The Role of Time Use in Promoting Healthy Energy Balance

Contractor and Cooperator Report No. 70
December 2011

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Abstract

This study assesses the relationship between time use and body mass index (BMI) and shows time use changes since the 1970s. The analyses suggest eating-related time, food preparation time (for women only), and television viewing time are all linked to BMI. Between 1975-76 and 2006-07, American women and men spent less time in primary eating/drinking activities and more in secondary eating/drinking. Food preparation and clean-up time declined substantially for women while it increased modestly for men. Television/video viewing time rose modestly. Analyses suggest that socio-demographic shifts, especially the decline in married couples with minor children, the decline in men's employment, and the rise in women's employment, may be contributing to less healthy weight-related time use choices.

Acknowledgments

The author wishes to thank Robert Stevens for his invaluable research assistance and W. Keith Bryant for his thoughtful comments.

This study was conducted by the University of Utah, under a cooperative research agreement with USDA's Economic Research Service (ERS) Food Assistance and Nutrition Research Program (FANRP): agreement number 58-5000-7-0133 (ERS project representatives: Joanne Guthrie and Hodan Farah Wells). The views expressed are those of the author and not necessarily those of ERS or USDA.

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Executive Summary

Americans' weight gain over the past 30+ years has created a serious public health challenge. In the late 1970s, 23.2 percent of Americans age 20-74 were obese (ie.., body mass index $\geq$ 30.0) (Flegal et al. 1998). This number had climbed to 32.2 percent by 2007-08 (Flegal, Carroll, and Ogden 2010) and it is projected that by 2020, this percentage will grow to 41.8 percent (Ruhm 2007). Concern about the health challenges posed by Americans' growing waistlines has precipitated a spate of research that relates time use choices regarding physical (in)activity and eating to weight as measured by the body mass index (BMI).

The current research builds on the existing literature in several ways. First, none of the studies done to date allow for the possibility that BMI and time use are simultaneously determined. That is, choices about time use may have implications for BMI and BMI may influence choices about time use. If this is true, then past investigations may misstate the magnitude of the relationship between time spent in specific activities and BMI. Second, although the literature shows that food stamp program (FSP) participation is linked to higher BMIs for women, few explanations for the observed relationship have been put forth. We assess if differences in time use partially explain the positive association between FSP participation and BMI among low-income women. Third, very little research has examined the question of what drives Americans' weight-related time use choices (e.g., eating time, physical activity time) and how these choices may be shifting over time. Existing studies often highlight trends in specific time use categories in isolation (e.g., trends in vigorous physical activity time) and they do not typically investigate the underlying reasons for any observed shifts. We provide a more comprehensive picture of trends in energy balance-related time use and assess the extent to which socio-demographic and economic factors have contributed to the observed changes.

The data for this research project come from four nationally representative surveys that utilize the same basic methodology to gather 24-hour recall time diaries for respondents. The four data sets are: (a) The 1975-76 Time Use in Economic and Social Accounts (TUESA) (Juster et al. 2001), (b) The Americans' Use of Time, 1985 (ATUS) (Robinson 2007), (c) The Family Interaction, Social Capital, and Trends in Time Use, 1998-99 (FISCT) (Robinson, Bianchi, and Presser 2001), and (d) The combined 2006 and 2007 American Time Use Surveys linked to the 2006 and 2007 Eating and Health Modules (ATUS) (U.S. Bureau of Labor Statistics 2008). The samples used in the current analyses are limited to respondents who were age 25 to 64 at the time of the survey.

We make use of the household production framework (Becker 1965; Becker 1991) that allows us to (1) explicitly recognize that time use choices may affect BMI and BMI may affect time use choices, (2) identify specific types of time that are hypothesized to be associated with weight, and (3) elaborate on what roles, if any, prices, wages, and food stamp eligibility/receipt play in the weight-related time use choices that people make.

