

## Review

# Eating Patterns, Dietary Quality and Obesity

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Obesity among children has reached epidemic proportions. Today, an estimated one in four children in the United States is overweight, while 11% are obese. Children who are overweight tend to remain so up to 20 years of age; in general, they have a 1.5- to twofold higher risk for becoming overweight as adults. The prevalence of overweight has increased approximately twofold in the 20-year period from 1974 to 1994, with the largest increases observed among 19- to 24-year-olds. The annual increases in weight and obesity that occurred from 1983 to 1994 were 50% higher than those from 1973 to 1982. Overweight youth are 2.4 times as likely to have a high serum total cholesterol level, and 43.5 times as likely to have three cardiovascular risk factors. Although the total energy intake of children has remained the same, and the macronutrient density of the diet has changed, the percentage of energy from fat has decreased, while that from carbohydrates and protein has increased. Children have been consuming lower amounts of fats/oils, vegetables/soups, breads/grains, mixed meats, desserts, candy, and eggs, and increasing amounts of fruits/fruit juices, beverages, poultry, snacks, condiments, and cheese. Changes in specific eating patterns may explain the increase in adiposity among children; e.g., increases have occurred in the number of meals eaten at restaurants, food availability, portion sizes, snacking and meal-skipping. Successful prevention and treatment of obesity in childhood could reduce the adult incidence of cardiovascular disease. Because substantial weight loss is difficult to maintain, the prevention of obesity by promoting healthier lifestyles should be one of our highest priorities in the new millennium.

### Key teaching points:

- Obesity among children has reached epidemic proportions.
- Children who are overweight tend to remain overweight as adults.
- Changes in specific eating patterns (i.e. meal patterns and meal frequency, restaurant food consumption, beverage consumption, portion sizes, and dietary quality) may explain the increase in adiposity among children.
- More studies are needed to better understand how eating patterns, either singularly or in combination, affect total energy intake.
- Prevention of childhood obesity should be one of the highest priorities in the new millennium.

## INTRODUCTION

Obesity has reached epidemic proportions in the United States [1, 2]. Between 1980 and 1990, a 40% increase in the prevalence of obesity in U.S. adults occurred [3]. Obesity contributes to the major causes of death in the United States

and is an important risk factor for atherosclerotic cardiovascular disease, type 2 diabetes, dyslipidemia, hypertension, and other chronic diseases [4, 5]. Further, obesity is commonly associated with insulin resistance/hyperinsulinemia, which is thought to mediate the above disorders [6, 7]. Direct and indirect costs associated with obesity exceed \$99 billion annually

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[8, 9]. Since obesity has its onset in childhood, observations on the evolution of obesity during childhood and young adulthood are important.

Obesity among children has increased dramatically over the past three decades [10–13]. Today, an estimated one in four children in the United States is at risk of overweight (body mass index (BMI) above 85th percentile), while 11% are overweight (BMI above 95th percentile). Obesity tracks over time; that is, obese children tend to become obese adults [10, 14, 15]. The odds ratio for obesity at age 35 years increased from 2 for males and females who were obese between the ages of one and six years, to 5 to 10 for children who were obese between the ages of 10 to 14 years [14]. Overweight children tend to remain overweight during follow-up periods of up to 20 years [11, 16] and, in general, have a 1.5- to twofold increased risk of being overweight as adults. Obesity in early life is associated with several risk factors for coronary heart disease [17, 18] and is predictive of coronary heart disease [19], hypertension [20], and diabetes [20] in adulthood.

This increase in children’s obesity has important ramifications on adult health. Diabetes mellitus is increasing in the adult population while the age of onset of adult Type 2 diabetes is decreasing, and is now commonly found among adolescents [21, 22]. Children as young as eight years of age are being diagnosed with Type 2 diabetes [21, 22]. In the Bogalusa Heart Study, we documented an unusual high prevalence of obesity among young black females, and it is recognized that a higher incidence of diabetes occurs in black adults. Starting at about nine years of age, black females begin to develop a greater

amount of obesity than that observed in white females; the emergence of obesity tends to accelerate after puberty.

