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Recommendations have been made to reduce the fat content of school lunch to a level consistent with the 1990 "Dietary Guidelines for Americans". Research to date has focused primarily on acceptability of fat-modified meals. This study was designed to determine if reducing the fat content of school lunch to ≤30% of kcal also effectively reduced a child's 24-hour intake of fat. The effect on intake of energy and other macronutrients was also assessed and micronutrient intake reported. Thirty-eight 5th-grade boys and girls were served high-fat lunches (43% of kcal, 34 g fat) for three consecutive days one week and low-fat lunches (29% of kcal, 23 g fat) the same three days of the following week. All lunches were similar in energy content. Consumption was ad libitum. Food intake at lunch was estimated by subtracting each child's weighed plate waste from the average amount served of each food item. Students kept three-day food diaries

to record food intake the rest of each day. Each child and a parent were interviewed the weekend following each period to enhance the accuracy of the food diaries. Energy and nutrient intakes were estimated using the Food Processor II computer program. Average three-day nutrient intakes for the two periods were compared using paired t-tests. The difference in mean 24-hour intake of fat was 3% of kcal (35% of kcal vs 32%, $p<.01$) between the high-fat and the low-fat periods. The decrease in 24-hour fat intake was offset by a corresponding increase in carbohydrate intake (from 52% of kcal to 55%, $p<.01$), and total energy intake was constant between the two periods. Mean fat intake at lunch was lower during the low-fat period (13 g vs 22 g, $p<.01$) and students consumed an average of 58 fewer kcal (425 vs 483, $p<.01$). Fat intake at lunch was 28% of kcal as compared to 40% during the high-fat period ($p<.01$). Students partially compensated for the fat deficit in the low-fat lunches by consuming more fat (13 g vs 8 g, $p<.01$) and compensated entirely for kcals during after-school snacks. Reducing the fat content of a single meal (school lunch) did make a significant contribution towards satisfying the 1990 Dietary Guidelines for the children's 24-hour intake of fat and carbohydrate without compromising kcal intake.

REDUCING THE FAT IN SCHOOL LUNCH: THE EFFECT ON 24-HOUR INTAKE BY FIFTH GRADERS

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INTRODUCTION

There is currently considerable interest in modifying the nutrition standards of the National School Lunch Program (NSLP) to be more consistent with contemporary dietary recommendations. One of the objectives of The National School Lunch Act is to "safeguard the health and well-being of the Nation's children" by providing nutritious lunches at school (1). As enacted in 1946, the Act reflected public health concerns of the time when interpreting this goal by stipulating a meal pattern designed to ensure nutrient adequacy. More recent dietary recommendations, however, as put forth in the 1990 "Dietary Guidelines for Americans" (Dietary Guidelines) (2), emphasize the need for Americans to reduce fat and cholesterol, moderate salt and sugar, and increase fiber and complex carbohydrate intake as a means to reduce risk of chronic disease. <u>The Surgeon General's Report on Nutrition and Health</u> (3) points out that "as the diseases of nutritional deficiency have diminished, they have been replaced by diseases of dietary excess and imbalance - problems that now rank among the leading causes of illness and death in the United States...". In theory, there is considerable support for incorporating these Dietary

Guidelines into school nutrition programs. In practice, however, there are significant barriers to full implementation (4). To date, the U.S. Department of Agriculture (USDA), which administers federal child nutrition programs, has encouraged but not required schools participating in the NSLP to serve meals that reflect the Dietary Guidelines (5).

Of particular concern is the fat content of school lunches relative to recommendations for total fat intake. The Surgeon General's report (3) singles out overconsumption of fat as the chief dietary factor compromising health status of the public in this country. Accordingly, the Dietary Guidelines specifically recommend that all healthy Americans, including children over two years of age, reduce their daily intake of fat to 30% or less of kcalories. The recommendation is based on substantial evidence that development of heart disease begins in childhood (6,7) and the belief that lifelong dietary habits are established early (6,8). National nutrition surveys indicate that American children currently consume an average of 36% of kcal as fat (9,10).

Incorporation of the Dietary Guidelines into the NSLP has been endorsed by professional and health organizations such as the American School Food Service Association (11), the American Dietetic Association (12), and The

Expert Panel on Blood Cholesterol Levels in Children and Adolescents (7). The U.S. Department of Health and Human Services (DHHS) includes a recommendation to reduce fat in school lunches to less than 30% of kcal in its national health objectives for the year 2000 (8). Two consumer advocacy groups making similar recommendations are the Citizen's Commission on School Nutrition (13) and Public Voice for Food and Health Policy (14). In recognition of the difficulties schools encounter in trying to carry out these recommendations (4), two of the above proposals (8,13) suggest that changes consistent with the Dietary Guidelines be phased in over a period of 10 years.

Schools have the potential to significantly influence dietary intake and therefore children's health through school nutrition programs (8,15). Over 16 million elementary school children consume about 25% of their total nutrient intake each day from USDA subsidized lunches prepared at school (ref). Students who also participate in the school breakfast program may consume as much as 60-80% of their nutrients at school (13,16).

If reducing fat in the noon meal is to have an influence on long-term health, it must result in a decrease in total daily fat intake by participating children. Furthermore, the desired changes in macronutrient intake must be accomplished without compromising the energy or nutrient adequacy of the diet.

Research to date on implementing current dietary guidelines in school lunches has focused on immediate concerns such as meal acceptability and cost implications. The literature provides little quantitative data on how related menu modifications affect children's overall diet.

The primary purpose of this study was to determine if reducing the fat content of school lunch to a level consistent with the Dietary Guidelines effectively reduced a child's total 24-hour intake of fat. The impact that modifying fat in the noon meal has on total intake of energy, protein, carbohydrate was also assessed. Thirty-eight fifth-grade children were served "traditional" high-fat lunches (43% of kcal from fat) for three consecutive days one week and low-fat lunches (29% of kcal from fat) for three days the following week. Total food intake for the 24-hour periods beginning with lunch were estimated from self-maintained 3-day food diaries and from plate waste measurements of treatment lunches. Statistical comparisons of the mean 3-day intake between the two treatment periods were made for kcalories, fat, carbohydrate, and protein. The lunch content and total intakes of vitamins A, C, and B6, thiamin, riboflavin, niacin, calcium, iron, magnesium and zinc are reported.

LITERATURE REVIEW

Nutritional Goals of the National School Lunch Program

The primary nutritional goal of the National School Lunch Program is to provide approximately one-third of a child's Recommended Dietary Allowances (RDA) (17) (Appendix A). In developing the meal requirements, all nutrients for which adequate reliable food composition data were available, as well as kcalories, were considered (5). It is expected that by serving a wide variety of foods all nutrient needs will be met when lunches are averaged over a period of time. The minimum lunch pattern for children in grades 4-12 is as follows: meat or meat alternate - 2 oz, vegetable and/or fruit - 3/4 cup, bread or bread alternate - 8 servings/week, and milk - 8 fluid oz (5). The lunch pattern in more detail can be found in Appendix B.

The most recent USDA menu planning guide (5) advises, but does not require, that schools consider the Dietary Guidelines in menu planning and keep fat, sodium, and sugar at moderate levels.

Nutritional Adequacy of School Lunches

The National Evaluation of School Nutrition Programs (18), completed in 1983, established the superior nutritional quality of traditional USDA school lunches relative to non-USDA lunches. The study also demonstrated that program participants have higher 24-hour nutrient intakes than non-participants. Twenty-four hour dietary recalls were obtained from a nationally representative sample of 6301 children in grades 1-12, 3893 (62%) of whom ate school lunches on the days recalled. It was found that the USDA lunch, as consumed, met the one-third RDA goal for 9 of the 12 nutrients examined (energy, protein, vitamins A and C, thiamin, riboflavin, niacin, calcium, and phosphorus). The one-third RDA standard was not met for magnesium, vitamin B6, or iron (19). Low values for vitamin B6 and magnesium could be attributed at least in part to data base inadequacies and did not necessarily represent lower than recommended intakes. In 24 hours, intake of energy and all nutrients except vitamin C and iron was greater for program participants. Twenty-four hour intake of vitamin C and iron was not significantly different between participants and non-participants.

Akin et al. (20) reported similar findings in their analysis of data from the 1977-78 Nationwide Food Consumption Survey. Children ages 6-11 who ate school lunches had greater 24-hour intakes of energy and 12 nutrients (including vitamin C and iron) compared to children who consumed other types of lunch. Average intakes for school lunch participants in this study were also consistently nearer to or above the RDA's for their age group.

Fat Content of School Lunch

Research on the dietary impact of the NSLP has historically centered on the stated goal of nutrient adequacy, and the fat content of school lunches either as served or consumed has not often been reported. Data on fat that are presented in the literature are sometimes incomplete or difficult to interpret. Most school districts do not analyze their menus, and no recent national studies have measured the average fat content in school lunches (13). Therefore, it is difficult to ascertain or generalize about the fat content of school lunches as currently served.

Articles published from 1973-1990 that do report fat content (21,22,23,24,25,26,27,28,29) and a consumer advocacy group report (13) indicate that an elementary school lunch menu may provide anywhere from 24-67 g of fat, or 36-63% of kcal from fat. According to a USDA Consumer Advisor (16), about 37-40% of kcal in school lunch comes from fat.

In Oregon, menu analysis has been done by the Portland, Corvallis, and Eugene school districts. Information provided to the author by the food service directors shows that, as of summer 1990, the fat content of daily menus served in the elementary schools in these districts ranged from 29%-54% of kcal. The average fat content of cycle menus averaged from 32%-42% of kcal.

The type of milk served can significantly affect the percent of kcalories provided by fat (21,13). A calculation based on five sample menus showed that the fat content was reduced by 5-9% by serving skim rather than whole milk (13).

Progress Implementing Dietary Guidelines

A nationwide survey of 177 school food service directors conducted in 1989 (14) found that 80% of food service directors were aware of the Dietary Guidelines and believed that fat should be reduced. Eighty percent also said they have taken "some steps" in that direction. However, there are considerable obstacles to full implementation of current dietary recommendations in school food service programs (4,14,16).

A key issue is the need to maintain or increase student participation rates in order to keep lunch programs financially solvent. Modified meals must be appealing to students and competitively priced. However, popular food items are often high in fat, sodium, and sugar; and food service professionals believe children are resistant to change (4,14). Survey results (14) suggest that more nutrition education in the classroom and reinforcement at home are needed to support school food service attempts to influence eating behavior. Greater involvement on the part of the food industry is needed both to increase availability of appropriate and acceptable products and to assist in promoting these products to students.

Another potential barrier is that the costs of preparing modified meals may initially be higher. Modified products may cost more, especially when they are not available in institutional-sized packaging (30). Schools are financially dependent on USDA-donated commodities which have traditionally included a large proportion of high-fat foods, such as ground meat and luncheon meat, dairy products, vegetable oil, and fried potatoes (31). Food service personnel need to be trained in new preparation techniques, modified recipes must be tested and standardized, and equipment needs may change.

Reducing the fat content of school lunches within the confines of the reimbursable meal pattern necessarily reduces the energy content of a meal. To maintain caloric equivalency, schools must supplement meals with larger amounts of complex carbohydrate foods like fruits, vegetables, and whole grains. The USDA currently does not provide additional reimbursement to accomodate such changes to the required meal pattern.

Many schools lack the specialized resources necessary to analyze menus to ensure that nutritional goals are being met. Those who do analyze menus express a need for better nutrient composition information on vendor and commodity food products (13).

Recent changes in school lunch milk requirements (32) work against progress that has been made to increase consumption of lower fat milk. Schools now must offer whole milk in addition to low-fat milk and no longer have the option of offering skim milk or buttermilk in place of low-fat milk (31).

Confounding the problem is the fact that school food service professionals appear to be confused about the appropriate target level for fat in school lunch (14). Many are unaware that a consensus now exists among health agencies in support of the goal of 30% of total kcal from fat. The American School Food Service recommends that each day's total diet must be considered when planning individual menus (11). However, there is insufficient data on the role that lunch plays in the total diet on which to base practical advice for application of this concept. Consumer group recommendations (31,13) call for the USDA to provide stronger leadership by mandating a target fat level and providing more specific assistance in planning menus that meet current dietary recommendations.

Despite obstacles and a lack of supporting research or national leadership, there has been significant activity at the grass roots level directed towards making meals served under the NSLP more healthful. California has established an innovative statewide program with its comprehensive "School Nutrition: Shaping Healthy Choices" campaign, designed to assist child nutrition programs with modeling healthy eating practices as an integral part of a comprehensive health program (33). A 1989 California statute requires development of new nutrition guidelines for all food and beverages sold on public school campuses (34). These standards will include guidelines for fat, saturated fat, and cholesterol and will specify that when choice is available, foods lower in fat and cholesterol are to be used if comparable in nutritional value. The campaign goes beyond providing nutrition guidance by establishing regional model projects; including cost monitoring, marketing, training and evaluation components; and incorporating food industry involvement.

Role of the USDA

Authority to mandate changes in the school lunch program rests with the USDA. While the USDA has strongly encouraged schools to serve lower fat meals (5,35), no specific target level for fat content has been established.

In 1989 Congress mandated that the USDA and the U.S. Department of Health and Human Services (DHHS) jointly develop new nutrition guidelines for child nutrition programs by November 1991 and that these guidelines be applied when preparing meals served under the NSLP (32). A government publication, Dietary Guidance for Child Nutrition Programs, is scheduled for distribution in spring of 1992. It will be a "generic" and "nonquantitative" publication, to be followed by updated menu planning guides for specific programs (16). It is not known at this time what the exact nature or specifics of this new guidance will be. Given the sizeable federal investment in the school lunch program ($3.9 billion in cash and commodities for the 1989-90 school year)(16), it is anticipated that this guidance will reflect national nutrition policy as defined by the 1990 Dietary Guidelines.

The 1989 legislation also provides for establishment of a national Food Service Management Institute which will generate much needed technical assistance and an expanded research base to support efforts to make school lunches more healthful.

Specifications for USDA commodity food products are presently undergoing revision (13,16). Changes to date include lowering the maximum allowable level of fat in meat products, adding new fish and poultry products, making part skim milk mozzarella cheese available, prohibiting use of animal fat or highly saturated vegetable fats in commodity processing, and offering more complex carbohydrate foods (i.e., whole wheat flour, bulgur, brown rice, pasta products, dried legumes, and dried and fresh fruits).