Using nationally representative data from the ATUS06-07, we find that cross-sectional analyses that do not adjust for the likelihood that BMI and time use are simultaneously determined likely misstate the true impact of time use on BMI. We also conclude that Americans' time use decisions have important implications for their BMIs. The analyses suggest that both eating and beverage drinking time and context matters. The more time Americans spend in primary eating activities, the lower their BMI and the more time that Americans spend drinking beverages as a secondary activity, the higher their BMIs. In the case of women only, time spent in food preparation is inversely related to BMI while for men only, time spent sleeping is inversely related to BMI. For both men and women, sedentary time, as measured by

television/video viewing time is positively related to BMI. In addition, the reduced form models suggest that increases in grocery prices, opportunity costs, and non-wage income are all associated with lower a BMI, holding other factors constant.

When we turn our focus to low-income food stamp-eligible individuals in the ATUS06-07, we observe a positive association between FSP participation and BMI for women even after we control for self-selection into the FSP. But, we conclude that there is little evidence that FSP participation alters low-income women's physical (in)activity or eating patterns, with the exception of secondary time spent drinking liquids. The absence of evidence regarding shifts in weight related time use associated with FSP participation suggests that researchers may want to examine other possible explanations for the female FSP participants' relatively higher BMIs.

In taking a closer descriptive look at four different nationally representative time use data sets, we observe that between 1975-76 and 2006-07, American women and men made considerable changes in how they chose to allocate the time they spend in weight-related activities. Time spent in primary eating/drinking activities declined, secondary eating/drinking time rose, and physical activity time rose for both men and women. Food preparation and clean-up time declined substantially for women while it increased modestly for men. In contrast, television/video viewing time increased modestly while sleep time both remained relatively constant. Multivariate analyses reveal that there have not been significant structural changes in the relationship between socio-demographic factors and time use over this historical period for men. Instead, men's observed time use shifts appear to be the result of shifting socio-demographic characteristics (e.g., decline in the fraction of men who are married). In contrast, both changes in the structural relationships and shifts in socio-demographic characteristics are associated with women's shifting time use.

Taken together, our findings regarding trends in primary eating time, secondary drinking time, and time spent in food preparation and clean-up (by women) and their relationship to BMI serve to reinforce nutritional educators' emphasis on preparing meals and setting aside time where eating is one's primary focus. In addition, it is unlikely that time use choices play a large role in the elevated obesity risk observed among female food stamp recipients. On the physical activity side of the balance sheet, our analyses suggest that public health directives aimed at getting people to turn off their television may also be key to shifting Americans' energy balance toward healthy body weights. Analyses of time use trends suggest that socio-demographic shifts, especially the decline in the fraction of adults who are married with minor children in the home, the decline in men's employment and the rise in women's employment, may be contributing to less healthy time use choices.

The Role of Time Use in Promoting Healthy Energy Balance

Americans' weight gain over the past 30+ years has created a serious public health challenge. In the late 1970s, 23.2 percent of Americans age 20-74 were obese (ie.., body mass index $\geq$ 30.0) (Flegal et al. 1998). This number had climbed to 32.2 percent by 2007-08 (Flegal, Carroll, and Ogden 2010). Moreover, it is projected that by 2020, this percentage will grow to 41.8 percent (Ruhm 2007). Obesity rates today are especially high among certain groups including Black women (Office of Minority Health 2011) and female food stamp recipients (Chen, Yen, and Eastwood 2005; Gibson 2003; Meyerhoefer and Pylypchuk 2008). The dramatic growth in obesity rates, overall and among specific sub-groups, portends a future where Americans health care expenditures will continue to rise because of the association between weight and the risk of contracting heart disease, type 2 diabetes, and certain types of cancers.

Concern about the health challenges posed by Americans' growing waistlines has precipitated a spate of research that relates time use choices regarding physical (in)activity to weight as measured by the body mass index (BMI). Not surprisingly, cross-sectional investigations of physical (in)activity typically conclude that higher levels of physical activity are linked to lower BMI (Ching et al. 1996; DiPietro 1995; Gordon-Larsen, Adair, and Popkin 2002; Dunton et al. 2009; Tudor-Locke et al. 2010; Strath et al. 2008) while more sedentary time spent watching television is associated with higher BMI (Bowman 2006; Tucker and Bagwell 1991; Bowman 2006; Cleland et al. 2008; Dunton et al. 2009; Tudor-Locke et al. 2010; Brown et al. 2011).

