Economics of Walking and Obesity

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I. Introduction

Obesity in America is a prevalent issue, referred to as an "epidemic" by the popular media, for which a myriad of preventative measures have been prescribed. Implementation of fat food taxes, subsidization of gym memberships and organic foods, and the importance of regular exercise have all been put forth as a means for a reduction in obesity, but said reduction has yet to come to fruition. As of 2011, obesity rates were at an all-time high with 35.7% of American Adults boasting a BMI ≥ 30 and this number is projected to grow—an additional burden to our already exorbitant health care costs [1]. So as we continue to talk the talk, I propose it's time we walk the walk.

Walking is an underexplored, and possibly undervalued dual means of travel and exercise that could serve to reduce obesity rates in the United States, and provide broad individual and social benefits. Walking is free and a non-discriminatory, easily accessible method of travel and exercise, and foreseeable reductions in obesity with increased engagement in the practice are expected by much of the literature. *Hill et al (2003)* asserts a reduction in energy storage (achieved through reduction of energy inputs and/or an increase in expenditure of energy) of just 100 Kcal/day would close the energy gap that exists between the obese and their normal sized counterparts. They propose taking 15-20 minutes to walk a mile a day would be sufficient to "completely abolish the energy gap and hence weight gain for most of the population" [2]. Utilizing this 100kcal/day figure, Edwards predicts a reduction in the rate of increase of obesity from 0.5%/yr to 0.2%/yr with just the 8.3 minutes of additional brisk walking per day that results from use of public transit [3]. Deviating from theoretical analyses, in a case study of 11 obese women observed over a period of a year [4] and a separately conducted study of approximately 3000 men and 3000 women observed over a period of 5 years [5], brisk walking 30 minutes or more a day alone resulted in significant weight loss.

Walking has therefore been presented as an attractive, seemingly foolproof method of combating the rising prevalence of obesity, and many programs have followed suit, such as the 10,000-step program practiced by many and implemented across businesses nationwide [6]. However, though there is an established association between walking and weight loss, I would like to further explore how effective walking actually is in reducing obesity in our diverse nation, as I believe there may exist discrepancies between socioeconomic class and urban vs. rural regions. Being that obesity is more prevalent in rural areas of higher deprivation [7,8], these areas must be targeted foremost to reduce obesity, and one must determine if walking would be substantial enough to outweigh possible differences in health behaviors of lower socioeconomic and regionally rural populations.

The following analysis is thereby concerned with the act of walking as a feasible preventative and counteractive measure in the fight against obesity in the United States. And as importantly, whether the benefits of walking can be generalized to the greater public, or whether they will pose varied effects on obesity as related to socioeconomic and demographic factors.

I use two separate datasets in my analysis of walking and its effect on obesity, being the *Behavioral Risk Factor Surveillance System (BRFSS 2011)* and the

National Household Travel Survey (NHTS 2009). My analysis of the BRFSS 2011 dictates correlation between individuals of higher BMI and those who are poorer, less educated, and live in either rural or suburban settings. Higher BMI is also correlated with minority populations. My analysis of the NHTS 2009 reveals a higher prevalence of walking is noted to have a correlation with individuals who are more highly educated and who live in a city setting, while income has a more ambiguous relationship with walking. I cannot correct for endogeneity as I do not have a good instrumental variable, so the true causal relationship of the above could be quite different. The relationships in the following analysis are discussed assuming conditional independence, and it is hoped that the bias of the coefficients is small enough so that the correlations drawn are representative of the true causal effect.

II. Datasets and Methods

I employ two separate datasets in my analysis of walking and its effect on obesity, being the *Behavioral Risk Factor Surveillance System (BRFSS 2011)* and the *National Household Travel Survey (NHTS 2009)*.

The CDC is responsible for the dataset I use to assess the relationship between walking and BMI, the BRFSS 2011, which is a set of surveys that monitor state-level prevalence of the major behavioral risks among adults associated with premature morbidity and mortality. Surveyors collected data through landline and cell phone* on

* The institutionalized and on-duty military personnel were excluded from the survey. The maximum BMI allowed for a United States soldier in most branches is 27.5 [18], which is the average for males in the United States. For prison inmates, the average prevalence of obesity (BMI ≥ 30) is 22.8% [19], which is below the national average of 35.7% (national averages are as reported by the BRFSS). It is therefore expected that the inclusion of these groups in the survey would decrease the median BMI noted in the BRFSS dataset.

actual behaviors, and these datasets include a wealth of information and all the figures of interest: type of physical exercise including walking habits, education, annual income, Metropolitan Statistical Area (MSA), and BMI.

There are several concerns that arise with the BRFSS as well that I feel are necessary to address. As expressed by *Hutto et al and Mucci et al (2008)*, the validity of BRFSS and other self-reported data is best when respondents are asked about behaviors which are not sensitive, and when questions refer to discreet events such as enrollment in health care plans, immunization or testing. As walking is not an overwhelmingly sensitive subject, I do not expect disingenuousness regarding the reporting of walking habits, however I think misreporting may come into concern with variables such as self-reported weight and height, from which BMI is derived. As for under- or over-reporting of weight and under- or over-reporting of height, I am unable to account for either by any means with the data available.

Using BRFFS 2011, I derive the effect of time spent walking, income, and population density, on BMI as follows:

$$BMI = \alpha + \beta(educ) + \gamma(income) + \delta(MSA) + \epsilon(min\ phys\ act\ wk) + \boldsymbol{BX} + \varepsilon$$

Where α is a fixed effect based on state fixed effect, $\boldsymbol{X}$ is a vector of socioeconomic and demographic controls, and ε is a white-noise error. *Educ* is a vector of binary variables associated with education level, *income* is a vector of binary variables associated with annual household income level, *MSA* is a vector of binary variables associated with Metropolitan Statistical Area†, and *min phys act wk* is a vector of binary variables associated with minutes of physical activity per week (the minutes reported are for the physical activity that the individual deemed to be their primary form of physical activity in the past month).

It should be noted that the BRFSS did not ask whether or not an individual walked throughout his or her week, but instead asked for the individual's primary form of exercise in the past month and then requested the average minutes per week performing that exercise. I cannot therefore determine the walking habits of all respondents in my sample, only those who have reported walking as their most practiced form of exercise. Thus, I have elected to create a dummy variable in which walking and other forms of exercise performed with moderate to vigorous intensity are compared to low intensity forms of physical exercise or none at all, to establish walking's effectiveness in reducing BMI in comparison to other forms of physical activity and no activity at all. I as well look at a subset of the sample containing only those respondents who reported walking as their primary form of exercise in the past month to determine the effects of minutes spent walking on BMI within this group‡.

I also derive the effects of the various socioeconomic and demographic

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† A formal definition of metropolitan areas established by the Office of Management and Budget, a division of the U.S. Government. Metropolitan statistical areas serve to group counties and cities into specific geographic areas for the purposes of a population census and accounts for population density and proximity to a major city.

‡ An instrumental variable was explored here but was unfortunately determined to be weak following an F-test analysis. The variable suggested incorporated temperature as an explanation of BMI through walking only. Average temperatures were obtained for each month for each state, and a specific temperature was assigned to an individual based on the state where and month when the respondent completed the survey. This temperature (t) was then subtracted from what I determined to be a comfortable walking temperature (65 degrees F). The variable was calculated as follows: $|t-65|$, where a greater magnitude would be associated with a greater discomfort for walking.

variables (education, income, MSA) on minutes spent walking within the subset of my sample containing only those who reported walking as their primary form of exercise:

$$Min\ Spent\ Walking = \alpha + \beta(educ) + \gamma(income) + \delta(MSA) + \boldsymbol{BX} + \mu$$

This mirrors the regression model employed using the NHTS 2009 dataset and is to serve as a means for comparison across datasets.

The NHTS 2009 is the authoritative source of national data on the travel behavior of the American public. The dataset allows analysis of daily travel by all modes, including characteristics of the people traveling such as education and income, their household, and their vehicles. The design is a list-assisted random digit dialing (RDD) computer-assisted telephone interviewing (CATI) survey conducted over an entire year. Travel data was collected from the civilian, non-institutionalized population of the United States. The site contains comprehensive data extending from 1969 to 2009, and I use the 2009 dataset, as it is the most current.

The 2009 NHTS collected data by means of a daily travel diary in which household respondents were asked to self-report all trips, their purposes, starting and ending times, and the means of transportation during an assigned travel day. Individuals were asked to fill out the travel diaries on their respective travel day, and then to relay that information later in telephone interviews. Walking for all purposes, whether part of daily commutes, chores or errands, recreation or exercise, were part of daily trips recorded.

As concerned by Edwards, walking time in the NHTS is a limited measure. Because the survey covers only one travel day per individual, estimates could be potentially misleading as the day whereon the survey was administered may not be representative of said individual's regular behaviors. As defined by the NHTS, responses for a typical weekday include activity over a 24-hour period starting and ending at 4 AM, while on weekends the travel day begins on Friday at 6PM and ends on Sunday at midnight. There is a large difference in the time horizon and possible difference in reported walking between weekends and weekdays. Also, self-reported walking time may not be a good objective measure of walking. As reviewed by Tudor-Locke and Myers (2001), the literature examining objective and subjective measures of walking typically reveals that individuals under-report total walking. To address the first limitation, I explore how excluding respondents whose travel day fell on the weekend affects the results. As for under-reporting or over-reporting, I am unable to account for either by any means with the data available.

