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Submitted Article

Obesity and Self-control: Food Consumption, Physical Activity, and Weight-loss Intention

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Abstract *We find that despite a stronger intention to lose weight, overweight and obese individuals in the United States are less likely to meet the federal recommendations for fruit and vegetable consumption, energy and nutrient intakes, and physical activity than are normal-weight individuals. By utilizing the Rotter score that measures self-control capability, we find that obese individuals exhibit a lower degree of self-control than normal-weight individuals, and that this lack of self-control is associated with poor eating and exercise behaviors, as well as increased Body Mass Index and obesity risk. We discuss three mechanisms that are regularly employed to overcome self-control problems: physician advice, improvement in the built environment, and commitment devices. Our results suggest that knowledge-based anti-obesity intervention policies are likely to have limited effects.*

Key words: Obesity, self-control, food consumption, physical activity, weight-loss intention, doctor's advice, nudging, commitment device.

JEL codes: D03, D91, I18, I38.

Food consumption and engagement in physical activity are economic decisions in that consumers balance the immediate and future utility and disutility that result from current eating and exercise choices. The traditional economic model assumes that people have time-consistent inter-temporal preferences and rational expectations of the future costs and benefits of their current decisions (Rabin, 2002). As a result, utilizing a traditional economic model results in utility-maximizing decisions that are dynamically consistent. However, there is an apparent gap between long-run intentions and short-run actions. Although individuals intend to exercise regularly and eat healthy when planning for the long run, it is likely difficult for them to, for example, run on the treadmill and skip desserts in the short run. Indeed, many empirical studies have documented that people have time-inconsistent preferences and self-control problems (Ariely and Wertenbroch 2002; Burger and Lynham 2010; DellaVigna and Malmendier 2006; Fang and Silverman 2009; Hoch and Loewenstein 1991; Read and Van Leeuwen 1998; Shapiro 2005; Thaler 1981). Although models of rational decision-making have been developed for the consumption of addictive substances (i.e., Becker and Murphy 1988), it is questionable to argue that the alarming prevalence of obesity in the United States is the result of the optimal choice of individuals given that little uncertainty and straightforward reasoning exists about the health and economic consequences of overeating and a lack of physical activity.

The objectives of this study are to examine the differences in eating and exercise behaviors between normal-weight and obese individuals, the differences in their self-control capabilities, and how these self-control capabilities affect eating and exercise behaviors. To achieve these objectives, we employ four nationally representative data sets: the Behavioral Risk Factor Surveillance System Survey (BRFSS), the National Health and Nutrition Examination Survey (NHANES), the National Longitudinal Survey of Youth 1979 (NLSY79), and the National Longitudinal Survey of Youth 1997 (NLSY97).

This study makes several contributions to the literature. First, we provide a comprehensive comparison between normal-weight and obese individuals in terms of eating and exercise behaviors, nutrition and energy intakes, and weight-loss intentions for the U.S. adult population. We find that obese individuals choose food consumption and physical activity that appear to be suboptimal because their weight-loss intentions are inconsistent with their actual behaviors. Second, to our knowledge, this is the first study to empirically test the difference in self-control capabilities between normal-weight and obese individuals. We find that obese individuals have a lower self-control capability than their normal-weight counterparts. We also find strong associations between the lack of self-control and poor eating/exercise behaviors and an increase in both body mass index (BMI) and obesity risk.

An analysis of individual behaviors is the first step towards a better understanding of obesity, where individuals display time-inconsistent preferences and exhibit a lack of self-control. The results suggest that inferences made under the assumption of complete rationality and time consistency can lead to significant bias. For example, an erroneous conclusion that individuals who desire a lower weight eat more fruits and vegetables and/or exercise more than other individuals would overstate the impact of knowledge-based intervention policies (e.g., nutrition educational programs). In fact, U.S. consumers spend more than $65 billion annually on various weight-loss programs (Marketdata-Enterprises 2012), and the number of bariatric procedures performed in the U.S. increased from 13,365 in 1998 to approximately 2,000,000 in 2007 (Mechanick et al. 2009). The central theme of the growing literature on behavioral obesity is to recognize the time-inconsistent features of individual behaviors and a lack of self-control, and to design intervention policies that respond to such features (Just 2006; Ruhm 2012). We discuss three mechanisms that are used to bridge the gap between weight-loss intentions and eating/exercise behaviors. We find that weight-related counseling from health care professionals increases the intention to lose weight among obese individuals and their probability of meeting the recommended levels of fruit and vegetable consumption, but it has no positive effect on their physical activity. Improvement in the built environment is found to be effective in nudging individuals towards more healthy eating and increased physical activity.

Commitment devices appear to be promising, but face challenges to becoming effective.

Literature Review

Hyperbolic individuals have a tendency to pursue immediate gratification and place short-term impulses over long-term goals, thus have self-control problems (Angeletos et al. 2001; Laibson 1997). In the context of weight management, a present-biased preference affects how individuals evaluate the benefits and costs of weight-related behaviors (e.g., food consumption and physical activity), and choices (weight-loss strategies). When actions involve immediate rewards, the present-bias effect causes the immediate gratification and gain to eclipse future health consequences. Examples include the overconsumption of food, especially excessively cheap and unhealthy food (Cutler, Glaeser, and Shapiro, 2003), and the use of health-compromising weight-loss strategies (Fan and Jin 2013). However, when actions involve immediate costs and delayed rewards, such as diet moderation and engagement in physical activity, individuals who lack self-control tend to procrastinate. Some studies have found that while obese individuals are more likely to choose smaller, immediate rewards and have greater difficulties in delaying gratification for food (Bonato and Boland 1983; Weller et al. 2008), they simultaneously greatly discount the long-run benefits of nutritious meals and exercise (Epstein et al. 2010; Weller et al. 2008). To examine the coexistence of overeating and excess weight, Ruhm (2012) developed a dual model that includes a utility-maximizing deliberative system and an affective system that includes impulsive responses and ignores long-term consequences. The affective system is consistent with present-biased preferences, which lead to food overconsumption and procrastination regarding healthy eating and exercise behaviors.