Less work has been done that examines time spent in eating-related activities and BMI, but here too a relatively clear pattern emerges. These studies typically find that people tend to

consume more calories if they eat/drink while simultaneously engaged in other activities (Bellisle and Dalix 2001; Bertrand and Schanzenbach 2009; Stroebele and De Castro 2004, 2004, 2006; Wansink 2004, 2006). In addition, the more time people spend eating where eating is their primary focus (e.g., sitting down to a meal), the lower their BMIs (Hamermesh 2010).

In this research project, we build on the existing literature in several ways. First, none of the studies done to date allow for the possibility that BMI and time use are simultaneously determined. That is, choices about time use may have implications for BMI and BMI may influence choices about time use. If this is true, then past investigations may misstate the magnitude of the relationship between time spent in specific activities and BMI. Second, although the literature shows that FSP participation is linked to higher BMIs for women, few explanations for the observed relationship have been put forth. We assess if differences in time use partially explain the positive association between FSP participation and BMI among low-income women. Third, very little research has examined the question of what drives Americans' energy balance-related time use choices and how these choices may be shifting over time. Existing studies often highlight trends of specific time use categories in isolation (e.g., trends in vigorous physical activity time) and they do not typically investigate the underlying reasons for any observed shifts. We provide a more comprehensive picture of trends in energy balance-related time use and we assess the extent to which socio-demographic and economic factors have contributed to the observed changes.

The report is organized around answering the following research questions:

1. *Are choices about time use and BMI endogenous?*
2. *Among low-income individuals, does food stamp program participation affect energy balance-related time use?*

3. *How has the composition of energy balance-related time use shifted over the past 30+ years and what socio-demographic and economic factors are linked to observed shifts?*

We conclude that BMI and time use choices are endogenous and that cross-sectional analyses that do not adjust for this likelihood likely under-estimate the true impact of time use on BMI. After adjusting for endogeneity, we find evidence of significant relationships between sedentary time, eating time, and food preparation time (for women only), and BMI. In addition, the reduced form models suggest that increases in grocery prices, opportunity costs, and non-wage income are all associated with lower a BMI.

We find little evidence that food stamp program participation affects weight-related time use. The absence of evidence regarding shifts in weight related time use associated with FSP participation suggests that researchers may want to examine other possible explanations for the female FSP participants' relatively higher BMIs.

Finally, we observe that between 1975-76 and 2006-07, Americans time spent in primary eating/drinking activities declined, secondary eating/drinking time rose, and physical activity time rose for both men and women. Food preparation and clean-up time declined substantially for women while it increased modestly for men. In contrast, television/video viewing time has increased only modestly while sleep time has remained relatively constant. Multivariate analyses reveal that both changes in the characteristics of the population (e.g., percent married) and changes in the relationship between socio-demographic variables and time use are responsible for this shift.

The Data Used to Answer the Questions

The data for this research project come from four nationally representative surveys that utilize the same basic methodology to gather 24-hour recall time diaries for respondents. Diary

based information is considered to be the most valid and reliable way to measure time use (Bianchi, Robinson, and Milkie 2006; Robinson 1985). The four data sets are: (a) The 1975-76 Time Use in Economic and Social Accounts (TUESA) (Juster et al. 2001), (b) The Americans' Use of Time, 1985 (ATUS) (Robinson 2007), (c) The Family Interaction, Social Capital, and Trends in Time Use, 1998-99 (FISCT) (Robinson, Bianchi, and Presser 2001), and (d) The combined 2006 and 2007 American Time Use Surveys linked to the 2006 and 2007 Eating and Health Modules (ATUS) (U.S. Bureau of Labor Statistics 2008).

The samples used in the current analyses are limited to respondents who were age 25 to 64 at the time of the survey. Younger respondents are excluded so as to avoid the inclusion of individuals whose eating and exercise habits may be dictated by their parents. Respondents over age 64 are excluded because these individuals are more likely to have health conditions that may affect some aspects of their time use. Key information about each survey including sample design, time period, mode of administration, and respondent criteria is summarized in Table 1.