We have documented secular increases in relative weight and adiposity among children in Bogalusa, Louisiana over two decades [10–13]. The prevalence of overweight among these children in 1973–1974 increased approximately twofold by 1994, with the largest increases observed among 19- to 24-year-olds. Furthermore, the yearly increases in relative weight and obesity from 1983 through 1994 were 50% greater than those between 1973 and 1982 [11]. During the decades of the 70s and 80s, the average increase in the body weight of children was 2.5 kg, without a significant increase in height. During the decade of the 80s to 90s, the increase was 5 kg. Using data collected on 10-year-olds in seven cross-sectional dietary surveys conducted in Bogalusa, mean BMI significantly increased ( $p < 0.0001$ ) from 17.2 to 19.6 (Fig. 1). Based on Bogalusa standards for race and gender specific percentiles, the percentage of overweight 10-year-olds significantly increased ( $p < 0.0001$ ) from 13% (1973–1974) to 39% (1993–1994). Similarly, the percentage of obese (BMI > 95th percentile) 10-year-olds significantly increased ( $p < 0.0001$ ) from 4% (1973–1974) to 21% (1993–1994) (Fig. 2).

The explanation for this increased body weight may be due to greater inactivity and television watching [23]. Two to four hours per day of sedentary activity, such as watching television, have been documented. Factors contributing to inactivity have included the decrease in physical education programs in the school system and the increase in the use of automobiles and buses to transport school children. We have shown that, despite

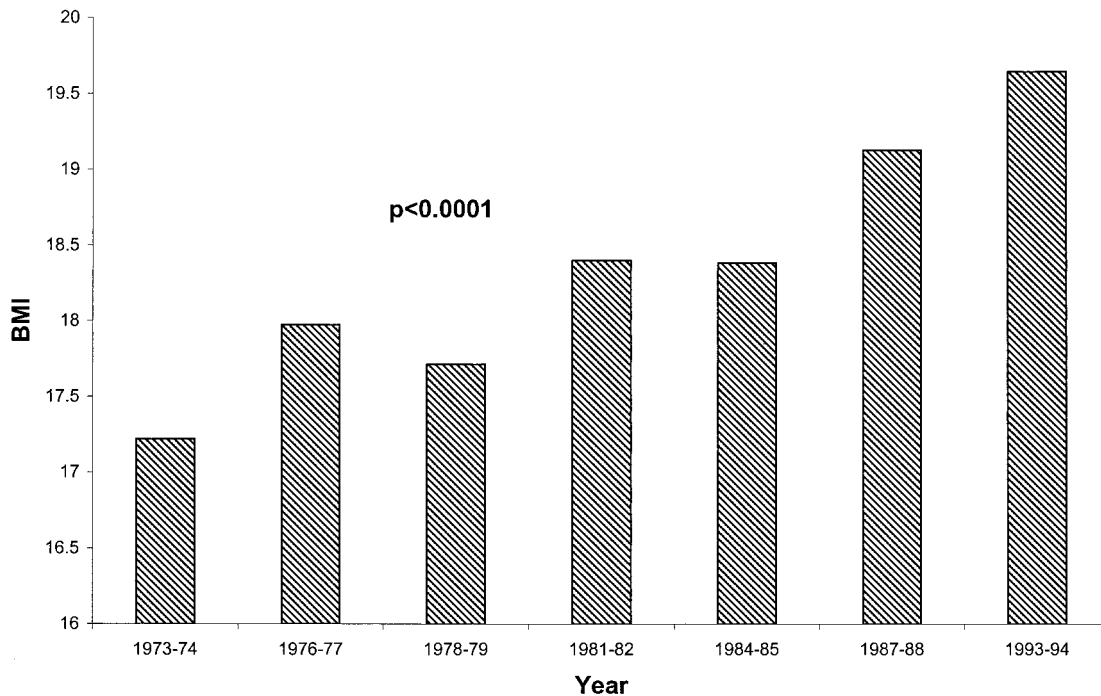
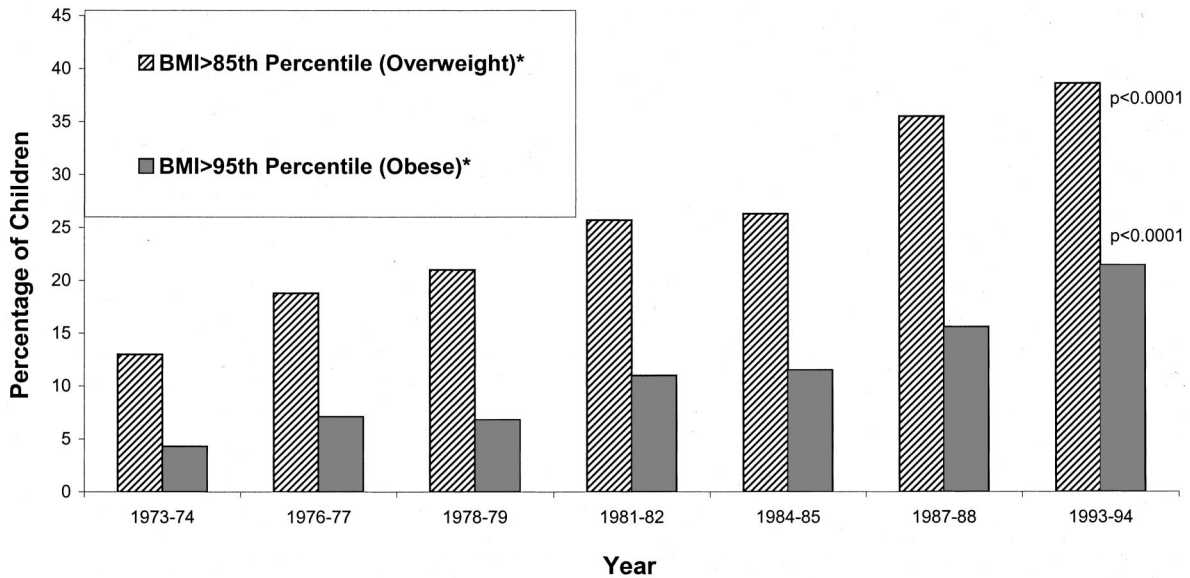