Using NHTS 2009, I derive the prevalence of walking amongst different combinations of education level, annual incomes, and varied controls including the population density and housing density of the individual's permanent residence, urban/rural nature of the residence, race, gender, gas price, age, and time (defined as whether the survey was administered on a weekday or during the weekend). The use of instrumental variables for education as it affects walking was explored, but none of the variables within the dataset were valid instruments for education and so I am restricted to finding interesting relationships in the data by employing a series of regressions based upon the basic form:

$$\ln(Min\ Spent\ Walking + 1) = \alpha + \beta(educ) + \gamma \boldsymbol{ln}(income) + \delta(location) + \boldsymbol{BX} + \mu$$

Where α is a fixed effect based on state fixed effect, $\boldsymbol{X}$ is a vector of socioeconomic, demographic and time controls, and u is a white-noise error. *Educ* is a vector of binary variables associated with education level, *income* is the natural log of annual household income, and *location* is a vector of binary variables associated with an individual's permanent address. For *location*, respondents' residences are placed into one of four categories: Urban, Second City, Suburban, or Town and Country[§]. I also estimate probit and tobit models with similar specifications.

III. Results

BRFSS 2011

Table 1 outlines the characteristics of the BRFSS 2011 dataset, which is restricted to ages 30-65 years. My sample is comprised of adults with an average age of 55 years old, average BMI of 27.67, median BMI of 26.63 (a BMI of 25 to 30 is classified as 'overweight' by international Body-Mass Index standards), predominantly white, and divided 40% males and 60% females[**].

Table 2 displays the characteristics of a subset of this sample containing only those who reported walking as their primary source of exercise in the past month

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[§] **Urban**
- Urban areas have highest population density scores based on density centiles
- 94% of block groups designated Urban have a density centile score between 75 and 99
- Downtown areas of major cities and surrounding neighborhoods are usually classified as urban

Suburban
- Suburban areas are not population centers of their surrounding communities
- 99% of block groups designated Suburban have a density centile score between 40 and 90
- Areas surrounding urban areas are usually classified as suburban

Second City
- Second Cities are population centers of their surrounding communities
- 96% of block groups designated Second City have a density centile score between 40 and
- Satellite cities surrounding major metropolitan areas are frequently classified as Second Cities

Town and Country
- Town/Rural areas include exurbs, farming communities, and various rural areas
- 100% of block groups designated Rural have a density centile between 0 and 20
- 98% of block groups designated Town have a density centile between 20 and 40
- Exurban towns have slightly denser populations than rural areas

[**] This imbalance noted is not a consequence of the restriction on age (30-65 y.o.) as, without this restriction, the dataset maintains the same uneven proportions of men and women. This could be due to higher compliance amongst women to complete the interview by phone or maybe women are more likely to answer the household phone or a cellular phone.

(approximately 17% of the entire sample). This relieves the dataset of participants who did not report walking as their primary form of exercise, and effectively creates a sample that can be used to observe the relationship between minutes spent walking and BMI amongst those who determined it to be their primary source of exercise. The subset is comprised of adults with an average age of 56 years old, average BMI of 27.62, median BMI of 26.63, predominately white, and split 34% male and 66% female.

With no true way of observing the walking habits of all of the respondents in my sample, I have elected to run an OLS on both my entire sample (the characteristics of which are displayed in Table 1) and said subset (the characteristics of which are displayed in Table 2).

Table 3 shows the OLS estimated coefficients of Model A where minutes spent walking is the dependent variable. Model A coefficients represent the minutes spent walking associated with the various independent variables of interest using the subset of the sample containing only those who reported walking as their primary source of exercise in the past month. There exists a statistically significant positive correlation between education and walking (for those who elect walking as their primary form of exercise, a college graduate walks 2.64 more minutes per week than someone who only graduated high school). This is with exception of the "Never attended school or only kindergarten" category which is statistically insignificant. Income displays a less clear relationship with walking, showing that those who make more than $75,000 annually walk more than their counterparts who make between $25,000 and $75,000, but less than those who make less than $20,000 annually.

There is a statistically significant positive correlation between age and walking. Those who do not live in the center city of an MSA walk significantly less per week than those who do. Those who do not live in an MSA (i.e. rural area) walk 7.32 minutes less per week and those in a suburban setting walk 4.88 minutes less per week than those in the city. All minorities, with the exception of Blacks, walk more than Whites on a statistically significant level and females walk 18.70 minutes less per week than males within this subset, also at a statistically significant level.

Table 3 also shows the OLS estimated coefficients of Model B where BMI is the dependent variable, and uses the same subset of the sample as Model A (the subset containing only those who reported walking as their primary form of exercise). Model B coefficients show the BMI associated the independent variables of interest and with minutes spent walking. There exists a statistically significant negative correlation between education and BMI, with BMI successively increasing with each drop in education level. For those who elect walking as their primary form of exercise, a college graduate has a BMI of 0.8143 less than someone who only graduated high school. Income displays a statistically significant negative relationship with BMI, showing that those who make more than $75,000 annually have a substantially lower BMI than those who make less than $75,000, with BMI successively increasing with each drop in income level. There is a statistically significant negative correlation between age and BMI amongst those who said walking was their primary form of exercise. Those who do not live in the center city of an MSA have significantly higher BMI’s than those who do. Those who do not live in an MSA (i.e. rural area) have a BMI of 0.4051 higher and those in a suburban setting have a BMI of 0.3372 higher than those in the city. All minorities, with the exception of Asians, have higher BMI's than Whites on a statistically significant level and females have a BMI of 1.537 less than males within this subset, also at a statistically significant level. Minutes walked per week is statistically significant and negatively correlated with BMI, decreasing BMI by 0.0009 with each minute increase in walking per week for those who chose walking to be their primary source of exercise.

Finally, Table 4 shows the OLS estimated coefficients of Model C, where BMI is the dependent variable and the entire sample is incorporated. Model C coefficients represent the BMI associated with the independent variables of interest and a dummy (*min phys act per wk*) comparing moderate to vigorous walking and other forms of moderate to vigorous physical exercise to no physical activity at all. This reveals how effective walking is at reducing BMI in comparison to other forms of physical activity and doing nothing whatsoever. There exists a statistically significant negative correlation between education and BMI, with BMI successively increasing with each drop in education level. A college graduate has a BMI of 0.8892 less than someone who only graduated high school. Income displays a statistically significant negative relationship with BMI, showing that those who make more than $75,000 annually have a substantially lower BMI than those who make less than $75,000, with BMI successively increasing with each drop in income level. There is a statistically significant positive correlation between age and BMI. Those who do not live in the center city of an MSA have significantly higher BMI's than those who do. Those who do not live in an MSA (i.e. rural area) have a BMI of 0.3937 higher and those in a suburban setting have a BMI of 0.2089 higher than those in the city. All minorities, with the exception of Asians, have higher BMI's than Whites on a statistically significant level and females have a BMI of 1.288 less than males within this subset. Those who chose moderate to vigorous walking as their primary form of exercise for the past month had a BMI of 0.4677 less than those who reported doing low intensity or no exercise in the past month, at a statistically significant level.

NHTS 2009

Table 5 outlines the characteristics of the sample of all respondents, which is restricted to ages 30-65 years in order to ensure education level attained is not confounded by age. My sample is composed of adults with average age of 50 years, predominantly white, largely living in a region denominated "Town and Country", and divided relatively evenly in gender with slightly more females than males.

Those who elect to walk, being a small proportion of the population in the dataset (approximately 8.5%), may possess characteristics or concerns distinct from their non-walking counterparts (i.e. higher value of life) and I therefore think this sample of people are worth observing separately. Table 6 displays the characteristic of the sample of respondents who reported walking at least 1 minute throughout their travel day.

The sample in Table 6 is similar in character to that concerned in Table 5, restricted to ages 30-65 years composed of primarily adults with average age of 50 years, predominantly white, largely living in a region denominated "Town and Country", and divided relatively evenly in gender with slightly more females than males.

It is evident that a significant portion of respondents reported no walking throughout their designated travel day (reference Table 5), and therefore *minutes spent walking* is severely skewed by the overwhelming proportion of 0 minutes recorded. I address this issue by drawing on several different models designed to mitigate the effects of such a scenario (specifically probit and tobit regression models). I also run an OLS regression using the sample addressed in Table 6, comprised of only the respondents that reported positive minutes of walking throughout their travel day.

Table 7 shows the OLS estimated coefficients of Models D and E. Model D concerns the sample of only those who reported positive minutes of walking throughout their travel day and Model E concerns the entire sample (walkers and non-walkers).

Model D1 represents ordinary least squares (OLS) estimated coefficients using the sample containing *only* those who reported at least 1 minute of walking throughout their travel day. Model D2 represents the same method of estimation run excluding weekend trips from the amount of walking reported for the purpose of a robustness check. As there was not a significant difference between the model excluding weekends and that including weekends, I have elected to focus my analysis and discussion on the model that includes both weekdays and weekends.

In Model D1, there is not a statistically significant relationship between walking and education level. Income has a significant positive effect of 2.90% additional minutes of waking with a 1% increase in income. Gas Price has a significant positive correlation with walking. With a 10 cent increase in gas price there is a

0.38% increase in minutes spent walking. Population density is positively correlated with walking and housing density is negatively correlated with walking. Age is positively correlated with walking. Those who live in a "Town and Country" setting walk significantly less (3.53% less) than their Urban counterparts. All minorities, where statistical significance is shown, walk more than Whites and males walk significantly more than females.