Effects of Implementing Dietary Guidelines

The few published studies which evaluate the effects of implementing recent dietary guidance in school lunch focus primarily on the noon meal only. Studies address the acceptability of modified meals (21,22,30,36,37) and make comparisons of nutrient content (24), nutrient intake (21,22,38), and cost (30,37) between traditional and modified lunches. With one exception (38), these studies do not address the effects that modified school meals have on a child's total diet.

Coale and Bedford (37) compared student response to fat-controlled lunches (average 30% kcal from fat) served for one month at a small elementary school to comparable regular menus. Based on questionnaires, plate waste studies, and participation rates, they reported that fat-controlled menus were acceptable but children still tended to prefer higher fat foods. The fat-controlled menus cost an average of $0.015 less per student meal than the comparable regular menus. However, when the monetary value of USDA-donated foods, many of which are higher in fat, is excluded, the regular menus cost less. The tendency to use more high-fat donated commodity foods makes it difficult to do a realistic cost comparison with fat-controlled menus.

Sandoval et al. (24,36) compared acceptability and the nutrient content of 20 days of altered menus (reduced fat, sugar, and sodium content and increased fiber) to traditional menus served in six elementary schools. Acceptability varied depending on the menu item. There were no significant differences in average nutrient content between altered and traditional menus for energy and nine key nutrients. The altered menus in this study were high in fat (38% of kcal), however, relative to the current standard of 30%, which limits applicability of these results.

Frank et al. (22) offered fifth-grade students in four schools a choice between modified (30% kcal as fat, reduced sugar and salt) and traditional lunches as one component of an extensive cardiovascular health promotion program. Plate waste was not significantly different for the two types of meals. In a comparison of one day's menus in two schools, students consumed an average of 34% of kcal as fat from the low-fat lunch and 41% from the high-fat lunch. Average energy consumption was 38% less from the low-fat meal (318 kcal from low-fat versus 510 kcal from high-fat meal.) The energy content of all five modified menus as served averaged 555 kcal, which was 42% less than the average of the traditional menus (950 kcal). As in the study by Sandoval et al. (36), the preference for modified versus traditional foods varied depending on the particular item; but there was a tendency to prefer the traditional items. The observations reported, however, were made during the early stages of the health promotion program. It was anticipated that longer exposure to the curriculum might result in a shift toward more healthy food choices.

Garey et al. (21) reported the effect that serving different types of milk had on nutrient intake from lunch. Three different meals were each paired with 1%-fat chocolate milk, 3.5%-fat milk, and 1%-fat milk. The 1%-fat chocolate flavored milk was most acceptable and resulted in the least milk and plate waste. The lowest percent of kcalories consumed as fat came from meals paired with 1%-fat chocolate milk (34% versus 43% and 40% when paired with 3.5%-fat and 1%-fat milk, respectively). Intake of protein, calcium, vitamin A, riboflavin, and phosphorus as a percentage of the RDA was highest from meals served with low-fat chocolate milk. Total energy intake was 100 kcal lower from meals served with 1%-fat white milk than for the other two milk pairings.

A two-year intervention study (30) conducted at two boarding high schools attempted to increase the ratio of polyunsaturated to saturated fats (P/S ratio) served at meals without altering total fat content. Modified foods rated favorably in student palatability surveys. However, regular items were slightly preferred over fat-modified counterparts (mean preference values of 3.46 versus 3.25, respectively, on a scale of 5). In this study, modified foods generally cost more than the regular foods.

Student fat intake over a 24-hour period was measured in the boarding school study (38). The intervention involved not only lunch but breakfast and dinner as well, so students obtained only 28% of daily kcal outside the dining halls. During the study, the dietary P/S ratio increased by 81% for intervention males and by 47% for intervention females over their respective control groups. The follow-up dietary data revealed a concurrent decrease in total fat consumption. Total dietary fat intake for intervention males went from 34.5% of kcal at baseline in the fall to 31.9% the following spring. Dietary fat intake for intervention females decreased from 34.2% to 30.7% of kcal. The percent change in fat consumption was 2% greater for intervention males and 8% for intervention females than for the respective control groups. Energy intake also decreased over the course of the study. The change in kcalorie intake was 7% greater for intervention males and females than for the control groups.

No explanation was offered for the reported decrease in energy and fat consumption that apparently resulted from the intervention, despite the fact that the amount of total fat served was not changed. Perhaps the palatability surveys did not accurately reflect acceptability of the fat-modified foods. At the point of selection, students conceivably avoided the fat-modified foods and chose more low-fat (and lower kcalorie) foods than they would have otherwise.

In summary, the existing literature suggests that fat-controlled meals can be acceptable to students but that there is a tendency to prefer higher fat foods. Fat intake from lunch as a percent of kcalories can be significantly lower for students who consume lower fat meals. However, it has been shown that the energy content of modified-fat lunches, both as served and consumed, may be lower as well. Micronutrient content of low-fat meals can be comparable that of high-fat meals, and serving low-fat chocolate milk can result in improved intake of some nutrients. Finally, cost comparisons are difficult to make because modified menus may utilize fewer donated government commodities.

The USDA is currently sponsoring two school lunch projects that will include assessments of total dietary intake (16). Data collection for both studies will be completed by the end of the 1991-92 school year. The Dietary Assessment Study, involving 4000 students, is the first major study that will compare the nutrient content of USDA and non-USDA meals using the Dietary Guidelines as well as the RDA and food groups. It is anticipated that fat will be included in the determination of how USDA meals contribute to students' total nutrient intake. The USDA also awarded 3-year grants to sponsor Menu Modification Demonstration Projects in elementary schools in five school districts. The purpose is to gather information on the process and impact of menu changes within current meal patterns that are consistent with dietary guidelines (39). Data will be collected from students on what they ate at lunch and during the entire day (16).

Caloric Compensation

It has been argued that lowering the fat content of school lunch may prove harmful by reducing the child's total daily caloric intake to below their energy needs (40). This concern is based on the likelihood that modified lunches will either be lower in kcalories as served (if not supplemented with additional high carbohydrate foods) or that children will consume less energy from them. Fat is more energy dense (about 9 kcal/g) than carbohydrate or protein (about 4 kcal/g). Therefore, even if adequate kcalories are served in a low-fat lunch, children must eat a greater volume of less energy dense carbohydrate- or protein-rich foods to achieve the same energy intake they would from a high-fat lunch. They conceivably may not be inclined or able to do so at a single meal or in the limited time allocated for lunch.

There is evidence, however, that both adults and children will compensate for a kcalorie deficit in a meal or preload within a short period of time. Foltin et al. (41) demonstrated that caloric compensation by male adults living in an experimental facility occurred within five hours after consuming low-kcalorie lunches. Two groups of three men each consumed similar-appearing lunches containing either 431 or 844 kcal for three consecutive days. Subjects could select freely from a wide variety of foods for snacks and meals the rest of the day. There was no significant difference in total daily energy intake between the different lunch conditions. Subjects compensated for low-kcalorie lunches by increasing the number of food items eaten during the following meal.

Short-term caloric compensation was also shown to occur among free-living adult male and female subjects (42). Low-kcalorie lunches providing only 32% as much energy as was consumed from baseline lunches were eaten for 14 consecutive days. Total daily energy intake was estimated from self-maintained food records. While decreases in mean daily caloric intake were observed (148 and 173 kcal for males and females, respectively), these differences were not significantly different from baseline energy intake. The degree of compensation for low-kcalorie lunches observed was fully evident by the end of the first day and remained constant over the 14-day period.

Birch and Deysher (43) demonstrated that preschoolers could self-regulate short-term energy intake by adjusting food consumption in response to preloads of different caloric density. Children compensated for a low-kcalorie pudding preload by eating a greater quantity of snack foods served 20-40 minutes later than they did after consuming a high-kcalorie pudding preload.

Garcia et al. (44) reported on the eating behavior of 45 rural Mexican preschool children. Children were observed continuously for one day and food intake was determined by weighing portions served and plate waste. It was found that total daily energy intake of children served meals of low caloric density (less than 100 kcal/100 g of food) did not differ significantly from children served meals of higher caloric density. The group eating low density meals consumed less energy from meals but compensated by eating more from snacks, without eating any more frequently than children who consumed high density meals.

Not all studies demonstrate such immediate and precise regulation of energy intake (45,46,47,48,49). Foltin et al. attribute the lack of accuracy in caloric regulation observed in some studies to the experimental conditions. They note that previous studies were limited by maintaining subjects on liquid diets or placing constraints on food consumption and availability. For example, in a study by Lissner et al. (45), subjects had access only to calorically-diluted foods throughout the day, although there was no restriction on quantity consumed. Foltin et al. manipulated foods in the required noon meal only, with unrestricted access to a wide variety of commercially available foods the rest of the day. Lissner et al. observed that palatability ratings for the 3-day rotating menu declined significantly over the three 14-day experimental periods. Their recognition that monotony may have influenced intake supports Foltin et al.'s identification of limitations imposed by the method. Foltin et al. conclude from their work that humans are capable of regulating intake in response to caloric manipulations under more natural conditions when subjects have access to a wide variety of foods.

Regulation of Fat Intake

One cannot predict with confidence the effect that reducing fat at lunch might have on subsequent short-term fat intake by children. There is good evidence that humans regulate short-term protein and carbohydrate intake

(50,51), but little is known about physiological mechanisms that may directly or indirectly control dietary fat intake (52). Mechanisms that have been proposed for protein and carbohydrate control cannot be readily extrapolated to explain control of fat intake. It is theorized that short-term control of macronutrient intake may be related to the percent of body stores turned over on a daily basis (50). Since protein and carbohydrate body stores are low, immediate replenishment is needed. However, stores of fat are relatively large and daily turnover is low, so a similar mechanism for short-term regulation of fat intake is unlikely to be sufficiently sensitive to affect daily intake. Also, it is believed that the liver may be a key feedback organ. In this case, intake of fat would not be sensed as immediately as protein and carbohydrate because it is absorbed through the lymph system and bypasses the liver (53).

Studies investigating the consequences of manipulating dietary fat in a single meal (41,53,54,55,56) have emphasized satiety or the impact that meal fat content has on total food intake with inconsistent results. Rolls et al. (55) reported that self-selected energy intake was lower after a high-starch preload than after a fat preload. Geliebter (56), however, reported no difference in energy intake following liquid fat or carbohydrate preloads. Driver (53) reported similar hunger ratings after high-carbohydrate and high-fat liquid meals, whereas Van Amelsvoort (54) reported greater hunger following fat-rich meals. Two studies (41,55) that address the effects on subsequent intake of specific macronutrients are inconclusive. It does not appear that any related research has been conducted with children as subjects.

Foltin et al. (41) manipulated the macronutrient content of lunches as well as kcalories, resulting in four different lunch conditions served to six male subjects: low-fat/low-kcal, high-fat/high-kcal, low-CHO/low-kcal, and high-CHO/high-kcal. The low-fat meal contained 14 g of fat (29% of kcal) and the high-fat meal contained 63 g of fat (67% of kcal). Fat intake after (not including) the low-fat lunch was significantly higher than after the high-fat lunch, and fat intake after the high-fat lunch was significantly less than under the other three conditions, although absolute differences were small. However, total daily fat intake (lunch included) was still significantly higher under the high-fat condition than under the other three lunch conditions. Therefore, the changes in fat intake after lunch were not sufficient to compensate fully for the difference in fat content of the lunches. Caloric compensation was complete, regardless of the macronutrient content of the lunches, and accomplished by alterations in carbohydrate, fat, and protein intakes later in the day. It was concluded that subsequent fat intake was related to the fat content of the noon meal, which suggests that some physiological or cognitive regulation of intake occurred. However, adjustments in macronutrient intake appear to be secondary to the regulation of kcalories. The authors suggest that further research should address the influence that palatability differences between fat and carbohydrate foods may have on food intake.

Relative constancy of fat intake by rats has been described in given situations (57). For example, rats fed a high-protein diet (32% of kcal) self-selected 60% of daily intake as fat. When fed a low-protein diet (10% of kcal), the rats switched to a high-carbohydrate, low-fat diet (20% of kcal as fat)(58). The change in fat intake observed may have resulted indirectly from a regulation of protein intake. Selection of a high-carbohydrate, protein sparing diet, would be advantageous when protein was limiting (57).

Nutritional Adequacy of Fat-Controlled Diets

Concern has been expressed that the micronutrient intake of certain populations, including children, consuming reduced-fat diets may be compromised (7,8). However, there are few data to support this thesis. To the contrary, McPherson et al. (59) found that middle-to upper-class children on low-fat diets did not appear to be at risk of developing micronutrient deficiencies. In a sample of 138 children in grades 5-12, those eating diets that provided <30% of kcal from fat (15% of the sample) consumed most nutrients at levels that were either the same or greater than children eating diets higher in both fat and kcalories. Only intake of sodium and beta-Carotene was greater per 1000 kcal in subjects with higher fat intakes. The authors concluded that recommended fat-modified dietary patterns are neither unusual nor unattainable for school-aged children.

Two studies (60,61) have demonstrated the nutritional adequacy of low-fat diets for adults. Dougherty et al. (60) reported a "marked improvement" in vitamin intake by adults consuming an experimental 25% fat diet as compared to their intake from a 40-44% fat diet. Buzzard et al. (61) reported on the micronutrient content of self-selected diets of 17 free-living women following three months of intervention counseling for reducing fat intake while maintaining nutritional adequacy. Absolute intakes of 7 of 14 reported nutrients were greater at 3 months than at baseline despite a 25% reduction in mean energy intake. Intakes at three months exceeded two-thirds of the RDA levels for all 14 nutrients and exceeded 100% of RDA levels for 10 of 14 nutrients.

Dietary Assessment Methodology

The most commonly used method to measure the current dietary intake of children is the 24-hour recall (62). In this method, subjects are interviewed and asked to recall in as much detail as possible the nature and quantity of everything eaten in the previous 24-hour period. Dietary recalls in a pediatric sample, however, have not been adequately tested; and attempts to validate them have led to varying conclusions (62). Baranowski et al. (63) reported that "a review of the literature revealed no reports of valid (accurate reflection of true intake) and reliable (reproducible) methods for children to self-record their dietary intake." However, Stunkard and Waxman (64) and Carter et al. (65) concluded from their literature reviews that self-reports of food intake by children are relatively accurate.