Previous studies support a positive relationship between BMI and present-biased preference (Borghans and Golsteyn 2006; Ikeda, Kang, and Ohtake 2010; Komlos, Smith, and Bogin 2004; Smith, Bogin, and Bishai 2005; Zhang and Rashad 2008). Except for the study by Ikeda, Kang, and Ohtake (2010), who indicate that time preference is constructed based on the respondents' answers to survey questions, the aforementioned studies use various proxies for the present-biased preference, such as savings rates. Based on experimental data, Richards, Patterson, and Tegene (2007) find that obesity and discount rates are positively related, and that individuals' inter-temporal choices over food consumption exhibit present bias.

To the best of our knowledge, this study is the first in the obesity literature to empirically test the difference in self-control capabilities between normal-weight and obese individuals, and also the first to investigate the association between self-control and eating/exercise behaviors and weight outcomes using a nationally representative data set.

Patterns of Eating and Exercise Behaviors and Weight-loss Intention

We adopt the standard BMI classification used by the World Health Organization (WHO), where normal weight is defined as a BMI between 18.5

and 25, overweight is defined as a BMI between 25 and 30, and obese is defined as a BMI over 30. Class I and Class II obese ($30 \leq$ BMI < 40) and morbidly obese (BMI ≥ 40) are examined as separate groups for certain analyses.

Food Consumption and Energy/Nutrient Intakes

We investigated the association between BMI classes and food consumption from two different perspectives: (1) the probability of meeting the federally recommended levels of fruit and vegetable consumption using the BRFSS 2001-2003 data; and (2) energy and nutrient intakes using the NHANES 2000-2010 data.[1] The BRFSS is a survey of health and risk behaviors among non-institutionalized civilian individuals aged 18 years and older, while the NHANES is designed to assess the health and nutritional status of adults and children in the United States. One's BMI is self-reported in the BRFSS and measured in the NHANES. For both data sets, we dropped underweight individuals, pregnant women, and individuals under 25 years of age from the sample.[2] Stratification and sampling weights for each data set were used to produce correct estimates and corresponding standard errors.

Based on the BRFSS 2001-2003 data, we created two dummy variables indicating whether the respondent met the recommended levels of fruit and vegetable consumption during the week prior to the survey: eating vegetables at least three times per day (Veg3) and eating fruits at least twice per day (Fruit2). Each dummy variable equaled one if the respondent met the recommended level, and zero otherwise. We ran a probit model using each food consumption indicator as the dependent variable and BMI classifications as independent variables. For each model, we controlled for demographic characteristics such as age, gender, race and ethnicity backgrounds, marital status, educational level, employment status, household income, household size, and number of children less than 18 years old in the household. We also incorporated health-related variables such as self-reported health conditions, whether the individual had any type of health insurance in the previous year, and whether the individual was told by health professionals that he/she had diabetes, high blood pressure, or high blood cholesterol. A set of year dummies was also included.

Table 1 presents the marginal effects of the probit estimations. As shown in column 1 of table 1, relative to normal-weight individuals, overweight, Class I and Class II obese, and morbidly obese individuals are 6%, 11%, and 20% less likely to meet the recommended fruit consumption level, respectively.[3] The differences in vegetable consumption are smaller: overweight or obese individuals are 5-7% less likely to meet the recommended consumption level of vegetables (column 2, table 1).

An alternative measure of eating habits is energy and nutrient intake. Based on dietary intake recall data from the NHANES 2000-2010, we constructed five variables to measure daily energy and nutrient intakes: percentage of calories from fat and saturated fat, total sodium (milligrams),

[1]Approximately 17% and 22% of the BRFSS respondents meet the recommended consumption levels of fruits and vegetables established by the 2010 Dietary Guidelines for Americans (USDA-USDHHS, 2010).

[2]Some young people were enrolled in school when surveyed. We dropped them from the sample because we controlled for both education and employment in all analyses.

*[3]The percentage changes are calculated by dividing changes in percentage points by the baseline percentages. For example, the percentage change is equal to 100% *0.0134/0.2164 = 6% for overweight individuals.*

Table 1 Marginal Effects of BMI Classes on Fruit and Vegetable Consumption, Physical Activity, and Weight-loss Intentions (BRFSS 2001-2003)

	Food Consumption		**Physical Activity**		**Weight-loss Intentions**		
	Fruit2 (1)	**Veg3 (2)**	**PhyMod (3)**	**PhyVig (4)**	**Losewt (5)**	**Fewercal (6)**	**Phyact (7)**
Overweight	−0.0134***	−0.0136***	−0.0356***	−0.0309***	0.315***	0.288***	0.257***
($25 \leq$ BMI < 30)	(0.0046)	(0.0049)	(0.0060)	(0.0052)	(0.0055)	(0.006)	(0.006)
Class I and II Obese	−0.0243***	−0.0151***	−0.0881***	−0.0798***	0.465***	0.444***	0.3640***
($30 \leq$ BMI < 40)	(0.0052)	(0.0057)	(0.0069)	(0.0058)	(0.0049)	(0.00570)	(0.0065)
Morbidly Obese	−0.0434***	−0.0188	−0.1690***	−0.138***	0.420***	0.448***	0.333***
(BMI ≥ 40)	(0.0095)	(0.0116)	(0.0134)	(0.0105)	(0.0049)	(0.00745)	(0.0124)
Normal-weight Baseline	0.2164	0.2777	0.5368	0.3400	0.31164	0.2636	0.2561

