5 (0.2)
	5	12.9 (0.2)	12.6 (0.2)	13.0 (0.1)	12.9 (0.4)	12.4 (0.3)
	8	12.6 (0.2)	11.6 (0.2)	12.7 (0.1)	11.9 (0.3)	11.7 (0.3)
Folic acid (μg)*†	3	267 (5)	259 (5)	257 (3)	268 (8)	263 (7)
	5	266 (6)	247 (6)	255 (4)	256 (10)	262 (9)
	8	228 (5)	200 (5)	230 (4)	195 (8)	218 (8)
Vitamin A (IU)*†	3	1133 (30)	1094 (27)	1092 (22)	1215 (49)	1033 (37)
	5	1033 (28)	912 (26)	1007 (19)	977 (45)	935 (39)
	8	691 (24)	579 (22)	779 (17)	532 (31)	613 (32)
Vitamin D (μg)*†	3	7.6 (0.2)	7.2 (0.2)	7.7 (0.1)	7.2 (0.3)	7.3 (0.2)
	5	6.9 (0.2)	6.2 (0.2)	7.1 (0.1)	6.0 (0.3)	6.6 (0.3)
	8	6.4 (0.2)	5.2 (0.2)	6.9 (0.1)	5.2 (0.3)	5.3 (0.3)
Vitamin C (mg)	3	85 (3)	85 (3)	79 (2)	92 (6)	85 (5)
	5	89 (4)	92 (4)	81 (2)	103 (7)	89 (6)
	8	82 (4)	79 (3)	74 (2)	81 (6)	87 (5)
Total fibre (g)*	3	15.2 (0.2)	15.1 (0.2)	15.0 (0.2)	15.4 (0.4)	15.0 (0.4)
	5	14.4 (0.3)	15.3 (0.3)	14.9 (0.2)	14.8 (0.5)	14.9 (0.4)
	8	14.4 (0.3)	14.3 (0.3)	14.7 (0.2)	13.7 (0.4)	14.7 (0.4)

*Significantly different by sex ($P < 0.05$).
†Significantly different by race/ethnicity ($P < 0.05$).

Discussion

The purpose of our study was to investigate how nutrient intakes change over time in a cohort of youth, specifically examining how diets compare with recommended intakes and differential trends in intake by sex and ethnicity. Our conclusions regarding the nutrient adequacy of the diet for this sample of youth mirror what other national surveillance data have revealed: while vitamin status of our youth is generally good, our youth have diets high in fat, saturated fat and sodium, and deficient in calcium and iron[8–12]. In general, we found that levels of percentage energy from total fat, saturated fat and sodium exceeded recommended levels for both sexes and for all ethnic groups studied at all grade levels. As seen in most studies, dietary cholesterol levels were within the recommended levels for all groups. Intakes of folic acid, vitamin D and vitamin C met or exceeded the recommended levels for both sexes and at all grade levels. No sex or ethnic group met recommended levels of calcium at any time period studied and females consistently failed to meet recommended levels of iron.

Besides considering nutritional adequacy of the diet, this study provides an opportunity to study how the diet changes over time, comparing groups of youth by two demographic factors. Our data show statistically significant different trends over time for some nutrients by sex and ethnic group. Females' energy intake remains somewhat stable while males' intakes increase over time, and females showed a greater decrease in their intake of percentage energy from total fat relative to the males, moving them closer to the dietary recommendation for energy from total fat. However, they also had lower intakes of calcium, iron, folic acid and vitamins A and D over time as compared with the males. Since energy intake was included in the analytical models, these nutrient differences can be attributed to females choosing foods of lower nutrient density per kcal than males; lower nutrient

