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Does Fruit and Vegetable Intake Decrease Risk for Obesity in Children and Adolescents?

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DOES FRUIT AND VEGETABLE INTAKE DECREASE RISK FOR OBESITY IN CHILDREN AND ADOLESCENTS?

By

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ABSTRACT

Childhood obesity is increasing drastically and the need for interventions is evident. As a result of obesity, children are now developing chronic diseases such as cardiovascular disease and type 2 diabetes, which are usually seen only in adults. The impact of increased fruit and vegetable consumption on decreasing obesity risk has been examined in many epidemiologic studies due to the low energy density of fruits and vegetables. However, results from these studies have found that increased fruit and vegetable consumption alone is not the "cure all" solution to decreasing childhood obesity. Obesity is caused by lifestyle, environmental, and genetic factors that all need to be taken into consideration when developing intervention programs. Although increased fruit and vegetable intake is an important aspect of obesity prevention, it needs to be coupled with decreased consumption of high fat and high sugar foods and increased physical activity.

The following thesis will discuss the definition and diagnosis of childhood obesity; health complications of obesity; the prevalence of childhood obesity; and treatment of childhood obesity. It will also discuss the benefits of fruit and vegetable consumption and will review research concerning the affects of fruit and vegetable intake on body-mass index (BMI).

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INTRODUCTION

Childhood obesity has become prevalent among children in the United States. Obesity related diseases and health conditions once only seen in adults are now being found in children. Obesity is caused by lifestyle, genetic, and environmental factors. Therefore, management of obesity includes modification in lifestyle and environmental factors and understanding of genetic predispositions. Diet adjustments are part of lifestyle modification. Increased fruit and vegetable consumption has been touted to prevent obesity and other debilitating health conditions. However, findings from research studies are varied concerning the actual benefits of fruit and vegetable consumption and weight regulation. A health condition that has many different factors contributing to its formation cannot have one "cure all." Could weight loss and weight maintenance best be achieved with a combination of increased physical activity, decreased total caloric intake, and increased consumption of fruit and vegetables?

OBESITY

Definition and Diagnosis

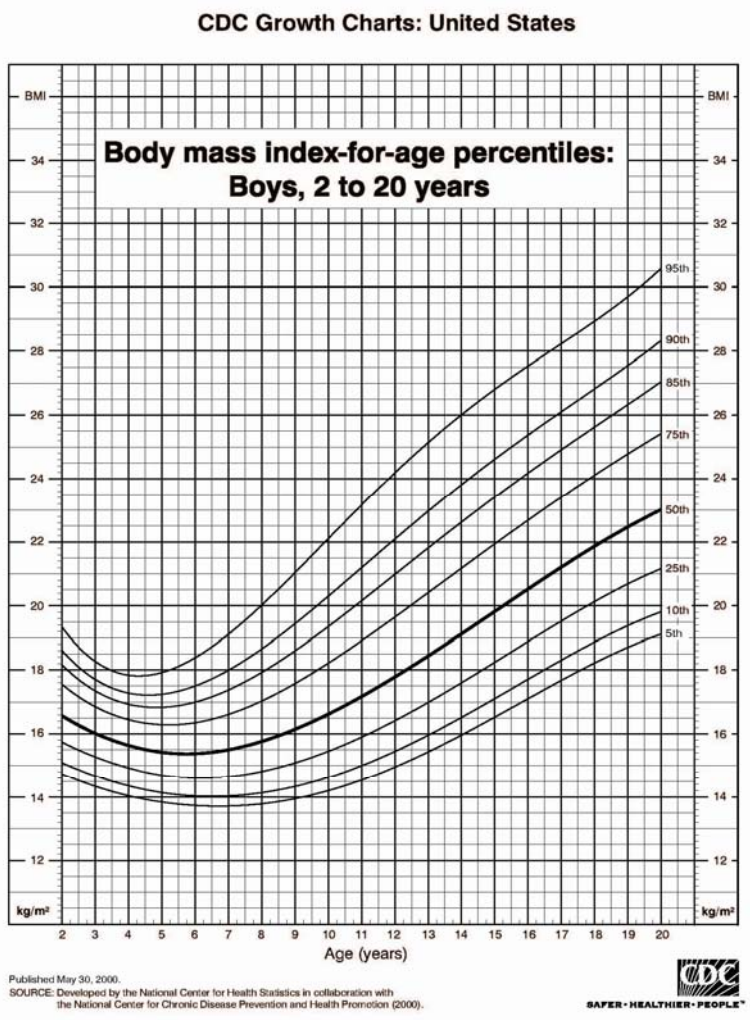
Overweight is defined as a Body-Mass Index (weight in kilograms divided by height in meters squared) of 25.0-29.9 in adults(1). Obesity is a state of extreme fatness and is classified as a Body-Mass Index (BMI) of greater than or equal to 30.0 with the highest class of obesity having a BMI greater than or equal to 40.0 in adults (1). However, children and adolescents are held to a different measurement standard because they are still growing. BMI for children is calculated using the same formula as adults, but it is compared to growth charts provided by the Center for Disease Control (Fig. 1) (2). Children with a BMI at or above the 95^{th} percentile for children of the same age and sex are considered overweight, and children between the 85^{th} and