*Notes: Each column represents a probit model estimation in which the dependent variable is a dummy variable indicating whether the respondent met the recommendation for fruit consumption (Fruit2), vegetable consumption (Veg3), moderate physical activity (PhyMod), or vigorous physical activity (PhyVig), or whether the respondent reported that he/she had tried to lose weight (Losewt) by consuming fewer calories and/or fat (Fewercal), or engaging in physical activity (Phyact). A rich set of demographic factors and health-related variables are included as control variables, in addition to year fixed effects. Each model has 138,982 observations. Asterisks, ***, ** and *, indicate 1%, 5%, and 10% significance levels, respectively. Standard errors of marginal effects are in parentheses.*

total calories, and total fiber (grams) consumed. We converted fat and saturated fat to calories based on the transfer formulas used by the USDA, and then calculated the percentage of calories derived from fat and saturated fat by dividing these calorie levels by total calories.[4] We found that more than 11% of the daily calories consumed by U.S. adults came from saturated fats. This share is higher than the level recommended by the 2010 Dietary Guidelines for Americans, which is 10%. The average daily sodium intake by U.S. adults (3,489 milligrams per day) is more than double the adequate intake level (1,500mg/day) recommended by the Institute of Medicine (IOM). We also found that on average, U.S. adults consume 16 grams of dietary fiber per day, which is significantly less than the level recommended by the IOM.[5]

We estimated the relationship between BMI classes and energy/nutrient intakes by regressing each of these five outcome variables on BMI classes. In addition to the interview day of the week and year dummies, each regression controls for a rich set of demographic information, including gender, age, race, a dummy variable for being born in the United States, family income, ratio of family income to the federal poverty level, and educational level. We ran the estimation on two samples: the full sample and a subsample excluding overweight/obese individuals who either do not perceive themselves as overweight, or do not want to lose weight. The baseline group was made up of normal-weight individuals. The results of OLS regressions are presented in table 2.

Columns 1 and 2 of table 2 show that overweight/obese individuals consume a greater proportion of daily calories from fat and saturated fat than normal-weight individuals. Given the normal-weight baseline (the last row of table 2), the share of calorie intake from fat increases by 7% for morbidly obese individuals in the full sample. A significant increase in the fat contribution to daily calorie intake is also observed among both Class I and Class II obese (5%) and overweight individuals (2%). Overweight, Class I and Class II obese and morbidly obese individuals also have a 2%, 7%, and 8% increase, respectively, in the share of energy consumed from saturated fat. In the case of daily sodium intake, no significant difference was found between normal and overweight individuals. However, compared with normal-weight individuals, the sodium intake was 5% and 11% higher, respectively, for Class I and Class II obese and morbidly obese individuals. We did not find a significant difference in total calorie intake across BMI classes. In the case of dietary fiber, overweight and Class I and Class II obese individuals consumed 2% and 4% less dietary fiber, respectively, than normal-weight individuals.

We would expect that individuals in the subsample, excluding those who do not perceive themselves as being overweight or do not desire to lose weight, are more motivated to improve their energy and nutrient intakes because they presumably have a stronger desire to do so. However, such expectations are not supported by the results in panel B of table 2. We found that among this particular subsample, overweight, Class I and Class II obese and morbidly obese individuals still have a statistically higher proportion of daily calorie consumption from fat and saturated fat, a higher

[4]*Please see: http://healthymeals.nal.usda.gov/hsmrs/HUSSC/Formulas%20for%20Calculations.pdf.*
[5]*The IOM recommends 38 and 25 grams for men and women aged 50 or younger per day, and 20 and 21 grams for men and women over 50 per day, respectively.*

Table 2 Effects of BMI Classes on Daily Intakes of Energy and Nutrients (NHANES 2000-2010)

	Percentage of Calories from				
	Fat (1)	**Saturated Fat (2)**	**Total Sodium (mg) (3)**	**Total Calories (4)**	**Total Fiber (gm) (5)**
Panel A: Full Sample (No. of observations = 22,718)					
Overweight ($25 \leq$ BMI < 30)	0.578***	0.254***	−6.159	−12.392	−0.384*
	(0.177)	(0.063)	(39.406)	(19.911)	(0.220)
Class I and Class II Obese ($30 \leq$ BMI < 40)	1.725***	0.720***	161.435***	−11.847	−0.754***
	(0.238)	(0.098)	(42.644)	(20.235)	(0.201)
Morbidly Obese (BMI ≥ 40)	2.123***	0.833***	370.063***	53.271	−0.338
	(0.440)	(0.172)	(61.274)	(32.499)	(0.283)
R-square	0.045	0.042	0.159	0.225	0.078
Panel B: Subsample excluding overweight/obese individuals who either did not perceive themselves as being overweight or did not want to lose weight (No. of observations = 17,759)					
Overweight ($25 \leq$ BMI < 30)	0.672***	0.259***	−45.008	−55.638***	−0.606**
	(0.209)	(0.072)	(43.306)	(21.110)	(0.255)
Class I and II Obese ($30 \leq$ BMI < 40)	1.806***	0.729***	151.956***	−18.693	−0.806***
	(0.254)	(0.103)	(43.594)	(20.541)	(0.206)
Morbidly Obese (BMI ≥ 40)	2.110***	0.808***	382.882***	62.309*	−0.249
	(0.440)	(0.170)	(64.146)	(33.217)	(0.290)
R-square	0.043	0.040	0.157	0.219	0.083
Normal-weight Baseline	32.577	10.637	3482.220	2209.200	16.286

*Notes: Each column represents a regression model in which a rich set of demographic factors are controlled for. Asterisks, ***, ** and *, indicate 1%, 5%, and 10% significance levels, respectively. Standard errors are in parentheses.*

daily sodium intake, and a lower intake of daily dietary fiber. The only exception involves total daily calorie intake. That is, overweight individuals consume 3% fewer calories than normal-weight individuals.