Emmons and Hayes (66) demonstrated that the ability of children in Grades 1-4 to recall a school lunch eaten improved increasingly with age. A comparison was made between school lunches as reported by 431 children in 24-hour recalls and the known meals eaten. Children in Grade 1 remembered an average of 60.5% of the foods eaten and children in Grade 4 remembered an average of 80.6%. For children in Grade 4, the correlation between the nutritive levels of the meal as calculated from the recalls and the meal actually eaten was significant at the 0.01 level for all nine nutrients measured. Correlation coefficients ranged from .58 to .92. A comparison was also made between the children's recalls and their mothers' recalls of food consumed at home. At all grade levels, children's recall of the school lunch was more closely correlated with the actual lunch eaten than was the child's recall of the home diet when compared to the mother's. It was concluded that young children can accurately provide information on their own diet, as well if not better than can their mother.

Baranowski et al. (63) reported that agreement between food intake as self-reported by 24 children in Grades 3-6 and an observer's record of the child's consumption was "acceptably high" (82.9%). Children recorded intake for two days using a frequency of food consumption method, in which they noted at the end the day the number of times they ate foods from designated categories. Neither grade level nor parental assistance affected accuracy of form completion. The findings were qualified by stating that data was collected under ideal conditions: children were given 40 minutes of training in form completion, they knew they were being observed, and enthusiasm was easily maintained over a short recording period.

Frank et al. (67) evaluated the reproducibility of 24-hour recalls by 30 fifth graders by having two nutritionists independently interview each child for the same 24-hour period. There were no systematic differences between the duplicate interviews; however, the coefficients of variation for kcalories, the P/S ratio, and the sucrose-to-starch ratio "implied some lack of agreement." They also reported that:

> Children 10 years of age and older had been identified in earlier testing...to be capable respondents to a 24-hour dietary recall. This preteenage student appeared to be an attentive and reliable interviewee and perhaps less likely (than older children) to fabricate responses.

In another study, Frank et al. (22) compared observed- with self-reports of food items chosen by fifth graders at lunch. Agreement of 83-94% occurred between the two reports when students recorded their selections shortly after the meal.

Special techniques may be required to improve the quality of dietary information collected from children. Frank et al. (68) developed a standardized interview which allowed children ages 10-16 to serve as their own respondent in a reproducible 24-hour recall. Interviews lasted 30-40 minutes and included the following components: probing questions to clearly identify food items eaten, probes to determine if food was traded at lunch, a "Product Identification Notebook" to prompt recall of snack items consumed, and generic graduated food models for quantifying portion sizes. Detailed information about school lunches served during the data collection period was obtained from food service personnel in advance.

Van Horn (69) summarized other recommendations for improving the accuracy of dietary self-reports by children as follows: adequate training of the child, use of food models and pictures, attractive appearance of the instrument used to record data, maintaining overall simplicity, and administering individual interviews for children under the age of 12 as a substitute to self-recording.

Eck et al. (62) investigated the relative contribution made by the mother and/or father in improving recall of a meal eaten by the child the previous day. The "consensus recall," which combined input from both parents and the child, provided a more accurate estimate of the child's intake than did the recalls taken from each parent independently. The 34 children, ages 4-9, all came from intact, middle to high socioeconomic status families which limits generalizability of results to other socioeconomic groups.

Garrahie et al. (70) reported on the value of a "debriefing" interview to clarify information recorded by the mother in a 1-day food diary of her child's intake. For eight of the nine nutrients analyzed there were no significant differences in group mean nutrient values between the corrected (including interview modifications) and the uncorrected food diaries. It was suggested that the interview contributed little additional information because the study's participants were highly motivated, well educated, given detailed instructions, appeared to be very meticulous in completing the diaries, and were required to record for a single 24-hour period only.

The number of days of dietary data that are needed to best estimate usual nutrient intake has not been clearly established. One day's diet, whether recalled or recorded, is generally considered to yield a reliable and valid characterization of the average nutrient intake of a large group (66,71,72,73). Trulson (74) defined a "large group" as having 60 or more subjects. However, because an individual's diet varies greatly from day to day, a single day's intake may not be sufficiently representative of the usual food patterns of an individual (or a small group) (73). For this purpose it is considered necessary to collect information on food intake over a longer period of time (62,66). Subjects are often asked to maintain a detailed written diary of all food consumed over a number of days. The average nutrient intake estimated from these multiple diet records is generally considered to be the most valid self-reported measure of an individual's usual intake (75).

Studies (15,73,76) demonstrate that food records kept for a period of only 3-4 days may be sufficient to adequately characterize usual intake. Jackson et al. (76) had 18 adult subjects who were on modified-fat diets keep 14 days of consecutive diet records. To determine the minimum number of daily records that would be reliable for monitoring dietary adherence, they compared mean nutrient values from all possible combinations of 3,4,5,7,9 and 11 day records to the mean values for 14 days. It was concluded that 4-day records "gave information approximating 7-day records" and were "acceptable as a reasonable compromise" when mean intake of calories, dietary cholesterol, and dietary fats were analyzed. Guthrie and Crocetti (77) and Hauser (78) similarly indicate that 3-day diet records appear to provide more accurate results than 7-day records or 24-hour recalls. Block (73) cites a study (79) which, based on a small sample of elderly adults, suggests that the accuracy of recording deteriorates over time so that an individual's records may become unreliable after the first few days.

The use of a 3-day diet record has not been validated in an elementary school-aged population. La Porte (15) had sixth graders complete 3-day food records to evaluate the effectiveness of a nutrition education program. They reported that students had difficulty determining portion sizes and completing the forms correctly. Instructions were "thoroughly discussed," food models presented, and children were asked to have parents assist them in completing the form. No follow-up interviews were conducted.

Eck et al. (62) discuss design conditions in validation studies that may contribute to the reported accuracy of recalls by children. Dietary recalls conducted in structured settings with cycle menus, such as a school or camp, may be biased by subjects' expectations of usual food combinations. Experimental recalls have sometimes been collected very shortly after consumption, and the presence of an observer in the home may increase awareness of food consumed. Several researchers (62,64,65) have reported the existence of the "flat slope syndrome" in dietary studies with children. This refers to the tendency to over-report small intakes and under-report large intakes, resulting in a smaller apparent difference between groups than might be observed if the measurement were more accurate (65). In other words, when group data are averaged, accuracy occurs to some extent because errors in reporting cancel one another out (62). Other validation study limitations include the use of small samples and special populations, measuring food intake during the recall period (64), and making the assumption that observers are accurate in estimating intake (65).

Davidson et al. (80) and Baranowski et al. (71) report findings that raise important questions about the accuracy of current methods for assessing dietary intake in any population. Davidson et al. closely observed 32 urban children ages 7-10 for two years, and daily food intake was recorded by investigators at three separate occasions during the second year. The mean 3-day intakes of kcalories, protein, calcium and iron derived from this "child following" method were all higher than previously published survey values, suggesting that traditional methodologies may underestimate nutrient intake. It was observed that children consumed much food in a very casual fashion. Such actions that occur "below the level of consciousness" may be difficult to recollect and therefore under-reported by traditional methods.

Baranowski et al. (71) demonstrated that validation studies based on analyses of nutrient intake rather than foods consumed may overestimate agreement with true intake. They compared the mother's 24-hour recall of her child's food consumption (n=56) with an observer's report for both nutrients and foods. They found that mean differences for nutrient intake were quite small between the mother's and the observer's reports. However, only 64.8% complete agreement and 7% partial agreement was obtained on foods consumed. The authors explain that "because all foods contain many nutrients, reporting a food that is different from the one actually consumed minimizes differences in reports of nutrient intake because most foods contribute to the tally of most nutrients." They suggest that placing more emphasis on techniques to improve recall of specific foods would help minimize variability in mean nutrient values estimated from food recalls.

METHODS

Subject Selection

Children were recruited from two fifth-grade classes at Hoover Elementary School in Corvallis, Oregon. The choice of school was based on principal and teacher interest in participating. To maximize sample size, the largest schools in the district were approached first. Hoover was the fourth largest school in the district with 450 students in kindergarten through fifth grade.

Expectations and responsibilities of participants were explained in class and an information sheet was sent home to the parents. The research objective and details of the treatment meals were not revealed. Informed consent was obtained from both the student and a parent; and students were screened for any dietary restrictions, food allergies or intolerances that might seriously inhibit consumption of meals served. Copies of the letter to parents, information sheet, and the consent form are in Appendices C-E. Treatment lunches were provided free of charge to all participants.

Of the 56 children enrolled in both classes, 41 agreed to participate (73%). Data for three students were eliminated from the statistical analyses due to incomplete diet records or failure to eat at least one treatment lunch each week, for a final sample size of 38 (68% participation). Height and weight measurements were taken once during the last week of the study. Children received no nutrition education in class that school year either before or during the study.

The study was conducted during the first, third and fourth weeks of October, 1990.

Description of Subjects

Summary statistics describing the sample appear in Table 1. Of the 38 fifth graders included in the analyses, 24 were girls (63%) and 14 were boys (37%). Thirty-two of the children were 10 years old (84%) and six were 11 years old (16%). Their mean height was 145.0 centimeters (57 inches), and their mean weight was 36.5 kilograms (80 pounds). As a group, the subjects tended towards leanness and none were obese. Mean weight by stature (81) was between the 15th and the 50th percentiles for both boys ages 2-11 and girls ages 11-17 in the United States. No subjects were over the 85th percentile in weight by stature, and 14% of boys and 17% of girls were below the 15th percentile. The students were all white, with the exception of one Korean child and two siblings who had one Persian parent and one American parent.

According to the school principal, parents in families served by the school are generally professional, educated, and in the upper-middle to lower-upper income

Table 1. Descriptive data of subjects.

Sex	No.	Age 10 yrs (no.)	Age 11 yrs (no.)	Height (cm)	Range (cm)	Weight (kg)	Range (kg)
Female	24	22	2	145.2 ± 6.8*	135-161	36.5 ± 5.7	27-52
Male	14	10	4	144.7 ± 5.1	132-154	36.5 ± 5.7	25-47
Total	38	32	6	145.0 ± 6.2	132-161	36.5 ± 5.6	25-52

* Mean ± standard deviation

brackets. Only 14% (eight) of all students in the two classes were eligible for free or reduced price meals.

Subjects reported that they generally ate school lunch an average of two to three times per week. Sixteen of the students said they ate school lunch less than once a week and only 14 participated five days a week.

Approvals

The study design was approved in advance by
Committee for the Protection of Human Subjects a
State University, the Assistant Superintendent of
Corvallis Schools, the Hoover Elementary School p
both fifth-grade teachers, and the district Food Services Director.

Treatment Lunches

Students were served specially prepared school lunches on six days during a 2-week period. On Tuesday, Wednesday, and Thursday of the first week, subjects were served one of three different high-fat meals. On each of the same days of the following week they were served one of three different low-fat meals. There were a total of six different treatment menus (Figure A), and the same meal was served to all subjects each day.

All meals conformed to the school lunch meal pattern established by the USDA for grades 4-12 (5) (Appendix B).

Fig. A. Treatment lunch menus.

HIGH-FAT LUNCHES

<u>Tuesday</u>
French Bread Pepperoni Pizza
Tossed Salad w/ French Dressing
Banana
2% Milk

<u>Wednesday</u>
Corn Dog
French Fries w/ Catsup
Veggies w/ Ranch Dressing
2% Chocolate Milk

<u>Thursday</u>
Chicken Patty Sandwich w/ Tartar Sauce
Buttered Green Beans
Pear Slices
Peanut Butter Cookie
2% Milk

LOW-FAT LUNCHES

<u>Tuesday</u>
Beef & Bean Burrito
Corn
Honeydew Melon Cubes
Animal Crackers
2% Milk

<u>Wednesday</u>
Chef Salad w/ French Dressing
Dinner Roll
Orange Wedges
Low-fat Fruit Yogurt
2% Chocolate Milk

<u>Thursday</u>
Turkey Bologna & Cheese Sandwich
French Fries
Strawberry Gelatin Salad
1% Chocolate Milk

The selection of individual menu items was based on discussions with the food services director. The goal was to maximize student meal consumption by offering familiar and popular foods from the regular school lunch menus. However, meals were not tested for acceptability prior to the study.

Nutrient composition of the menus was estimated using "The Food Processor II Nutrition & Diet Analysis System", version 3.05 with ASCII (The Food Processor II)[1] computer software. Nutrient values in this program are based on USDA data as well as over 400 additional references. Vendor-specific data were added to the data base when available. Recipes were analyzed using the yield factor method (82).

The low-fat and high-fat meals were similar in energy content (Table 2). The average kcalorie content of all six meals was 699 kcal. This is equivalent to 35% of the recommended daily energy intake for children ages 7-10 (17). Menus were planned to provide approximately the same energy level as that of the cycle menu being used at the time in the Corvallis School District (average of 706 kcal, based on serving 2% milk).

The total macronutrient composition of each meal as served and the average for each 3-day treatment period are shown in Table 2. The high-fat meals provided an average

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[1]ESHA Research, Salem OR; 1990.

Table 2. Macronutrient and energy content and percent contribution to meal kcalories of treatment lunches as served.

Meal	Nutrient Content				Percent Contribution		
	Energy (kcals)	Fat (g)	Carbo-hydrate (g)	Protein (g)	Fat (%kcal)	Carbo-hydrate (%kcal)	Protein (%kcal)
High-Fat Lunches							
Tuesday	716	34	84	30	40%	44%	16%
Wednesday	681	32	80	20	42%	47%	12%
Thursday	670	35	68	24	46%	40%	14%
Average	**689**	**34**	**77**	**25**	**43%**	**43%**	**14%**
Low-Fat Lunches							
Tuesday	681	21	99	28	27%	57%	16%
Wednesday	739	25	99	34	30%	52%	18%
Thursday	704	23	102	25	29%	57%	14%
Average	**708**	**23**	**100**	**29**	**29%**	**55%**	**16%**

of 43% of kcal from fat, and the low-fat meals provided an average of 29% of kcal from fat. The difference in fat content between the two periods was primarily offset by a corresponding difference in the carbohydrate content of the meals (77 g or 43% of kcal during the high-fat period and 100 g or 55% of kcal during the low-fat period). Protein content of the high-fat meals (25 g or 14% of kcal) was slightly lower than that of the low-fat meals (29 g or 16% of kcal).

