Vegetarian diets and childhood obesity prevention[1–4]

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ABSTRACT

The increased prevalence of childhood overweight and obesity is not unique to industrialized societies; dramatic increases are occurring in urbanized areas of developing countries. In light of the consensus that obesity is a significant public health concern and that many weight-loss interventions have been unsuccessful in the long term, an exploration of food patterns that are beneficial in the primary prevention of obesity is warranted. The focus of this article is to review the relation between vegetarian diets and obesity, particularly as they relate to childhood obesity. Epidemiologic studies indicate that vegetarian diets are associated with a lower body mass index (BMI) and a lower prevalence of obesity in adults and children. A meta-analysis of adult vegetarian diet studies estimated a reduced weight difference of 7.6 kg for men and 3.3 kg for women, which resulted in a 2-point lower BMI (in kg/m^2). Similarly, compared with nonvegetarians, vegetarian children are leaner, and their BMI difference becomes greater during adolescence. Studies exploring the risk of overweight and food groups and dietary patterns indicate that a plant-based diet seems to be a sensible approach for the prevention of obesity in children. Plant-based diets are low in energy density and high in complex carbohydrate, fiber, and water, which may increase satiety and resting energy expenditure. Plant-based dietary patterns should be encouraged for optimal health and environmental benefits. Food policies are warranted to support social marketing messages and to reduce the cultural and economic forces that make it difficult to promote plant-based dietary patterns. *Am J Clin Nutr* 2010; 91(suppl):1525S–9S.

INTRODUCTION

Approximately 34% of the US adult population is obese, and 67% are overweight or obese (1, 2) on the basis of current clinical guidelines [overweight: body mass index (BMI; in kg/m^2) = 25.0–29.9; obesity: BMI ≥30.0] (3). The increased prevalence of pediatric overweight (BMI-for-age ≥85th percentile but <95th percentile) and pediatric obesity (BMI-for-age ≥95th percentile) (4) is no longer unique to industrialized societies because dramatic increases are occurring in urbanized areas of developing countries. Ironically, developing nations must now channel scarce resources to reduce the incidence of both undernutrition and overnutrition among their youth. It is estimated that 10% of children are overweight or obese worldwide (5), and in the United States 1 in 6 is obese and 1 in 3 is overweight or obese (6).

Overweight status during childhood has negative health consequences during childhood, adolescence, and adulthood. Obesity is a major risk factor for type 2 diabetes (T2D) and the incidence of prediabetes, and T2D is currently on the rise along the continuum of life (7). Although the prevalence of T2D among adults is rising, the most dramatic increase in the incidence of this disease is in children and adolescents (7). The increase in the prevalence of obesity is one of the major determinants for the increase in the prevalence of T2D in children. It is estimated that the lifetime risk of developing T2D is 33% of boys and 39% of girls for children born in 2000 (8). The potential health, economic, and psychological burden of T2D among youth is devastating, and the disease progression in children may become more severe than in adults (9–11). Beyond age 3 y, the likelihood that an overweight condition or obesity will persist into adulthood is positively associated with a child's advancing age. Once an obese child reaches age 6 y, there is a >50% probability that obesity will persist. Of greatest concern is that 70–80% of obese adolescents will remain obese as adults. In addition, data from the Harvard Growth Study has shown that being overweight during the adolescent years predicts adult morbidity from several chronic diseases and mortality from all causes regardless of adult body weight (12).

Epidemiologic evidence has identified a number of metabolic abnormalities and diseases that are mediated by being overweight or obese. In light of the consensus that obesity is a significant public health concern and that the majority of weight loss interventions have been unsuccessful in the long term (13), a closer exploration of vegetarian diets that are beneficial in the primary prevention of obesity is warranted. Thus, the focus of this article will be to explore the health effects of vegetarian diets and the potential biological reasons for the protective effects of plant foods in the context of preventing childhood overweight and obesity.

VEGETARIAN DIETS AND OBESITY IN ADULTS

In this section we will discuss the findings of cross-sectional data from epidemiologic studies. Epidemiologic evidence has consistently shown that an inverse relation exists between vegetarian diets and BMI. We will first present data from studies among the largest cohort of vegetarians in the United States, the

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Adventist community, followed by data from other studies conducted in Europe.