We summarize the patterns of food consumption and energy and nutrient intakes below.

Finding 1: *Relative to their normal-weight counterparts, overweight/obese individuals are characterized by poor eating habits, as they are less likely to meet the recommended levels of fruit and vegetable consumption and nutrient and energy intakes.*

Physical Activity

Although physical activity has health benefits and should be considered when addressing weight management (USDA-USDHHS 2010), less than half of U.S. adults (44%) meet the recommended level of physical activity according to *Healthy People 2020*.[6] Based on the BRFSS 2001-2003 data, we created two dummy variables, PhMod and PhVig, to indicate whether the respondent met the recommendation for either moderate or vigorous physical activity.[7] The variable PhMod took the value of one if the respondent reported participating in moderate physical activity for at least 30 minutes per day at least five days per week. The variable PhVig took the value of one if the respondent reported participating in vigorous activity for at least 20 minutes per day at least three days per week.

We ran a probit model using each physical activity indicator as the dependent variable and BMI classes as independent variables, in addition to the same set of control variables as those used in the food consumption analysis discussed above. Columns 3 and 4 of table 1 present the marginal effects of BMI classes. Relative to normal-weight individuals, overweight and Class I and II obese individuals were less likely to meet the recommended levels of moderate and vigorous physical activity. The same pattern was found for morbidly obese individuals with much larger differences: a 31% (41%) lower probability of meeting the recommended levels for moderate (vigorous) physical activity. These results can be summarized below:

Finding 2: *Overweight and obese individuals are less likely to meet the recommended levels of physical activity than their normal-weight counterparts.*

Dynamic Relationship between Weight Status and Eating and Exercise Behaviors

To examine the dynamic relationship between weight status and eating/exercise behaviors, we explored a panel data set, the NLSY97, from which we observed individuals' behavior over time. The NLSY97 panel is a nationally representative sample of 8,984 youths aged 12–16 years by December 31, 1996. Compared with the BRFSS definitions discussed in the previous sections, the recommended levels of fruit and vegetable consumption are the same, but the recommended level of physical activity is defined slightly differently, that is, engaging in exercise that lasts at least 30 minutes for at least five days during a typical week. To examine whether a change in weight status improves the probability of meeting the recommended levels

[6]*Please see: http://www.healthypeople.gov/2020/default.aspx.*

[7]*The definitions of PhMod and PhVig are not exactly the same as those cited by the 2008 Physical Activity Guidelines for Americans. However, such definitions have been widely used in the literature and public health surveys/interventions.*

of fruit and vegetable consumption or physical activity, we estimated the following linear probability model:

$$\Delta Y_i = \alpha \Delta OS_{1i} + \beta \Delta OS_{2i} + \gamma \Delta OS_{3i} + X_i * \delta + \Delta SE_i * \delta + \varepsilon_i$$

The first three dependent variables, ΔY_i, are binary variables, with one indicating a change from failing to meet the recommended level in 2002 to meeting the recommend level in 2007 in terms of fruit and vegetable consumption or physical activity, and zero otherwise. In other words, the dependent variable ΔY_i equals one if an individual i improved his/her eating and exercise habits during the period between 2002 and 2007, and zero if no improvement was observed. The fourth dependent variable is a binary indicator, with one indicating a change from not desiring to lose weight in 2002 to desiring to lose weight in 2007, and zero otherwise. We also created four variables indicating four types of changes in obesity status during the same time period. These variables include ΔOS_{1i}, which indicates that a non-obese individual i in 2002 became obese in 2007; ΔOS_{2i}, which indicates that individual i was obese in both years; ΔOS_{3i}, which indicates that an obese individual i in 2002 became non-obese in 2007; and ΔOS_{4i}, which indicates that individual i was non-obese in both years. We used the fourth group as our base group. The vector X includes time-invariant characteristics: gender, ethnic background, age in 2002, and a depression indicator.[8] The vector ΔSE_i includes changes in health status, job status, rural-urban residence, and poverty status. Sampling weights of the NLSY97 were used to produce correct estimates and corresponding standard errors.

As shown in table 3, compared with individuals who maintained a non-obese status, those who became obese did not increase their probability of meeting the recommended levels of fruit and vegetable consumption (columns 1 and 2 of table 3). None of the coefficients associated with the three types of changes in obesity status is statistically significant. As for physical activity, we found that the probability of meeting the recommended level of physical activity decreased by 11 percentage points for individuals who became obese compared with those who maintained a non-obese status (column 3 of table 3). These results can be summarized below:

Finding 3: *Compared with individuals who maintain a non-obese status, a change from non-obese to obese does not improve an individual's probability of meeting the recommended levels of fruit and vegetable consumption and physical activity.*

Discrepancies between Weight-loss Intentions and Eating and Exercise Behaviors

Findings 1-3 show that compared with normal-weight individuals, overweight/obese individuals have poor eating and exercise behaviors, and even a status change from normal weight to obese does not improve their behaviors. We then took this analysis one step further by examining the discrepancies between weight-loss intentions and eating/exercise behaviors using the BRFSS 2001-2003 data and the NLSY97 data.