Table 1. Time Diary Data Sets Used in the Analyses

	TUESA75-76	ATUS85	FISCT98-99	ATUS06-07
Sample Design	Multi-stage area probability sample	Simple random sample (telephone and mail-back) and stratified sample (personal interviews)	Simple random sample	Stratified three-stage sample[b]
Time Period	10/1/75-11/30/75[a]	1/1/85-6/30/86	3/7/98 - 12/9/99	1/1/06-12/31/07
Mode of Administration	Personal Interviews	Telephone, mail-back and personal interview surveys	Telephone	Telephone
Respondent Criteria	Randomly selected individual in the household age 18 or older plus his/her spouse if s/he was married	Randomly selected adults age 18 or older living in the contiguous United States	Randomly selected individual in the household age 18 or older	Randomly selected individual in the household age 15 or older
N	2,406	4,939	1,151	25,189[b]

[a] Respondents in the TUESA completed up to four, 24-hour diaries between 10/1/75 and 9/30/76. Following past research (Robinson and Godby 1997; Bianchi, Robinson, and Milkie 2006), we use only the Wave 1 diaries from October and November 1975 in order to maintain comparability with the other surveys were diary data for only one day have been gathered.

[b]There were 12,943 respondents in the 2006 ATUS and 12,246 respondents in the 2007 ATUS.

The extraordinary level of detail in the ATUS06-07, FISCT98-99, and TUESA75-76 allow us to separate time spent eating into time spent eating where eating is the respondent's

primary focus and secondary eating time (i.e., time when the respondent's primary activity was something other than eating, but when eating was still taking place). The ATUS06-07 also allows for the separation of secondary drinking time from secondary eating time. We capitalize on the comparative advantages of these four data sets in several of the analyses presented here. All analyses done with each of the four surveys are weighted using the appropriate sampling weights included with the data sets.

None of the four data sets contain the type of detail on respondents' nonwage income and wage rates that we would like to have (e.g., income is often measured as a categorical variable). Consequently, we turn to the March Supplement to the Current Population Survey to generate opportunity cost-based wage rates and household nonwage income estimates. We use individuals age 25-64 in the various March Supplement to estimate wage equations that correct for sample selection bias using the techniques developed by James Heckman (Heckman 1979). Equations are estimated separately for women and men using the appropriate CPS weights. Coefficients from these equations are used to generate predicted hourly opportunity costs of time for each respondent. A random error is added to each predicted wage based on a mean of zero and a variance that is equal to the variance of the estimating equation. Estimates of offered wage rates provide approximate opportunity cost estimates of the value of time for employed individuals and lower-bound estimates of the value of time for non-employed individuals (Heckman 1979).

In the case of household nonwage income, we again restrict the CPS sample to individuals age 25-64 in each of the appropriate years. We then estimate regressions using the appropriate CPS weights where total, annual nonwage income for the household is the dependent variable. Coefficients from these equations are then used to generate predicted nonwage income values for our four samples of respondents. A random error is added to each predicted nonwage

income value based on a mean of zero and a variance that is equal to the variance of the estimating equation.

Both the opportunity cost estimates and the income estimates are presented in terms of 2006 dollars. The equations on which these estimates are based are available from the author upon request.

Finally, for selected analyses that make use of the ATUS06-07, we use grocery price data and data on the structure of the food stamp program (FSP) in a state. Grocery price data come from the Council for Community and Economic Research's (C2ER) state-based cost of living index for 2006 and 2007 (American Chamber of Commerce Research Association 2008). The only detailed geographic information contained in the ATUS is the respondent's state of residence and residential urbanicity. Thus, our linkage of grocery price information is done based on information about the respondent's state of residence, urban/rural status, and the quarter in which the respondent was interviewed. In those rare cases where the respondent was located in a micro area within a state that had no micro grocery price index, we use the state-wide average. Data on the structure of the FSP in each state are obtained from the Food Stamp Program Rules Database (Finegold, Margrabe, and Ratcliffe 2007). This information is linked to the ATUS06-07 based on the respondent's state of residence.