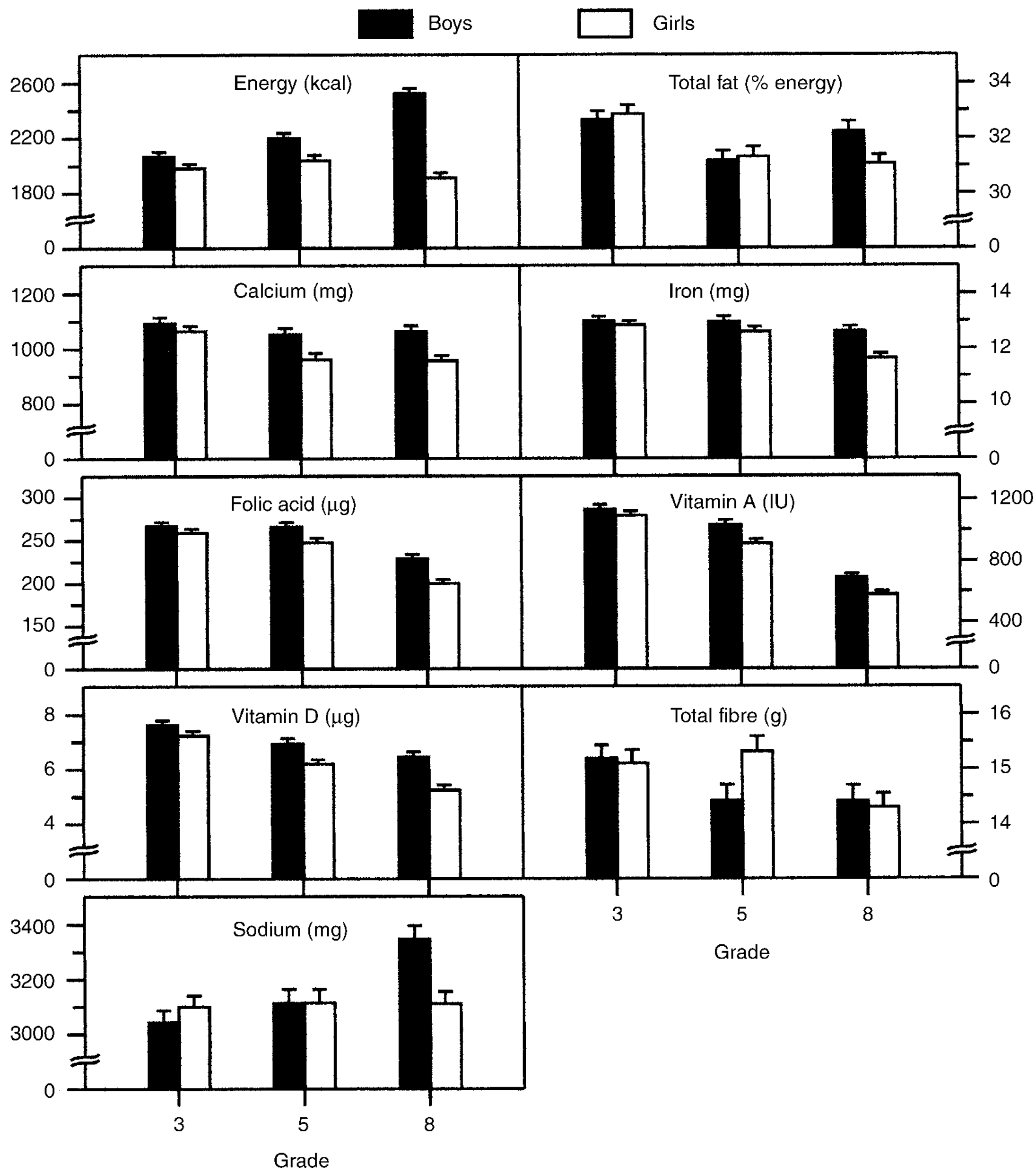

Fig. 1 Comparison of mean nutrient intake over time for boys and girls. All nutrients shown were significantly different by sex ($P \leq 0.05$). Data adjusted for ethnicity, CATCH intervention and field site. Bars indicate one standard error for each mean. Adjusted subgroup means were constructed from the fitted model by the following procedure. Grade- and sex- specific means were calculated from the model equation by fixing grade and sex using equal weights for each level of site, intervention group and race/ethnicity. Grade- and race/ethnicity-specific means were calculated by fixing grade and race/ethnicity and using equal weights for each level of site, intervention group and sex. For variables in mass units (g, mg, μg, IU) the model also included energy intake, which was set at the overall mean (2118 kcal)

intakes cannot be attributed to the lower energy intakes of females.