Based on the BRFSS data, we created three weight-loss intention variables indicating whether the respondent tried to lose weight (Losewt) and whether the respondent specifically did so by eating less food and fewer

[8] *The question on depression was only asked in the first year of the survey (1997).*

Table 3 Effects of the Change in Obesity Status on the Change in Eating/Exercise Behaviors and Weight-loss Intentions (NLSY97)

	Change from 2002 to 2007			
	Probability of Meeting the Recommended Level of			
	Fruit Consumption (1)	**Vegetable Consumption (2)**	**Physical Activity (3)**	**Weight-loss Intention (4)**
From Non-obese to Obese	−0.0400	−0.0073	−0.1111**	0.0743*
	(0.0343)	(0.0260)	(0.0442)	(0.0405)
From Obese to Obese	0.0196	−0.0042	−0.0422	−0.0596
	(0.0247)	(0.0195)	(0.0387)	(0.0378)
From Obese to Non-obese	0.0158	−0.0230	0.0158	−0.1532
	(0.0618)	(0.0189)	(0.0639)	(0.0937)
# of Observations	2,069	2,069	2,069	2,069

*Notes: The dependent variables in columns 1-3 are binary indicators, with one indicating a change from not meeting recommended levels of fruit/vegetable consumption or physical activity in 2002 to meeting the recommended levels in 2007, and zero otherwise. The dependent variable in column 4 is a binary indicator, with one indicating a change from not desiring to lose weight in 2002 to desiring to lose weight in 2007, and zero otherwise. The respondents are divided into four groups based on the change in their obesity status from 2002 to 2007: non-obese to non-obese, non-obese to obese, obese to obese, and obese to non-obese. The non-obese to non-obese group is our base group. Control variables include gender, ethnic background, age, depression indicators, health status change, job change, urban residence status change, and poverty status change. Asterisks, ***, **, and *, indicate 1%, 5%, and 10% significance levels, respectively. Standard errors are in parentheses.*

calories (Fewercal), or by increasing their level of exercise (Phyact) during the previous 30 days. The NLSY97 respondents were asked to report whether they had an intention to lose weight. As shown in columns 5-7 of table 1, we found that compared with normal-weight individuals, the intention of overweight/obese individuals to lose weight was more than doubled (increased by 101% for overweight individuals, 149% for Class I and Class II obese individuals, and 135% for morbidly obese individuals). We also found that respondents have a statistically stronger intention to lose weight if they become obese (column 4 of table 3). We summarize the results on weight-loss intention below:

Finding 4: *Overweight and obese individuals have a much stronger intention to lose weight than normal-weight individuals.*

Combining what we have found so far, overweight/obese individuals have, on average, a greater intention to lose weight either through healthy eating, physical activity, or both than do normal-weight individuals (Finding 4). However, overweight/obese individuals are less likely to meet the recommended levels of fruit and vegetable consumption (Finding 1), energy and nutrient intake (Finding 1), and moderate and vigorous physical activity (Finding 2). These results show significant discrepancies between weight-loss intentions and actual eating and exercise behaviors (Finding 4 vs. Finding 1 and Finding 2). Furthermore, a status change from non-obese to obese does not improve eating and exercise habits, even though individuals who experienced such a change had a stronger intention to lose weight than those individuals who maintained a normal-weight status (Finding 3). Such discrepancies are further supported by the analysis using the NHANES 2000-2010 data. As shown in panel B of table 2, even though overweight/obese individuals correctly perceive themselves as overweight or indicated their desire to lose weight, their energy and nutrient intake was not improved compared with normal-weight individuals. Thus, we conclude in Finding 5:

Finding 5: *Overweight and obese individuals exhibit significant discrepancies between their weight-loss intentions and actual eating and exercise behaviors.*

Self-Control and Weight-loss Behaviors

Weight-loss intention can be viewed as one immediate antecedent of actual weight reduction. However, there is a psychological conflict between desire and willpower (the self-control used to overcome desire) (Hoch and Loewenstein 1991). The degree of success of eating healthy and staying physically active depends not only on a person's intention, but also on a person's control over his or her eating and exercise behaviors. Indeed, Findings 1-5 suggest that obese individuals lack self-control to achieve their weight-loss goals. Self-control capability has been linked with important life outcomes, for example, health and longevity (Rosengren et al. 2004; Stürmer, Hasselbach, and Amelang 2006), labor market participation (DellaVigna and Paserman 2005), and social and risk behaviors (Burger 1984; Nunn 1988). We link the self-control capability with individuals' eating and exercise behaviors and weight outcomes.

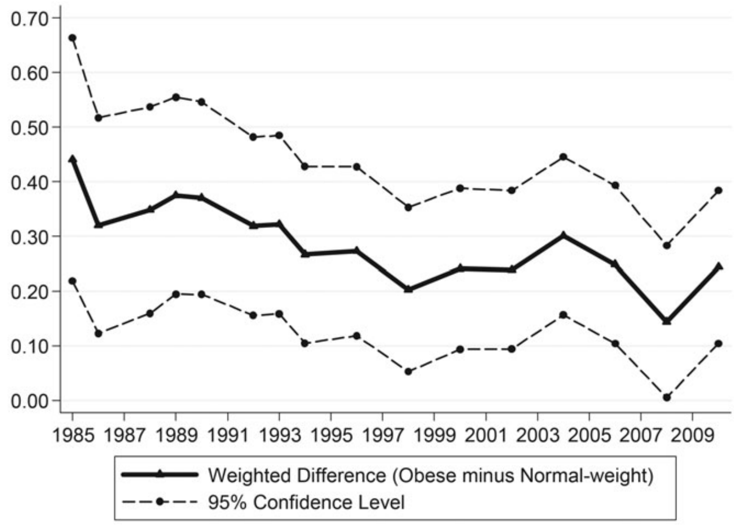
According to the literature on behavioral economics, obese individuals with self-control problems could be either naïve or sophisticated (O'Donoghue and Rabin, 1999). Naïve individuals who do not fully understand their lack of self-control may overeat and/or exercise less one day because they expect to diet and/or become physically active the next day. Such individuals procrastinate healthy eating and exercising, and overestimate their future self-control capability. Sophisticated individuals realize their self-control problems and may employ commitment devices to increase their probability of exhibiting "good" behaviors. However, an effective commitment device is difficult to achieve. A well-documented study on infamously ill-fated New Year's resolutions proves that a lack of willpower and/or self-control can easily break a well-orchestrated plan (Bryan, Karlan, and Nelson 2010). We expect that self-control capabilities differ between normal-weight and obese individuals, and that a lack of self-control might have adverse effects on eating and exercise behaviors.