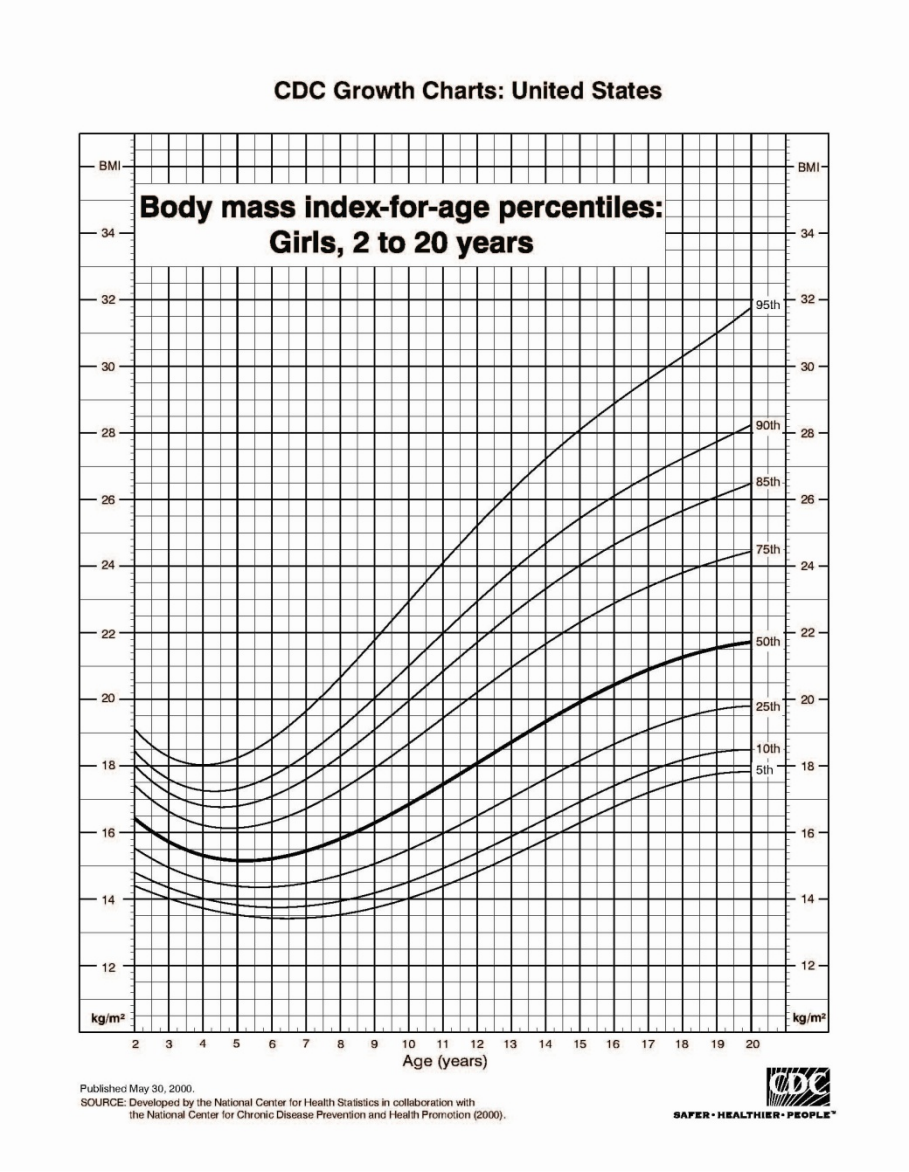
95th percentile are considered at risk for becoming overweight. Assessment of children who are overweight includes calculation of BMI; obtainment of a family history of cardiovascular disease (CVD), type 2 diabetes mellitus (DM), or cancer in first-degree or second-degree relatives; assessment of diet and eating patterns; recorded physical activity; and obtainment of symptoms and signs of syndromes associated with overweight in children and adolescents (3).Occasionally, a fasting blood glucose, insulin, and lipoprotein profile is also taken (3).

