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Will Eating More Vegetables Trim Our Body Weight?

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Abstract

The purpose of the study is to examine the dietary consequences of greater consumption of vegetables by type and source. Dietary outcomes include calorie intake, USDA's healthy eating index (HEI) scores, and intakes of fiber and sodium. We fit a fixed-effects model with two-day intake data from the 2003-4 National Health and Nutrition Examination Survey. Our results suggest that the effect of vegetable consumption on diet varies greatly by type of vegetables and where the food is prepared. As stated in the 2010 *Dietary Guidelines for Americans*, "Eating [vegetables and fruits] instead of higher calorie foods can help adults and children achieve and maintain a healthy weight." Our results support the statement and call for attention to how to incorporate vegetables into healthy foods, both at home and away from home.

Introduction

Health benefits of consuming fruits and vegetables have been well documented. Most of fruits and vegetables are major contributors of a number of nutrients that are under-consumed in the United States (DGAC, 2010). Further, greater consumption of fruits and vegetables has been shown to be associated with a reduced risk of cardiovascular disease (heart attack and stroke), certain types of cancer, and type 2 diabetes (DGAC, 2004). Consequently, increasing fruit and vegetable consumption has been a mainstay of Federal dietary guidance for decades.

Fruits and vegetables are high in water and fiber content and therefore low in energy density. Consuming fruits and vegetables may promote satiety and decrease energy intake. With high prevalence of overweight and obesity and the enormous cost associated with obesity in the United States, the role of fruit and vegetable consumption in achieving and maintaining healthy weight has received increasing attention.

Not all fruits and vegetables are created equal in terms of nutrition. In the 2005 *Dietary Guidelines for Americans*, the recommended vegetable consumption for the first time is disaggregated into five vegetable subgroups with greater encouragement given to consuming dark green vegetables, red and orange vegetables, and legumes. Despites strong and repeated encouragement to consuming more fruits and vegetables, the majority of Americans do not consume enough fruits and vegetables, especially those vegetables which are particularly lacking in Americans' diets. For example, total vegetable intake among adults was 1.6 cups during 2001-4, compared with the recommended 2.5 cups based on the USDA pattern (DGA, 2010).

The consumption of dark green vegetables, red and orange vegetables, and legumes reached only half of the recommended amounts.

Fruits and vegetables are often used as ingredients in foods, some of which can be calorie rich. Some popular salad dishes offered in restaurants are packed with calories. For example, the Waldorf chicken salad with blue cheese dressing at a major national chain restaurant contains 1,570 calories, which is close to the estimated energy requirement of 1,600 calories per day for women aged 51 or older with sedentary lifestyles. This leaves little room for the consumption of other foods during the day. Clearly, where and how we eat fruits and vegetables can greatly affect our calorie intake.

The purpose of the study is to examine the dietary consequences of greater consumption of vegetables by type and source. Dietary outcomes include calorie intake and USDA's healthy eating index (HEI) scores. Inadequate fiber intake has been a persistent challenge in improving Americans' diets. The attention on excessive sodium intake has been heightened in the 2010 *Dietary Guidelines for Americans*. We also examine the effect on fiber and sodium intakes when we increase vegetable consumption.

Evidence on the Consumption of Fruits and Vegetables and Weight Status

Since 1980, the U.S. Department of Health and Human Services and the U.S. Department of Agriculture have worked together to develop and disseminate the *Dietary Guidelines for Americans*, which provides information and advice based on a review of the most recent scientific evidence to help consumers choose a healthy eating pattern. Reviewing the literature on the health benefits of eating fruit and vegetable consumption has been a major task undertaken by the Dietary Guidelines Advisory Committee. The scientific evidence of the

relationship between fruit and vegetable consumption and weight status has been reviewed during the development of 2005 and 2010 *Dietary Guidelines for Americans*. This review signifies the growing interest in the relationship between fruit and vegetables consumption with weight status.

A large number of observational studies have been conducted to examine the relationship between fruit and vegetable consumption with body weight and weight status (p. 176, DGAC, 2004). Most of the studies were based on cross-sectional data such that their results offer limited causal inferences. Among the perspective studies and experimental trials, mixed results on the relationship between fruit and vegetable consumption with body weight have been reported. Consequently, it was concluded that fruits and vegetables may be a useful component of programs designed to achieve and sustain weight loss. However, there is no conclusive evidence to suggest that increase consumption of fruits and vegetables can prevent weight gain in the first place.

Data and Sample

We use data from the 2003-4 National Health and Nutrition Examination Survey (NHANES), conducted by the Centers for Disease Control and Prevention (CDC). CDC has conducted NHANES surveys prior to and after 2003-4, but 2003-4 survey is the first time respondents report their food intakes for two non-consecutive days. In our study we employ the fixed-effects model to examine the relationship between vegetable intakes and calorie intake and other dietary outcomes. The fixed-effects model is based on the observed differences for the same study object so that earlier survey data with only one-day intake can't be used in this study.