Self-control Measures

Self-control is measured by the difference between the inter-temporal allocation viewed as optimal, and the allocation that would actually be chosen (Ameriks et al. 2004).[9] This study uses the Rotter locus of control in

[9]*The literature measures behaviors such as substance use to gauge individual self-control ability (DellaVigna and Paserman, 2005) or uses questionnaires and experimental techniques to estimate self-control ability/problems. The latter techniques take different directions. One direction is to take the time-versus-money approach, asking survey respondents to state how much money he/she would require at various future dates to give up fixed immediate monetary rewards (Thaler and Shefrin 1981). The implied high discount rates are used as evidence that the respondent has a self-control problem due to a*

Figure 1 Difference in the Rotter Score between Obese and Normal-weight Individuals (NLSY79)



the NLSY79 to measure self-control capabilities. The Rotter (1966) locus of control refers to the extent to which individuals believe they can control their lives through self-motivation or self-determination (internal control) as opposed to the extent that the environment controls their lives (external control).

The NLSY79 cohort is a nationally representative sample of youth aged 14-22 in 1979. The survey was conducted annually from 1979 to 1994, and biennially since 1996. We used the NLSY79 panel from 1985 to 2010 in this study, because BMI data were not available prior to 1985. The 1980 interview contained a series of questions about the Rotter internal versus external locus of control. For each of four Rotter Scale questions, the respondents chose within a four-point scale with a lower number indicating a stronger level of self-control. The scores for each question were then summed. The maximum score was 16, indicating the greatest external control, while the minimum score was four, indicating the greatest internal control.

Figure 1 shows that relative to normal-weight individuals, obese individuals had a higher average Rotter score in every survey year between 1985 and 2010, and these differences were statistically significant. This finding is summarized below:

Finding 6: *Overweight or obese individuals have a lower degree of self-control capability than normal-weight individuals.*

Does Self-control Ability Affect Eating and Exercise Behaviors and Weight Status?

We constructed six dependent variables based on the NLSY79 data to investigate the effects of self-control capability on weight status and weight-related behaviors. The first two variables were BMI and the obese

discounting of the present and a preference for the future. Another type is to create a scenario involving a possible temptation and asking respondents to reflect on their ability to resist the temptation.

status of the respondents. We also created two binary variables for the exercise behaviors of the previous week, indicating whether the respondents participated in vigorous activity for at least 10 minutes that caused heavy sweating or large increases in breathing or heart rate (*Vigor*), or strength training activities for at least 10 minutes (*Strength*) for at least three days. Two variables characterizing respondents' eating behaviors included the number of times the respondent ate food from a fast food restaurant, such as McDonald's, Kentucky Fried Chicken, Pizza Hut, or Taco Bell (*Fast Food*), and the number of times the respondent consumed a soft drink or soda that contained sugar (*Soft Drinks*) over the previous seven days. The control variables included gender, age, income level, racial and ethnic background, education level, and whether the respondent lived in an urban area or not. We pooled the data from different survey years and controlled for year and individual fixed-effects.

As shown in columns 1 and 2 of table 4, the Rotter score is positively associated with BMI and obesity risk. As far as exercise is concerned, the Rotter score is negatively associated with the probability of engaging in vigorous physical activity or strength training (columns 3 and 4 of table 4). We also found that the Rotter score is positively associated with a greater frequency of fast food and sugared soft drink consumption (columns 5 and 6 of table 4). Thus, as summarized in Finding 7 below, self-control capability as measured by the Rotter score is an important determining factor of individuals' eating and exercise behaviors. A lower degree of self-control is associated with poor eating and exercise behaviors, an elevated BMI, and a higher risk of becoming obese.

Finding 7: *Individuals who have a lower degree of self-control capability are more likely to be obese and have poor eating and exercise habits.*

Efforts to Bridge the Gap between Weight-loss Intention and Eating/Exercise Behaviors

Weight-related Counseling from Health Care Professionals

Weight-related counseling provided by health care professionals may help overweight/obese individuals better understand the costs and benefits of healthy eating and staying physically active. Patients who are advised by their health care providers, especially physicians, to modify their behaviors are generally more confident and motivated to engage in lifestyle modifications such as dietary changes and increased physical activity (Galuska et al. 1999; Huang et al. 2004; Kreuter, Chheda, and Bull 2000).

Using the BRFSS 2001-2003 data, we ran probit models to examine the effect of a doctor's advice to lose weight on improving healthy eating and physical activity. In addition to the same set of control variables shown in table 1, we also included a dummy variable indicating whether the respondents reported that they had received advice from a doctor to lose weight, and we controlled for individuals' BMI so that the doctor's advice did not capture the effect of BMI. We ran the probit model on two subsamples separately: the obese sample and the obese sample of individuals who desired to lose weight. Individuals who desired to lose weight were those whose desired weight was lower than their reported weight.