Models E1 and E2 represent the OLS estimations of minutes spent walking associated with the independent variables of interest, again with and without weekend trips, but run on the *entire* sample. As there was not a significant difference between the model excluding weekends and that including weekends, I have elected to focus my analysis and discussion on the latter.

In model E1, there is a 7.57% difference (college - high school) in time spent walking between a high school graduate and a college graduate, and from there, an additional 5% gain in minutes walked with attainment of a graduate or professional degree. Income has a significant negative effect of 5.36% reduction in minutes of waking with a 1% increase in income. Gas price has a significant positive correlation with walking. With a 10 cent increase in gas price there is a 0.14% increase in minutes spent walking. Population density is not significantly correlated with walking and housing density is positively correlated with walking. Age is not significantly correlated with walking. Those who do not live in an Urban setting walk significantly less (5.37% to 6.92% less) than those who do. All minorities, where statistical significance is shown, walk less than Whites and there is no significant relationship between walking and gender.

To account for the large response of 0 minutes walking, I employed a probit model (reference Table 8) to investigate the effects of the independent variables on the probability someone chooses to walk (marginal effects displayed in Models F1 and F2), and I followed Edwards [3] in using a tobit model (reference Table 8), a standard model used when dealing with a corner solution††, the coefficient estimates of which are shown in Models G1 and G2.

In Model F1, the probit estimates that those who have not earned a college degree are 2.00% to 3.00% less likely to walk than a college graduate, and that those earning a doctorate of some sort are 1.70% more likely to choose to walk than their Bachelor's-earning counterparts. With a 1% increase in income, individuals are 2.00% less likely to choose to walk. With a 10 cent increase in gas price there is only a 0.004 % increase in minutes spent walking, although it is statistically significant. Population density does not significantly affect the probability that someone will choose to walk and housing density increases the probability that someone will walk, although negligibly. Age is not significantly related to the probability someone walks. Those who do not live in an Urban are 0.70% to 1.30% less likely to walk than those who do. Blacks are 2.20% less likely to choose to walk than Whites and males are 0.60% less likely to choose to walk than females.

Model G1 shows the tobit coefficient estimates. There is a 6.63% difference (college - high school) in time spent walking between a high school graduate and a

††In this application, y is an observable choice or outcome describing some agent with the following characteristics: y takes on the value 0 with positive probability but is a continuous random variable over strictly positive values. In effect, we have an agent who is solving a maximization problem. For some of these individuals, the optimal choice will be the corner solution, y = 0. As Wooldridge [12] points out, it is problematic to use OLS in this setting and tobit is a better suited model.

college graduate, and from there, an additional 2.85% gain in minutes walked with attainment of a graduate or professional degree. Income has a significant negative effect of 4.11% reduction in minutes of waking with a 1% increase in income. Gas price has a significant positive correlation with walking, increasing minutes spent walking by 0.15% with a 10 cent increase in gas price. Population density is not significantly correlated with walking and housing density is positively correlated with walking. Age is not significantly correlated with walking. Those who do not live in an Urban setting walk significantly less (1.98% to 3.04% less) than those who do. Blacks walk 3.11% less than Whites and males walk 1.10% less than females.

IV. Discussion

The objective in analyzing the NHTS 2009 dataset is to realize conditional correlations in walking with varying education levels, incomes, and locations. These certain trends that are identified can then be reconciled with the walking and obesity data analysis of the BRFSS 2011, and can provide grounds for explanation of higher BMI's amongst certain socioeconomic and demographic classes as attributable to the prevalence of walking amongst these classes. This is crucial as this paper intends to point to walking as a reasonable or fanciful means of preventing increase in or reducing obesity rates. The prevalence of walking across certain specifications achieved from this analysis of the NHTS 2009 data is essential because if lower socioeconomic class is, say, associated with a high level of walking *and* high BMI, then a prescription of increased walking is not likely to be effective in fighting the heart of the issue that is obesity. This being said, this paper extends more generally to suggesting the areas public policy should be focused upon, or conversely shy away from, to achieve efficient allocation of resources to prevent increase in or reduce obesity rates.

I will first establish that there is indeed a statistically significant effect of walking on BMI and explore how BMI varies amongst various selected independent variables (education, location, income, race, etc.) using the BRFSS 2011, and then I will elaborate upon the prevalence of walking as it varies amongst these same groups using the NHTS 2009.

BRFSS 2011

Looking at Model C, it can be seen that there is a clear, significant negative correlation between minutes spent walking and BMI conditional on other controls. Those who performed moderate to vigorous walking as their primary form of exercise in the past month had significantly lower BMI's (-0.4677) than those who did not perform any moderate to vigorous physical activity in the past month. Given a male with a height of 70 in. and weight of 190 lbs. (about average height and weight for a male in the United States according to the BRFSS) this would be equivalent to a 4 to 5 lb. reduction in weight if one were to take up walking as their primary form of exercise as opposed to doing nothing, and if this correlation can be interpreted as causation under the conditional independence assumption. Assuming all of this loss is body fat, losing 4 to 5 lbs. would provide more than modest health benefits. According to studies referenced in the *Harvard Health Publication*, a review of health-related studies and their applications to society, people with high blood pressure who lost a modest 10 lbs. over six months reduced their systolic blood pressure by amounts equivalent to the reductions brought about by treatment with some blood pressure medications. Also, in a study of people who were at risk for type 2 diabetes, those who lost just 7% of their weight (equivalent to a loss of 13 lbs. in the average 190 lb. man) cut their risk of diabetes by nearly 60% [21]. Walking is indeed an easy and effective step towards this weight loss goal.

Walking actually appears to have reductive effects on BMI* similar in magnitude to working out on an elliptical, and significantly reduces BMI unlike racquetball and working out on a bicycling machine. These are all activities that require a fitness club membership under most circumstances, and being that walking is an easily accessible and free activity‡‡, such results point to the fact that a gym membership is not necessary to achieve significant losses in BMI and promote walking as a free and effective alternative. Walking is as well a non-discriminatory means of reducing obesity within the United States, as it maintains a significant negative effect upon BMI even when running Model C separately for each minority population and gender. So why not promote other free and equally accessible activities, such as running, that have a greater effect on BMI? Walking still stands as a more attractive means of exercise to promote amongst the general population, as many overweight individuals may not have the desire or physical capacity to take up

* BMI, although the standard of measurement used by health-related industries internationally, is a somewhat limited measure of obesity. BMI can be misleading in individuals who exhibit extraordinarily large weight due to large muscle mass yet low body fat composition. Therefore activities such as swimming, wrestling, rugby and football that involve intensive muscle building show a positive relationship with BMI—but this should not be interpreted as an increase in body fat necessarily. In the case of activities wherein muscle building is not a major component (Active Gaming Devices and Shore Fishing) we can likely attribute their positive association with BMI to a higher body fat percentage within the individuals who selected these activities as their primary form of exercise in the past month.

‡‡ "Free" refers to the absence of direct monetary costs associated with walking. However, potential costs could arise with the decision to walk such as bad weather and crime in an area. Such costs would be greater for lower socioeconomic individuals who may not be able to afford protective, weather-proof clothing and who are located in areas of higher incidence of crime.

running. Walking is a less strenuous yet effective option that will garner greater compliance amongst those higher BMI individuals who need exercise most.

Within the BRFSS 2011 dataset, these higher BMI individuals tend to be members of minority populations, specifically Blacks and Hispanics (Table 11, below), and typically have fewer years of education, lower income levels and reside in more rural settings (although MSA is a less consistent estimator of BMI) as represented by the results from Model B and Model C. Such trends evidence the need for a focus on minority groups and the underprivileged members of society in our effort to reduce obesity in order to attain the greatest reduction in obesity-related health issues and expenditures nationwide.

Table 11

Race	Mean BMI	Median BMI
White	27.91	26.79
Black	30.57	29.21
Hispanic	28.72	27.65

Education

Education has a strongly negative effect upon BMI. The difference in BMI between a college graduate and someone with a lower level of education is successively reduced with each additional level of education achieved in both models (Model B, consists of only those who reported walking as their primary form of exercise, and Model C, including the entire sample). This is with exception to the education level denoted “never attended school or only kindergarten” within Model C wherein the difference in BMI between no school and a college level of education is actually less than the difference between an “elementary” level of education and college level. This may be due to the fact that individuals at this lowest level of education are largely involved in more labor-intensive jobs [13] that require a greater physical exertion and thus facilitate a lower BMI. As for the prevailing negative correlation existent between education level and BMI, it may be attributed to an increase in health consciousness, or higher value of life, that accompanies a higher level of education [14] and therefore a conscientious decision by educated individuals to avoid unhealthy behaviors that correlate with higher body fat composition and higher BMI.

Income

Individuals of lower income have a higher BMI across all income brackets relative to those who make more than $75,000 annually in both models B and C. Given the positive association between education and income this makes sense that both variables would effectively reduce BMI. Again, the lowest income bracket in Model C, similar to the behavior of the lowest education level, does not follow the trend of successively increasing magnitudes of BMI with each drop in income level. Like those of the lowest education level, individuals in the lowest income bracket may be stuck in lower-paying, labor-intensive jobs [13] that cause these individuals to have lower BMI. It may also be due to the fact that those in the lowest income bracket have lower consumption than their counterparts in the next highest income bracket. Although they may still be consuming cheaper, unhealthy foods, they are consuming less quantitatively due to severe financial constraints, effectively reducing BMI with this drop to the lowest income level.