NHANES respondents report their intakes of foods, which may contain a mixture of vegetables as the sole ingredient or as a part of the food. We use the MyPyramid Equivalents Database (MPED, Bowman et al., 2008) to convert food intakes into vegetable intakes by type. Because 2003-4 MPED is the most recent database to derive vegetable intake data, we can't use the NHANES data available after 2003-4.

In addition to reporting the food and the amount consumed, NHANES respondents also report where the food was obtained and eaten. We define home and away-from-home foods based on where the food is obtained, not where it is eaten. Home food is purchased at a retail store, such as a grocery store, a convenience store, or a supermarket. Food away from home is purchased mainly from foodservice establishments, schools, and other places, where foods are typically ready to eat and consumed as is. The NHANES sample size is 5000 for each year. After excluding children under 2 and those who did not have complete intake data, there are 7647 individuals included in our study.

We use the 2005 Healthy Eating Index (HEI-2005), developed by USDA's Center for Nutrition Policy and Promotion (CNPP), to measure how well an individual's diet adheres to the 2005 Dietary Guidelines for Americans (Guenther et al., 2008). We use the HEI-2005 to calculate the total HEI scores for 2003-4 NHANES respondents. We use the fixed-effects model to estimate changes in the consumption of vegetables by type and source on calorie intake, total HEI-2005 scores, and density for fiber and sodium intake. Vegetables are rich in fiber and excessive sodium consumption has received increasing attention.

Empirical Model

To examine whether differences in vegetable intake by type and by source result in differences in caloric intake, HEI scores, and other nutrition densities, we employ a fixed-effects (first-difference) model to account for unobserved individual food preferences. Consider a basic OLS model of the general form

$$y_i = \mu + \beta X_i + \epsilon_i \quad (1)$$

where y_i is a measure of the outcomes for individual *i*; μ is an intercept; β is a vector of coefficients for a set of predictors X_i, and ϵ_i is an error term. The estimate of the vector X_i is unbiased as long as there is no correlation between any element of X_i and ϵ_i. In reality, there might exist some types of correlation due to unobserved characteristics which affect both predictors X_i and the outcome y_i. Ignoring these factors will lead to possible bias estimates for β. One way to overcome this problem is to consider the estimate equation in the form

$$y_{it} = \mu_t + \beta X_{it} + \gamma Z_i + \alpha_i + \epsilon_{it} \quad (2)$$

where y_{it} is a measure of outcomes (e.g. caloric intake, HEI scores, or selected nutrition densities) for individual *i* at time *t*; μ_t is an intercept that varies over time; β is a vector of coefficients for time-variant set of predictors X_{it} such as type, quantities, and source of food consumed; γ is a vector of coefficients for time-invariant (at least for a short time period) set of predictors Z_i such as cooking skills or knowledge about nutrition, and demographics; α_i is a person-specific error term (unobserved) such as eating habit or food preferences; and ϵ_{it} is a person- and time-specific error term.

One way to eliminate the effects of unobserved time-invariant characteristics (e.g. eating habit or food preferences) is to difference out these characteristics and therefore do not have to concern about their correlation with observed characteristics in X. Hence, for time (t+1), we have

$$y_{i,t+1} = \mu_{t+1} + \beta X_{i,t+1} + \gamma Z_i + \alpha_i + \epsilon_{i,t+1} \quad (3)$$

Subtracting equation (2) from equation (3), we'll have

$$y_{i,t+1} - y_{it} = (\mu_{t+1} - \mu_t) + \beta(X_{i,t+1} - X_{it}) + (\epsilon_{i,t+1} - \epsilon_{it}) \quad (4)$$

which can be rewritten as a first-difference equation

$$\Delta y_i = \Delta\mu + \beta\Delta X_i + \Delta\epsilon_i \quad (5)$$

Since individual-specific and time-invariant effects α_i has been differenced out, and assuming that observed characteristics ΔX_i is uncorrelated with the error term $\Delta\epsilon_i$, we can obtain unbiased estimate of β by doing OLS regression on the first-difference equation (5). Another advantage of using first differencing method with our data is that we can eliminate problems associated with single day measures of the food intake, many of which are truncated at zero.

Empirical results

The survey commands available in Stata are used to incorporate the complex survey design employed in NHANES and sample weights in the estimation of the fixed-effects model. Vegetables are disaggregated into four types – dark green and orange vegetables, potatoes, tomatoes, and others variables—and each type is disaggregated into at home and away from home consumption. We use HEI-2005 to score dietary component and HEI-2005 is based on the 2005 *Dietary Guidelines for Americans*, which treats the recommended consumption for red and

orange vegetables separately. In addition to the eight consumption variables for vegetables, we also include two variables to control for total food intake and whether the intake day is weekday or weekend. Eating more than usual amount of foods in a day is likely to increase calorie intake for the day. It is likely that our food intake varies between weekday and weekend. Preliminary results are summarized in table 1. The overall-goodness-of-fit (R^2) is quite high for the calorie intake model (0.472) and appears to be reasonable for other dietary outcomes, ranging from 0.027 for the percent of calories from saturated fat to 0.115 for fiber.