Health Complications of Obesity

Overweight children are more likely to be overweight as adults and are at risk for developing many health problems such as sleep apnea, gallbladder disease, eating disorders, CVD, and type 2 DM (1, 3). Children who are overweight have also been found to develop hypertension, dyslipidemia, and elevated serum insulin levels (1, 3). Typically, these health complications are found in adults, but they are now being found in children and adolescents due to increases in childhood obesity. This may cause decreased quality of life in both child- and adulthood.

Figure 1.





Prevalence

Due to increased consumption of food and decreased physical activity, obesity has become a national epidemic, and it has affected children as well as adults. Statistics taken from the Center for Disease Control (CDC) and the National Health and Examination Survey (NHANES) show that the prevalence of obesity in children 6-11 years of age increased from 11.3% in 1994 to 18.8% in 2004 (Table 1.) (4). Obesity in children and adolescents 12-19 years of age increased from 10.5% in 1994 to 17.4% in 2004 (4). Overweight children are 6 times more likely to be overweight as adults, which will consequently continue to increase the prevalence of obesity into adulthood (5).

Table 1. Prevalence of overweight among children and adolescents ages 6-19 years, for selected years 1963-65 through 1999-2002

Age (years)[1]	*NHANES 1963-65 1966-70*[2]	*NHANES 1971-74*	*NHANES 1976-80*	*NHANES 1988-94*	*NHANES 1999-2000*	*NHANES 2001-02*	NHANES 2003-04
6-11	4.2	4	6.5	11.3	15.1	16.3	18.8
12-19	4.6	6.1	5	10.5	14.8	16.7	17.4

[1]Excludes pregnant women starting with 1971-74. Pregnancy status not available for 1963-65 and 1966-70.
[2]Data for 1963-65 are for children 6-11 years of age; data for 1966-70 are for adolescents 12-17 years of age, not 12-19 years. NHANES data on the Prevalence of Overweight Among Children and Adolescents: United States, 2003–2006. CDC National Center for Health Statistics, Health E-Stat.

Treatment of Childhood Obesity

When treating childhood obesity, care should be taken to ensure the child or adolescent is receiving adequate nutrients and calories to promote growth. Therefore, treatment is complicated and needs to be monitored closely. The goal for children 2 to 6 years of age who have a BMI at or above the 95th percentile is weight maintenance (3). Weight maintenance will give the child time to "grow into" his or her weight (1). However, if the child has a BMI over the 95th percentile and has a weight-related complication or is over age six, a one-pound-per-month weight loss is prescribed (3). Weight maintenance can be attained when energy expenditure and intake stay balanced. Weight maintenance and weight loss can be achieved by focusing on a high nutrient, low energy diet and increased physical activity (3). Family involvement is critical to the success of the treatment, but the therapy is dependent on many other factors including willingness of the child and family to change lifestyle, availability of healthy food options at home and school, and opportunities for physical activity.