The Analysis Approach

We make use of the household production framework (Becker 1965; Becker 1991) that allows us to (1) explicitly recognizes the possible endogeneity in the choices regarding time use and energy balance outcomes; (2) identify specific types of time that are associated with positive energy balance; and (3) elaborate on what roles, if any, prices, wages, and food stamp

eligibility/receipt play in the input demand for specific types of time and the production of energy balance as measured by BMI. In the context of a one-period model, an individual is posited to gain utility or satisfaction from (1) energy balance (as captured by BMI), participation in the food stamp program ($P_f = 1$ if the household participates in the food stamp program and 0 if not), and (2) other home produced goods (G), conditional on a set of pre-existing preference shifters ($\underline{Z_u}$). Mathematically,

$$(1) \qquad U = u(BMI, P_f, G; \underline{Z_u}) = u(BMI, G; \underline{Z_u}) + \delta P_f$$

where δ = the marginal disutility of participation in the food stamp program. Disutility is assumed to occur because of stigma and the fixed costs of participation, i.e., $\frac{\partial U}{\partial P_f} < 0$.

This formulation follows the general approaches developed by others (Cawley 2004; Hamermesh 2008). In this simplest formulation, an individual combines his/her primary times spent in food-related activities (T_f), and physical activities (T_e), and a vector of market goods ($\underline{X_{fe}}$) to produce BMI. Mathematically,

$$(2) \qquad BMI = b(T_f, T_e, \underline{X_{fe}}; \underline{Z_{fe}}) \qquad \frac{\partial BMI}{\partial T_i} > 0 \qquad i=f, e$$

where $\underline{Z_{fe}}$ is a vector of predetermined variables that influence an individual's technical ability to produce energy balance (e.g., gender, age). Similarly, there is a standard production function for other home produced goods, G. Mathematically,

$$(3) \qquad G = g(T_g, \underline{X_g}; \underline{Z_g}) \qquad \frac{\partial G}{\partial T_g} > 0$$

By substituting (2) and (3) into (1), the household utility function becomes,

(4) $U = u[b(T_f, T_e, \underline{X}_{fe}; \underline{Z}_{fp}), g(T_g, \underline{X}_g; \underline{Z}_g), P_f; \underline{Z}_u]$

In addition to facing the technological constraints imposed by the household production functions described in (2) and (3), the individual also faces income and time constraints,

(5) $\underline{X}\underline{P} = wM + V + P_f(B_f(M) - C_f)$

(6) $T = T_f + T_e + T_g + M$

where, $\underline{X} = \underline{X}_{fe} + \underline{X}_g$, $\underline{P}$ = price vector for the market goods, w = wage rate of the individual, M = hours of market work of the individual, V = nonlabor income, $B_f(M)$ = the benefit function for the food stamp program, C_f = the monetary costs of participating in the food stamp program, T is the total amount of time available to the individual, and all other variables continue to be defined as they were previously. By solving for M in equation (6) and substituting it in equation (5), the full income constraint becomes,

(7) $Tw + V + P_f(B_f(M) - C_f) = \underline{X}\underline{P} + T_f w + T_e w + T_g w$

The input demand equations for an individual's time are derived by maximizing equation (4) subject to the full income constraint specified by equation (7), and solving for the first order conditions. The reduced form demand equations for time inputs in this model have the following general format,

(9) $T_j = t(w, \underline{P}, V, P_f(B_f(M) - C_f); \underline{Z}_{fe}, \underline{Z}_u, \underline{Z}_g)$ j=f,e,g.

The primary insight we gain from the above formulation is that the technical relationships between production inputs and the production outputs affect the demand for time spent in food related activities and physical activities along with preferences, prices, income, and food stamp participation. Simultaneously, choices about time affect the production of household commodities, including energy balance. Thus, to test the hypothesis that food related time and

physical activity time affect energy balance, one should ideally estimate the system of time-use equations simultaneously with the structural production function after imposing the restrictions implied by the technical relationships underlying the production functions and the preference ordering relationships underlying the utility function.