Fig. 1. Secular trends in mean body mass index (BMI) in 10-year-old children from 1973 to 1994.



\*Based on Bogalusa standards for race and gender specific percentiles

Fig. 2. Secular trends in percentage overweight (BMI > 85th percentile) and obese (BMI > 95th percentile).

the increasing adiposity, these children's total energy intake remained unchanged from 1973 to 1994, while intake of total fat decreased and carbohydrate increased [24, 25]. These trends in the children's nutrient intakes were consistent with the changes observed in their food consumption patterns.

The dietary causes of obesity are complex and poorly understood [26]. While individual nutrients and foods have been implicated in obesity, few attempts have been made to identify eating patterns in this regard. We would conjecture that changes in eating patterns might explain the marked increase in children's obesity because foods are generally not eaten in isolation, and the overall pattern of consumption may have a greater cumulative impact on obesity than any single food or nutrient. For the purpose of this review, eating patterns include restaurant food consumption, beverage consumption, portion sizes, meal patterns and meal frequency, school meal participation and consumption, and dietary quality.

### Dietary and Food Intakes of Children and Adolescents

Since 1973, the macronutrient composition of children's diets has changed favorably [24, 27]. The percentage of energy from protein and carbohydrate has increased, the percentage of energy from fat has decreased from 38% to 33% (Fig. 3), and the percentage of energy from saturated and monounsaturated fatty acids has decreased, while that from polyunsaturated fatty acid has increased (Fig. 4). The total energy intake of children has remained the same, while energy per kilogram of body weight has decreased (Fig. 5). Despite the decline since 1973 in percent energy from fat, close to 75% of children exceeded the