Location (MSA)

In both models, those residing in a suburban area or not in an MSA (i.e. rural area) have significantly higher BMI's than those who live in the center city of an MSA. According to Model C, those who are located in a suburban area have a BMI of approximately 0.20 higher than those in the city and those not located in an MSA have a BMI of almost 0.40 higher. This magnitude of difference in BMI associated with MSA status is even more pronounced amongst those who elected walking as their primary source of exercise as shown by Model B. There are several factors that come into play when concerning locational effects on BMI (quality of food available, price of quality food, access to health care and education, cultural effects, etc.) but I propose that it is a largely a difference in the amount of walking individuals do as it relates to the availability of public transit and proximity to goods and services. Individuals located in an urban setting have access to public transit and most necessities are located within walking distance, thereby creating an environment wherein walking is the preferred and primary mode of transportation. According to *Vandegrift et al (2004)*, suburban locations are associated with a higher prevalence of obesity due to the fact that the markets that provide needed goods and services are too far away from the residence to make walking a feasible means of travel. Those in a suburban setting forgo walking in favor of driving, and the same logic can be used to reconcile the increase in BMI associated with living in a rural locale.

So now that a clear negative relationship between walking and BMI has been shown, is it a feasible means of reducing obesity within the United States given vast differences in race, incomes, education, and locations? Will walking effectively reduce BMI across all of these groups, or will the beneficial effects be inconsistent? In other words, now knowing that a higher BMI is associated with minorities, lower education, lower income, and suburban and rural settings, the prevalence of walking amongst each of these groups must be determined in order to evaluate the reality of walking as a means to fight obesity. If walking is indeed less prevalent within groups that display a higher BMI, then we can point to differences in walking habits as a possible underlying factor and prescribe walking as a way to reduce BMI amongst these groups. I use the NHTS 2009 to evaluate said prevalence.

NHTS 2009[§§]

Education

Education appears to have a positive effect upon *minutes spent walking* across all specifications with a closer look required into the "less than high school graduate" category. When viewing the OLS models, there is an increase in minutes spent walking associated with this "less than high school graduate" education level as compared to a Bachelor's degree level amongst those who reported positive walking, and an insignificant effect of the "less than high school graduate" education level on walking when incorporating the entire sample of walkers and non-walkers. At first look, it could be surmised that those without a high school degree are largely involved

[§§]It should be noted that I have elected to observe results derived from the models including weekends and weekdays, as the difference between the two regression models (including weekends and excluding weekends) is not significant and including weekends allows for a larger sample size and more representative sample.

in unskilled, labor-intensive vocations of some sort that require more walking on the job [13]. This would explain the lower BMI associated with individuals at the lowest education level. As well, low income is associated with lower education, and therefore these individuals may not be able to afford or have access to a car, leaving walking as their sole mean for transportation. As for the subsequent increases in level of education attained, there is a significant increase in minutes walked according to model B1, and it may be attributed to an increase in knowledge of healthy behavior or increase in value of life [14], hence a conscientious increase in the practice of walking.

However, returning to the OLS regression modeling only those who reported positive walking, education is much less significant of a factor upon walking within the group who has elected to walk in comparison to the OLS regression modeling the entire sample of walkers and non-walkers. This suggest that the decision to go from zero walking to positive walking is significantly affected by level of education, and taking note of the fact that only 8.5% of my sample actually reported walking at all, simply convincing people to make the decision to walk could have substantial effects upon the health of our population. The marginal effects of both the probit and tobit models display an increase in probability that an individual will choose to walk given an increase in education level. The probit estimates that those who have not earned a college degree are 2 to 3% less likely to walk than a college graduate, and that those earning a doctorate of some sort are 1.7% more likely to choose to walk than their Bachelor's-earning counterparts. The tobit mirrors these results, estimating a highly significant positive effect of education level on minutes spent walking.

So there is an increase in prevalence of walking shown here, and decrease in BMI shown in the BRFSS analysis, associated with higher education. And while a causal relationship cannot be drawn between these variables, correlation suggests that walking behavior could indeed play a role in the disparity in BMI amongst education levels, a role that, if promoted through higher education, has great potential to reduce BMI.

Separate regressions for each gender and racial category were conducted for closer comparison, and while there are largely no significant differences between groups, the few that were noted are realized in the area of education.

While a minute difference, a comparison of simple OLS regressions run on each gender reveals education has less of an effect on the walking habits of females than males at the lowest and highest education levels defined by the survey. That is, if a female were to obtain a Bachelor's, she would not walk significantly more or less than if she had not obtained a high school degree in the first place or earned a professional degree (Table 9).

Why do females behave differently regarding walking at these extremes? Interestingly, across all ages (restricted up to 45 y.o. as births are rare in women above this age), birth rates for women are substantially higher at the lowest (0-8 years) and highest (16 years or more) education levels[20]. If we assume that women tend to walk with their children, and that more activities that are travel and walking related are involved with having children, the women of the lowest and highest education levels likely walk more due to the higher number of children they have, and therefore their walking behavior is not substantially different from a college graduate at the lowest and highest education levels. Education and number of children are effectively substitutes in this case.

As for racial differences, it is noted that education does not have a significant effect on walking behaviors of major minorities in the US, specifically those who define themselves as Black or Hispanic. Compare this observation to the White proportion of the sample wherein education has a hugely significant effect on walking (Table 10).

So from where does this racial divergence in education's effects on walking originate? It is possible that education level is relatively concentrated at a specific level within minority populations making these populations all of largely equivalent education levels. However in conducting a frequency test on Whites, Blacks and Hispanics, the proportions of the populations at each education level are relatively similar when compared to each other and all follow a similar bell curve distribution. So the levels of education attained are alike proportionally in each race, therefore it cannot be a discrepancy in access to education that causes walking to be unaffected by education in minority populations, but instead I propose it must be a lack in the quality of education these minorities have access to.

This lower quality of education is likely associated with the location of these minorities' households. Interestingly, within each racial group, location does not pose a significant effect on minutes spent walking. Again, I conducted a frequency test across races and, regarding location, there is no difference in the proportion of whites and that of minorities in the areas they elect to live (as given by the 4 denominations listed being Town and Country, Urban, Suburban, and Second City). So there must be a difference within these locations that is not realized by the broad denominations given in my data set. Given that the race comparison regression shows that, for each race, living within a particular urban-rural region does not have a significant effect on walking, while recognizing a huge effect of education on walking for Whites that is not observed in minorities, I speculate that there is a fundamental difference in the concentration of races in certain areas within these denominations (i.e. ghetto slums vs. downtown district of the Urban setting), wherein minorities have more limited access to quality education.

This insignificant effect of education on walking amongst minority groups may also be attributed to unobserved cultural differences, the understanding of which is beyond the scope of the datasets utilized. As BMI is more prevalent within minority groups, this paper reveals the importance of research into possible differences in location and cultural behaviors that render education ineffective in promoting walking amongst minority groups. This paper points to a need for further research into said behaviors in order to effectively move forward in the fight against obesity amongst the US's minority populations.

Given this interesting discrepancy in the effects of education on walking between Whites and notable American minority groups, I propose that a general education subsidization policy would not effectively promote walking amongst *all* groups of individuals. Such a unique situation necessitates quality assurance of education on multiple grounds, including an increase in quality of health education provided through nutritional classes for teachers and parents, subsidization of educational resources for areas that have low access to quality teachers and facilities, as well as an increase in education years themselves (which will be achieved through a higher retention rate that follows a higher quality of education). There needs to be an increase in years of *quality* education in order to promote walking and reduce BMI within the United States.

<u>Income</u>

Concerning income, there is a positive effect of 2 to 3% additional minutes of waking with a 1% increase in income within the sample containing only those who walked, but interestingly a negative effect within the sample including all respondents (those who did and those who did not report walking). For the sample of only those who reported at least some walking, which disregards the large proportion of 0 values, an increase in income is associated with an increase in walking, which is sensible given that income is positively associated with education level. However, within the sample that contains both walkers and non-walkers, income appears to have a negative effect significant at the 1% level, shown across the OLS, probit and tobit models for which all 0 values in *minutes spent walking* are accounted. This may be due in part to a higher disregard for health [25] or willingness to spend more on alternative forms of transportation that accompanies an increase in disposable income for some individuals. It may also be due to lifestyle choices that accompany various income levels such as location of residence—however this is unclear.

This suggests that progressive income transfers would not be a select policy measure to effectively promote walking in aims to reduce obesity in the United States. Walking behavior does seem to be significantly responsive to the price of gas though, however the associated increase in minutes spent walking is economically insignificant (approximately 0.1% increase with a 10 cent increase in gas price). So imposition of a gas tax would cause people at each income level to substitute walking for driving but not at a significant level, furthering the message that the financial situation of an individual seems loosely related to walking habits.

Being that lower socioeconomic status is associated with more walking in the specified models at a statistically significant level, does this mean the credibility of walking as a foolproof means of fighting obesity is also challenged? Low socioeconomic status is associated with higher BMI even with an already established higher prevalence of walking.

However, in reviewing *Vandegrift et al (2004)*, he also acknowledges that, although researchers have found that there is an inverse relation between income and obesity, the rate of obesity has risen in light of rising incomes in the past decade, largely due to the "new location patterns produced by suburban sprawl" [22]. This may explain my seemingly contradictory results (the negative relationship between walking and income determined in the NHTS, even though BMI is reduced with an increase in income level in the BRFSS).