Cross-sectional, population-based data from the US Department of Agriculture's (USDA's) 1989–1991 Continuing Survey of Food Intakes by Individuals (CSFII)[9] show that only about half of females aged 12–19 met recommended intakes of iron and less than 40% met recommended intakes of calcium; over 85% and 50% of males met recommended intakes of iron and calcium, respectively. Likewise, using the CSFII data, Muñoz *et al.*[8] showed that males aged 12–19 were more likely to meet energy-based recommendations for all food groups, and have higher intakes of grains, vegetables, dairy and meats compared with females.

Low intakes of calcium are particularly concerning for females, especially during puberty, since bone density reaches full genetic potential during this time period. We suspect that the reduction in calcium, vitamin A and vitamin D may be related to a reduction in milk consumption. Additional analysis from this CATCH cohort revealed that lactose intake decreased significantly, sucrose intake remained stable and fructose intake

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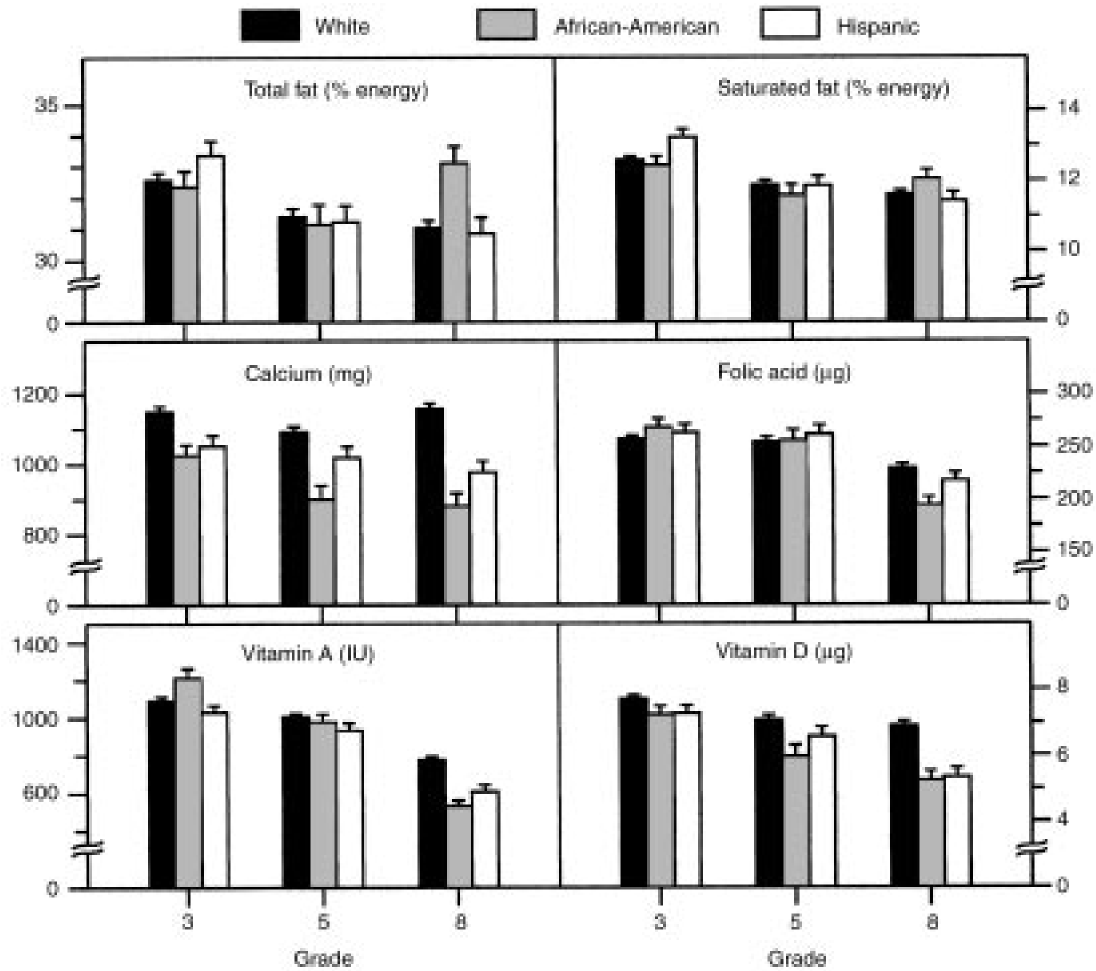