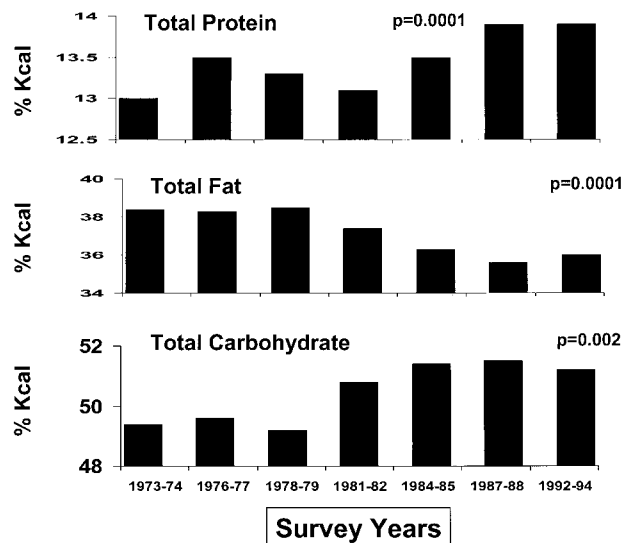


Fig. 3. Intake of macronutrients of 10-year-old children in the Bogalusa Heart Study (1973–1994), by survey year.

current fat recommendation in 1994 [24], and overall dietary quality did not improve [28].

Nutrient and food intakes of children are consistent with national trends in the food supply, as well as trends in the types of foods consumed by children [24, 27, 29]. There has been a decline in the percentage of total fat consumption coming from fats/oils, mixed meats (combination dishes), pork, eggs, milk and desserts (Fig. 6). In contrast, the percentage of total fat consumption coming from poultry, cheese, and snacks has increased (Fig. 6). Major changes have occurred in the consumption of foods in the "other" food group category. The

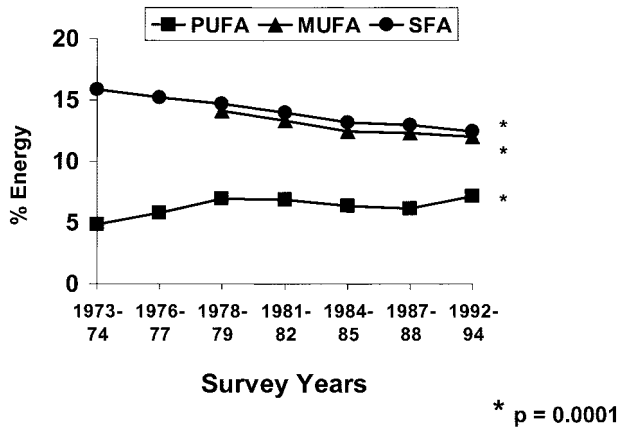


Fig. 4. Fatty acid intake of 10-year-old children in the Bogalusa Heart Study (1973–1994) by survey year.

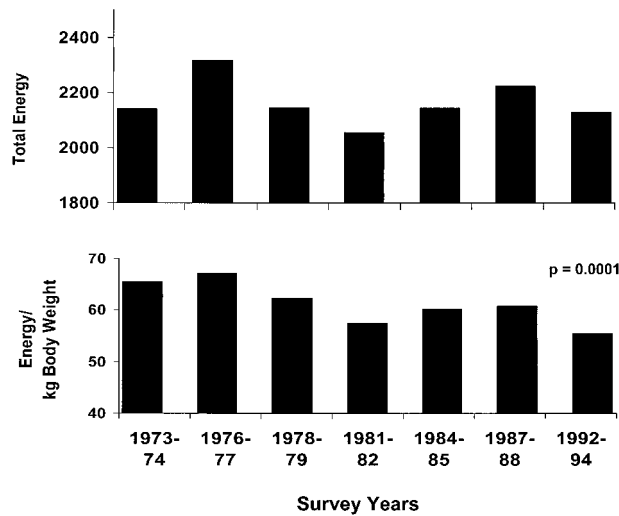
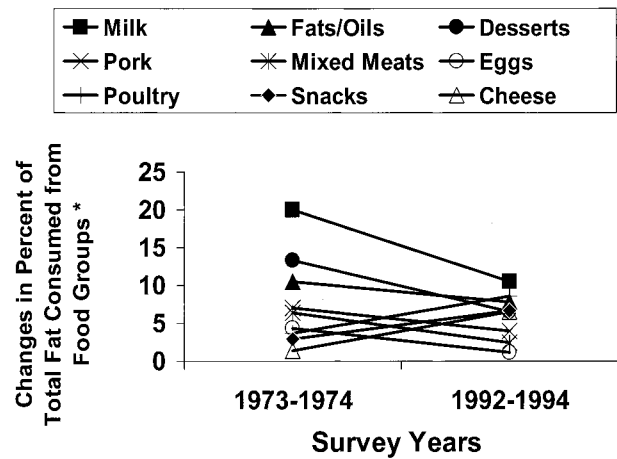


Fig. 5. Energy intake of 10-year-old children in the Bogalusa Heart Study (1973–1994), by survey year.

largest increase has occurred in the soft drink category (including carbonated water and carbonated juice drinks) [27]. Concomitantly, consumption of dairy products has decreased [27, 30, 31].