Table 4 The Effect of the Rotter Scale on Weight Status and Eating and Exercise Behaviors (NLSY79)

	Weight Status		**Physical Activity**		**Food Consumption**	
	BMI (1)	**Obesity Risk (2)**	**Vigor (3)**	**Strength (4)**	**Fast Food (5)**	**Soft Drinks (6)**
Rotter Scale	0.079***	0.004**	−0.004**	−0.005***	0.021*	0.096**
	(0.007)	(0.002)	(0.002)	(0.002)	(0.011)	(0.043)
Region Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	98,491	98,491	25,695	28,694	11,218	11,209
R-square	0.137	0.069	0.039	0.030	0.034	0.053

*Notes: The dependent variables are BMI, an obesity indicator, a binary variable indicating participation in vigorous physical activities or sports for at least 10 minutes at least 3 days per week, a binary variable indicting participation in strength training activities for at least 10 minutes a day at least 3 days per week, the number of times the respondent ate food from a fast food restaurant in the previous 7 days, and the number of times the respondent drank a soft drink or soda in the previous 7 days. The control variables are gender, age, income, racial and ethnic backgrounds, education level, and whether the respondent lived in an urban area or not. Asterisks, ***, **, and *, indicate 1%, 5%, and 10% significance levels, respectively. Robust standard errors are in parentheses and clustered on an individual level.*

Table 5 Marginal Effects of a Doctor's Advice on Weight-loss Intentions, Fruit and Vegetable Consumption and Physical Activity (BRFSS 2001-2003)

	Food Consumption		**Physical Activity**		**Weight-loss Intention**		
	Fruit2 **(1)**	**Veg3** **(2)**	**PhyMod** **(3)**	**PhyVig** **(4)**	**Losewt** **(5)**	**Fewercal** **(6)**	**Phyact** **(7)**
Obese Sample (No. of observations = 39,196)							
	0.0154**	0.0141*	−0.0194**	−0.0057	0.1600***	0.158***	0.126***
Doctor's Advice	(0.0076)	(0.0085)	(0.0098)	(0.0079)	(0.0076)	(0.0088)	(0.0100)
Baseline[a]	0.1565	0.2201	0.4236	0.2373	0.7023	0.6015	0.4976
Obese Sample Excluding Those Who Do Not Want to Lose Weight (No. of observations = 37,952)							
	0.0147*	0.0130	−0.0195**	−0.0029	0.1390***	0.140***	0.111***
Doctor's Advice	(0.0077)	(0.0086)	(0.0100)	(0.0080)	(0.0075)	(0.0088)	(0.0010)
Baseline[a]	0.1548	0.2187	0.4227	0.2342	0.7333	0.6295	0.5193

*Notes: Each entry represents a separate probit estimation. The dependent variables and control variables are the same as those shown in table 1. Asterisks, ***, **, and *, indicate 1%, 5%, and 10% significance levels, respectively. Standard errors of marginal effects are in parentheses.*

[a] The base value is the estimated probability of meeting the recommended levels of fruit and vegetable consumption, meeting the recommended levels of moderate and vigorous physical activity, or the weight-loss intention of the respondents that were included in the same estimation sample but did not receive doctor's advice to lose weight.

Columns 5-7 of table 5 show that a doctor's advice to lose weight is associated with a statistically significant and greater intention to lose weight for obese individuals, but the effect is smaller in magnitude for those who desire to lose weight. Columns 1 and 2 of table 5 show that a doctor's advice to lose weight helps obese individuals meet the recommended consumption levels of fruits and vegetables, regardless of whether they had indicated a desire to lose weight or not; the probability of meeting the recommended consumption levels increased by approximately 6-10%. However, we did not find a statistically significant, positive effect of doctors' advice on individuals' probability of meeting the recommended levels of moderate and vigorous physical activity in both samples (see columns 3 and 4 of table 5). The differences in the effects of a doctor's advice to engage in healthy eating or physical activity could be due to several factors. Engaging in physical activity may be more costly and require more self-control than eating more fruits and vegetables. Physicians are more capable of providing diet counseling than providing exercise counseling (Bleich, Pickett-Blakely, and Cooper 2011). Nevertheless, the fact that a doctor's advice increases weight-loss intention through physical activity but does not increase the probability of meeting the recommended levels of moderate and vigorous physical activity suggests that overweight/obese individuals may face a greater challenge in becoming more physically active.

The effectiveness of a doctor's advice on food consumption and weight-loss intention suggests that health care professionals are uniquely positioned to impact obesity care and prevention. The U.S. Preventive Services Task Force recommends that clinicians screen all adult patients for obesity and offer intensive counseling to promote sustained weight loss (Moyer 2012). However, most obese patients do not receive an obesity diagnosis or weight-related counseling (Bleich, Pickett-Blakely, and Cooper 2011). Of the 209,000 overweight/obese respondents of the BRFSS 2001-2003 who were asked to report whether they received any weight-related advice from health care professionals, only 24% reported that they had received such counseling.

Improving Food Environments and Neighborhood Physical Activity Facilities

Several field studies have shown that minor changes in food environments can successfully nudge consumers who lack self-control towards healthy food choices. For example, moving the salad bar from against the wall to the middle of the room in a middle school cafeteria boosts the sales of salad (Just and Wansink 2009). Hanks, Just, and Wansink (2013) provide extensive formats of the nudging used to encourage junior-senior high school students to eat more fruits and vegetables by making these foods more convenient (e.g., fresh fruits located next to the cash register), more attractive (e.g., fresh fruits displayed in nice bowls or tiered stands), and normative (verbal prompt by cafeteria staff on the selection of fruits and vegetables). To a large extent, nudging reduces searching costs because fruits and vegetables stand out nicely in food arrangements and decrease the time cost as the selection of healthy foods are rewarded by convenience. Nudging expands the gain and/or utility of consuming fruits and vegetables as these food items become more attractive. As a result, individuals who lack self-control, such as junior-senior high school students, purchase and consume more fruits and vegetables even though they would not have done so in a food environment without nudging. More importantly, changes in food environments can be a win-win situation for both consumers and food marketers if designed properly (Just and Payne 2009; Just and Wansink 2009), which makes nudging practically attractive.