This underscores the importance of location, and weakness of income-related reforms, in the development of policies to reduce BMI through the promotion of walking.

Location

According to model E1, which predicts effects of location on walking comparable to the predictions in the other models, those who live in "Town and

Country", "Suburban", and "Second City" walk less (around 5-6% less, significant at the 5% level) than respondents categorized as living in an "Urban" region.

This lower walking time may serve to partially explain the higher rate of obesity in rural and suburban areas referenced to in the literature [15, 16] and observed in the BRFSS 2011 analysis. As for the Second City (defined as a satellite city outside of a major city), it likely does not share the walking friendly, compact infrastructure or the major Urban area it lies outside of and may contain a larger proportion of individuals who make long commutes to work, thereby rendering walking a less attractive method of travel or exercise, again raising BMI for these individuals.

This calls for the adoption of walking friendly infrastructure present in urban settings by rural and suburban areas. Such ideas have already been explored such as increasing the connectivity of roads in residential neighborhoods, incorporation of parks and community centers, and increasing the housing density of neighborhoods [23], which actually shows a significant positive effect on walking across all models in the NHTS (even when separating model E1 by race).

I realize that implementation of public transit and walking-friendly infrastructure such as sidewalks in settings outside a major MSA is not usually economically efficient, and I therefore propose smaller scale changes personalized to the community. Along with the suggestions of *Saelens et al (2003)*, I propose communities be constructed with a "school-centered" layout in mind. This would work in most settings outside of a large MSA. There would be a school in each community center, so that most individuals would be in close proximity to a center for learning, facilitating children walking to school or taking a bus (which increases walking as observed by Edwards'). It has been shown that such school-centered communities also breed higher quality education, as teachers tend to be local residents to the community fostering a more personal and invested relationship with students [24], further promoting walking through increase in quality education as discussed.

I think the strongest assertion this paper makes is for investment in human capital, primarily education, and small-scale changes on a community based level to promote walking and thereby reduce obesity. The other options regarded, such as a gas tax, public transit and large development of areas outside of a main city, are either not politically popular or economically infeasible and thus cannot be put forth as realistic or timely choices. Education is federally mandated and managed, and small-scale community development is locally regulated, so both are thus realistic avenues through which policy can encourage walking and reduce BMI. In order to observe the large-scale reduction in the increasing rate of obesity we hope to see in the US, I propose educational reform as the most promising way of achieving this.

Admittedly, I cannot correct for endogeneity without a good instrumental variable, and the true causal relationship between walking and BMI and education and walking could be very different. Controlled experiments have shown walking to effectively reduce BMI, however no such causal relationship has been drawn between education and walking within the literature. Educated people could be people who enjoy living in urban areas and walking. On the other hand, maybe they are forced to live in urban areas to take advantage of employment opportunities that offer higher incomes and it is actually the characteristics of the location where one lives that forces he or she to walk. Even in such a case though, it would be difficult and likely inefficient to force individuals to move to Urban areas in order to promote walking and thus decrease obesity. Again, education is therefore the most promising means of curbing obesity through walking, as it is acceptable and feasible to promote education through nation-wide policy implementation.

V. Conclusion

Individuals of higher BMI are poorer, less educated, and live in either rural or suburban settings. BMI is also higher amongst minority populations. A higher prevalence of walking is noted amongst individuals who are more highly educated and who live in a city setting. In order to effectively reduce BMI through promotion of walking in the United States, we must implement policy measures that are wary of possible cultural biases associated with minority populations and focus on quality assurance of education on the national stage and small-scale community-specific development of pedestrian friendly infrastructure where economically feasible (which would have to be determined by local officials). Through such policy reform, the epidemic that is obesity may not be the insuppressible disease we thought it to be—we may just be able to walk it off.

Works Cited

1. Cynthia L. Ogden, Ph.D.; Margaret D. Carroll, M.S.P.H.; Brian K. Kit, M.D., M.P.H.; and Katherine M. Flegal, Ph.D. *Prevalence of Obesity in the United States*. NCHS Data Brief. Center for Disease Control and Prevention. January 2012. http://www.cdc.gov/obesity/data/adult.html Web.

2. James O. Hill, Holly R. Wyatt, George W. Reed, John C. Peters. *Obesity and the Environment: Where Do We Go from Here?* Science 7 February 2003: Vol. 299 no. 5608 pp. 853-855. http://dx.doi.org/10.1126/science.1079857. Web.

3. Ryan D. Edwards. *Public transit, obesity, and medical costs: Assessing the magnitudes*. Preventive Medicine Volume 46, Issue 1, January 2008, Pages 14–21 http://dx.doi.org/10.1016/j.ypmed.2007.10.004 Web.

4. Grant Gwinup, MD. *Effect of Exercise Alone on the Weight of Obese Women*. JAMA Internal Medicine: May 1975, Vol 135, No. 5. Print.

5. Alfredo Morabia, MD, PhD, and Michael C. Costanza, PhD. *Does Walking 15 Minutes per Day Keep the Obesity Epidemic Away? Simulation of the Efficacy of a Populationwide Campaign*. American Journal of Public Health. March 2004, Vol 94, No. 3. Print.

6. 10,000 Steps Program. http://www.10000steps.org.au/

7. Youfa Wang and May A. Beydoun. *The Obesity Epidemic in the United States—Gender, Age, Socioeconomic, Racial/Ethnic, and Geographic Characteristics: A Systematic Review and Meta-Regression Analysis*. Oxford Journals: January 25, 2007. Print.

8. Paul Daniel Patterson MPH, Charity G. Moore MSPH, PhD, Janice C. Probst MS, PhD, Judith Ann Shinogle MS, PhD. *Obesity and Physical Inactivity in Rural America*. The Journal of Rural Health.

9. C.E. Tudor-Locke, A.M. Myers. *Methodological considerations for researchers and practitioners using pedometers to measure physical (ambulatory) activity*. Res. Q. Exerc. Sport, 72 (1) (2001), pp. 1–12. Print.

10. Mucci LA, Wood PA, Cohen B, Clements KM, Brawarsky P, Brooks DR. *Validity of self-reported health plan information in a population-based health survey.* Journal of Public Health Management Practice. 2006, 12:570-7.

11. Hutto B, Sharpe BA, Granner ML, Addy CL, Hooker S (2008). *The effect of question order on reporting physical activity and walking behavior.* Journal of Physical Activity, 5: 16-29.

12. Tobit Model. https://files.nyu.edu/mrg217/public/tobit1.pdf

13. Autor, David H., Lawrence F. Katz and Melissa S. Kearney. *The Polarization Of The U.S. Labor Market*, American Economic Review, 2006, v96(2,May), 189-194.

14. Savelyev, Peter A. "Conscientiousness, education, and longevity of high-ability individuals." *Unpublished manuscript. University of Chicago, Department of Economics* (2010).

15. Gallimore, Jonathan M., Barbara B. Brown, and Carol M. Werner. "Walking routes to school in new urban and suburban neighborhoods: An environmental walkability analysis of blocks and routes." *Journal of Environmental Psychology* 31.2 (2011): 184-191.

16. Parks, S. E., R. A. Housemann, and R. C. Brownson. "Differential correlates of physical activity in urban and rural adults of various socioeconomic backgrounds in the United States." *Journal of Epidemiology and Community Health* 57.1 (2003): 29-35.

17. Flegal KM, Carroll MD, Ogden CL, Curtin LR. Prevalence and trends in obesity among US adults, 1999–2008. JAMA. 2010;303(3):235–241.

18. Military BMI Requirements. http://www.livestrong.com/article/359551-military-bmi-requirements/

19. Houle B. Obesity disparities among disadvantaged men: national adult male inmate prevalence pooled with non-incarcerated estimates, United States, 2002-2004. *Soc Sci Med*. 2011;72:1667–1673.

20. Birth and Fertility Rates by Educational Attainment: United States, 1994. Vol. 45 No. 10 supplement. 20 pp. (PHS) 97-1120. http://www.cdc.gov/nchs/data/mvsr/supp/mv45_10s.pdf

21. Edited by Harvard Health Publications in consultation with Miquel Alonso-Alonso, M.D., Instructor in Neurology, Harvard Medical School Division of Cognitive Neurology, Beth Israel Deaconess Medical Center; and Kathy McManus, M.S., R.D., L.D.N., Director of Nutrition, Brigham and Women's Hospital, Harvard Medical School. *Lose Weight and Keep it off*. 2012.

22. Vandegrift, Donald and Yoked, Tommer. Obesity rates, income, and suburban sprawl: an analysis of US states. *Health and Place*. Vol. 10:3. 221-229. 2004.

23. Saelens, BrianE. and Sallis, JamesF. and Frank, Lawrence D. Environmental correlates of walking and cycling: Findings from the transportation, urban design, and planning literatures. *Annals of Behavioral Medicine*. Vol. 25:2. 80-91. 2003.

24. Hopkins and Stern. Quality teachers, quality schools: International perspectives and policy implications. *Teaching and Teacher Education*. Vol. 12:5. 501-517. 1996.