The food choices of most U.S. children and adolescents do not meet the recommended intakes of food groups outlined in the Food Guide Pyramid [28]. The percentage of 2- to 19-year-olds who did not meet the recommendations ranged from approximately 70% for fruits, grains, meats, and dairy products to approximately 64% for vegetables. Only 1% of children met all of the food group recommendations, only 5% met the recommendations for four or more food groups, and 16% met none of them. Only 44% of school children consumed servings from all four food groups at least two times daily [32].

Relatively little is known about the complex physiological, environmental, genetic and psychological factors that contribute to obesity. The role of diet in the development of obesity is poorly understood. Limitations of dietary methodology make it



\* All Significant @ p<0.05

Fig. 6. Changes in percent of total fat consumed, by food groups, by 10-year-old children in the Bogalusa Heart Study during 1973–1994 vs. 1992–1994.

difficult to show an association between dietary composition and the prevalence of obesity [33]. There is an urgent need to identify dietary factors that contribute to obesity among children and young adults, so that prevention efforts can be effectively targeted at an early age. Eating patterns and diet quality provide particularly promising aspects of diet to explain obesity.

### Eating Patterns

Differing eating patterns confound our understanding of the relationship between nutrient intake and chronic diseases, including obesity [34]. Eating patterns include restaurant food consumption, beverage consumption, portion sizes, meal patterns and meal frequency, school meal participation and consumption, and dietary quality. Some research has reported on each of these eating pattern components.

**Restaurant Food Consumption.** Eating patterns are changing among children and adults. The traditional pattern of the family eating at the kitchen table has changed with fewer families eating meals together. Approximately 46% of family food expenditures were spent on food and beverages outside the home, with 34% of the total food dollars spent on fast foods [30]. In 1994–1995, 57% of Americans consumed at least one food item away from home on any given day, compared to 43% in 1977–1978 [35]. Children consumed one-quarter of their meals away from home. Older children consumed a higher proportion of meals prepared away from home, increasing from 18% for preschoolers to 26% for school-age children and 27% to 30% for adolescents. Fast-food restaurants accounted for more than half of away-from-home meals [36].

Estimated frequency of fast-food meals was positively associated with energy intake in women [37]. Fifty-six percent of premenopausal women reported eating out five times or less during the week, while 44% reported eating out between six

and thirteen times. Women who reported eating out a greater number of times per week reported greater total energy intake and consumed a poorer-quality diet [38].

The frequency of consuming restaurant food was positively associated with increased body fatness in adults [39]. Obese persons chose more total food at a fast-food restaurant than did their leaner counterparts, but this did not occur at the other types of eating establishments studied [40]. The increasing proportion of household food income spent on food prepared away from home may help to explain the rising national prevalence of obesity.

**Beverage Consumption.** Soft drink consumption may be replacing more nutritious beverages such as milk and possibly fruit juices among adolescents [31]. Consumption of soft drinks increased dramatically among adolescents from 1977–1979 and 1994 [41]. The proportion of adolescent boys and girls daily consuming soft drinks increased by 74% and 65%, respectively. Concomitantly, milk consumption decreased among these youths over the same period. Children were most likely to have a suboptimal numbers of servings from the fruit and vegetable group among those food groups in the USDA Food Guide Pyramid [42, 43]. High soft drink consumption was positively associated with higher energy intakes [31], which also may have contributed to childhood obesity. In a prospective observational analysis [44], consumption of sugar-sweetened drinks was associated with obesity in children. Due to a number of limitations of this study, caution must be taken in interpreting these findings. An association has been reported between excessive consumption of fruit juice ( $\geq 12$  fl oz/day) and short stature or obesity among two- through five-year-old children [45]. However, those findings are controversial [46–50], and later studies have not supported these results [50, 51].