The household production model described above guides our multivariate empirical work. Practical data issues (e.g., time use censoring at zero, the absence of good wage rate information and data on spouses' time use) prevented us from expanding the model in several ways that we had originally planned. Specifically, we were not able to allow for endogeneity of wage rates, FSP participation, and spouses' time use in the full model. In addition, we were unable to test for specific functional forms of the time use production function relationship. Instead, as was mentioned earlier, we use wage regressions based on the Current Population Survey to estimate the respondents' opportunity costs. Analysis of FSP participation and energy balance-related time use is done separately from the central production function analysis. No attempt is made to incorporate both spouses' time use in married couple households. Finally, we estimate linear approximations of the production function rather than any specific functional form. These are all limitations of our empirical work that we will re-visit at the end of this report.

While we had to place some limitations on our empirical work over the course of this project, we also expanded it at times in ways we had not originally envisioned. Specifically, we did not originally intend to analyze sedentary time use (i.e., time spent watching television/videos and time spent sleeping). But, the further we delved in to the literature, the more it became apparent that we should take a closer look at sedentary time if we wanted to generate a more complete picture of changes in energy balance-related time use over the past

30+ years. In addition, as we began to analyze the TUESA75-76 and ATUS06-07 data, we became convinced that our descriptive analyses would be enhanced by including observations from the two intermediate nationally representative time diary surveys. Thus, we added the ATUS85 and FISCT98-99 data. Finally, mid-way through the project the ATUS07 data became available and it too was added to enrich the power of those aspects of the study that make use of the ATUS06-07.

Question 1: Are choices about time use and BMI endogenous?

Among the four data sets we use, only the ATUS06-07 contains information on both time use and BMI. Thus, we are limited to the ATUS06-07 when answering question 1. For this analysis, in addition to restricting the sample to those age 25-54, we exclude women who are pregnant as their reported BMIs are likely not reflective of their usual BMIs. We also exclude extreme BMI reports (e.g., > 60.0 and < 16.0) and respondents with extreme values on time use (e.g., those who report spending more than 20 hours watching television). These sample restrictions result in a sample of 8,856 women and 7,586 men in our study.

We focus on seven time-use categories that are potentially related to BMI. The first category measures the amount of primary time the respondent spends eating and drinking (i.e., time where eating and drinking has her/his primary attention). Secondary eating time is captured by the amount of time the respondent reports eating as a secondary activity (i.e., time where something else has her/his primary attention). Secondary time spent drinking anything other than plain water is measured separately. Other food related activities are measured by the time spent in food preparation and clean-up excluding related travel time.

Physical activity cannot be adequately measured by simply summing the time respondents report spending in exercise and sports as we would end up omitting things like bicycling to work, chasing after a toddler, and doing physically demanding household chores. Thus, rather than use only time spent in the ATUS sports and exercise categories, we sum time spent in all activities in the ATUS activity lexicon that generate metabolic equivalents (METs) of 3.3 or more. We select these activities based on the work done by Tudor-Locke et al. (Tudor-Locke et al. 2009) who have linked the ATUS time use lexicon to the Compendium of Physical Activities. We choose a threshold of 3.3 METs because this captures activities such as exterior house cleaning, lawn and garden work, caring for and helping household children, playing sports with household children, active transportation time (i.e., walking or biking), as well as most forms of sports, exercise, and recreation. It excludes routine household activities such as interior housekeeping and playing with children in non-sports. The compendium also identifies time spent in certain occupations (i.e., building and grounds cleaning and maintenance, farming, construction and extraction) as generating a minimum of 3.3 METs. To control for occupational physical activity requirements, we include a dummy variable in the male equation that takes on a value of "1" if the respondent works in one of these occupational categories. Only a handful of female respondents report working in these fields and thus we exclude this dummy from the female regressions. We sum only spells of 10 minutes or more of physical activity time because prior work has established 10 minutes as the minimum duration necessary to impact an individual's energy balance (Centers for Disease Control and Prevention 2008).

Finally, we use two measures of inactivity: television/video viewing time and time spent sleeping. These two measures have been associated with BMI and/or obesity risk in previous

studies that have related single categories of time use to BMI (Anic et al. 2010; Bjorvatn et al. 2007; Bowman 2006; Cleland et al. 2008; Lauderdale et al. 2009; Tucker and Bagwell 1991).