25. Phelps, Charles. Applications and Extensions of Demand Theory. *Health Economics*. 2010.

TABLE 1a: BRFSS 2011 entire sample

Variable	Count	Avg/Proportion
Education		
Never attended school or only kindergarten	654	0.13
Grades 1 through 8 (Elementary)	15214	3.01
Grades 9 through 11 (Some high school)	30555	6.04
Grade 12 or GED (High school graduate)	149387	29.55
College 1 year to 3 years (Some college or technical school)	136060	26.92
College 4 years or more (College graduate)	172668	34.16
Refused/Non-response	929	0.18
Total	505467	
Income		
Less than $10,000	26736	5.29
Less than $15,000	28602	5.66
Less than $20,000	35729	7.07
Less than $25,000	43709	8.65
Less than $35,000	51745	10.24
Less than $50,000	64474	12.76
Less than $75,000	67569	13.37
$75,000 or more	114328	22.62
Don’t know/Not sure	36192	7.16
Refused	36383	7.20
Total	505467	
Age		55.34
BMI		27.62
MSA		
In the center city of an MSA	135400	26.79
Outside the center city of an MSA but inside the county containing the center city	89459	17.70
Inside a suburban county of the MSA	57761	11.43
In an MSA that has no center city	2083	0.41
Not in an MSA	144396	28.57
Refused/Non-response	302227	59.79
Total	506467	

TABLE 1b: BRFSS 2011 entire sample (cont.)

Race		
White	396273	78.40
Black	41056	8.12
Asian	9492	1.88
American Indian, Alaska Native	7088	1.40
Hispanic	38764	7.67
Other	13794	2.73
Total	506467	
Gender		
Female	198812	39.33
Male	307655	60.87
Total	506467	
Type of Physical Activity (Moderate to Vigorous)		
Walking	125288	24.79
Other	90107	17.83
None	7976	1.58
Refused/Non-response/Not Asked	283096	56.01
Total	506467	

The sample consists of adults of age 30-65 years. Household income is measured over the previous 12 months. MSA is established by the Office of Management and Budget, a division of the U.S. Government. Metropolitan statistical areas serve to group counties and cities into specific geographic areas for the purposes of a population census and accounts for population density and proximity to a major city.

TABLE 2a: BRFSS 2011 sample of those who reported walking as their primary source of exercise

Variable	Count	Avg/Proportion
Education		
Never attended school or only kindergarten	199	0.10
Grades 1 through 8 (Elementary)	5135	2.63
Grades 9 through 11 (Some high school)	10527	5.39
Grade 12 or GED (High school graduate)	55406	28.37
College 1 year to 3 years (Some college or technical school)	53677	27.48
College 4 years or more (College graduate)	69942	35.81
Refused/Non-response	436	0.22
Total	195322	
Income		
Less than $10,000	10219	5.23
Less than $15,000	10691	5.47
Less than $20,000	13450	6.89
Less than $25,000	16508	8.45
Less than $35,000	20072	10.28
Less than $50,000	25797	13.21
Less than $75,000	27534	14.10
$75,000 or more	44709	22.89
Don’t know/Not sure	12589	6.45
Refused	13753	7.04
Total	195322	
Age		56.05
Minutes of Walking (per week)		205.24
BMI		27.66
MSA		
In the center city of an MSA	54163	27.73
Outside the center city of an MSA but inside the county containing the center city	34922	17.88
Inside a suburban county of the MSA	22007	11.27
In an MSA that has no center city	816	0.42
Not in an MSA	57567	29.47
Refused/Non-response	25847	13.23
Total	195322	

TABLE 2b: BRFSS 2011 sample of those who reported walking as their primary source of exercise (cont.)

Race		
White	154867	79.29
Black	16183	8.29
Asian	3086	1.58
American Indian, Alaska Native	2849	1.46
Hispanic	13398	6.86
Other	4939	2.53
Total	195322	
Gender		
Male	66111	33.85
Female	129211	66.15
Total	195322	

The sample consists of adults of age 30-65 years who reported walking as their primary source of exercise for the month (thus there are obviously no 0 values for minutes spent walking). Household income is measured over the previous 12 months. MSA is established by the Office of Management and Budget, a division of the U.S. Government. Metropolitan statistical areas serve to group counties and cities into specific geographic areas for the purposes of a population census and accounts for population density and proximity to a major city.

TABLE 3a: BRFSS 2011 OLS regression results using subset of only those who reported walking as their primary source of exercise

	A (OLS; Walking as primary only)		B (OLS; Walking as primary only)	
Education				
Never attended school or only kindergarten	5.0128		101.1085	**
	8.7868		41.1723	
Grades 1 through 8 (Elementary)	-12.66	***	116.1265	***
	1.884		8.4269	
Grades 9 through 11 (Some high school)	-3.0591	*	90.8607	***
	1.3405		5.8842	
Grade 12 or GED (High school graduate)	-2.6435	***	81.431	***
	0.7202		3.16	
College 1 year to 3 years (Some college or technical school)	-2.3408	***	77.8727	***
	0.7018		3.0799	
College 4 years or more (College graduate)				
Income				
Less than $10,000	9.699	***	74.0939	***
	1.3405		5.8874	
Less than $15,000	4.6378	***	77.6801	***
	1.2952		5.6744	
Less than $20,000	4.7946	***	61.9081	***
	1.174		5.1477	
Less than $25,000	1.6767		51.0205	***
	1.0666		4.6682	
Less than $35,000	-2.6022	***	49.2347	***
	0.9782		4.2841	
Less than $50,000	-2.5047	***	58.7878	***
	0.8773		3.8435	
Less than $75,000	-3.3458	***	59.5258	***
	0.8489		3.717	
$75,000 or more				
Age (30-65 y.o.)	0.0641	***	-2.8814	***
	0.0175		0.0777	

TABLE 3b: BRFSS 2011 OLS regression results using subset of only those who reported walking as their primary source of exercise (cont.)

MSA				
In the center city of an MSA				
Outside the center city of an MSA but inside the county containing the center city	-1.8974	**	15.2547	***
	0.7757		3.4056	
Inside a suburban county of the MSA	-4.8874	***	33.7199	***
	0.9206		4.0419	
In an MSA that has no center city	-5.7833		-2.8863	
	4.2179		18.5246	
Not in an MSA	-7.3192	***	40.5116	***
	0.6743		2.9541	
Race				
White				
Black	-2.612	**	222.2476	***
	1.0274		4.5165	
Asian	-7.212	***	-236.134	***
	2.1784		9.5512	
American Indian, Alaska Native	17.0285	***	151.0603	***
	2.312		10.1488	
Hispanic	4.3583	***	40.7777	***
	1.1491		5.0849	
Other	11.3589	***	74.1962	***
	1.7536		7.6917	
Gender				
Male				
Female	-18.696	***	-153.652	***
	0.5761		2.5081	
Minutes Walked (per wk)			-0.0914	***
			0.0044	
Sample Size	188972		179170	

*** (0.1%); ** (1%); * (5%); . (10%). Coefficients are on top and Huber-White Robust standard errors are on bottom. Divide coefficients by 100 to get actual change in BMI.

Model A: $Min\ Spent\ Walking = \alpha + \beta(educ) + \gamma(income) + \delta(MSA) + \boldsymbol{BX} + \mu$

Model B: $BMI = \alpha + \beta(educ) + \gamma(income) + \delta(MSA) + \epsilon(min\ spent\ walking) + \boldsymbol{BX} + \varepsilon$

TABLE 4a: BRFSS 2011 OLS regression results of BMI on independent vars. using entire sample

	C (OLS; entire sample)	
Education		
Never attended school or only kindergarten	83.2667	*
	33.8228	
Grades 1 through 8 (Elementary)	139.1646	***
	7.3893	
Grades 9 through 11 (Some high school)	98.1524	***
	4.9848	
Grade 12 or GED (High school graduate)	88.9227	***
	2.667	
College 1 year to 3 years (Some college or technical school)	89.2863	***
	2.5422	
College 4 years or more (College graduate)		
Income		
Less than $10,000	69.5716	***
	4.8473	
Less than $15,000	94.6343	***
	4.98	
Less than $20,000	64.3004	***
	4.5667	
Less than $25,000	65.0471	***
	4.1447	
Less than $35,000	56.7935	***
	3.7733	
Less than $50,000	60.882	***
	3.2157	
Less than $75,000	53.7613	***
	2.9459	
$75,000 or more		
Age (30-65 y.o.)	1.4058	***
	0.1026	
MSA		
In the center city of an MSA		
Outside the center city of an MSA but inside the county containing the center city	4.3077	
	2.7798	
Inside a suburban county of the MSA	20.8902	***
	3.2672	
In an MSA that has no center city	11.9188	
	15.1379	
Not in an MSA	39.3758	***
	2.4816	

TABLE 4b: BRFSS 2011 OLS regression results of BMI on independent vars. using entire sample (cont.)

Race		
White		
Black	218.6885	***
	3.625	
Asian	-224.756	***
	7.0662	
American Indian, Alaska Native	109.2347	***
	8.0356	
Hispanic	49.3656	***
	3.917	
Other	71.5637	***
	5.9536	
Gender		
Male		
Female	-128.75	***
	2.0526	
Minutes of Physical Activity (per wk)		
Active Gaming Devices	33.505	
	24.455	
Bicycling Machine	-3.946	
	8.433	
Bicycling	-185.921	***
	6.9574	
Elliptical	-54.8867	***
	8.3663	
Football	17.0295	
	73.7834	
Racquetball	-30.3854	
	35.0641	
Running	-265.504	***
	5.0371	
Soccer	-192.175	***
	21.4265	
Shore/Stream Fishing	186.1669	
	147.5122	
Swimming	7.9524	
	11.4427	
Walking	-46.7684	***
	2.3894	
Wrestling	2.1449	
	65.0078	
None to minimal intensity		
Sample Size	293179	

*** (0.1%); ** (1%); * (5%); . (10%). Coefficients are on top and Huber-White Robust standard errors are on bottom. Divide the coefficients by 100 to get the actual change in BMI associated with the independent variables.