The mean micronutrient content of the meals served is shown in Table 3. Mean nutrient content exceeded 30% of the RDA for nine of ten vitamins and minerals estimated during the high-fat treatment period and for all ten micronutrients during the low-fat treatment period. The zinc content of the high-fat lunches is understated due to a missing value for the chicken patty sandwich. Imputing a value of 1.3 mg of zinc for the chicken patty, it is estimated that the mean zinc content of the high-fat lunches was about 3.9 mg, or 39% of the RDA. Nutrient data for the lunches was otherwise fairly complete, with only the following other values missing: B6 and magnesium in the chicken patty (high-fat week); B6, vitamin C, magnesium, and zinc in the bacon bits (low-fat week); and zinc in the animal crackers (low-fat week).

Meals were prepared and plated in the Hoover School kitchen by the primary investigator and an undergraduate

Table 3. Mean micronutrient content of treatment lunches as served and comparison to RDA.

Nutrient	High-Fat Lunches		Low-Fat Lunches	
	Content	% RDA*	Content	% RDA
Vitamin A (RE)	397§	57	217	31
Thiamin (mg)	0.5	47	0.5	53
Riboflavin (mg)	0.8	65	1.0	81
Niacin (mg)	4.7	36	5.8	44
Vitamin B6 (mg)	0.6	40	0.5	32
Vitamin C (mg)	18	39	39	86
Calcium (mg)	484	60	458	57
Iron (mg)	3.4	33	4.8	48
Magnesium (mg)	83	49	94	56
Zinc (mg)	2.6¶	26¶	3.8	38

* For children ages 7-10 years old

§ 3-day mean

¶ When an imputed value of 1.3 mg zinc is included for the chicken patty sandwich, estimated mean content is 3.9 mg or 39% of the RDA.

or graduate nutrition student assistant. Rolls, cookies, gelatin salad, mayonnaise and most salad dressings were prepared from standardized recipes by the district's central kitchen. Individual serving portions were not weighed when plated if the quantity was easily estimated or measured (i.e., 2 tbsp of catsup or 1/2 cup beans). The actual amount served of each menu item was estimated by averaging the weights of five randomly selected portions of the menu item after plating.

It was determined after meals were served on the first treatment day that the scale was weighing light by about 40%. The reported quantities served and plate waste measurements for that day were adjusted accordingly. Scales were calibrated prior to plating meals for the balance of the study.

Students picked up their meals in the kitchen and took them back to their classrooms to eat. Consumption was ad libitum, and a student teacher made notes of any food traded by children. The investigator was not present in either of the classrooms during the meals. Students were instructed to leave their trays with uneaten food on their desks when they finished. Trays were collected after students left the classroom for recess and labeled with the student's name at that time. The children were not told that plate waste would be measured.

<u>Data Collection</u>

Actual consumption of treatment lunches was calculated by subtracting the weighed plate waste of each menu item for each student from the average amount served and adjusting for reports of food traded between subjects.

Estimates of food consumed the rest of the day were based on self-maintained 3-day food diaries. Students recorded food intake for a 3-day baseline period at the beginning of the study (also a Tuesday, Wednesday, Thursday) and during each of the treatment periods, for a total of 9 days of food records. A copy of the "Daily Record" form provided can be found in Appendix F. Children were given 45 minutes of classroom instruction on recording intake, and a set of food models was available in each classroom throughout the study to help them estimate quantities. Appendix G is a detailed listing of the food models used. Students were given a bright colored pencil and a special folder to keep their food records in.

An interview was held with each child and a parent in their home following each 3-day period to clarify information on the food records. Interviews were scheduled at the family's convenience and usually held during the weekend. They were conducted by the primary investigator and four other graduate students in Community Nutrition. For the most part, each interviewer met with the same families throughout the study.

Interviewers reviewed each food record line by line with the student. They used food models and household measures (Appendix G) to confirm or fill-in estimated portion sizes, inquired about preparation methods and brand names used, clarified ambiguities, and probed for potentially missing information (i.e., skipped meals, use of condiments, sugar on cereal, etc.). Students were contacted later by phone if additional questions arose. Students were also asked how many times a week they typically ate school lunch.

A number from zero to nine was later assigned to each meal period on each food record to represent the percent range of food items added by the interviewer. For example, a "1" indicated that from 10-19% of food items listed for the meal period were added during the course of the interview.

Interviewers were trained in a one-hour session, using written training materials from the Strong Heart Dietary Study (83). These were supplied by one of the interviewers who had collected dietary information for that study during the previous summer. Interviewers also met for a follow-up meeting each week.

Estimation of Nutrient Intake

Nutrient intake for each student was estimated from dietary records and plate waste data using The Food Processor II computer program. Sources of nutrient data for foods not found in the original data base included Bowes and Church's Food Values of Portions Commonly Used (84); food package labels; nutrition information requested from manufacturers; and Appendix H (Fast Foods) in Understanding Nutrition (85). The Joy of Cooking (86), Betty Crocker's Cookbook (87), and Nutritive Value of American Foods in Common Units (88) were consulted for ingredient proportions of mixed dishes or recipes not obtained from families. When necessary, eating establishments were called for additional information about foods eaten away from home. A default list (Appendix H) was developed for entering food items when quantities, sizes, or types were not clearly specified.

Missing nutrient values were not imputed for foods added to the data base from other sources. Nutrient data was complete for kcalories and total fat. The percent of missing values for other reported nutrients ranged from 0.1% for carbohydrate and protein to 7.6% for zinc (Appendix I).

Food intake of each student was entered into The Food Processor II by meal periods as defined on the Daily Food

Records (Lunch, Afternoon Snacks, Dinner, Evening Snacks, Breakfast, and Morning Snacks). Lunch intake during the two treatment periods was entered both as recorded by the student and as estimated from plate waste for use in validating accuracy of student records. All food record data were entered by the primary investigator, and a random sample of records was cross-checked by another graduate student.

There appeared to be a pattern of missing breakfast data on the third day of each period for five of one interviewer's subjects. When it was confirmed through phone calls that four of those subjects typically always ate breakfast, representative breakfasts were entered to supply the missing data for eight meals. For another subject who reported she "sometimes skips" breakfast, no data was entered for the two breakfasts in question.

Statistical Analyses

Statistical analyses of nutrient intake data and demographic data were performed using the "Statistical Package for the Social Sciences" software, version 2.0 (SPSS/PC+)[2]. Mean 3-day intakes of kcalories, fat, protein, and carbohydrate for baseline and each of the two treatment periods were calculated by meal period and for the 24-hour period beginning with lunch. Distribution

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[2]SPSS,Inc., Chicago, IL; 1988.

normality of 3-day mean intakes of energy and each nutrient among subjects was confirmed using the Kolmogorov-Smirnov test for normality (89). Percent contribution to kcalories by each macronutrient was estimated for lunch and the 24-hour period by the following method: nutrient gram weights were multiplied by average kcalorie per gram values (carbohydrate - 4 kcal/g, protein - 4 kcal/g, and fat - 9 kcal/g) and divided by total kcalories. Paired t-tests (90) were used to detect differences between mean nutrient intakes for the high-fat and the low-fat treatment periods. Dependent variables measured were mean intakes of kcalories and grams of fat, carbohydrate, and protein for the total day and for each of the meal periods. The difference in mean percent of kcalories contributed by fat, carbohydrate, and protein between periods was tested statistically only for lunch and the total day. For the other meal periods, the mean percents of kcalories were calculated manually and simply reported. Results were reported as significant at the $p<.05$ level. Mean 3-day intake of micronutrients is reported but differences between weeks were not tested statistically since no attempt was made to control the level served at lunch.

Treatment lunch intake was based on actual consumption as calculated from plate waste data for the above analyses. Nutrient intake for all other meals was based on the subject's own food records.

If a student did not consume a treatment lunch, they were eliminated from all analyses which included that day. For all other missed meals (with the exception of the eight breakfasts previously discussed), zero values were input for each nutrient and averages were calculated over all 38 subjects.

To validate the accuracy of the students' self-recorded food diaries, paired t-test comparisons were made between 3-day mean lunch intake as recorded by the students and 3-day mean lunch intake as calculated from plate waste. The mean daily percent of food items added by interviewers was evaluated over time as a measure of subject fatigue.

Limitations and Controls

The sample was neither randon
representative of fifth graders in Cc ... gs
cannot necessarily be extrapolated to a ... iation.

Castonguay (52) has identified the foi ... ng non-physiological factors that may influence hunger or appetite: socio-economic level, cultural mores, habit, peer influence, education, expectations, emotional state, temperature, illness, and eating disorders. This study design included controls for some of these factors. The population served by the school selected is relatively homogeneous in terms of parental income, education, and cultural background. The school district had not placed any unusual emphasis on nutrition education or on menu modifications so students as a group should have been minimally influenced by expectations. The effect of weather was neutral since the study was conducted when weather was mild. Children who were ill enough to experience a reduction in food intake generally did not eat the treatment lunch and therefore were eliminated from that day's analyses on that basis. Habit, peer influence, emotional state, and eating disorders were not controlled for.

Davidson (80) reported that differences in energy intake between boys and girls are not significant in this age group. Fat intake has also been shown to be independent of sex at this age (25,67) so gender mix was not controlled or included as a factor in the statistical analyses.

The ability to measure spontaneous response to a meal in terms of subsequent intake is dependent upon subjects having control over what they eat. A study of 40 urban elementary school-aged children (80) revealed that they had considerable autonomy over food selection and that casual eating inside and outside the home made a significant contribution to intake. Garcia et al. (44) reported that rural Mexican children had a great deal of choice about what they ate and when, and that 45% of all kcalories were consumed outside of meals. The impression from dietary interviews conducted in this study is that these children, too, had a high degree of autonomy over food selection.

The study design did not control for possible carryover, order, or course of time effects. Similar studies (41,42,45) have found that these effects did not influence response. It was also expected that these effects would not be factors given that only one meal was manipulated, the number of days between treatment periods (Friday through Monday), and that students were free to eat as they chose for the remainder of the day.

Care must be exercised in interpreting the micronutrient data for several reasons. First, it is difficult to attribute differences in micronutrient intake between the 2 weeks to the treatment lunches because the micronutrient levels served were not controlled. For this reason, the significance of observed differences was not statistically tested and conclusions based on those differences cannot be made with any confidence. Secondly, more days of dietary records and/or a larger sample than was used in this study may be required to adequately characterize intake and detect true differences in micronutrient intake. Research on adult diets show that the length of time required to estimate intake from dietary records for some of the micronutrients, particularly vitamin A, is generally greater than for the macronutrients (72,77). Since children's diets tend to be less variable than the diets of adults (80), fewer days may be required to characterize micronutrient intake of children. Finally, 24-hour intakes may be understated for some of the micronutrients because of missing values in the data base (Appendix I).

RESULTS

24-Hour Intake on Low- and High-Fat Treatments

Table 4 gives a comparison of mean 24-hour energy and macronutrient intakes between the two treatment periods. There was no significant difference in daily energy consumption between the high-fat period (1655 kcal) and the low-fat period (1665 kcal, p=.852).

Actual fat intake was not significantly different (63 g during the high-fat week vs 59 g during the low-fat week, p=.086). However, percent of kcalories consumed as fat over 24 hours during the high-fat period (35%) was significantly higher than during the low-fat period (32%, p=.000).

Total daily carbohydrate intake as a percent of kcalories was significantly lower during the high-fat than the low-fat period (52% vs 55%, p=.000) although the difference in gram intake was not. Protein intake was constant at 15% of kcal.

The number of students consuming lower fat diets increased substantially from the high-fat to the low-fat week (Table 5). Only 8% of the students derived less than 30% of their kcalories from fat during the high-fat week compared to 39% of the students during the low-fat week. Conversely, during the high-fat week 24% of the students consumed diets providing more than 36% of energy as fat

Table 4. Comparison of mean 24-hour energy and macronutrient intakes and percent contribution to total kcalories between high-fat and low-fat weeks.

Nutrient	High-Fat Week	Low-Fat Week
Mean Intake		
Energy (kcal)	1655 ± 301*	1665 ± 401
Fat (g)	63 ± 11	59 ± 16
Carbohydrate (g)	215 ± 48	228 ± 55
Protein (g)	62 ± 16	63 ± 19
Percent Contribution§		
Fat (% kcal)	35^a	32^b
Carbohydrate (% kcal)	52^a	55^b
Protein (% kcal)	15	15

* Mean ± standard deviation

§ Percent calculations are based on average kcalorie per gram values and may not add to 100%.

a,b Different superscripts in a row indicate difference between weeks is significant at $p<.01$.

Table 5. Mean number and percent of students consuming diets at three levels of total fat intake during baseline and treatment weeks.

Week	Students With Diets at Three Levels of Total Fat Intake		
	≤30% kcal no. (%)	31-36% kcal no. (%)	>36% kcal no. (%)
Baseline	10 (28)	15 (42)	11 (31)
High-Fat	3 (8)	26 (68)	9 (24)
Low-Fat	15 (39)	20 (53)	3 (8)

while only 8% consumed fat at this level during the low-fat week.

Treatment Lunch Intake

Energy and macronutrient intakes from the high-fat and low-fat treatment lunches are compared in Table 6. Energy intake from the high-fat lunches was significantly greater than from the low-fat lunches (483 vs 425 kcal, respectively, p=.000).

Mean fat intake from the high-fat lunches was significantly greater than from the low-fat lunches, both as grams and as a percent of kcalories. Students consumed 9 g more fat from high-fat lunches than from low-fat lunches (p=.000). The average fat intake from the high-fat lunches was 40% of meal kcalories compared to 28% from the low-fat lunches (p=.000).

The reduction in kcalories consumed as fat from the low-fat lunches was compensated for primarily by a significant increase in carbohydrate consumption. Students consumed an average of 5 more grams of carbohydrate from the low-fat than from the high-fat lunches (p=.005), and the percent kcalories consumed as carbohydrate increased from 47% during the high-fat period to 58% during the low-fat period (p=.000). Protein intake in grams was not significantly different (p=.085),

Table 6. Comparison of mean treatment lunch energy and macronutrient intakes and percent nutrient contribution to meal kcalories between high-fat and low-fat weeks.

Nutrient	High-Fat Week	Low-Fat Week
Mean Intake		
Energy (kcal)	483 ± 132[*,a]	425 ± 124[b]
Fat (g)	22 ± 7[a]	13 ± 5[b]
Carbohydrate (g)	56 ± 14[a]	61 ± 16[b]
Protein (g)	18 ± 6	17 ± 6
Percent Contribution to Meal§		
Fat (% kcal)	40[a]	28[b]
Carbohydrate (% kcal)	47[a]	58[b]
Protein (% kcal)	15	15

* Mean ± standard deviation

a,b Different superscripts in a row indicate difference between weeks is significant at p<.01.