Analysis Approach

To examine the relationship between time use and BMI, ideally one would have longitudinal data on time use in various activities. Unfortunately, no such data exist. Conceptually, cross-sectional time diary data of the type available in the ATUS have two disadvantages. First, time spent in various activities on any given day may deviate from an individual's usual time use patterns. As such, there is measurement error in the independent time use variables that likely bias the coefficient estimates toward zero (Wolfe 1996). Second, any observed association between time use and BMI obtained using cross-sectional data may reflect reverse causality. For example, having a high BMI may lead one to spend less time being physically active. To address both data shortcomings, we adopt a model of time use where BMI and time use are simultaneously determined.

In our model, BMI is a function of time use, biological traits (e.g., age, gender, race/ethnicity, health status) and socio-demographic characteristics (e.g., marital status, number of children, employment status, and education). Decisions about how much time to spend in various activities is a function of household roles (e.g., self-identification as the primary meal preparer, self-identification as the primary grocery shopper), structural factors (e.g., number of children in the home, marital status, employment status, gender, race/ethnicity, age, weekend or weekday diary, season of the year, rural residence, region of residence), prices (e.g., the respondent's wage rate, grocery prices), and income.

We estimate three different sets of equations separately for men and women. In the first formulation, we estimate a model where our time use measures are treated as predetermined

variables that affect BMI. We then estimate an instrumental variables model that recognizes that the time use and BMI causality may run in both directions when one is analyzing cross-sectional data of the sort used here. In the final formulation, we estimate reduced form models of BMI. In this formulation, BMI is estimated as a function of the biological and socio-demographic variables and the strictly exogenous factors that are posited to affect time use (Greene 1993). Essentially, these latter two estimation approaches both incorporate the hypothesis that time use and BMI are simultaneously determined.

Key to identifying the preferred model is undertaking tests for endogeneity and then, if endogeneity is confirmed, identifying "instruments" that are correlated with time use but unrelated to the error term in the BMI equation (Greene 1993). We test for endogeneity by estimating the Durbin-Wu-Hausman F-statistic (Baum, Schaffer, and Stillman 2003). Strength of the instruments is assessed by calculating a variation on the squared partial correlation between the instruments excluded from the second stage and the endogenous regressors (Bound, Jaeger, and Baker 1995). Independence of the instruments from the error term in the BMI equation is assessed by calculating Hansen's J statistic (Baum, Schaffer, and Stillman 2003).

The instrumental variables used to identify the system in our application are self-identification as the primary meal preparer, self-identification as the primary grocery shopper, whether the diary day was a weekend, whether the diary day was in the summer, whether the diary day came from 2007, the grocery price index, the hourly opportunity cost of time, and the household's annual nonwage income. The instrumental variables approach involves first estimating the time use equations and using the coefficients from these equations to generate predicted time use values for all respondents in the sample. These predicted values are then included as regressors in the BMI equations. If all of the necessary conditions are met, the

estimated coefficients using this approach are purged of possible reverse causation. This approach has the added advantage of also addressing the typical time use measurement issue since the predicted values may be thought of as approximating usual time spent in the various activities.

Separate equations are estimated for women and men to allow for the possibility that there are biological factors related to gender that interact with time use and are associated with BMI. All analyses are weighted using the appropriate ATUS weights. The ATUS weights compensate for the survey's oversampling of certain demographic groups, the oversampling of weekend day diaries, and differential response rates across demographic groups (U.S. Bureau of Labor Statistics 2008).

Results

The typical male in our sample is about 44 years old, married, and has one minor child in the home. He is often the primary grocery shopper (most often when he is not married), but not the primary meal preparer in his household. He has some college education and is currently employed. His hourly opportunity cost of time is almost $21/hr. and he lives in a household that has approximately $1,669 in nonwage income per year. The typical female respondent in our sample is very similar. She is also 44 years old, married, and has one minor child in the home. She is most often both the primary grocery shopper and the primary meal preparer. She has some college education and lives in a household that has approximately $1,604 in nonwage income per year. The hourly opportunity cost of her time is lower at $16.84/hr., about 80 % of her male counterpart's, and she is also employed outside of the home.