FRUIT AND VEGETABLES

Health Benefits of Fruit and Vegetable Consumption

Many epidemiological studies have been conducted to test the beneficial effects of fruit and vegetable intake on many different disease states such as heart disease, cancer, and stroke (6, 7). Recent studies have tested fruit and vegetable intake in relationship to cataracts, diverticulosis, chronic obstructive pulmonary disease (COPD), and hypertension (6). The results from the research have been positive indicating that fruit and vegetable consumption is protective from various chronic diseases. The nutrients found in fruits and vegetables work synergistically to prevent risk factors for these health conditions. For example, sulfides contained in vegetables

may detoxify carcinogens and stimulate anticancer enzymes (6). Phytoestrogens and phytoesterols found in vegetables are antioxidants, which inhibit growth of cancer cells (6). Phytoestrogens also play a preventative role in heart disease and hypertension by lowering blood cholesterol levels and platelet aggregation (6). Antioxidative flavinoids, found in mostly fruits and a couple of vegetables, are protective against cancer, heart disease, stroke, and COPD (6). Flavinoids may inhibit growth of cancer by reducing cell proliferation (6). They also inhibit clot formation and inflammatory actions, which decrease risk for heart disease, stroke, and hypertension (6). Furthermore, flavinoids enhance the function of vitamin C. Vitamin C is an antioxidant that participates in the regeneration of vitamin E, another antioxidant. Other vitamins found in fruits and vegetables are potassium and folate, which both help in the prevention of heart disease and hypertension (6). Fruits and vegetables also have fiber, which binds to and aids in excretion of cholesterol, fats, and carcinogenic substances. Fiber contributes to motility of substances through the digestive tract and prevents diverticulosis from occurring (6).

Cardiovascular disease is the leading cause of death in the United States and contributes to about 27% of deaths each year (8). Cancer is the second leading cause of death (8). These leading causes of death have many components that contribute to their formation. However, increased fruit and vegetable consumption greatly reduce some of the risk factors for heart disease and cancer. Furthermore, greater intake of fruits and vegetables would also decrease the risk for the other health conditions previously mentioned. One can conclude that increased consumption of these foods would be beneficial to health.

EFFECTS OF FRUIT AND VEGETABLE CONSUMPTION ON BMI

A prospective cohort study was conducted by Field et. al to determine the association between fruit and vegetable intake and change in BMI among children and adolescents (9). The study included 8,203 girls and 6,715 boys between 9-14 years of age. These study subjects were children of women participating in the Nurses' Health Study II. Body-mass index was calculated using self-reported height and weight. At baseline, 12.7% of the girls and 14.6% of the boys were classified as overweight. Prevalence of obesity was 4.9% of the girls and 8.4% of the boys. Dietary intake and physical activity was evaluated using the Youth/Adolescent Questionnaire (YAQ). Fruit and vegetable intake was categorized as follows: fruit (including juice), fruit not including juice, juice, vegetables, vegetables not including French fries, vegetables not including potatoes, and fruit and vegetables. Total calories were also collected and analyzed. The type and duration of physical activity participants engaged in were assessed by eighteen questions in the questionnaire. The Tanner Stage of Development was used to determine pubertal status. Results from study participants were considered valid if the study participant completed at least two of the four questionnaires given during the three-year time frame of the study.