Epidemiologic studies have consistently shown that vegetarians are thinner than comparable nonvegetarians (14). According to the 1994–1996 Continuing Survey of Food Intakes by Individuals, vegetarians in the United States have a mean BMI of 22.1 as compared with a mean BMI of 25 among nonvegetarians (15). We conducted a meta-analysis in 2001 of 36 studies in women and 24 studies in men using references from Messina and Messina's publication "The dietician's guide to vegetarian diets" (16). Both sexes showed no significant difference in height between vegetarians and nonvegetarians (men: $P = 0.48$; women: $P = 0.46$); however, vegetarians had significantly lower weight (-7.7 kg for men and -3.3 kg for women; $P < 0.0001$ and $P = 0.007$, respectively) and a 2-point lower BMI (**Table 1**) (17).

Adventists are a group in whom a healthful vegetarian diet is firmly entrenched. Members of the Adventist community practice a healthy lifestyle and share many similar sociodemographic and lifestyle characteristics. Because Adventists differ mainly in dietary practices, they are a valuable study population in which to compare the differences in health outcomes between vegetarians and nonvegetarians. In 1976, the Loma Linda University Adventist Health Study-1 enrolled a cohort of 34,000 adults residing in California. Approximately 45% of the Adventists were vegetarian, and the remaining 55% consumed meat, fish, or poultry at least once per week or more often. For both sexes, vegetarian eating patterns among the Adventists were associated with a lower BMI, and BMI increased as the frequency of meat intake increased (18). However, because nonvegetarian Adventists typically consume less meat than the general population, it is important to compare our findings with those from non-Adventist cohorts (*see* European cohort discussion below) because the lack of substantial meat consumption among the Adventist nonvegetarians may underestimate the differences in BMI observed between vegetarians and nonvegetarians.

In 2002, the Adventist Health Study-2 enrolled a cohort of 97,000 Adventists from across the United States and Canada and collected data on diet, physical activity, lifestyle, and demographic factors. Dietary pattern status was further classified as vegan, lactoovovegetarian, pesco-vegetarian, semi-vegetarian, and nonvegetarian. A progressive increase in BMI was observed as meat and animal products were included in the diet. The vegan and lactoovovegetarian diets provided greater protection against overweight and obesity than a meat-containing diet (**Figure 1**) (19). More specifically, the vegan group had a 5.2 lower BMI than the nonvegetarian group. Hence, irrespective of age, sex, and geography (eg, environmental factors influencing physical activity patterns), vegetarians are leaner than nonvegetarians and have a lower prevalence of obesity (19).

In the Oxford Vegetarian Study, Appleby et al (20) evaluated dietary patterns and other lifestyle factors with BMI by using cross-sectional data from 1914 men and 3378 women between ages 20 and 89 y. Lower BMI was observed in vegetarians compared with nonvegetarians, and nonvegetarians consumed less fiber, more alcohol, and more animal fat than vegetarians. After adjustment for lifestyle factors and the aforementioned dietary factors, the differences in BMI were reduced by 33% but remained significant. Therefore, these confounding factors did not fully explain the protective role of vegetarian diet patterns in obesity prevention, which suggests that an independent effect exists for low meat consumption. These findings were supported by those from the Oxford cohort of the European Prospective Investigation into Cancer and Nutrition (EPIC) study, which enrolled 57,498 participants and included a high proportion of vegetarians and vegans (21). Cross-sectional analysis of dietary, anthropometric, and lifestyle data showed the highest BMI in the "meat-eaters" group and the lowest BMI among vegans; pesco-vegetarians and lactoovovegetarians had similar intermediate mean BMIs. Less than 5% of the differences in BMI between the meat eaters and the vegans were due to lifestyle factors (eg, smoking, physical activity, and educational level). Finally, in Germany, an inverse relation between BMI and vegetarian status (strict vegetarian compared with occasional meat eater) was observed in a cohort of ≈20,000 vegetarians (22).