§ Percent calculations are based on average kcalorie per gram values and may not add to 100%.

representing about 15% of kcalories consumed during both treatment periods.

Comparisons of amounts of food served and consumed and plate waste during the two treatment periods are presented in Table 7. During the low-fat week, mean gram weight of food served was 11% higher yet on the average, students consumed 5% less food by weight than during the high-fat week. Percent plate waste for the high-fat week was 33% as compared to 42% for the low-fat week.

Students consumed meals that were more energy dense than those served during each treatment period. High-fat lunches consumed averaged 135 kcal/100 g versus 129 kcal/100 g as served. Low-fat lunches consumed averaged 124 kcal/100 g as compared to 120 kcal/100 g as served.

Intake from Subsequent Meal Periods

A comparison of lunch and 24-hour intakes (tables 4 and 6) suggests that the kcalorie deficit from the low-fat lunch was fully compensated for at some point within the 24-hour period, since daily energy intake during the two periods was the same. Also, the difference in 24-hour fat intake between the two treatment periods (4 g) is smaller than the difference observed at lunch (9 g), which suggests that partial compensation for fat occurred sometime during the day.

Table 7. Amounts of food served and consumed and plate waste from treatment lunches.

Meal	Served (g)	Consumed (g)	Consumed (% served)	Plate Waste (g)	Plate Waste (% served)
High Fat Lunches					
Tuesday	590	420	71	170	28
Wednesday	484	342	71	142	29
Thursday	522	315	60	207	40
Average	**532**	**359**	**67**	**173**	**33**
Low-Fat Lunches					
Tuesday	563	366	65	197	35
Wednesday	627	318	51	309	49
Thursday	575	346	60	229	40
Average	**588**	**343**	**58**	**245**	**42**

To identify when compensation occurred, macronutrient intake for the remainder of the 24-hour period following lunch was analyzed by meal periods. Table 8 shows that full kcalorie and partial fat compensation was completed during after-school snacks. Energy intake from snacks following low-fat lunches was significantly higher than from snacks following high-fat lunches (p=.013), and more than compensated for the lower energy intake from low-fat lunches. Fat intake from afternoon snacks was significantly higher during the low-fat week by 5 g (p=.004).

Carbohydrate and protein intake from after-school snacks were also significantly higher (by 9 g and 2 g, respectively) during the low-fat period.

A comparison between the cumulative values for lunch and afternoon snack for each treatment period (Table 8) confirms that net compensation for energy and fat occurred before dinner. When lunch and snacks are considered together, there is no longer a significant difference in cumulative kcalorie intake between the two periods. Cumulative fat intake for lunch and snack is lower by 3 g during the low-fat period (p=.038), which accounts almost entirely for the 4 g difference in fat intake observed over the 24-hour period. Cumulative carbohydrate intake for lunch and snack is higher during the low-fat period by

Table 8. Comparison of mean energy and macronutrient intakes by meal periods between high-fat (HF) and low-fat (LF) weeks.

Meal Period	Week	Energy* (kcals)	Fat (g)	Carbo-hydrate (g)	Protein (g)
Lunch	HF	483 ± 132[a]	22 ± 7[a]	56 ± 14[a]	18 ± 6
	LF	425 ± 124[b]	13 ± 5[b]	61 ± 16[b]	17 ± 6
Afternoon Snack	HF	211 ± 151[c]	8 ± 6[a]	33 ± 23[c]	4 ± 4[c]
	LF	291 ± 188[d]	13 ± 9[b]	42 ± 26[d]	6 ± 5[d]
Lunch + Snack	HF	695 ± 187	29 ± 8[c]	89 ± 27[a]	22 ± 6
	LF	716 ± 196	26 ± 9[d]	103 ± 26[b]	23 ± 7
Dinner	HF	566 ± 163	22 ± 8	64 ± 21	28 ± 11
	LF	541 ± 208	21 ± 10	61 ± 24	28 ± 12
Evening Snack	HF	82 ± 99	3 ± 4	12 ± 15	2 ± 3
	LF	87 ± 109	3 ± 4	14 ± 17	1 ± 2
Breakfast + A.M. Snack	HF	316 ± 131	9 ± 6	50 ± 21	11 ± 6
	LF	321 ± 107	9 ± 5	51 ± 18	11 ± 5
24-Hour Total	HF	1655 ± 301	63 ± 11	215 ± 48	62 ± 16
	LF	1665 ± 401	59 ± 16	228 ± 55	63 ± 19

* Mean ± standard deviation

a,b Different superscripts in a column indicate difference between weeks is significant at $p<.01$.

c,d Different superscripts in a column indicate difference between weeks is significant at $p<.05$.

14 g (p=.005), which also explains the increase in 24-hour carbohydrate consumption.

There were no significant differences in energy or macronutrient intakes between the two treatment periods for any of the remaining meal periods (Table 8).

It should be noted that nutrient intakes for each meal period are averaged over 38 subjects, regardless of whether all students actually consumed that particular meal. All subjects ate lunch and dinner but not all ate snacks and breakfast. Therefore, average values reported for snacks and breakfast are less representative of actual intakes for individuals than values reported for lunch and dinner.

<u>Baseline Intake</u>

Baseline macronutrient and energy intake data for 36 students are presented in Table 9. Two students entered the study late and did not keep baseline food records. Mean 24-hour energy intake at baseline was 1773 kcal. Average daily macronutrient intake as a percent of kcalories averaged 33% from fat (66 g), 53% from carbohydrate (235 g), and 15% (68 g) from protein.

The mean energy intake from baseline lunches was 489 kcal. The nutrient contribution to kcalories at lunch was 39% from fat (21 g), 48% from carbohydrates (60 g), and 15% from protein (18 g). Percent kcalories from fat was

Table 9. Mean baseline energy and macronutrient intakes and percent nutrient contribution to meal kcalories by meal period.

	Mean Intake				Percent Contribution§		
Meal Period	Energy (kcals)	Fat (g)	Carbo-hydrate (g)	Protein (g)	Fat (%kcal)	Carbo-hydrate (%kcal)	Protein (%kcal)
Lunch	489 ± 97*	21 ± 5	60 ± 19	18 ± 5	39	48	15
Afternoon Snack	253 ± 146	9 ± 6	39 ± 23	6 ± 6	32	62	9
Dinner	566 ± 205	22 ± 9	64 ± 26	30 ± 15	34	45	21
Evening Snack	146 ± 155	6 ± 8	21 ± 21	2 ± 3	37	58	6
Breakfast/Snack	321 ± 126	8 ± 6	52 ± 19	12 ± 6	23	64	14
24-Hour Period	1773 ± 394	66 ± 18	235 ± 56	68 ± 21	33	53	15

* Mean ± standard deviation, n=36

§ Percent calculations are based on average kcalorie per gram values and may not add to 100%.

higher for lunch than any other meal period in the day.

Almost half (44%) of baseline lunches were brought from home, 48% were hot school lunches, and 7% were selected from the school salad bar (Table 10). The average contribution of each type of lunch to kcalories and fat consumed is shown in Table 10. The hot school lunches eaten were higher in fat (43% of kcal) than lunches from home or the salad bar (35% of kcal). The percent of fat from baseline hot school lunches may not be representative, however, since 44% of those meals were eaten on the day "Nachos" were served. The "Nachos" menu is one of the higher fat choices (45% kcal from fat) in a 2-week cycle which averages 39% of kcal from fat. The proportion of lunches purchased at school (55%) during baseline was probably representative for this sample since subjects reported that they typically eat school lunch about half the time (2-3 days/week).

Table 11 shows a comparison of this sample's baseline lunch intake with that of 194 10-year-old participants in the Bogalusa Heart Study (67). Average fat intake by the Corvallis students in this study was 33% of kcal, as compared to 38% for the Bogalusa cohort, yet the percent fat intake at lunch for the two groups was about the same.

There is no breakfast program at the school so all breakfasts were consumed at home or at a restaurant.

Table 10. Mean energy and fat intakes and percent contribution of fat to meal kcalories of each type of baseline lunch.

Type of Lunch	Percent of Sample (n=107)	Energy (kcal)	Fat (g)	Fat (%kcal)
Home	45	533 ± 147*	21 ± 9	35
School-hot lunch	49	457 ± 134	22 ± 7	43
School-salad bar	6	406 ± 166	16 ± 8	35

* Mean ± standard deviation

Table 11. Comparison of baseline lunch and total fat intakes of Corvallis and Bogalusa Heart Study fifth graders.

	Corvallis	Bogalusa¶
Lunch Intake		
Energy (kcals)	489 ± 97*	497 ± 23
Fat (g)	21 ± 5	21 ± 23
Carbohydrate (g)	60 ± 19	56 ± 21
Protein (g)	18 ± 5	19 ± 28
Fat Contribution		
Lunch (% kcal)	39	38
Total Day (% kcal)	33	38

* Mean ± standard deviation
¶ Intakes estimated from 24-hour recalls

The average percent contribution of each baseline meal to total 24-hour energy intake was as follows: lunch - 28%, afternoon snacks - 14%, dinner - 32%, evening snacks - 8%, breakfast - 16%, and morning snacks - 2%. Total snack contribution was 24% of kcal.

Micronutrient Intake

Micronutrient consumption from treatment lunches and a comparison to the RDA is presented in Table 12. Micronutrient intake was lower relative to the RDA than the energy contribution of the meal for only zinc during the high-fat week and for vitamin A during the low-fat week. Zinc and vitamin B6 intakes during the high-fat week are underestimated because of missing values for the chicken patty. Comparing the two treatment weeks, lunch micronutrient intake was lower during the low-fat week than the high-fat week for vitamins A and B6 and calcium.

Table 13 shows the mean 24-hour micronutrient intake for both treatment periods and a comparison to the RDA. For 7 of the 10 micronutrients evaluated, the mean total intake was higher or equal during the low-fat week than during the high-fat week. As at lunch, only vitamins A and B6 and calcium were consumed at a higher level during the high-fat week than the low-fat week.

Nutrient intakes meeting 75% of the RDA or above are considered adequate (91). Mean consumption over a

Table 12. Mean micronutrient intake from treatment lunches and comparison to RDA.

Nutrient	Mean Lunch Intake High-Fat Week	Mean Lunch Intake Low-Fat Week	% RDA* High-Fat Week	% RDA* Low-Fat Week
Vitamin A (RE)	216 ± 85	122 ± 59	31	17
Thiamin (mg)	0.3 ± .1	0.3 ± .1	30	30
Riboflavin (mg)	0.5 ± .2	0.6 ± .2	42	50
Niacin (mg)	3.4 ± 1.0	3.4 ± 1.2	26	26
Vitamin C (mg)	11 ± 3	19 ± 8	24	42
Vitamin B6 (mg)	0.4 ± .1	0.3 ± .1	29	21
Calcium (mg)	338 ± 143	254 ± 115	42	32
Iron (mg)	2.4 ± .7	3.0 ± 1.0	24	30
Magnesium (mg)	57 ± 16	56 ± 20	34	33
Zinc (mg)	1.9 ± .6	2.2 ± .9	19	22
Energy (kcals)	483 ± 132	425 ± 125	24	21

* For children ages 7-10 years old
§ Mean ± standard deviation

Table 13. Mean 24-hour micronutrient intake during high-fat and low-fat treatment weeks and comparison to RDA.

Nutrient	Mean 24-Hour Intake		% RDA*	
	High-Fat Week	Low-Fat Week	High-Fat Week	Low-Fat Week
Vitamin A (RE)	876 ± 510	843 ± 368	125	120
Thiamin (mg)	1.3 ± .4	1.4 ± .5	130	140
Riboflavin (mg)	2.0 ± .7	2.0 ± .7	167	167
Niacin (mg)	15 ± 6	16 ± 6	115	123
Vitamin C (mg)	62 ± 46	78 ± 58	138	173
Vitamin B6 (mg)	1.4 ± .6	1.3 ± .6	100	93
Calcium (mg)	1057 ± 347	951 ± 363	132	119
Iron (mg)	11 ± 5	12 ± 5	110	120
Magnesium (mg)	212 ± 57	222 ± 74	125	131
Zinc (mg)	8 ± 2	9 ± 3	80	90
Energy (kcals)	1655 ± 301	1665 ± 401	83	83

* For children ages 7-10 years old

§ Mean ± standard deviation

24-hour period was well above 75% of the RDA for all nutrients reported during both high and low-fat weeks. Intakes greater than 100% of the RDA were achieved for all nutrients except vitamin B6 during the low-fat week and zinc during both weeks.

The percent of students consuming 75% or more of the RDA (Table 14) during the low-fat week was greater than or equal to that during the high-fat week for all nutrients except riboflavin, calcium, and vitamin B6.

Validation of Methodology

In order to assess the accuracy of students' self-maintained food records a comparison was made between nutrient intake as estimated from the student's food records and "actual" intake as estimated from plate waste measurements for the treatment lunches (Table 15). An evaluation of nutrient intakes averaged over the two treatment weeks indicates that students tended to over-report intake by about 6%. This difference was significant for fat and protein but not energy and carbohydrates.

The percent of food items added by the interviewer for each meal period (reported as a single digit category representing a 10% range) was determined as a measure of subject "fatigue" over time in maintaining records. Figure B shows the average of these percent categories for

Table 14. Percent of students whose 24-hour micronutrient intake was above and below 75% of the RDA during high-fat and low-fat treatment weeks.