Results of this study found no beneficial effects of fruit and vegetable intake on weight. Confounding factors that could have affected BMI were controlled for (age, height change, activity levels, and Tanner Stage of Development). Those children consuming two servings of fruits and vegetables daily compared to those consuming five or more servings of vegetables a day had no significant difference in BMI. Fruit and vegetable consumption was very similar between the males and females. However, there was a small inverse relationship between vegetable intake and BMI among the males, but the significance of that relationship disappeared

when total calories was incorporated into the statistical model. This suggests that total calorie intake and not vegetable consumption was the factor influencing BMI.

Strengths of this study were its large population size and control of confounding factors. Although self-reported height, weight, and pubertal development could lead to bias and misclassification, the researchers for this study cited other studies, which found that self-reporting among preadolescents and adolescents in these areas are close to actual measurements taken by those researchers. Therefore, self-reported personal information in this study was considered accurate. The study did have some limitations. The participants in the sample population might not be representative of adolescents of a lower socioeconomic status, since they are children of the nurses participating in the other study. Furthermore, dietary patterns other than fruit and vegetable intake were not evaluated. This could alter the results of the study due to confounding factors in dietary habits, which were not controlled for.

A clinical trial conducted by Epstein et. al tested the difference between increased fruit and vegetable intake and decreased fat and sugar intake in families with children at risk for childhood obesity (10). The researchers wanted to test the effectiveness of a parent-focused approach for combating childhood obesity. The goal of the trial was to alter behavior and eating habits in the parents and their child, which would theoretically lead to weight loss in the parents and promote healthier lifestyle habits in the child. The trial included 30 families who had at least one obese parent and one non-obese child 6-11 years of age (10). The families were randomized into one of the following two treatment groups: decreased consumption of high-fat, high sugar foods or increased consumption of fruits and vegetables. To be eligible for the study, the child had to have a BMI of less than the 85^{th} percentile and at least one parent with a BMI above the 85^{th} percentile (10). The participating parent had to attend the study's treatment meetings. The

study subjects and their family members could not be on any other weight loss program, have any psychiatric problems, or have any dietary or physical activity restrictions. The families were then followed for one year.

Weight measurements of the parents were taken at each treatment meeting. Meetings for the parents were held weekly for eight weeks, then biweekly for four weeks, followed by two monthly meetings during a six-month period. Parents received counseling and lesson modules on weight control and prevention, the Traffic-Light Diet, developing a healthy eating and activity environment for children, behavior change techniques, and maintenance of behavior change (10). The parents also received a 30-minute individual meeting with a therapist and attended a 30-minute group meeting at each treatment session. Parents were instructed to follow the Food Guide Pyramid and to consume 1,200-1,500 calories per day to promote weight loss. Furthermore, the parents were taught to increase physical activity, increase access to fruits and vegetables, and decrease access to high-fat/high-sugar foods in the home. Workbooks for the children were sent home with parents to be completed together. The workbooks contained modules and activities, which corresponded to the learning modules the parents received at the meetings.

Results from this study found that children's weight stayed stable over the length of the study, but that parents in the high fruit and vegetable group had a significant weight loss (-12.01 $\pm$ 11.05 percentage of overweight) from baseline weight and had a significantly greater weight loss compared to those in the low-fat/low-sugar group (-3.94 $\pm$ 4.17 percentage of overweight) (10). Consumption of fruits and vegetables in parents increased 3.41 $\pm$ 3.47 servings per day in the fruit and vegetable group compared to a decrease of 0.23 ($\pm$ 3.66) servings per day in the decreased fat and sugar group (10). Consumption of high-fat/high-sugar foods in parents

decreased in both treatment groups by 6.47 (± 4.63) servings per day in the fruit and vegetable group and 8.22 (± 6.19) servings per day in the decreased fat and sugar group (10). For the children in the fruit and vegetable group, fruit and vegetable intake increased by 0.72 (± 1.11) servings per day; high-fat/high-sugar foods decreased by 4.50 (± 7.97) servings; and percentage of overweight decreased by 1.10 (± 5.29). Children in the fat and sugar group had a decrease in fruit and vegetable intake by 0.55 (± 1.31) servings; decreased high-fat/high-sugar foods by 8.50 (± 7.58) servings; and the percentage of overweight children decreased by 2.40 (± 5.39) (10). Therefore, between all parent and child groups, intake of high-fat/high-sugar foods decreased, but only fruit and vegetable consumption increased among those in the fruit and vegetable group.