Model C: $BMI = \alpha + \beta(educ) + \gamma(income) + \delta(MSA) + \epsilon(min\ phys\ act\ wk) + \boldsymbol{BX} + \varepsilon$

TABLE 5a: NHTS 2009 sample of walkers and non-walkers

Variable	Count	Avg/Proportion
Education		
Less than high school graduate	26338	3.86
High school graduate, include GED	144262	21.16
Some college or Associate's degree (Vocational)	190133	27.88
Bachelor's degree (BA, AB, BS)	179594	26.34
Graduate or Professional Degree (MA,MS,MBA,MD,PHD,EdD,JD)	137426	20.16
Not ascertained/avaiable	4076	0.60
Total	681829	
Income		$71,200
Gas Price (cents)		286.20
Population Density (per sq. mile)		3541
Housing Density (per sq. mile)		1550
Age (restricted to 30-65 y.o.)		50.30
Location		
Second City	120282	17.64
Suburban	170728	25.04
Town/Country	317768	46.61
Urban	73037	10.71
Other	12	1.76E-03
Not ascertained/avaiable	2	3.00E-04
Total	681829	

TABLE 5b: NHTS 2009 sample of walkers and non-walkers (cont.)

Race		
White	586440	86.01
African American, Black	36776	5.39
Asian Only	16054	2.35
American Indian, Alaskan Native	4925	0.72
Native Hawaiian, other Pacific	2067	0.30
Multiracial	4509	0.66
Hispanic/Mexican	18213	2.67
Other	7024	1.96
Not ascertained/avaiable	5821	0.85
Total	681829	
Gender		
Male	304043	44.59
Female	377786	55.41
Total	681829	
Time		
Weekend	200267	29.37
Week Day	481562	70.63
Total	681829	
Reason for Trip		
To engage in physical exercise (gym, sports, etc.)	24831	3.64
Other	653741	95.88
Not ascertained/available	3257	0.48
Total	681829	
Minutes Spent Walking (per trvl day)		1.29
% of respondents who report walking		8.52
Sample Size	681829	

The sample consists of adults of age 30-65 years. Household income is measured over the previous 12 months. Location is defined as an individual's permanent residence and is categorized by one of the four domains presented in the table according to a density centile score and whether it is designated as a population center for its surrounding communities as determined by Claritas, Inc. This is a classification used by most research and marketing institutions.

TABLE 6a: NHTS 2009 sample of walkers only

Variable	Count	Avg/Proportion
Education		
Less than high school graduate	2719	4.68
High school graduate, include GED	9408	16.19
Some college or Associate's degree (Vocational)	13714	23.61
Bachelor's degree (BA, AB, BS)	16320	28.10
Graduate or Professional Degree (MA,MS,MBA,MD,PHD,EdD,JD)	15572	26.81
Not ascertained/available	350	0.60
Total	58083	
Income		$70,740
Gas Price (cents)		290.2
Population Density (per sq. mile)		5366
Housing Density (per sq. mile)		2843
Age (restricted to 30-65 y.o.)		50.39
Location		
Second City	10866	18.71
Suburban	14589	25.12
Town/Country	21766	37.47
Urban	10859	18.69
Other	3	0.01
Total	58083	

TABLE 6b: NHTS 2009 sample of walkers only (cont.)

Race		
White	49413	85.07
African American, Black	2905	5.00
Asian Only	1540	2.65
American Indian, Alaskan Native	497	0.86
Native Hawaiian, other Pacific	178	0.31
Multiracial	420	0.72
Hispanic/Mexican	1769	3.05
Other	711	2.33
Not ascertained/available	650	1.12
Total	58083	
Gender		
Male	25335	43.62
Female	32748	56.38
Total	58083	
Time		
Weekend	17085	29.41
Week Day	40998	70.59
Total	58083	
Reason for Trip		
To engage in physical exercise (gym, sports, etc.)	12264	21.11
Other	45819	78.89
Not ascertained/available	80	0.14
Total	58083	

The sample consists of adults of age 30-65 years who reported at least 1 minute of walking throughout their designated travel day. Household income is measured over the previous 12 months. Location is defined as an individual's permanent residence and is categorized by one of the four domains presented in the table according to a density centile score and whether it is designated as a population center for its surrounding communities as determined by Claritas, Inc. This is a classification used by most research and marketing institutions.

TABLE 7a: NHTS 2009 OLS regression results

	D1 (OLS; walking only)	D2 (OLS; walking only)	E1 (OLS; entire sample)	E2 (OLS; entire sample)
Education				
Less than high school graduate	3.20 *	2.38E+00	1.39	3.03
	1.52E-02	1.75E-02	2.69E-02	3.21E-02
High school graduate, include GED	-1.67 .	-1.15	-7.57 ***	-6.40 ***
	9.25E-03	1.08E-02	1.38E-02	1.53E-02
Some college or Associate's degree (Vocational)	-1.09	-8.51E-01	-5.18 ***	-4.48 **
	8.17E-03	9.56E-03	1.29E-02	1.42E-02
Bachelor's degree (BA, AB, BS)				
Graduate or Professional Degree (MA,MS,MBA,MD,PHD,EdD,JD)	-1.07E-01	3.52E-01	5.58 ***	4.69 **
	8.06E-03	9.38E-03	1.55E-02	1.67E-02
ln(Income)	2.90E-02 ***	2.07E-02 ***	-5.36E-02 ***	-4.72E-02 ***
	4.85E-03	5.69E-03	1.00E-02	1.08E-02
Gas Price	3.82E-02 ***	4.27E-02 ***	1.42E-02 **	1.80E-02 ***
	3.05E-05	3.58E-05	5.08E-05	5.42E-05
Population Density	1.73E-04 .	2.98E-04 **	-7.31E-05	-3.11E-04
	9.90E-07	1.13E-06	2.81E-06	2.98E-06
Housing Density	-6.15E-04 ***	-7.00E-04 ***	2.63E-03 ***	3.12E-03 ***
	1.14E-06	1.32E-06	4.88E-06	5.33E-06
Age	2.78E-03 ***	3.42E-01 ***	4.76E-02	2.62E-03
	1.89E-04	2.19E-04	5.89E-04	5.69E-04
Location				
Second City	5.31E-01	2.39E-01	-6.72 **	-8.45 **
	1.07E-02	1.23E-02	2.20E-02	2.62E-02
Suburban	4.91E-01	3.79E-01	-5.37 *	-5.34 .
	1.12E-02	1.30E-02	2.31E-02	2.78E-02
Town/Country	-3.53 **	-4.28 **	-6.92 **	-7.95 **
	1.20E-02	1.39E-02	2.49E-02	2.96E-02
Urban				

TABLE 7b: NHTS 2009 OLS regression results (cont.)

	D1 (OLS; walking only)		D2 (OLS; walking only)		E1 (OLS; entire sample)		E2 (OLS; entire sample)	
Race								
White								
African American, Black	5.40	***	3.83	*	-6.75	***	-6.84	**
	1.42E-02		1.61E-02		1.81E-02		2.12E-02	
Asian Only	7.05	***	5.28	*	-5.76	*	-4.26	
	1.79E-02		2.10E-02		2.93E-02		3.52E-02	
American Indian, Alaskan Native	1.43E+01	***	1.30E+01	***	2.16		-6.00	
	3.03E-02		3.66E-02		5.57E-02		5.96E-02	
Native Hawaiian, other Pacific	-3.80E-01		-7.14		-1.25E+01	*	-1.50E+01	*
	5.39E-02		6.18E-02		5.81E-02		6.61E-02	
Multiracial	4.01		5.71		6.29E-01		1.08	
	3.25E-02		3.76E-02		5.92E-02		7.09E-02	
Hispanic/Mexican	1.77E+01	***	1.72E+01	***	-5.04	.	-4.33	
	1.75E-02		2.04E-02		2.93E-02		3.50E-02	
Other	1.39E+01	***	1.40E+01	***	-1.18		-3.51	
	2.83E-02		3.25E-02		4.84E-02		5.52E-02	
Gender								
Male	3.07	***	2.30	***	8.41E-01		1.13	
	5.82E-03		6.78E-03		8.87E-03		1.06E-02	
Female								
Time								
Weekends Included	YES		NO		YES		NO	
Sample Size	78113		55471		100354		80721	

*** (0.1%); ** (1%); * (5%); . (10%)

Coefficients are on top and Huber-White Robust standard errors are on bottom. The “Other” category in location is removed, as there exist only 12 observations in the entire sample and 3 for the sample excluding non-walkers, which is too small a subset for accurate comparison to the other locations. There also exist no weekday travelers that live in “Other” and thus returns NULL for “Other”.