**Portion Sizes.** When eating out, people consumed a greater total amount of food, or they chose higher-energy foods, or both. These tendencies appear to be increasing [30]. A comparison of food service portion sizes from 1957 to 1997 is particularly striking. The typical fast-food outlet hamburger in 1957 contained a little more than one ounce of cooked meat, compared to a burger weighing up to six ounces in 1997. The average soda was eight ounces in 1957, compared with 32 to 64 ounces in 1997. The average theatre serving of popcorn consisted of three cups in 1957, compared with 16 cups (“medium size”) in 1997. A typical muffin weighed less than 1½ ounces in 1957, compared with five to eight ounces in 1997. These increases reflect food supply data. Only a few studies have examined the influence of portion size on intake in adults [52–55] and children [56]. Adults consumed more food when served portions 1½ times larger than a standard portion size [57, 58]. Larger portion sizes have been shown to increase intakes of both lean and obese adults [52]. Similarly, five-year-old children consumed greater amounts when presented with larger portions [56]. Larger portion sizes could be contributing to the increasing prevalence of overweight among children and young adults [59].

**Meal Patterns and Meal Frequency.** Ninety-eight percent of students reported at least three daily eating occasions, and more than 50% reported five or more [60]. A large percentage of students from all age groups consumed breakfast, lunch, and dinner. Two-thirds of students consumed an afternoon snack, almost two-thirds consumed an evening snack, and only 15% consumed a morning snack. The incidence of various types of eating occasions differed somewhat by age and gender. Younger students were more likely to consume breakfast, lunch, and afternoon snack [60].

The percentage of students eating snacks increased by one-fourth from 60% in 1977–1978 to 75% in 1994–1996 [61]. Nearly all children one to 19 years of age reported eating at least one snack per day [62] and 36% of the children consumed at least four or more different daily snacks [61]. Other studies of adolescents show similar dietary patterns [63].

Individuals who consumed breakfast regularly had more adequate micronutrient intakes and better dietary quality than those who did not [64–66]. Children who consumed breakfast had significantly better Healthy Eating Index (HEI) scores for grains, fruits, milk products, and variety than children who did not [67]. Eating a nutritious breakfast may help control body weight [68] due to a reduced dietary fat intake and minimized impulsive snacking [69, 70]. Unfortunately, breakfast consumption has declined significantly between 1965 and 1991 for children and adolescents [65].

Eating dinner as a family was associated with some healthful dietary patterns [71]. Increased frequency of participation in the family dinner was associated with higher consumption of fruits and vegetables, fiber, folate, calcium, iron and vitamins B-6, B-12, C and E, lower consumption of saturated and trans fatty acids, soda and fried foods, and a decreased glycemic load [71].

Adolescents with a consistent meal pattern (i.e., three meals a day) were leaner than those with an inconsistent meal pattern [72]. This observation is in agreement with studies showing a link between obesity and skipping meals [32, 72–75]. An inconsistent meal pattern may mean skipping meals to reduce calories.

An inverse relationship has been observed between individuals’ frequency of eating and their body weight [76–83], suggesting that a “nibbling” or “grazing” meal pattern is associated with leanness. However, these studies are extremely vulnerable to methodological errors, which may generate spurious relationships due to dietary underreporting and post hoc alterations in eating patterns in response to weight gain.

**School Meal Participation and Consumption.** The National School Lunch Program (NSLP) and School Breakfast Program (SBP) have had a major, generally positive impact on the nutritional status of children [64, 84–90], with improvement of overall diet, mineral and vitamin intake. Alternatively, the introduction of school lunch and later school breakfast has likely contributed to obesity in low-socioeconomic-status children. NSLP participation was associated with higher intake of food energy, percentage of energy from fat, saturated fat, and

protein, and lower intakes of percent energy from carbohydrate. Intakes of vitamins A, B-12 and B-6, riboflavin, niacin, calcium, phosphorus, magnesium and zinc were higher among NSLP participants than nonparticipants [91]. Similar findings were observed with SBP participation [91]. In contrast with the findings involving NSLP participants, higher intakes of some nutrients among SBP participants appeared to stem from their consumption of larger amounts of food, rather than from consumption of more nutrient-dense foods [91].