	High-Fat Week		Low-Fat Week	
Nutrient	<75% RDA	≥75% RDA	<75% RDA	≥75% RDA
Vitamin A	24%	76%	16%	84%
Thiamin	8	92	3	97
Riboflavin	0	100	3	97
Niacin	11	89	11	89
Vitamin C	32	68	24	76
Vitamin B6	26	74	34	66
Calcium	8	92	18	82
Iron	18	82	8	92
Magnesium	5	95	3	97
Zinc	53	47	47	53

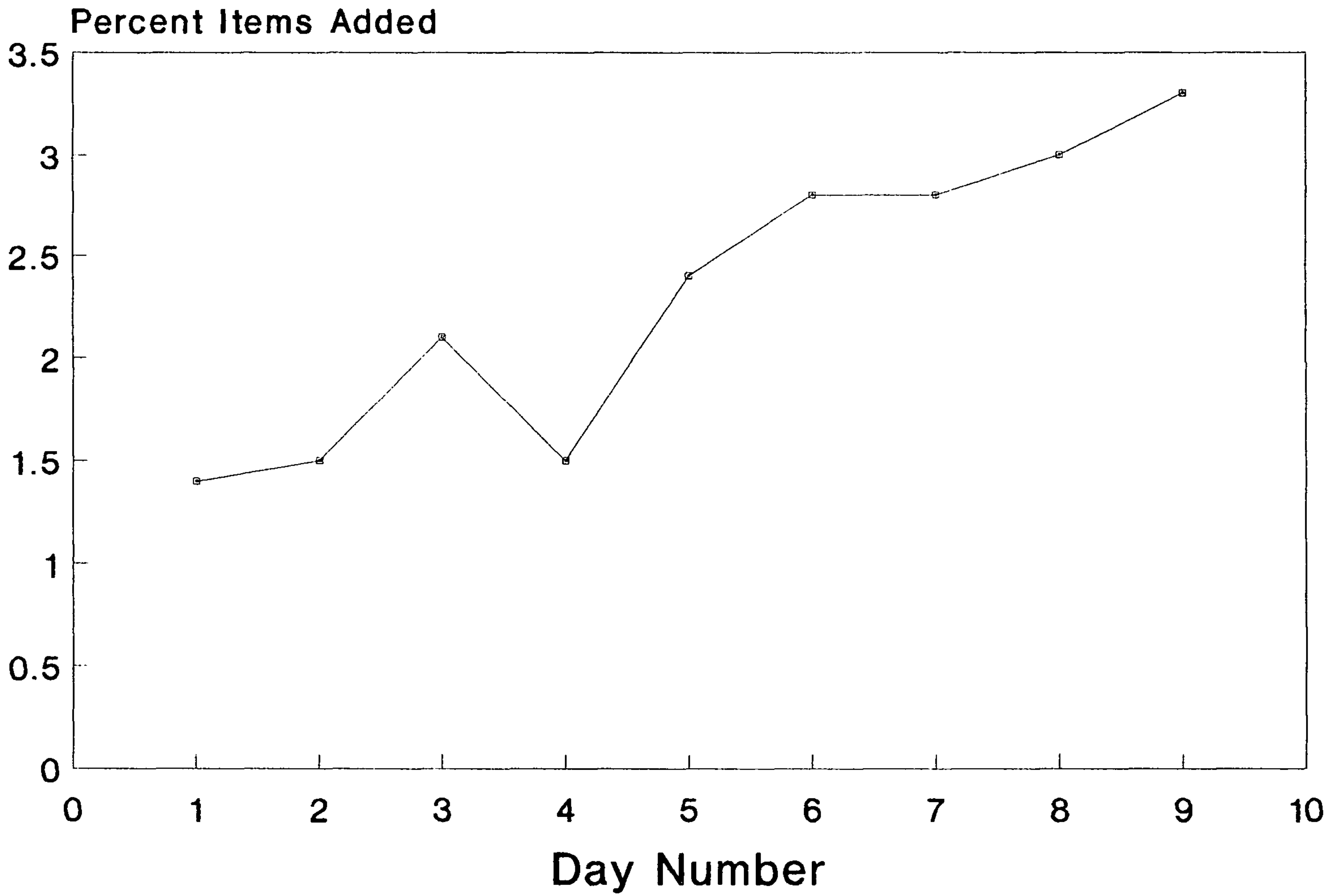
Table 15. Comparison of self-recorded versus actual nutrient and energy intakes at lunch.

Nutrient	Method	Two Week Average	High-Fat Week	Low-Fat Week
Energy (kcals)	Self-recorded	479 ± 110*	501 ± 123	456 ± 121
	Actual	453 ± 124	482 ± 134	425 ± 124
	Difference	6%	4%	7%
Fat (g)	Self-recorded	19 ± 5[a]	23 ± 7	15 ± 5[a]
	Actual	18 ± 6[b]	22 ± 7	13 ± 5[b]
	Difference	6%	5%	15%
Carbohydrate (g)	Self-recorded	61 ± 12	58 ± 12	63 ± 16
	Actual	58 ± 14	56 ± 14	61 ± 16
	Difference	5%	4%	3%
Protein (g)	Self-recorded	18 ± 5[a]	19 ± 5	18 ± 6
	Actual	17 ± 5[b]	18 ± 6	17 ± 6
	Difference	6%	6%	6%

* Mean ± standard deviation

a,b Different superscripts in a column indicate difference between methods is significant at p<.05.

Fig. B. Mean percent of food items added by interviewer by day.



each of the 9 days records were kept. It is evident from Figure B that during the last week of the study substantially more food items were added during the course of the interview than during the first two weeks. Within each 3-day period, more items were added each day than were added for the previous day. A similar trend is evident in Table 16, which groups the students into one of three categories according to the percent of items added daily. On Day 1, interviewers added less than 30% of the food items to the records of 86% of the students. By Day 9, the percent of students in this category dropped to 58%. More than 70% of the food items were added to the records of only 8% of the students on Day 1, whereas by Day 9, 21% of the students' food records required additions to this extent.

Table 16. Percent of food records to which an average of 0-29%, 30-69% and 70-100% of food items were added by the interviewers each day of the study.

Percent Food Items Added	Percent of Food Records per Level of Added Items								
	Day 1 (%)	Day 2 (%)	Day 3 (%)	Day 4 (%)	Day 5 (%)	Day 6 (%)	Day 7 (%)	Day 8 (%)	Day 9 (%)
0-29%	86	86	75	82	69	60	53	62	58
30-69%	6	3	14	11	22	29	37	22	21
70-100%	8	11	11	8	8	11	11	16	21

DISCUSSION

24-Hour Intake on Low- and High-Fat Treatments

The data presented here suggest that serving reduced-fat school lunches can result in a meaningful decrease in total 24-hour fat intake by elementary school-aged children. Mean total fat intake as a percent of kcalories was significantly lower during the low-fat lunch period than the high-fat lunch period (32% of kcal vs 35% of kcal, respectively). There was also a substantial increase in the number of students who consumed fat at the currently recommended level during the low-fat lunch treatment week. During the high-fat lunch week only 8% of the students derived 30% or less of their energy from fat compared to 39% of the students during the low-fat lunch week.

Total energy intake was not compromised as a result of serving low-fat lunches. This outcome was desired because students in this sample did not need to lose weight. Fat kcalorie replacement during the low-fat lunch period was accomplished almost entirely by an increase in carbohydrate intake while protein intake was unchanged. An increase in protein consumption under reduced-fat conditions would have been less desirable since students in this sample already consume adequate protein and there are no recognized advantages of eating more.

The net result was that the fifth graders in this study consumed a total diet that more closely approximated current dietary recommendations during a 3-day period of low-fat lunches than they did during 3 days of traditional higher-fat lunches.

Low- and High-Fat Treatment Lunch Intakes

During both treatments students consumed fat at lunch in proportion to the levels of fat served. Lunches consumed during the low-fat week averaged 28% of kcal from fat. The fat content of the meals served was 29% of kcal. During the high-fat week, lunches consumed averaged 40% of kcal from fat, compared to 43% of kcal from fat in the lunches served.

Significantly fewer kcalories were consumed from the low-fat lunches than from the isocaloric high-fat lunches in this study. This finding lends validity to the theory that children may be unable to consume a sufficient quantity of less energy dense foods from a low-fat meal in the time available for lunch at school. A comparison of the weight of food consumed from each of the six treatment lunches (Table 7) shows that, with the exception of the first high-fat lunch, comparable amounts of food were consumed during the two treatment periods. In fact, the second and third greatest amounts of food were consumed during the low-fat week. This suggests that there may indeed be some limiting quantity of food that the children will consume from a school lunch, regardless of the kcalorie content. It also means that higher plate waste percentages cannot necessarily be interpreted to mean that the low-fat meals were less acceptable.

No previous studies addressing the caloric adequacy of diets of varying energy density in this age group were identified. McPherson et al. (58) reported that children in grades 5-12 with lower levels of fat intake also consumed less energy than children with higher levels of fat intake. However, no data on amounts of food consumed were presented so conclusions about energy density of the diets cannot be drawn.

Researchers studying young children's diets in developing countries (44,92) report that diets providing 100 kcal/100 g are sufficiently energy dense to fill the caloric requirements of preschoolers. The low-fat lunches served in this study were 20% more energy dense, providing an average of 120 kcal/100 g. As recommended total energy intake for 10-year-old children is only 11% higher than that for 4- to 6-year-olds (17), one could infer that low-fat lunches as served in this study should be of sufficient caloric density to meet the needs of fifth graders. Garcia et al.(44) commented that energy density of meals may not be an issue beyond the age of 24 months. Applicability of existing literature on caloric density of children's diets to this study is limited. Preschoolers in developing countries may be more accustomed to diets of low energy density; and they may be given more than 15 minutes to eat, which is the typical length of an American elementary school lunch period. Also, the energy requirement from a single meal is related to eating frequency, which may vary between cultures and age groups.

An alternative explanation for lower kcalorie consumption from the low-fat lunches in this study is that the children simply didn't like the food as well. One cannot eliminate that possibility since acceptability of the menus was not confirmed prior to the study.

Compensation for Kcalories and Fat Following Low-fat Lunches

Although the students consumed less energy and fat from the low-fat lunches, it appears that they compensated within a short period of time by increasing relative energy and fat intake later in the day. Full compensation for the kcalorie deficit and a partial offset (50%) for the reduced fat intake occurred during after-school snacks. Snacks were generally consumed within 3-4 hours after lunch. This time frame is consistent with findings by Birch and Deysher (43) and Garcia et al. (44) that preschool children will balance total energy intake at the meal following preloads of different caloric density. The response observed was also within the 5 hour time frame observed by Foltin et al. (41) for caloric compensation by adults.

The observed increase in subsequent fat intake following the low-fat lunches is of particular interest. While the difference in fat consumption at lunch was not completely offset and total 24-hour fat consumption was still lower during the low-fat period, the children did consume over 50% more fat from snacks following the low-fat lunches than after the high-fat lunches. Foltin et al. reported only a small increase in fat intake after a low-fat lunch. It is conceivable that such a response would be more pronounced among free-living children. Foltin et al.'s subjects were adults, in a residential laboratory with free access to a well balanced variety of foods at any time other than during lunch. They were also being paid to complete work tasks on the computer, which may have inhibited snacking. Snacks, however, are a significant part of children's diets. Frank et al. (67) demonstrated that some children consume more kcalories from snacks than any single meal. Students in this sample derived 24% of their kcalories from snacks at baseline. While more kcalories were consumed at both lunch and dinner than from snacks, the snack contribution to total intake was still substantial. Also, children's snacks are frequently high in fat and sucrose (67), and have been shown to be higher in fat than those of adult women (93).

In this study, two unexpected incidents occurred during the low-fat treatment period that could have interfered with measurement of spontaneous responses to the noon meal in terms of subsequent intake. Additional statistical analyses, however, indicated that the effect on total fat and kcalorie intake, if any, was not significant. In one class, on the first low-fat day, birthday cake and ice cream were served shortly before the students were dismissed for the day. The other class participated in a "jog-a-thon" the following afternoon and all participants were given a raisin and peanut snack. Both of these "extra" snacks are significant sources of fat and kcalories. The jog-a-thon snack contained 171 kcal and 9 g of fat (46% of kcal), and the cake and ice cream provided 449 kcal and 19 g of fat (38% of kcal).

Since these two snacks introduced a factor that distinguished the two classes, a paired t-test was done to compare intake between the two classes for the after-school snack meal period during the low-fat week. While the class that had the birthday party did in a practical sense consume more energy (329 kcal vs 257 kcal) and more fat than the other class (14 vs 11 g) over the 3-day period, the differences were not statistically significant ($p=.254$ and $p=.326$, respectively). An analysis of variance was also done to see if there were any differences in snack intake among the three days of the low-fat period. Neither kcalorie nor fat intake was significantly different between any two of the three days at the $p<.05$ level.

The first class also participated in the jog-a-thon during the low-fat period but during a different meal period (between breakfast and lunch). An analysis of variance with class as a between-groups factor did reveal that fat intake was significantly higher during the jog-a-thon week for this meal period and that class was a significant factor. However, when the breakfast and snack periods were combined, the difference in fat intake between the two weeks was no longer significant nor was the class factor important. While these two incidents did not appear to have a statistically significant effect on the results, total intake of fat during the low-fat period might have been even lower had they not occurred and the effect of the low-fat lunches would have been more pronounced.

Implications

It is important that these changes in total macronutrient intake occurred when the fat content of only one meal was manipulated and in the absence of an attempt to modify eating behavior. These results should not, however, be used as an argument against the need for nutrition education in the schools. Rather, the fact that these students partially compensated for the low-fat lunches by increasing fat consumed during snacks only underscores the importance of concurrent nutrition education. Behavior modification and a supportive home environment which encourage changes in overall dietary habits are needed if full benefit of a modified school lunch program is to be realized.

While pressure is mounting to mandate implementation of the Dietary Guidelines in the NSLP, there is no guarantee that nutrition education will be offered universally. In 1985, only 12 states required nutrition education (8). Between 1982 and 1989, Congress appropriated only $5 million annually to the Nutrition Education and Training (NET) Program, compared to the previous high of $20 million in 1980 (13,31). While increased levels of funding were authorized for 1990 through 1994 (32), actual appropriations thus far have been short by 50%. Appropriations to date versus the authorization is as follows: 1990 - $5.0 million vs. $10.0 million, 1991 - $7.5 million vs. $15.0 million, and currently planned for 1992 - $10.0 million vs. $20.0 million (94,95). Therefore, modifications to lunch programs are likely to occur in a less than optimum environment. This study offers encouraging evidence that current attempts to decrease fat consumption at lunch alone may have a beneficial impact on total dietary fat intake of school children and lends support to continuation of these efforts.

Micronutrient Intake

Consuming low-fat lunches did not adversely affect mean 24-hour intake of the ten micronutrients reported. In fact, total nutrient intake during the low-fat week, as well as the percent of students consuming ≥75% of the RDA, was the same or higher for 7 of 10 of the micronutrients than during the high-fat week. Consumption of vitamins A and B6 and calcium were lower during the low-fat lunch week than the high-fat lunch week, yet mean intake exceeded 90% of the RDA for each of these three nutrients and was therefore quite adequate. Lower total intake of these three nutrients during the low-fat lunc
be partially explained by the fact that the lo
lunches served contained lower levels of these
than the high-fat lunches.