The BMI data from the Adventist studies and European studies (20, 22) that show the clear inverse association between BMI and the prevalence of obesity among vegetarians and nonvegetarians are summarized in **Figure 2**. In each of these studies, vegetarians on average have 1- to 2-point lower BMI values than meat eaters within the same cohort. Substantial variation in BMI values exists among the cohorts, and the US based cohorts have greater BMI than the European cohorts, which can be attributed to methodologic differences in data collection, geographic location, secular trends, and genetic or ethnic differences. Collectively, these epidemiologic data clearly suggest that meatless diets are associated with lower BMI values and a low prevalence of obesity in adults. In summary, consistency exists in the results between Adventist and non-Adventist cohorts across 2

TABLE 1
Anthropometric measurements in vegetarians: a meta-analysis of 36 early studies[1]

	Vegetarian		Nonvegetarian		
	No. of subjects	Weighted mean	No. of subjects	Weighted mean	*P* value
Men					
Height (cm)	402	176.6	422	176.8	0.48
Weight (kg)	490	68.2	720	75.8	<0.0001
BMI (kg/m^2)	589	22.6	813	24.7	<0.0001
Women					
Height (cm)	869	161.9	1092	161.5	0.46
Weight (kg)	928	60.5	1350	63.8	0.006
BMI (kg/m^2)	1140	23.6	1556	25.4	0.007

[1] Data are from reference 17.

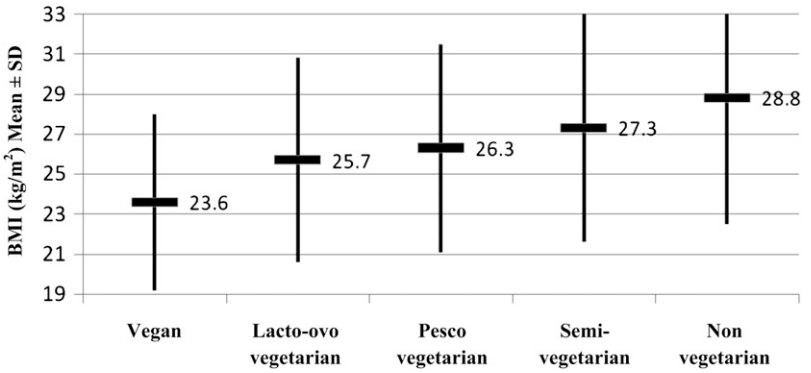

FIGURE 1. BMI according to vegetarian status for participants enrolled in the Adventist Health Study-2. Data are from reference 19.

continents, which supports the validity of the association between vegetarian diets and lower BMI in adults. In addition, other lifestyle factors such as smoking and alcohol consumption have not been shown to be strong contributing factors to the BMI difference between vegetarians and nonvegetarians across the studies.

ANTHROPOMETRIC VARIABLES IN VEGETARIAN CHILDREN AND ADOLESCENTS

Much less is known about vegetarian diets in children regarding the risk of overweight and obesity. Small studies in the 1970s and 1980s showed that vegetarian children tended to be leaner than nonvegetarian children, but the attained height for children on some vegetarian diets was shown to be compromised (23–29). In light of concerns surrounding the growth patterns in vegetarian children, we conducted several investigations of the effect of vegetarian diets on the growth and development of vegetarian children and adolescents. We explored the estimated effect of a vegetarian diet on the attained height in 870 white children aged 7–18 y who attended 16 Adventist schools in southern California in the late 1980s (30). Dietary patterns were evaluated by using a nonquantitative food-frequency questionnaire, and vegetarians were operationally defined as consuming meat less than once per week. Adventist children who were classified as vegetarian were taller than their omnivorous classmates: 2.5 and 2.0 cm taller for boys and girls, respectively. These findings did not change materially when adjustments for potential confounders (eg, parental height and socioeconomic factors) were further evaluated in a subset of 518 children.

We also conducted a 2-y longitudinal survey of 2272 schoolchildren aged 6–18 y attending public schools and Adventist schools and observed that Adventist prepubertal girls (aged 11–12 y) were 3 cm shorter than the controls in public schools (31) and that the onset of the pubertal growth spurt occurred 1 y earlier in public school girls than in Adventist school