### **Dietary Quality**

Interest in assessing overall dietary quality reflects increasing recognition of the limitations due to multi-collinearity of single nutrients or foods/food groups with which to characterize food consumption patterns. Evidence with regard to the dietary quality of U.S. school children is mixed [91]. While the average daily intakes of vitamins and minerals met the Recommended Dietary Allowances (RDA), more protein, total fat, saturated fat, and sodium were consumed than the Dietary Guidelines' goals for good health [92–95]. Students consumed more food energy on average than recommended, suggesting that some may be at risk of consuming more food energy than optimal. Alternatively, plate waste studies show 30% of food is not consumed [96].

The Healthy Eating Index (HEI) [43] provides an overall picture of the type and quantity of foods an individual consumes, his or her compliance with specific dietary recommendations, and the variety in the diet. As measured by the HEI [43], Americans' eating patterns have significantly improved since 1989 [67]. Despite this positive trend, only 12% of Americans had a diet that could be considered "good." Females and younger children tended to have a slightly more healthful diet than males and older children; African-Americans scored low on the milk and fat components of the HEI; and people living in the South had a generally poorer diet [97]. For both males and females, those with a better diet had a lower BMI [97]. This finding implies a connection between the quality of an individual's diet and his or her BMI.

### **Dietary Diversity**

Dietary diversity among and within food groups was not related to total energy, fat, sugar, sodium, or cholesterol intake [98]. Individuals who consumed the greatest variety of foods from all food groups had the most adequate nutrient intake [99]. Alternatively, dietary diversity within the sweets, snacks, condiments, entrees, and carbohydrate food groups was positively associated, and dietary diversity within the vegetable food group was negatively associated with energy intake and body fatness [39]. Energy density was the major difference between foods positively associated with increased body fat versus those foods, which were negatively associated [38]. When a variety ratio was included in regression models, the proportion of

dietary energy provided by fat was not a significant predictor of body fatness. However, the variety ratio was the strongest predictor of body fatness. An inverse relationship has been demonstrated between dietary diversity and BMI among women [100]. Low BMI was associated with higher dietary diversity scores in women but not men.

In animal studies, access to a variety of foods increased energy intake within and between meals, and promoted long-term weight and fat gain [101–107]. Humans consumed more total food when offered different foods than when variety was limited [108–113]. The long-term effects of dietary variety on food intake and changes in body weight are unknown. Increased amounts of high-energy sweets, condiments, and snacks have been made available commercially [114]. The recent excessive dietary variety, especially of high-fat and high-calorie commercial foods, has increased dramatically in recent years [114], and may have contributed to the rising prevalence of obesity nationally. In contrast, increased amounts of low-energy vegetables, prompted by high variety, have resulted in decreased energy intake and body fatness.

## **CONCLUSION**

Obesity is now considered the most prevalent nutritional disease of children and young adults in the United States. However, data on the relationships between patterns of eating and obesity are sparse. Several epidemiologic studies have attempted to relate nutrient intakes with obesity, but the results have been disappointing.

One limitation with epidemiologic surveys examining the role diet and eating patterns in obesity is the highly interrelated nature of dietary exposures. Thus, it is often difficult to distinguish the independent effects of nutrients, foods, or even specific eating patterns on weight status. The focus on dietary intake of specific nutrients, foods, or eating patterns must be evaluated through its effects on total energy intake as it relates to energy balance. Caution must be taken in attempting to interpret the current body of literature on diet-obesity relationships. Most studies are based on cross-sectional associations and not longitudinal ones; sample sizes are relatively small, and limited to specific populations; and many studies have not been replicated. It is generally accepted that obesity results from a positive energy balance, and that multiple environmental factors significantly affect energy balance and weight regulation. More studies are needed to better understand how specific environmental factors, either singularly or in combination, affect total energy intake. Moreover, cross-sectional and longitudinal approaches must be utilized in any endeavor seeking to analyze the associations between eating patterns, dietary quality and obesity.

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