Model Key

D1 and D2 (OLS run on sample of walkers only): $Min\ Spent\ Walking = \alpha + \beta(educ) + \gamma(income) + \delta(location) + \boldsymbol{BX} + \mu$

E1 and E2 (OLS run on sample of walkers and non-walkers): $\ln(Min\ Spent\ Walking + 1) = \alpha + \beta(educ) + \gamma(income) + \delta(location) + \boldsymbol{BX} + \mu$

TABLE 8a: NHTS 2009 probit and tobit results

	F1 (Probit Marg Eff)		F2 (Probit Marg Eff)		G1 (Tobit)		G2 (Tobit)	
Education								
Less than high school graduate	-0.014	*	-0.005		-3.32	*	-9.80E-01	
	0.006		0.008		1.47		2.31	
High school graduate, include GED	-0.028	***	-0.026	***	-6.63	***	-6.22	***
	0.003		0.004		8.04E-01		1.29	
Some college or Associate's degree (Vocational)	-0.019	***	-0.016	***	-4.57	***	-4.74	***
	0.003		0.004		7.08E-01		1.13	
Bachelor's degree (BA, AB, BS)								
Graduate or Professional Degree (MA,MS,MBA,MD,PHD,EdD,JD)	0.017	***	0.019	***	2.85	***	3.79	***
	0.004		0.004		7.19E-01		1.13	
ln(Income)	-0.02	***	-0.019	***	-4.11	***	-1.92	*
	0.002		0.003		4.62E-01		7.47E-01	
Gas Price	4.15E-05	***	5.71E-05	***	1.47E-02	***	1.73E-02	***
	1.73E-05		2.06E-05		2.70E-03		4.31E-03	
Population Density	9.00E-07		9.00E-07	.	1.66E-04		1.96E-04	
	6.00E-07		8.00E-07		1.03E-04		1.61E-04	
Housing Density	5.50E-06	***	5.60E-06	***	1.01E-03	***	9.20E-04	***
	8.00E-07		1.00E-06		1.30E-04		2.01E-04	
Age	1.04E-04		8.94E-05		3.49E-02		-1.13E-03	
	1.75E-04		2.09E-04		2.71E-02		4.35E-02	
Location								
Second City	-0.013	*	-0.02	**	-1.98	*	-2.15	
	0.005		0.005		1.00		1.61	
Suburban	-0.007	.	-0.015	*	-1.70		1.95	
	0.005		0.005		1.06		1.70	
Town/Country	-0.011	**	-0.02	***	-3.04	**	-4.37	*
	0.005		0.006		1.14		1.83	
Urban								

TABLE 8b: NHTS 2009 probit and tobit results (cont.)

	F1 (Probit Marg Eff)	F2 (Probit Marg Eff)	G1 (Tobit)	G2 (Tobit)
Race				
White				
African American, Black	-0.022 **	-0.023 **	-3.11 **	-1.69 .
	0.004	0.005	1.17	1.84
Asian Only	-0.002	0.009	3.54E-01	-3.95
	0.007	0.009	1.57	2.65
American Indian, Alaskan Native	-0.006	-0.016	3.46	4.26
	0.013	0.015	2.75	4.01
Native Hawaiian, other Pacific	-0.022	-0.018	-5.57	3.20
	0.017	0.021	4.79	6.62
Multiracial	0.008	0.003	2.21	7.95 .
	0.014	0.017	2.80	4.34
Hispanic/Mexican	-0.015	-0.015	-2.74E-01	3.02
	0.007	0.008	1.60	2.52
Other	0.003	-0.001	8.56E-01	5.10
	0.011	0.013	2.37	3.87
Gender				
Male	-0.006 *	-0.005	-1.10 *	-1.51 .
	0.002	0.003	5.15E-01	8.22E-01
Female				
Time				
Weekends Included	YES	NO	YES	NO
Sample Size	46326	38360	27426	19422

*** (0.1%); ** (1%); * (5%); . (10%)

Coefficients are on top and Huber-White Robust standard errors are on bottom. The “Other” category in location is removed, as there exist only 12 observations in the entire sample and 3 for the sample excluding non-walkers, which is too small a subset for accurate comparison to the other locations. There also exist no weekday travelers that live in “Other” and thus returns NULL for “Other”.

Model Key

F1 and F2 (marginal effects of probit run on sample of walkers and non-walkers): $Min\ Spent\ Walking = \alpha + \beta(educ) + \gamma(income) + \delta(location) + \boldsymbol{BX} + \mu$

G1 and G2 (tobit run on sample of walkers and non-walkers): $Min\ Spent\ Walking = \alpha + \beta(educ) + \gamma(income) + \delta(location) + \boldsymbol{BX} + \mu$

TABLE 9a: NHTS 2009 Gender Comparison

	Male		Female	
Education				
Less than high school graduate	-7.35	**	7.15E-01	
	2.69E-02		3.21E-02	
High school graduate, include GED	-7.92	***	-6.56	***
	1.38E-02		1.53E-02	
Some college or Associate's degree (Vocational)	-6.53	***	-4.23	**
	1.29E-02		1.42E-02	
Bachelor's degree (BA, AB, BS)				
Graduate or Professional Degree (MA,MS,MBA,MD,PHD,EdD,JD)	5.16	***	2.16	**
	1.55E-02		1.67E-02	
ln(Income)	-5.36E-02	***	-4.72E-02	***
	1.00E-02		1.08E-02	
Gas Price	1.31E-02	**	1.99E-02	***
	5.08E-05		5.42E-05	
Population Density	-1.21E-04		1.66E-04	
	2.81E-06		2.98E-06	
Housing Density	2.68E-03	***	2.43E-03	***
	4.88E-06		5.33E-06	
Age	8.04E-02		2.79E-02	
	5.89E-04		5.69E-04	
Location				
Second City	-1.64	**	-3.23	**
	2.20E-02		2.62E-02	
Suburban	-2.69E-01	*	-2.26	.
	2.31E-02		2.78E-02	
Town/Country	-1.13	**	-2.57	**
	2.49E-02		2.96E-02	
Urban				

TABLE 9b: NHTS 2009 Gender Comparison (cont.)

Race				
White				
African American, Black	-2.79	***	-4.14	**
	1.81E-02		2.12E-02	
Asian Only	1.35	*	-2.35E-01	
	2.93E-02		3.52E-02	
American Indian, Alaskan Native	6.70		3.87	
	5.57E-02		5.96E-02	
Native Hawaiian, other Pacific	-1.25E+01	*	-3.28	*
	5.81E-02		6.61E-02	
Multiracial	-2.18E-01		5.77	
	5.92E-02		7.09E-02	
Hispanic/Mexican	5.11E-01	.	7.04E-01	
	2.93E-02		3.50E-02	
Other	-3.91		5.28	
	4.84E-02		5.52E-02	
Time				
Weekends Included	YES		YES	
Sample Size	24442		30166	

*** (0.1%); ** (1%); * (5%); . (10%)

Coefficients are on top and Huber-White Robust standard errors are on bottom.

TABLE 10: NHTS 2009 Race Comparison

	White		Black		Hispanic		Entire Sample (B1)	
Education								
Less than high school graduate	-6.75E-02	**	9.32E-02		4.09E-02		1.39E+00	
	2.06E-02		8.08E-02		1.86E-02		2.69E-02	
High school graduate, include GED	-9.59E-02	***	1.03E-02		1.86E-02		-7.57E+00	***
	9.64E-03		3.63E-02		6.33E-02		1.38E-02	
Some college or Associate's degree (Vocational)	-7.88E-02	***	-4.47E-02		-3.96E-03		-5.18E+00	***
	8.88E-03		3.13E-02		5.94E-02		1.29E-02	
Bachelor's degree (BA, AB, BS)								
Graduate or Professional Degree (MA,MS,MBA,MD,PHD,EdD,JD)	2.70E-02	*	5.93E-02		1.88E-01	*	5.58E+00	***
	1.06E-02		4.28E-02		9.57E-02		1.55E-02	
ln(Income)	-2.59E-02	***	-8.81E-02	***	-1.62E-01		-5.36E-02	***
	6.93E-03		2.01E-02		3.71E-02		1.00E-02	
Gas Price	9.30E-05	**	-9.63E-05		1.79E-04		1.42E-02	**
	3.47E-05		1.23E-04		2.11E-04		5.08E-05	
Population Density	1.32E-06		-3.91E-06		9.72E-06		-7.31E-05	
	2.13E-06		6.16E-06		6.19E-06		2.81E-06	
Housing Density	2.92E-05	***	2.92E-05	**	6.49E-06		2.63E-03	***
	3.60E-06		9.80E-06		1.08E-05		4.88E-06	
Age	1.45E-03	***	-2.68E-03	*	-7.69E-04		4.76E-02	
	3.48E-04		1.29E-03		2.14E-03		5.89E-04	
Location								
Second City	-1.59E-02		-4.90E-02		-1.13E-01	.	-6.72E+00	**
	1.66E-02		4.73E-02		5.81E-02		2.20E-02	
Suburban	-6.88E-04		-3.10E-02		4.71E-02		-5.37E+00	*
	1.85E-02		5.03E-02		7.15E-02		2.31E-02	
Town/Country	6.14E-03		-6.76E-02		-8.15E-02		-6.92E+00	**
	1.71E-02		5.56E-02		7.10E-02		2.49E-02	
Urban								
Gender								
Male	-1.73E-02	**	3.04E-02		1.95E-02		8.41E-01	
	6.56E-03		2.45E-02		4.20E-02		8.87E-03	
Female								
Time								
Weekends Included	YES		YES		YES		YES	
Sample Size	47744		3017		1458		100354	

*** (0.1%); ** (1%); * (5%); . (10%)

Coefficients are on top and Huber-White Robust standard errors are on bottom.