Dietary Assessment Methodology

The age group of the subjects was chosen specifically to minimize the amount of error likely to occur when young children self-record dietary intake. It has been shown that 10-year-old children are capable of providing reasonably accurate and reproducible dietary information in a 24-hour recall and may be less influenced than older children by what they think is expected by the interviewer (63,66,67). For this study, a 3-day dietary record was deemed to be the more appropriate method for assessing usual dietary intake of a sample this size.

The comparison of self-recorded lunch intakes as modified by the interviewer versus weighed intakes indicated that students in this study tended to over-report lunch intake by about 6%. This degree of accuracy compares favorably with validation studies of self-reports of food intake (22,63,64). Agreements between weighed and self-reported estimates of food intake considered "acceptable" in the literature have ranged from ±10 to ±20%.

Assuming that accuracy in recording lunch was reflective of accuracy in recording the rest of the day's meals, the 3-day self-maintained food diary method used in this study appears to be a satisfactory way to estimate total food intake by fifth graders. Two factors, however, may have influenced lunch recording differently than the other meals. As the study progressed, students seemed to record lunch less carefully. Several commented during their end-of-week interviews that they "thought you (interviewers) knew what I ate" and that they felt it wasn't necessary to record the meal. Student reported lunch intake in these cases would have been based on their recall during the interview several days later and conceivably could be less accurate than if recorded by the student shortly after the meal was eaten. Also, interviewers knew the lunch menu for each day and prompted recall of specific foods served. Such prompting may have served to improve the accuracy of lunch records relative to other meals for which interviewers had no prior knowledge. A casual comparison of lunch intake as estimated from plate waste with individual student records revealed that students tended to recall that "all or nothing" of a food item was consumed at lunch, when in fact the item was partially consumed. How such a tendency might contribute to over- or underestimation is unclear. Nor can it be determined from this study whether this tendency applied only to prompted recall of lunch foods or to recording quantities of foods at all meals.

The follow-up interview was an essential component of the method used. For some subjects, a substantial amount of information was added during the interview (Table 16). Subject fatigue over time was evident by the increasing percentage of food items that were added by the interviewer both over the course of each study week and for the third week as compared to the first 2 weeks. As reported elsewhere (68), there also seemed to be a tendency to forget to record snacks or non-habitual meals, such as a birthday party at school. For this age group, food records would probably be more accurate if collected on a daily basis rather than collecting all 3 days at the time of the interview. For the most part subjects were able to serve as the respondent during the interview, although parental input added to the quality of the data.

Generalization of Results

Because the sample was relatively small and not randomly selected, one should use caution extrapolating the results from this study to the greater population of fifth graders.

The sample was not representative of school-aged children in terms of usual total dietary fat intake. As a group, total baseline fat intake as a percent of kcalories was 3% lower than the national average (33% vs 36%). It was evident from the food records that many of the families were conscious of total fat and saturated fat intake. Almost all reported using nonfat or low-fat milk, and many used lean cuts of meat, margarine vs butter, poultry without skin, and low-fat cream cheese. However, high-fat snacks were still widely available. Ice cream, cake, cookies, chips, and candy were frequently consumed snack items. Total fat intake when low-fat lunches are served and other meals are self-selected could well be greater than was observed in this study by a group of more typical students who have a higher fat intake.

The comparison of baseline lunch intake with that of students in The Bogalusa Heart Study reveals that subjects in this study were not necessarily atypical with respect to baseline fat intake at lunch. The fact that lunch fat intake was comparable between the two groups while 24-hour fat intake by Corvallis students was much lower could be a reflection of the influence that different home environments have on a child's eating behavior outside of school.

The responses to low-fat versus high-fat lunches observed in this study are based on consuming lunches of comparable kcalorie content as served. In actual practice, reduced-fat school lunches may be lower in kcalories unless energy content of menus is calculated and additional carbohydrates are served. When planning the low-fat menus for this study, it was necessary to include some food items which might typically be avoided in a low-fat menu (such as 2% rather than 1% milk; and french fries, cheese, and low-fat mayonnaise in one meal) in order to achieve the desired fat and kcalorie content. Meals modified by simply substituting lower fat foods in the current lunch pattern were documented in two research studies (21,22) to be 9%-42% lower in kcalories than the traditional counterparts. Under such circumstances, results reported here may not be applicable.

Students in this study were not given a choice of lunches. It is recognized that in a non-experimental environment, the hurdle of getting students to select a low-fat school lunch in the first place must be overcome before the benefits of consuming it can be realized.

Recommendations for Further Research

The results reported here should be confirmed by replication. In particular, the apparent increase in fat intake following the low-fat lunch needs to be investigated further since there is little in the current literature to support the observation. Evidence for short-term regulation of fat intake is weak, and few studies have reported the effect that manipulating the fat content of one meal has on subsequent macronutrient consumption.

Additional studies should utilize a larger sample of students whose usual total fat intake is more representative and include a greater percentage of regular school lunch participants. Consideration should be given to collecting dietary records for several non-consecutive days. It is believed that a number of independent 1-day records may yield a better estimate of nutritive intake than a multiple-day record (66,75). To establish adequacy of caloric intake from low-fat lunches, future studies should utilize low-fat meals that have been matched for acceptability with high-fat meals.

More information is needed on the contribution that the noon meal makes to a child's total fat and energy intake to confirm that 30% of kcal from fat is the appropriate target for school lunches. As pointed out in Healthy People 2000 (8), "Implementation activities (such as modification of the NSLP) should recognize that this objective (to reduce dietary fat intake) applies to the diet for a day or more, not to a single meal or a single food." In fact, for this particular sample, baseline fat intake at lunch (39% of kcal) was much higher than the average 24-hour fat intake (33% of kcal). This suggests that students could consume a school lunch containing more than 30% of the kcalories from fat and still achieve the objective of an overall intake of less than 30% of kcal. If so, it might be appropriate to set more modest goals for the fat content of meals served under the NSLP than are currently being recommended. Such meals might be more readily accepted by students, resulting in better student participation and therefore an even greater overall dietary impact.

If students make up for kcalories not consumed at lunch by eating more later in the day, then perhaps the reduced energy density of low-fat meals need not be a concern. In that case, the nutritive quality of that caloric compensation then becomes a critical issue.

Consuming the low-fat lunches served in this study did not appear to detrimentally affect the student's overall intake of 10 micronutrients. Additional studies should confirm whether the previously demonstrated superiority of 24-hour nutrient intake by participants in traditional school lunch programs (18,20) is compromised by serving students lower fat school lunches.

SUMMARY AND CONCLUSIONS

Thirty-eight fifth-grade students participated in a study designed primarily to measure the effect that reducing fat in school lunch would have on overall dietary fat intake. Students were served high-fat lunches (43% kcal from fat) for three days one week and low-fat lunches (29% kcal from fat) for three days the following week. The energy value of the six different menus was comparable. Nutrient intakes for the 24-hour periods beginning with lunch were estimated from self-maintained 3-day food records using the Food Processor II Nutrition & Diet Analyses System computer program. Actual food intake at lunch was also determined from plate waste measurements. No attempt was made to modify overall eating behavior during the study. Paired t-tests were conducted to identify differences in 3-day mean intake between the two treatment periods for kcalories, fat, carbohydrate, and protein; and intake of 10 micronutrients is reported.

The results from this study provide preliminary evidence that an elementary school child's total fat intake can be reduced by lowering the fat content of meals served through the NSLP. During the low-fat lunch period, fat contributed an average of only 32% of total daily kcalories compared to 35% of kcal from fat during the high-fat lunch period. Carbohydrate intake increased proportionately and protein intake remained constant. Consuming low-fat lunches also resulted in a substantial increase in the number of students deriving less than 30% of total kcal from fat. The effect of serving low-fat lunches was to change the fifth graders' total dietary profile to one that more closely approximated current recommendations for total macronutrient intake without compromising energy intake. The usual fat intake of this sample was lower than the national average (33% of kcal vs 36% of kcal, respectively). Therefore, results from this study may not necessarily be applicable to the greater population of school-aged children.

The fat content of lunches consumed reflected the level of fat served. Fat intake at lunch as a percent of kcalories during the low-fat period was 28% (13 g) as compared to 40% (22 g) during the high-fat period. However, the students partially offset this difference by increasing their intake of fat from after-school snacks by 50% during the low-fat period. Realizing the maximum benefit of school lunch modifications may be dependent on a supportive home environment and on providing concurrent nutrition education designed to modify overall eating behavior.

Energy intake from the low-fat lunches (425 kcal) was significantly lower than from the high-fat lunches (483 kcal). Students compensated fully for this kcalorie shortfall by consuming more energy from after-school snacks during the low-fat period. Total intake of 10 micronutrients did not appear to be compromised by the exchange of lunch for snack kcalories.

These results may not be applicable to a situation where the energy content of school lunches served is reduced to less than one-third of the RDA as a consequence of reducing fat. It is not clear from this study whether the decrease in kcalorie intake from low-fat lunches resulted from an inability to consume adequate quantities of less-energy dense foods or whether students simply found the low-fat meals less acceptable.

Estimates of energy and nutrient intake at lunch based on the students' own food records compared favorably with estimates as calculated from plate waste measurements. A 3-day self-maintained food record with a follow-up interview appears to be an acceptable method for characterizing average dietary intake for a small group of fifth graders.

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APPENDICES

APPENDIX A. Recommended dietary allowances

FOOD AND NUTRITION BOARD, NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL
RECOMMENDED DIETARY ALLOWANCES,[a] Revised 1989
Designed for the maintenance of good nutrition of practically all healthy people in the United States

Category	Age (years) or Condition	Weight[b] (kg)	Weight[b] (lb)	Height[b] (cm)	Height[b] (in)	Protein (g)	Fat-Soluble Vitamins: Vitamin A (μg RE)[c]	Vitamin D (μg)[d]	Vitamin E (mg α-TE)[e]	Vitamin K (μg)	Water-Soluble Vitamins: Vitamin C (mg)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg NE)[f]	Vitamin B_6 (mg)	Folate (μg)	Vitamin B_{12} (μg)	Minerals: Calcium (mg)	Phosphorus (mg)	Magnesium (mg)	Iron (mg)	Zinc (mg)	Iodine (μg)	Selenium (μg)
Infants	0.0–0.5	6	13	60	24	13	375	7.5	3	5	30	0.3	0.4	5	0.3	25	0.3	400	300	40	6	5	40	10
	0.5–1.0	9	20	71	28	14	375	10	4	10	35	0.4	0.5	6	0.6	35	0.5	600	500	60	10	5	50	15
Children	1–3	13	29	90	35	16	400	10	6	15	40	0.7	0.8	9	1.0	50	0.7	800	800	80	10	10	70	20
	4–6	20	44	112	44	24	500	10	7	20	45	0.9	1.1	12	1.1	75	1.0	800	800	120	10	10	90	20
	7–10	28	62	132	52	28	700	10	7	30	45	1.0	1.2	13	1.4	100	1.4	800	800	170	10	10	120	30
Males	11–14	45	99	157	62	45	1,000	10	10	45	50	1.3	1.5	17	1.7	150	2.0	1,200	1,200	270	12	15	150	40
	15–18	66	145	176	69	59	1,000	10	10	65	60	1.5	1.8	20	2.0	200	2.0	1,200	1,200	400	12	15	150	50
	19–24	72	160	177	70	58	1,000	10	10	70	60	1.5	1.7	19	2.0	200	2.0	1,200	1,200	350	10	15	150	70
	25–50	79	174	176	70	63	1,000	5	10	80	60	1.5	1.7	19	2.0	200	2.0	800	800	350	10	15	150	70
	51+	77	170	173	68	63	1,000	5	10	80	60	1.2	1.4	15	2.0	200	2.0	800	800	350	10	15	150	70
Females	11–14	46	101	157	62	46	800	10	8	45	50	1.1	1.3	15	1.4	150	2.0	1,200	1,200	280	15	12	150	45
	15–18	55	120	163	64	44	800	10	8	55	60	1.1	1.3	15	1.5	180	2.0	1,200	1,200	300	15	12	150	50
	19–24	58	128	164	65	46	800	10	8	60	60	1.1	1.3	15	1.6	180	2.0	1,200	1,200	280	15	12	150	55
	25–50	63	138	163	64	50	800	5	8	65	60	1.1	1.3	15	1.6	180	2.0	800	800	280	15	12	150	55
	51+	65	143	160	63	50	800	5	8	65	60	1.0	1.2	13	1.6	180	2.0	800	800	280	10	12	150	55
Pregnant						60	800	10	10	65	70	1.5	1.6	17	2.2	400	2.2	1,200	1,200	320	30	15	175	65
Lactating	1st 6 months					65	1,300	10	12	65	95	1.6	1.8	20	2.1	280	2.6	1,200	1,200	355	15	19	200	75
	2nd 6 months					62	1,200	10	11	65	90	1.6	1.7	20	2.1	260	2.6	1,200	1,200	340	15	16	200	75

[a] The allowances, expressed as average daily intakes over time, are intended to provide for individual variations among most normal persons as they live in the United States under usual environmental stresses. Diets should be based on a variety of common foods in order to provide other nutrients for which human requirements have been less well defined. See text for detailed discussion of allowances and of nutrients not tabulated.

[b] Weights and heights of Reference Adults are actual medians for the U.S. population of the designated age, as reported by NHANES II. The median weights and heights of those under 19 years of age were taken from Hamill et al. (1979) (see pages 16–17). The use of these figures does not imply that the height-to-weight ratios are ideal.

[c] Retinol equivalents. 1 retinol equivalent = 1 μg retinol or 6 μg β-carotene. See text for calculation of vitamin A activity of diets as retinol equivalents.

[d] As cholecalciferol. 10 μg cholecalciferol = 400 IU of vitamin D.

[e] α-Tocopherol equivalents. 1 mg d-α tocopherol = 1 α-TE. See text for variation in allowances and calculation of vitamin E activity of the diet as α-tocopherol equivalents.

[f] 1 NE (niacin equivalent) is equal to 1 mg of niacin or 60 mg of dietary tryptophan.