Some limitations to this study do exist. Since parents received counseling on total calorie restriction and increasing physical activity, it is hard to determine whether weight loss was completely related to increased fruit and vegetable consumption. Also, intake of high-fat/high-sugar foods decreased in the fruit and vegetable group, indicating that weight loss could be partially explained by a combination of increased fruit and vegetable consumption and decreased consumption of high calorie foods. Furthermore, weight loss and behavior change could be different in those participating if the target was the obese child instead of the parent. This study and other studies have shown that parent behavioral-change programs are good interventions for treatment of childhood obesity (10). However, this study sample might not be representative of the general population due to its small size and the pre-existing willingness of the parents to participate in a weight loss program.

A 12- year prospective cohort study by He et. al conducted in the Nurses' Health Study was conducted to examine the changes of intake of fruits and vegetables in relation to risk of obesity and weight gain among middle-aged women (11). Although the difference in age and

nutrition needs for growth between this study's participants and children and adolescents is a limitation, the long duration of the study and the large number of participants enrolled made it strong study and it was used to further illustrate the affects of fruit and vegetable intake on obesity.

Study subjects included 74,063 female nurses 38-63 years old. Study subjects were not eligible for participation if they had a history of cardiovascular disease, cancer, diabetes, or if they provided incomplete information concerning dietary intake, height, and weight. Study subjects completed a semiquantitative food frequency questionnaire to assess dietary patterns and fruit and vegetable intake. Subjects were placed in quintiles according to amount of fruits and vegetables consumed. Body-mass index was calculated using self-reported height and weight. Height and weight were monitored by questionnaire every other year. Odds ratios were adjusted for "age, year of follow-up, change in physical activity, changes in smoking status, changes in alcohol and caffeine consumption, baseline BMI or weight, change in use of hormone replacement therapy, and changes in energy-adjusted intakes of saturated fat, polyunsaturated fat, monounsaturated fat, *trans*-unsaturated fatty acid, protein, and total energy" (11).

Results from this study found an inverse relationship between fruit and vegetable intake and weight gain. Researchers also found that subjects with high fruit and vegetable intakes had a healthier lifestyle. These subjects exercised more, smoked less, and were most likely to use postmenopausal hormones (11). Study participants who ate more fruits and vegetables had a 25% lower risk of becoming obese (11). Those study participants who had lower weight at baseline gained more then those who were overweight. Among the study subjects who gained the most weight, those who had higher intakes of fruit and vegetables gained less then those with lower consumption.

Although researchers controlled for other lifestyle and dietary factors that would confound findings from the study, a causal relationship between increased fruit and vegetable intake and obesity cannot be determined because the study was observational in nature. The researchers recognized that the observational design of the study was a limitation and made it impossible to control for all confounding factors.

A randomized clinical trial by Warren et. al evaluated a pilot school program created to prevent obesity in children. The trial included 213 children 5-7 years old from 3 different primary schools in Oxford, England (12). The children were randomly assigned into one of the following prevention groups: the nutrition group ("Eat Smart"), the physical activity group ("Play Smart"), the combined nutrition and physical activity group ("Eat Smart Play Smart"), and the control group ("Be Smart"). The table (Table 2) provided on the next page lists the learning focus for each group for each school term.