Fig. 2 Comparison of mean nutrient intake over time by race/ethnic category. All nutrients shown were significantly different by race/ethnic group ($P \leq 0.05$). Data adjusted for sex, CATCH intervention and field site. Bars indicate one standard error for each mean

increased significantly over time in the total sample. There were no significant differences between the sexes for lactose or fructose intake. In females, sucrose consumption increased significantly over time (data not shown), suggesting that milk may be replaced with soft drinks or fruit drinks containing sucrose[41–44]. Low intakes of iron seen in the females at all grade levels are of concern because of the risk of iron-deficiency anaemia in females. In general, the reduction in folic acid does not present a major concern because intake levels are still above the Recommended Dietary Allowances, and the addition of folic acid fortification to the food supply (which occurred in January 1998) should further mitigate the risk of inadequate folic acid intakes and neural tube defects.

Our discussion of the differences by race/ethnicity needs to be prefaced by acknowledging the potential confounding that occurs with race/ethnicity and socioeconomic status (SES). It is possible that the differences we see in nutrient intake by race/ethnicity actually represent differences in SES[8,9,16,17]. We were not able to assess this possibility, because all the student-level data (including the 24-hour recalls) were obtained via student self-report, and students were not able to provide valid information to characterise SES. We attempted to use a school-level SES variable (proportion of students in the school qualifying for free or reduced price lunch) as a proxy measure of SES, but found the measure to lack the specificity to be helpful. More research is needed on the effects of SES on the nutritional intakes of youth. At the same time, most studies examining both race/ethnicity and SES show that ethnicity has an independent effect on children's diets after controlling for SES[16–18]. There may be several factors contributing to race/ethnicity differences seen in our results: residual confounding from poor measurement of SES; error in measuring race/ethnicity; culturally based food preferences or food preparation techniques; residential segregation affecting food supply and acquisition patterns; differential food marketing and promotions to different racial/ethnic groups; and other unexplored factors[45,46].

When differences between racial or ethnic groups are considered, it is particularly concerning that, by eighth grade, African-American students' intakes of energy from fat increased and only the African-American students showed an increase in saturated fat intake between fifth and eighth grade. The National Growth and Health Study showed that, after adjusting for income and education, African-American females had higher intakes of energy and energy from total fat than Caucasian females[17]. Higher intakes of fat by African-American youth were also seen in data from the third National Health and Nutrition Examination Survey (NHANES III)[16]. For youth aged 6–24, African-American respondents had significantly higher intakes of energy from total fat compared with Caucasian youth. The NHANES III data[16] also show higher intakes of energy from total fat in Mexican-American females as compared with Caucasian females, a finding not supported by our data.

The CATCH longitudinal data also show that decreases in calcium, vitamins A and D and folic acid seen over time were larger for the African-American and Hispanic students compared with other racial/ethnic groups represented in the CATCH sample. The decrease in vitamin D intake for African-American and Hispanic students was nearly triple the decrease exhibited by the Caucasian students. Using food-group data, the USDA's 1989–1991 CSFII showed that Caucasian children had higher intakes of dairy products and grains than non-Caucasian children[8] and the National Growth and Health Study reported that, after adjusting for income and education, African-American females had lower intakes of calcium than Caucasian females[17]. Reduction in calcium, vitamin A and D intakes may be related to decreased consumption of dairy products and may be attributed to real or perceived lactose intolerance in non-Caucasian populations. Lactose intakes decreased significantly over time in African-American and Hispanic students, while fructose intakes increased significantly in Hispanic students over time. No significant difference over time by race was seen for sucrose intake (data not shown). Although African-Americans and Hispanics are at lower risk for osteoporosis than Caucasians, calcium and vitamin A levels are still below recommended amounts and may result in negative health outcomes.