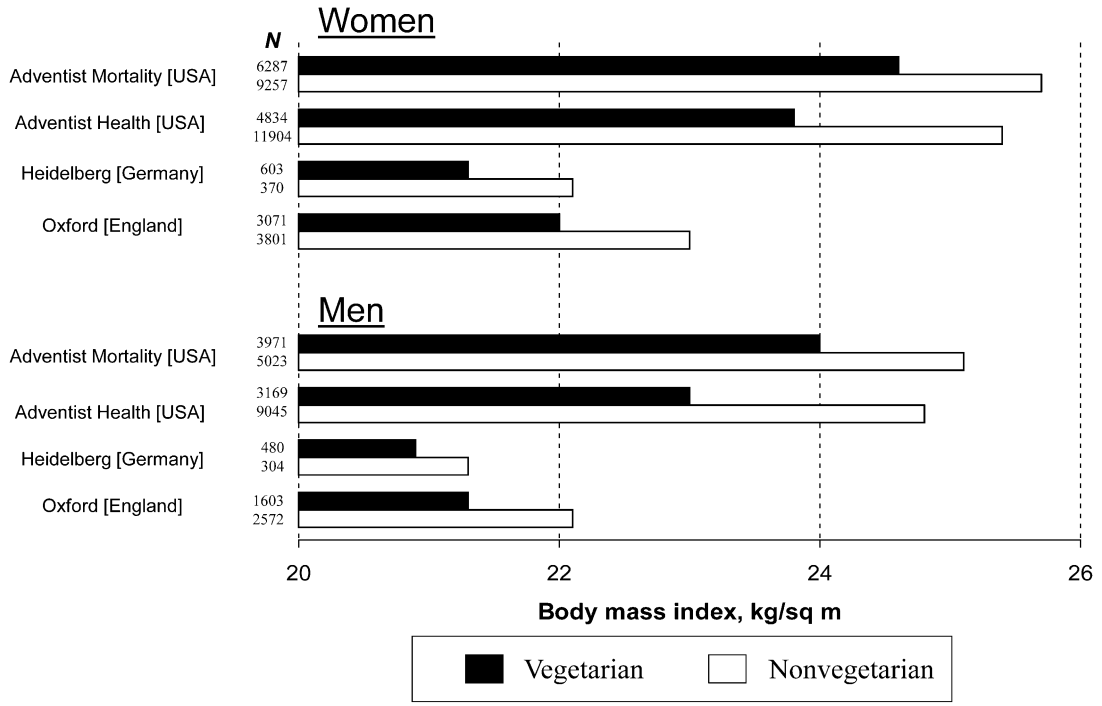

FIGURE 2. Mean BMI of vegetarians and nonvegetarians from 4 epidemiologic studies. Reproduced with permission from reference 17.

girls (32). These findings suggest that Adventist vegetarian girls experience a delay in the onset of pubertal maturation, which may reduce the risk of developing breast cancer (33). Boys and girls attending Adventist schools with a high proportion of vegetarians were leaner than their public school nonvegetarian peers after adjustment for height (1.27 and 1.16 kg, respectively) (32). As expected, BMI and skinfold values were also lower for vegetarians, and the BMI difference was greater between adolescent girls (17).

A more recent study of 215 adolescents attending 5 Adventist secondary schools in Australia showed that students consuming predominantly vegetarian foods had a significantly lower BMI, waist circumference, total cholesterol to HDL ratio, and LDL concentration than their omnivorous classmates (34). Exercise was not statistically associated with any of the previously mentioned cardiovascular risk factors, which suggests that a plant-based diet may directly influence these risk factors and promote health in this age group.

By using the nonquantitative food-frequency questionnaire data collected in the late 1980s by the study (30) that focused on the attained height of vegetarians, we conducted a further analysis to determine whether there is an association between 6 food groups (eg, meats; dairy products/eggs; fruit and vegetables; cereals, legumes, and nuts; junk food; and vegetable protein products) consumed by school-age children and the prevalence of overweight, which we defined as above the age- and sex-specific 75th percentile for BMI according to pre-2000 BMI cutoffs (35). The odds ratio (95% CI) of the risk of overweight in school-age children for the highest quartile (compared with the lowest quartile) in the 6 food groups is shown in **Figure 3**. We show that animal foods (meats and dairy products/eggs) are associated with an increased risk of overweight whereas plant foods are either protective (cereals, legumes, and nuts) or show no association (fruit/vegetables and vegetable protein products).

Similar to our findings, a recent review by Newby (36) on the role of plant foods and plant-based diets in protecting against childhood obesity showed no relation with fruit and vegetables; insufficient evidence with beans, legumes, and soy; and slight protection with grains and breakfast cereals, fiber, and plant-based dietary patterns. Most of the studies reviewed were cross-sectional in design, failed to adequately adjust for potential confounders, and did not consider the influence of reporting errors.