The results indicate that as we eat more vegetables, for all types and sources, calorie intakes increase as well. The relative calorie contributions of vegetable intakes by type and source strongly suggest that we can reduce calorie intake by substitution between vegetable types and sources. We eat most of dark green and orange vegetables at home, and each additional cup of such vegetables would result in 80 additional calories. In contrast, eating an additional cup of tomatoes away from home would increase calorie intakes by 364 calories. The large calorie contribution from tomatoes eaten away from home implies that away-from-home foods which contain tomatoes are rich in calories and tomatoes may account for a small portion of the food. In contrast, each additional cup of tomatoes consumed at home contributes less than 60 additional calories. Potatoes consumed away from home are often served in fried forms so that an additional cup of away-from-home potatoes would serve up 159 additional calories.

The overall HEI-2005 scores rise with greater consumption of dark green/orange variables and other vegetables both at home and away from home. The overall HEI-2005 scores also rise with at-home consumption of potatoes and tomatoes (not significant for tomatoes), but fall with away-from-home consumption of potatoes and tomatoes. Judging from the results on

calorie intake and overall HEI scores, eating more potatoes and tomatoes as they are currently prepared away from home will have adverse dietary effects.

We should moderate our sodium intake and increase fiber intake so that a positive coefficient for fiber and a negative coefficient for sodium imply a dietary improvement. Vegetable consumption for all types and source contribute positively to fiber intake, but the contributions are not significantly for potatoes and tomatoes away from home. Eating dark green/orange vegetables at home and potatoes at home and away from home help lower sodium intake for each 1,000 calorie intake. The consumption of tomatoes at home and away from home increases sodium intake for each 1,000 calorie intake.

Conclusion

Will eating more vegetables trim our boy weight? It depends. As documented in the Dietary Guidelines Advisory Committee reports (2004 and 2010), the literature on the health outcomes of vegetable consumption indicates major health benefits from eating more vegetables but the effect on weight status is inconclusive.

Tomatoes and potatoes are the two most important vegetables, in terms of quantity, in Americans' diets. Eating more tomatoes and potatoes from foods as currently prepared away from home will have adverse effect on diet and health. The consumption of tomatoes is of particular concern in achieving healthy weight and lowering sodium intake, two major dietary and health improvement emphasized in the 2010 *Dietary Guidelines for Americans*. Eating more potato-containing foods away from home also results in more calories and poor overall diet quality. Our results indicate that even though vegetables offer desirable nutritional profiles, all

vegetables can be prepared with less healthy ingredients as they are currently available, especially at eating out places.

Since 1980, the U.S. Department of Health and Human Services and the U.S. Department of Agriculture have worked together to develop and disseminate the *Dietary Guidelines for Americans* to advise Americans on making healthy food choices and achieve better health. The guidelines are updated every 5 years based on advances in scientific research. The recommendation on fruit and vegetable consumption has been revised from "Choose a diet with plenty of vegetables, fruits, and grain products" in 1990 to "Choose a variety of fruits and vegetables daily" in 2000. This revision reflects the fact that the composition of different fruits and vegetables varies widely with regard to nutrient and non-nutrient components. Starting in 2005 and continue in 2010, separate consumption recommendations are made by type of vegetables, with greater encouragement given to consuming dark green vegetables, red and orange vegetables, and legumes. As stated in the 2010 *Dietary Guidelines for Americans*, "… Eating [vegetables and fruits] instead of higher calorie foods can help adults and children achieve and maintain a healthy weight." Our results support the statement and call for attention to how to incorporate vegetables into healthy foods, both at home and away from home.

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Table 1. Fixed-Effects Results

VARIABLES	Energy	HEI 2005	Percent Fiber	Percent sodium
D_grams	56.606***	-8.020***		
	(2.571)	(0.030)	(0.007)	(1.967)
D_dgrorange_home	79.551**	4.711***	1.383***	-55.804*
	(36.337)	(0.710)	(0.245)	(29.511)
D_dgrorange_away	29.650	5.973***	1.068***	186.243
	(82.038)	(1.659)	(0.354)	(110.013)
D_other_home	16.191	2.183***	1.140***	74.706***
	(22.480)	(0.430)	(0.090)	(19.507)
D_other_away	23.741	1.626***	0.489***	91.305***
	(27.963)	(0.498)	(0.133)	(32.068)
D_v_potato_home	87.643***	1.728***	0.304**	-52.027**
	(20.492)	(0.291)	(0.110)	(20.959)
D_v_potato_away	159.023***	-1.509**	0.084	-75.769**
	(38.215)	(0.549)	(0.116)	(36.806)
D_v_tomato_home	58.709**	0.707	0.860***	178.876***
	(24.392)	(0.498)	(0.104)	(20.568)
D_v_tomato_away	363.708***	-2.229***	0.248	113.283***
	(40.125)	(0.604)	(0.277)	(40.687)
weekend	68.184*	-1.817**	-0.663***	-25.043
	(37.404)	(0.727)	(0.176)	(22.248)
Constant	-15.573	1.782***	0.406***	65.349***
	(16.465)	(0.304)	(0.094)	(19.055)
Observations	7647	7647	7647	7647
R-squared	0.472	0.067	0.115	0.057

Source: 2003-4 NHANES