Our findings should be considered in light of the limitations of the study. The sample was not a population-based sample; rather it was drawn from a large, school-based intervention study. Because students randomised to the CATCH intervention received interventions attempting to modify their fat, saturated fat and sodium intakes, we adjusted for treatment effects in our analysis so that time trends cannot be explained by exposure to CATCH-II interventions. Treatment effects were seen only for energy from fat, saturated fat and sodium, with exposure to CATCH interventions resulting in statistically significant decreases over time. Further details about the effects of the CATCH intervention are found elsewhere[21,22]. There were no differential effects by race/ethnicity or sex for treatment effects on nutrient intakes at the end of CATCH-II[13] or at the end of CATCH-III[22].

Even though our sample is not a population-based sample, four states and 96 public schools were represented in the study and the racial and ethnic composition of the sample is similar to the nation as a whole. Our sample was not large enough to study nutrient intakes of Asian or Native American children. Other racial and ethnic groups, including the option of 'multi-racial', are also missing from this sample and future research is necessary to understand the dietary patterns of these groups.

Our findings are also limited because they do not describe food-level or specific eating behaviours. The NDS system is a nutrient-based system and food-specific information is not easily retrievable for analysis. Further research examining differences in food choice behaviour by sex and race/ethnicity is very important, and needed especially for intervention studies. Since individuals eat food, not nutrients, we need to learn more about how food choices vary among sex and racial/ethnic groups over time in youth[47].

Our data are single 24-hour recalls and do not allow us to compare nutrient intakes with individual-level outcomes such as body mass index or total serum cholesterol. Single 24-hour recalls are appropriate, however, for comparing group means. While 24-hour recalls have been validated for use in children and youth[30], we know little about how response bias may change over time or differ by sex or ethnic group. It is possible that the lower than recommended levels of energy intake seen across the sample, and particularly in the females, reflect under-reporting of food intake. Finally, our data do not include information on vitamin or mineral supplements. Therefore it is possible that vitamin and mineral levels are higher than our results suggest. Twenty-two per cent of the CATCH sample report using multivitamins at least weekly; however, details on the nutrients provided or dose were not obtained[48].

Conclusion

This longitudinal glimpse of nutrient intakes of youth suggest that while some improvements occur, by and large diets become less nutrient-dense as students move into young adolescence. The only improvement noted is the decrease in intake of percentage energy from total fat and saturated fat that is seen in most subgroups examined. Unfortunately, all of the groups exceed the recommended amount of percentage energy from total and saturated fat. Intakes of vitamins, minerals and fibre decrease and sodium intakes increase as students move into young adolescence. While most of the declines in vitamins do not move youth to a deficiency level, the declines suggest a diet that is less nutrient-dense as youths get older. Shifts to less healthful nutrient intakes are particularly evident in females and non-Caucasian students. At a time when females are building bone mass and beginning menstruation, calcium and iron intake reach their lowest levels.

African-American youth are the only group to increase their intake of percentage energy from total fat in Grade 8 relative to Grades 3 and 5.

These findings suggest that nutrition education and intervention are needed throughout childhood and adolescence with an emphasis on choosing healthful foods. The change in adolescents' diet is most likely related to a complicated interaction of the need for autonomy – which is part of normal adolescent development, increased peer pressure, increased marketing of less healthful choices to teens, and more choices and opportunities to choose less healthful foods in their home and school environments. Nutrition education presented in the elementary grades and nutrition education curriculum alone are not sufficient for preparing students to choose healthful foods into their adolescent years. Environmental interventions to help adolescents eat more healthfully are needed in our schools, communities and the market place. Such interventions need to be culturally and gender appropriate and relevant, so that all our children will reap the benefits[49–52].

The CATCH intervention worked equally well across the sexes and the race/ethnicity groups available and defined in CATCH, suggesting that such school-based programmes with adequate duration, a co-ordinated focus and a strong environmental component are effective. Still, we need to learn how to prevent the differential declines we see across sex and race/ethnic groups. Such prevention will, most likely, require systemic social and political change affecting food supply and acquisition patterns in our communities, food marketing and promotions, gender roles and body image expectations, and re-distribution of economic and political power.

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