Our results show that it is more difficult to motivate overweight/obese individuals to engage in more physical activity compared with greater fruit and vegetable consumption. One practical channel is to provide neighborhood amenities and improve the quality of such amenities so that the costs of engaging in physical activity will be reduced and the benefits of utilizing such amenities will increase. The literature documents rich evidence supporting a strong association between access to neighborhood amenities (e.g., playgrounds, parks, trails) and increased outdoor physical activity (Bedimo-Rung, Mowen, and Cohen 2005; Roemmich et al. 2006). Fan and Jin (2013) find that adding a park/playground to a neighborhood significantly reduces the prevalence of childhood obesity, especially within young cohorts and poor neighborhoods. Furthermore, changing social norms on physical activity (Cohen, Scribner, and Farley 2000) and promoting a culture of healthy activity habits during childhood (Zimmerman 2009) can have sustainable and broad impacts on obesity.

Anti-obesity Commitment Devices

To battle the self-control problems associated with the time-inconsistent preference, sophisticated individuals may employ commitment devices to protect long-term goals from short-term unhealthy temptations. Commitment devices such as financial incentives should help people restrain their short-term impulses and materialize their weight-loss intentions by eating healthy and staying physically active. Financial incentives have been shown to be effective in battling addictive behaviors, such as smoking and substance abuse (Dallery et al. 2001; Giné, Karlan, and Zinman 2010; Lussier et al. 2006). These incentives might also play an important role in tackling obesity. Charness and Gneezy (2009) conducted experiments among college students and found that while simply informing people about the benefits of exercise had little effect, paying people to go to the gym successfully created a positive habit of exercising more.

The efficacy of financial incentives can be affected by the size of financial incentives, and it may differ in the short run and long run. Wing and Jeffery (2001) found that paying participants in weight-loss programs $25 per week for achieving and maintaining their weight loss goals had no effect on weight outcomes. Volpp et al. (2008) and John et al. (2011) found that financial incentives resulted in a significant weight loss during the intervention period, but the weight loss was not sustained in the long term. Individuals still need practical mechanisms through which to leverage financial incentives. Burger and Lynham (2010) analyzed a weight loss betting market in the UK using a data set from bookmaker William Hill from 1993 to 2006. The authors found that approximately 80% of bettors who spent money betting on their own behaviors with the hope of controlling their short-term craving for foods and of losing weight end up losing their bets, despite payoffs as high as $7,350. The authors conclude that individuals in this market are aware of their need for commitment devices to improve their self-control capability, but they are unable to design appropriate practical mechanisms, even with a significant high payoff if they succeed. DellaVigna and Malmendier (2006) collected data from three health clubs in New England and analyzed the patrons' contract choices and their day-to-day attendance. These authors find that monthly attendance was only 4.69 times for those individuals who purchased annual contracts. One of their interpretations is that some patrons use the annual health club membership as a commitment device to attempt to increase their future attendance, but a lack of self-control eventually invalidates the commitment device. These studies highlight a phenomenon that individuals who understand and use a commitment device still face self-control problems, and often fail to carry out their well-orchestrated plans. This notion raises an important question about behavioral interventions: how can the intervention make the targeted people "committed" to commitment devices? Interventions aiming to help individuals who lack self-control may also face a difficult ethical question: when an individual has a time-inconsistent preference, whose side do we take, the forward-looking self or the myopic self? Read (2006) noted that with regard to other people, we usually take sides based on our own perception of what is best for them. Nevertheless, in many cases, our judgment is not a valid substitute for the preferences of the individual we attempt to help. To avoid this ethical quagmire, policymakers may limit their efforts to the provision of commitment devices that will help individuals construct strategies to achieve their goals.

Conclusions

Using four nationally representative data sets (BRFSS 2001-2003, NHANES 2000-2010, NLSY79, and NLSY97), we find that compared with normal-weight individuals, overweight/obese individuals in the United States are much less likely to meet the recommendations for fruit and vegetable consumption, energy and nutrient intakes, and physical activity, but they have much greater intentions to lose weight. Even a weight status change from non-obese to obese is not associated with an improvement in eating and exercise behaviors. The findings can be explained by heterogeneous levels of self-control capabilities. We find that obese individuals have a lower degree of self-control capability and that a lack of self-control capability is associated with poor eating and exercise behaviors, as well as an increase in obesity risk and BMI.

We discussed three strategies that could potentially bridge the gap between weight-loss intentions and behaviors. We find that a doctor's advice to lose weight increases the probability of meeting the recommended levels of fruit and vegetable consumption among overweight or obese individuals, but is less effective in inducing more physical activity. An improvement in the built environment of food and neighborhood amenities could induce healthy weight-related behaviors. Commitment devices, while frequently employed by obese individuals to lose weight, face challenges to be effective.

We are aware of one main caveat in this study that calls for cautious interpretations of our results. We make an implicit assumption that all individuals have access to and can afford healthy foods and physical facilities and amenities. However, low-income populations who have a disproportionally high obesity prevalence are likely to face more challenges to engaging in healthy eating and physical activity. For example, they might have limited access to healthy foods and physical facilities/amenities, or they may have little time to engage in greater physical activity due to long working hours. Furthermore, they may have little to no access to weight-related physician counseling due to a lack of health insurance or limited coverage. Therefore, the discrepancies between weight-loss intentions and behaviors and the role of self-control might be overstated for these groups.

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