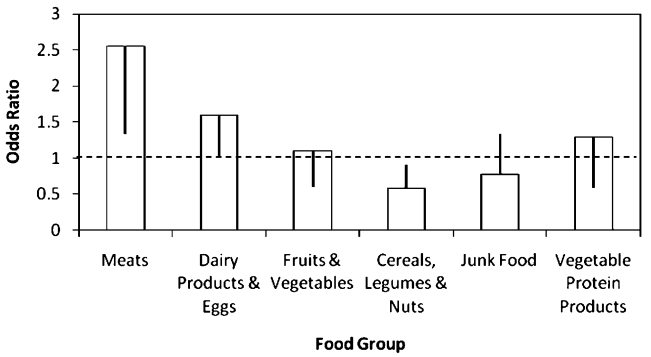

FIGURE 3. Odds ratios (with 95% CIs) of risk of overweight in school-aged children for the highest quartile (compared with the lowest quartile) in the 6 food groups. Data are from reference 35.

POTENTIAL BIOLOGICAL REASONS FOR A PROTECTIVE EFFECT OF VEGETARIAN AND PLANT-BASED DIETS

We believe that there are 3 root causes that may explain the differences in BMI observed between vegetarians and nonvegetarians. First, the avoidance of meat that contains saturated fatty acids and greater caloric density may be beneficial to weight management. Second, nondietary lifestyle factors, which include smoking, physical activity, and education level, may influence body weight. Finally, the greater intake and/or variety of plant foods that evolves into a plant-based diet may have a significant influence on the primary prevention of overweight and obesity and perhaps on the secondary prevention of obesity for weight loss and weight maintenance. However, studies to date are unable to elucidate the exact apportioning of disease risk related to the increased consumption of plant foods compared with the avoidance of meat.

Plant-based diets that feature the regular intake of fruit and vegetables are low in energy density, protein, and fat and high in nutrient density, complex carbohydrate, fiber, and water. High-carbohydrate meals may increase resting energy expenditure, which is supported by the findings that male vegetarians have an 11% higher resting metabolic rate than male omnivores (37). High fiber intakes may produce greater satiety and a reduced energy intake between meals (38). Studies in young adults and children have shown protein intake to be positively associated with BMI and an increased likelihood to become obese in later life (39, 40). In addition, the high polyunsaturated fat to saturated fat ratio observed in plant-based diets has been shown to elevate the resting metabolic rate by 3.6% (41).

HEALTH CONSIDERATIONS OF VEGETARIAN DIETS FOR CHILDREN

According to the American Dietetic Association position paper on vegetarian diets, well-planned vegetarian diets are appropriate for individuals during all stages of the life cycle, including childhood and adolescence (42). Problems resulting from an inadequate intake of calories, protein, calcium, zinc, iron, vitamin B-12, and vitamin D are more likely to occur during early years than in adulthood due to greater nutritional requirements relative to biological growth and development (43, 44). However, it is quite possible to achieve the Recommended Dietary Allowances or Adequate Intakes for macro- and micronutrients within different types of vegetarian diets (lactoovovegetarian, lactovegetarian, strict/total/pure vegetarian, semi-vegetarian, macrobiotic) if appropriately planned and monitored by a health care professional or registered dietitian (45). For specific guidelines on planning vegetarian diets for children and adolescents, please refer to Johnston et al (46). In addition, the reader is encouraged to download The Vegetarian Food Pyramid that was developed by the Department of Nutrition, School of Public Health, Loma Linda University, at http://www.vegetariannutrition.org/food-pyramid.pdf.

In conclusion, obesity represents a significant threat to the present and future health of children and leads to a wide range of physical and psychological consequences. Given the difficulty in treating adult obesity, the prevention of excess body weight gain is the best solution to reduce the rise in childhood obesity, which has a strong association with obesity in adulthood (47). Thus,

effective strategies for reducing childhood obesity are urgently needed. A plant-based diet seems to be a sensible approach for the prevention of obesity in children. It is suggested that the prevention of obesity in childhood and adolescence by the adoption of a vegetarian diet will subsequently decrease a broad range of adverse health effects in adulthood. Plant-based dietary patterns should be encouraged and promoted for optimal health and environmental benefits. Local, national, and international food policies are warranted to support social marketing messages and to reduce the social, cultural, economic, and political forces that make it difficult to promote plant-based dietary patterns.

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