Anthropometric measurements obtained were height, weight, circumferences (waist, hip, mid-upper arm, and head), and skinfold (biceps, triceps, subscapular, supra-iliac, and calf). Body-mass index was calculated using the height and weight measurements taken by the researchers. A questionnaire was administered to the children to assess their pre-existing nutrition knowledge. Information about the children's physical activity was collected by an interview with the child about their school day and transportation to school. Parents were given a questionnaire concerning their child's activity outside of school, the amount of television viewing, and the amount of computer use. Parents also completed a 24-hour recall and a food frequency questionnaire for their child. The parents then completed a questionnaire about themselves, which provided information about their social and medical history, dietary patterns, nutrition knowledge, and physical activity.

Table 2.
Learning Focus of Intervention and Control Groups

School Term	"Eat Smart"	"Play Smart"	"Eat Smart Play Smart"	"Be Smart"
1	Assessment of children's concepts of health and contributions of food to health	Assessment of children's concepts of energy and activity	Children received half nutrition education and half of the physical education each term	Children learned about food in a non-nutrition sense. Children learned about the human body, food processing, food in different countries, and food traditions
2	Fruit and vegetable tasting and games were used to promote fruit and vegetable consumption	Team games, fun physical activities, and quizzes were used to promote activity on the playground and reduction of television viewing	Activity book that accompanied each term's lessons was sent home. Activities included a weekly message to children and parents, coloring, quizzes, and craftwork	
3	Flash cards, quizzes, and craftwork used to teach positive messages about 'power' foods, breakfast, and snacking	Team games, fun physical activities, and quizzes were used to promote activity on the playground and reduction of television viewing	Parents received a newsletter at the end of each term discussing the lessons learned that term	
4	Tooth friendly foods were explored	Focus on the "activity pyramid" created from the U.S. recommendations for physical activity in children		

This study found no significant changes in BMI from baseline data. There were also no significant differences in BMI between treatment groups. However, there were positive results in nutrition knowledge, physical activity, and fruit and vegetable consumption. Nutrition knowledge scores increased by at least 1.0 in all intervention groups compared to baseline scores (12). The “Eat Smart” and the “Eat Smart Play Smart” groups had the largest increase in nutrition knowledge scores. A small increase in playground activity and the number of children walking to school was observed in all intervention groups. There was also a significant increase in consumption of fruits ($p<0.01$) and vegetables ($p<0.05$) (12).

The small population size and the lack of racial diversity (89% were Caucasian) within the study’s sample could be considered a limitation. Other limitations could be confounding factors given by parental influences. The average parental BMI was 24.5 and 39% of parents had obtained a college degree (12). Due to education of their parents, study subjects could have come from a higher socioeconomic status, which could have influenced the amount of fruits and vegetables consumed in the home and the amount of physical activity received at after-school clubs. Healthy parental patterns could have also influenced dietary and physical activity patterns in the children. Furthermore, the short duration of the study could have inhibited observation of changes in BMI.

A review of literature was conducted by Rolls et. al to assess what intervention studies have found concerning the relationship between fruit and vegetable consumption and weight management. Rolls et. al reports the role of energy density and satiety in connection to total calorie consumption in study participants (13). Energy density is the amount of total calories provided by a food in relationship to its weight. Satiety is the effects or feelings of fullness felt after eating. Factors that have the greatest influence on energy density and satiety are the water,

fat, and fiber content of the food item. Fruits and vegetables have a low energy density due to their high water, high fiber, and low fat content. Therefore, high consumption of fruits and vegetables in replacement of energy dense foods is a good approach to weight management.

Studies conducted on calorie intake and satiety have shown that study participants given a diet with similar weight and low energy density consumed less calories and were as satiated as those given a diet with similar weight and high energy density. Weight reductions were seen in the study participants. However, many of the studies combined increased fruit and vegetable intake with decreased total calorie intake. Since increased fruit and vegetable consumption and decreased calorie intake were not tested independently, it is difficult to determine whether weight reduction was a result of both or just one.