APPENDIX B. School lunch patterns

CHART 1

SCHOOL LUNCH PATTERNS FOR VARIOUS AGE/GRADE GROUPS

U.S. Department of Agriculture, National School Lunch Program

USDA recommends, but does not require, that you adjust portions by age/grade group to better meet the food and nutritional needs of children according to their ages. If you adjust portions, Groups I-IV are minimum requirements for the age/grade groups specified. If you do not adjust portions, the Group IV portions are the portions to serve all children.

COMPONENTS		MINIMUM QUANTITIES: Preschool, ages 1-2 (Group I)	Preschool, ages 3-4 (Group II)	Grades K-3, ages 5-8 (Group III)	Grades 4-12[1], age 9 & over (Group IV)	RECOMMENDED QUANTITIES[2]: Grades 7-12, age 12 & over (Group V)	SPECIFIC REQUIREMENTS
MEAT OR MEAT ALTERNATE	A serving of one of the following or a combination to give an equivalent quantity:						• Must be served in the main dish or the main dish and one other menu item • Vegetable protein products, cheese alternate products, and enriched macaroni with fortified protein may be used to meet part of the meat/meat alternate requirement. Fact sheets on each of these alternate foods give detailed instructions for use.
	Lean meat, poultry, or fish (edible portion as served)	1 oz	1½ oz	1½ oz	2 oz	3 oz	
	Cheese	1 oz	1½ oz	1½ oz	2 oz	3 oz	
	Large egg(s)	½	¾	¾	1	1½	
	Cooked dry beans or peas	¼ cup	³/₈ cup	³/₈ cup	½ cup	¾ cup	
	Peanut butter	2 Tbsp	3 Tbsp	3 Tbsp	4 Tbsp	6 Tbsp	
VEGETABLE AND/OR FRUIT	Two or more servings of vegetable or fruit or both to total	½ cup	½ cup	½ cup	¾ cup	¾ cup	• No more than one-half of the total requirement may be met with full-strength fruit or vegetable juice • Cooked dry beans or peas may be used as a meat alternate or as a vegetable but not as both in the same meal.
BREAD OR BREAD ALTERNATE	Servings of bread or bread alternate A serving is • 1 slice of whole-grain or enriched bread • A whole-grain or enriched biscuit, roll, muffin, etc. • ½ cup of cooked whole-grain or enriched rice, macaroni, noodles, whole-grain or enriched pasta products, or other cereal grains such as bulgur or corn grits • A combination of any of the above	5 per week	8 per week	8 per week	8 per week	10 per week	• At least ½ serving of bread or an equivalent quantity of bread alternate for Group I, and 1 serving for Groups II-V, must be served daily. • Enriched macaroni with fortified protein may be used as a meat alternate or as a bread alternate but not as both in the same meal. NOTE: *Food Buying Guide for Child Nutrition Programs*, PA-1331 (1983) provides the information for the minimum weight of a serving
MILK	A serving of fluid milk	¾ cup (6 fl oz)	¾ cup (8 fl oz)	½ pint (8 fl oz)	½ pint (8 fl oz)	½ pint (8 fl oz)	At least one of the following forms of milk must be offered: • Unflavored lowfat milk • Unflavored skim milk • Unflavored buttermilk NOTE: This requirement does not prohibit offering other milks, such as whole milk or flavored milk, along with one or more of the above.

[1]Group IV is highlighted because it is the one meal pattern which will satisfy all requirements if no portion size adjustments are made.

[2]Group V specifies recommended, not required, quantities for students 12 years and older. These students may request smaller portions, but not smaller than those specified in Group IV.

APPENDIX C. Letter to parents

September 24, 1990

Dear Parent:

Your child's class is being asked to take part in a research project sponsored by the Department of Nutrition and Food Management at Oregon State University. The objective of the study is to provide information that will help schools plan lunch programs that best meet the nutritional and health needs of the students. Please read the enclosed information carefully with your child. We request that both you and your child then sign the Informed Consent to authorize your child's participation in the study.

If you have any questions, please contact Nancy Krupin, who will be conducting the study. You can send a note with your child to school indicating that you would like a call or leave a message at the Department of Nutrition and Food Management office at OSU (737-3561). She can also be reached by calling collect to her home in Salem at 362-6542.

Please return one copy of the enclosed Informed Consent, signed by both parent and child, to your child's teacher by Friday, September 28. You may keep the second copy and the Study Information Sheet for your reference.

This study has the support and approval of Dr. Shirley Woods, Assistant Superintendent; Terry Vaughn, Principal; Joanne Keesee, R.D., Food Service Director; and your child's teacher. We believe that the study will benefit children by contributing to ongoing efforts to find appropriate ways to incorporate current dietary recommendations into the school lunch program. Participating children will benefit by becoming more aware of what they eat, which will enhance their ability to apply what they learn about nutrition in class.

Thank you very much for your cooperation.

Sincerely,

Nancy Krupin
Master of Science Candidate

Dr. Constance Georgiou
Asst. Professor, Nutrition

APPENDIX D. Study information sheet

P L E A S E   K E E P   T H I S

STUDY INFORMATION SHEET

Study Description

Participating students will be asked to keep a written record of everything they eat and drink for three days to provide baseline data. Students will then eat specially prepared school lunches for two three-day periods and again record everything they eat and drink during these periods (except at lunch). Follow-up interviews outside of class will be arranged after each three-day period to clarify information on the daily record. Height and weight of each student will be measured one time.

The lunches served will vary in macronutrient content (carbohydrate, fat, and protein) between the two three-day periods. The meals will consist of familiar and popular foods from the regular school lunch menus. Nutrient adequacy will be ensured by following the standard school lunch meal pattern required by the U.S. Department of Agriculture for this age group. The lunches will be provided free of charge to students.

Schedule

Tuesday, October 2 to Friday, October 5	Baseline data collection and practice period. No special lunches. Keep food and activity records beginning with lunch on Tuesday until lunch on Friday.
Friday, October 5 to Sunday, October 7	Follow-up interviews.
Tuesday, October 16 to Friday, October 19	Special lunches. Keep food and activity records beginning after lunch on Tuesday until lunch on Friday (not including lunches on Wednesday and Thursday).
Friday, October 19 to Sunday, October 21	Follow-up interviews.
Tuesday, October 23 to Friday, October 26	Special lunches. Keep daily records as during previous week.
Friday, October 26 to Sunday, October 28	Follow-up interviews.

Responsible Investigators

Research Coordinator - Nancy Krupin, Graduate Student
Department of Nutrition and Food Management, OSU
362-6542 (home in Salem)
737-3561 (department office, OSU)

Supervising Professor - Dr. Constance Georgiou, Assistant Professor
Department of Nutrition and Food Management, OSU

APPENDIX E. Informed consent

INFORMED CONSENT FOR PARTICIPATION IN RESEARCH STUDY

<u>Child's Consent</u>

I agree to keep a written record on the forms to be provided of everything I eat and drink as well my activities for nine days as scheduled.

I will carefully follow the instructions given in class for keeping these daily records. I will be as complete as possible in recording all the information requested.

I will be available for a short interview with the researcher or an assistant sometime during the weekend after each three-day period to answer any questions about items on my daily record.

I agree to eat the school lunches prepared for this study on the scheduled days.

I understand that information on my daily record will be treated with strict confidence. I am aware that research results will be reported for the group as a whole only, and my name will not be associated with any of the data. I understand that my participation is voluntary and that I can withdraw from the study at any time without penalty.

I understand what I am being asked to do, and I agree to participate in this study.

______________________________ ________________________
Student's signature Date

<u>Parental Consent</u>

I will be available to provide additional information, if necessary, during my child's follow-up interview after each three-day recording period. I understand that I may be asked to contribute information on foods prepared or served in the home. These interviews will be scheduled at a time convenient for my family.

I understand the nature of this research study and agree to let my child participate. I believe my child understands the commitment being made and is taking part willingly. My questions have been answered satisfactorily, and I know how to contact the researcher should other questions arise.

______________________________ __________________
Parent's signature Date

<u>Request for Study Results</u>

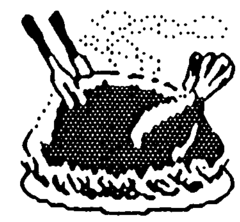
Please check the box if you would like to receive a summary of the study results.

<u>Dietary Restrictions</u>

Please indicate on the back of this page if your child has any specific food allergies or intolerances or other dietary restrictions.

APPENDIX F. Daily food record

Daily Food Record



Name ______________________ ID Number ________ Date ______________

Time	Place	Food or Drink Item	Amount	Complete Description or Preparation
LUNCH				
1				
2				
3				
4				
5				
6				
7				
AFTERNOON SNACKS				
8				
9				
10				
DINNER				
11				
12				
13				
14				
15				
16				
17				
EVENING SNACKS				
18				
19				
20				
BREAKFAST				
21				
22				
23				
24				
25				
26				
MORNING SNACKS				
27				
28				
29				
30				

Do you take any vitamin or mineral pills? Yes ______ No ______

If yes, what kind and how many? ______________________________

Was this a typical day? Yes ______ No ______

Interviewer ____________________ Date ____________

APPENDIX G. Food models

Model	Food	Measure
Graduated (dry beans in wax on paper plate)	Generic	1 cup 1/2 cup 1/4 cup 1 tablespoon 1 teaspoon
Artificial/ Realistic	Pork chop Turkey slices Ground beef patty Cheese slice Butter pat Ice cream scoop French fries	3.5 ounce 2 ounce 3 ounce 1 ounce 1 teaspoon 1/2 cup 1/2 cup
Real Food (in bowls covered with plastic)	Cheerios cereal Potato chips	1 cup 1 ounce
Household Measures		1 cup 1/2 cup 1/3 cup 1/4 cup 1/8 cup 1 tablespoon 1 teaspoon 1/2 teaspoon 1/4 teaspoon
Glasses		32 ounce 12 ounce 8 ounce 4 ounce
Cardboard Shapes	Generic	1/8 pizza wedge 4 inch square 2 inch square 4 inch circle 3 inch circle 2 inch circle
Ruler		12 inch
Dry Beans	Generic	2 cups

APPENDIX H. Default List

Item on Food Record	Entered As
Breads and Cereals	
Barbie cereal	Ralston's Jetson's cereal
Batman cereal	" "
Boboli pizza crust	Italian bread
bread	white bread, 28 gram/slice
bread without crust	0.9 piece white bread
cinnamon breadstick	1.5 ounce white bread 0.25 tsp. sugar 0.125 tsp. cinnamon
Coconola cereal	0.8 c granola 1.0 ounce chocolate kiss 3 each marshmallows
cornbread	2x2 inch square
PopTart	toaster pastry
rice	white rice, regular
spaghetti noodles	cooked without salt
Top Ramen noodles	chicken flavor, 2 c pkg
tortilla	flour, 10"
wheat bread	part whole wheat, 28 gram/slice
wheat roll (Hoover School)	1/2 Roll.Corvallis 1.0 ounce whole wheat roll
whipped cream/topping	Cool Whip
white bread	28 gram/slice
white bread (Hoover School)	23.6 gram/slice
whole wheat bread	part whole wheat, 28 gram/slice

Item on Food Record	Entered As
Fruits and Vegetables	
apple cider	apple juice, canned/bottled
apple, small	0.8 of 2.75 inch
apple	2.75 inch
applesauce	sweetened
banana, large	1.25 each
banana, small	0.8 each
broccoli, cooked	from fresh
Capri Sun fruit drink	fruit punch drink, canned
fruit juices (except cider)	from frozen concentrate
fruit, canned	lite syrup
Hi C beverage	fruit punch drink
lettuce	iceberg
mashed potatoes	prepared with milk and margarine (unless margarine listed separately)
red grapes	Thompson seedless
vegetables, cooked (except broccoli)	from frozen
Meats and Nuts	
bologna	beef & pork
chicken, fried at home	flour fried
chicken, in casserole	chicken meat, all, roasted
chicken, in stir fry	chicken breast, w/o skin

Item on Food Record	Entered As
ground beef	lean
hamburger	lean ground beef
lunch meats	beef & pork
meat balls	meat loaf
meats	lean and fat
peanut butter	smooth
peanuts	oil roasted, salted
sausage (on pizza)	pork sausage patty
sunflower seeds	oil roasted
turkey	turkey breast, roasted
turkey, deli	" " "
Dairy	
cottage cheese (Hoover School)	4% milkfat
cottage cheese, lowfat	1% milkfat
Farmer's cheese	mozzarella, part skim
margarine - stick	80% fat, hard
margarine - tub	60% fat, softspread
milk	2% lowfat white
mozzarella cheese	part skim
Snacks and Desserts	
Candy Bar ice cream	chocolate ice cream chocolate chips caramel swirls
brownies	2x2 inch square

Item on Food Record	Entered As
chocolate chip cookie with nuts (Hoover School)	choc chip cookie, homemade 28.5 grams walnuts - 1.5 grams
chocolate chip cookie (grocery store bakery)	0.6 ounce
cookies, homemade	2 inch - 0.6 ounce 2.5 inch - 0.8 ounce 3.0 inch - 1.0 ounce 3.5 inch - 1.3 ounce 4.0 inch - 1.5 ounce
diet cola	with asparatame
Dreyer's ice cream	rich
fortune cookie	vanilla wafer, 0.23 ounce
ice cream	vanilla, regular
Jog-a-thon snack	18.0 grams peanuts (dried, unsalted) 23.0 grams raisins
Kool-Aid	with sugar
Leo's birthday cake	0.5 piece white with icing 0.5 piece choc. w/icing 0.75 cup vanilla ice cream
Monster cookies	4.2 ounce, oatmeal raisin
popcorn	cooked in oil and salted
pumpkin cookie	0.9 ounce sugar cookie 1 tsp. icing 5.1 grams fondant candy
Rice Krispies Treat	2x2 inch square
taffy	fondant candy
Twix bar	1 bar or .5 package
yogurt covered pretzels	2.0 grams pretzel 2.8 grams icing

Item on Food Record	Entered As
<u>Miscellaneous</u>	
cooking spray	no fat entered
gravy	from dry mix
taco sauce	salsa

APPENDIX I. Percent missing entries in nutrient data base

Nutrient	Percent
Kcalories	0.0
Protein	0.1
Carbohydrates	0.1
Total Fat	0.0
Vitamin A	4.8
Thiamin	2.8
Riboflavin	2.6
Niacin	3.5
Vitamin C	5.7
Vitamin B6	6.2
Calcium	3.2
Iron	3.5
Magnesium	7.3
Zinc	7.6