Other intervention studies conducted to reduce chronic disease risk have advised study participants to increase fruit and vegetable intake to achieve the reduced disease risk. Researchers in these studies did not emphasize reduction in total calories, since the focus of the study was disease prevention and not weight loss. These intervention studies found increased consumption of fruits and vegetables among participants, but did not find any significant weight change (13). Thus, to achieve weight maintenance or weight loss, a diet high in fruit and vegetable intake needs to be coupled with a diet low in fat and total calories (13).

INTERVENTIONS TO INCREASE FRUIT AND VEGETABLE CONSUMPTION

The American Dietetic Association (ADA) has suggested an action plan to prevent childhood obesity focusing on the many environmental factors, which play a role in the incidence of this health condition (14). The ADA calls for support from the national government

to strengthen and provide funding for programs that provide families with services that help prevent and treat childhood obesity. Furthermore, the ADA requests additional funding for research that can determine the best approach to prevention and research that tests the effectiveness of these programs. The ADA also addresses the responsibility of the food industry, advertising and marketing industry, local governments, schools, and parents. Restaurants are starting to have healthier menu options, but there is still a lot of room for improvement. The advertising industry needs to monitor advertisements targeted to children and adolescents, which do not promote a healthy lifestyle. Local governments should create community organizations and facilities where children and youth can learn healthy eating behaviors and participate in physical activity. Schools should ensure that their school meals are meeting the Dietary Guidelines, children and youth are participating in physical activity, and that health and nutrition curriculum are taught in classes (14).

An intervention study that I have been involved with is “Viva Veggies,” currently being conducted at Utah State University (15). To increase the children’s knowledge on vegetables, a vegetable is spotlighted each month at Canyon Elementary School. During that month, the children receive the spotlighted vegetable in various dishes at lunch. The children receive nutrition education concerning the vegetable during class and in the after-school program. The nutrition curriculum teaches the children how the vegetable tastes, how the vegetable relates to the five senses, and how the vegetable grows.

A plate waste study was conducted at the beginning of the “Viva Veggies” project to determine vegetable consumption of the children. Results from the plate waste study showed that overall vegetable consumption for all three days was approximately 50% (15). Since the study is

still in progress, ending results of vegetable consumption and the effectiveness of the program have not been determined.

CONCLUSION

The research presented in this thesis suggests that to combat obesity in children and adolescents, there is not just one “cure-all.” Prevention and treatment includes modifications in behavior and environmental factors, in which fruit and vegetable consumption plays a part. However, eating more fruit and vegetables is not the cure for preventing obesity or promoting weight loss. It is the replacement of energy dense foods with fruits and vegetables that produces the anti-obesity effect (16). The goal is to increase the awareness of the public by teaching them how to eat a healthy diet and create a healthy lifestyle.

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AUTHOR'S BIOGRAPHY

Vanessa Reichmann, raised in West Jordan, Utah, graduated in 2004 from West Jordan High School with honors. She continued her education at Salt Lake Community College where she was placed on the Dean's List and received her Associate of General Studies, with science emphasis. Vanessa's previous love for nutrition and desire to become a registered dietitian blossomed after taking a nutrition course at the community college. After receiving her Associate's degree, she transferred to Utah State University to fulfill her dream. Vanessa was accepted into the Didactic Program in Dietetics in 2007 and will graduate with her Bachelor's of Science, with dietetic emphasis, in the spring of 2009. During her education at Utah State University, Vanessa has been able to help develop nutrition curriculum for local elementary schools and Food Sense as part of the Viva Vegetables research project. She has further participated in the Viva Vegetables project by helping with a plate waste study conducted at a local elementary school and by teaching nutrition curriculum to children in an after-school program. Vanessa has also taken advantage of other opportunities to develop her career skills, such as teaching cooking classes and helping the on-campus dietitian develop the Healthy Living Challenge.

Vanessa will complete a dietetic internship through the Utah State University Distance Internship after graduation. This internship will provide her with experiences necessary for developing the skills needed to be an excellent dietitian. Vanessa plans on getting her Master's degree after working in her career field for a couple of years.