The typical man and woman in the sample are overweight (defined by a BMI that is greater than 25.0 and less than 30.0). Indeed, fully 75 percent of the males in the sample are

overweight or obese while the corresponding figure for the females is lower at 57 percent. As a point of comparison, analysis of clinical data from the National Health and Nutrition Examination Survey (NHANES) show that in 2003-06, 72.6 percent of males age 20-74 and 61.2 percent of females age 20-74 were overweight or obese (National Center for Health Statistics 2009). While the years and our sample age ranges are not entirely comparable to those in the NHANES study (i.e., our sample age restriction is 25-64), the figures nonetheless suggest that, on average, the self-reported height and weight in the ATUS do a reasonable job of classifying adults' BMIs. In a more extensive comparison of ATUS BMI measures to NHANES BMI measures, Hamermesh [23] reaches the same conclusion for men but notes a modest downward bias in BMI reporting for women in the ATUS relative to NHANES.

The descriptive information on the time-use measures appears in Table 2. It shows that women and men, respectively, spend an average of a little more than an hour a day in eating where that is the main focus of their attention. They also spend more than 20 minutes per day on average engaged in eating as a secondary activity. (Paid work, watching television, and socializing and communicating with others were the most common primary activities that were done while eating was a secondary activity.) Secondary time spent drinking is much higher with the average time being 57 minutes for men and almost 69 minutes for women. Time spent in food preparation and clean-up is substantially greater for women than men (about 2.6 times more). Physically active time averages about 68 minutes a day for men and 35 minutes a day for women. Sleep time averages a little more than 8 hours for both men and women. Finally, the typical woman and man both spend considerable time watching television/videos, with men averaging 2.67 hours per day and women averaging 2.13 hours per day.

Table 2. Weighted Descriptive Statistics for the Time Use Measures: ATUS06-07

	Males				Females			
Time Use Variable	**Overall Mean[a]**	**Standard Deviation**	**Percent Non-Zero**	**Non-Zero Mean[a]**	**Overall Mean[a]**	**Standard Deviation**	**Percent Non-zero**	**Non-Zero Mean[a]**
Primary Eating Time	6.83	4.91	.96	7.11	6.44	4.72	.96	6.76
Secondary Eating Time	2.15	8.51	.52	4.28	2.26	8.81	.59	3.85
Secondary Drinking Time	5.74	16.82	.36	16.20	6.89	18.62	.41	16.56
Food Preparation Time	1.86	3.87	.43	4.60	4.79	6.08	.71	6.83
Physical Activity Time	6.77	16.79	.41	22.26	3.54	9.24	.32	11.27
Sleep Time	49.38	12.88	.99	49.44	49.98	12.46	.99	50.01
Television/Video Viewing Time	16.04	16.01	.81	19.70	12.81	13.50	.77	16.71

[a]Measured in 10-minute increments over a 24-hour period.

Also presented in Table 2 are the fractions of respondents who spend any time in each of the seven activities on the diary day. Note that virtually all respondents report that they spend some time engaged in eating as a primary activity and sleep. However, for most other activities, there are substantial numbers who report no time being spent in a particular time-use category. The censored distribution of time use leads us to use a tobit routine to estimate the first stage in our instrumental variables analyses. (For the tobit results, the reader is referred to (Zick, Stevens, and Bryant 2011).)

Table 3 shows the parameter estimates for all three models for both women and men. The ordinary least squares (OLS) model suggests that all seven time use categories are linked to BMI while the instrumental variables model indicates that only a subset of the time use

categories relate to BMI. Which model is to be preferred? The answer to that question hinges on three things: (1) an evaluation of whether endogeneity exists, (2) the strength of the instruments used to address any observed endogeneity, and (3) the independence of the instruments from the error process.

Table 3. Weighted BMI Parameter Estimates (t ratios in parentheses)

	Males			Females		
Independent Variables	**OLS Model**	**Instrumental Variables Model [a]**	**Reduced Form Model**	**OLS Model**	**Instrumental Variables Model [a]**	**Reduced Form Model**
Intercept	30.23 (54.86)**	33.22 (16.84)**	38.30 (21.38)**	29.98 (46.18)**	30.00 (11.74)**	35.40 (18.02)**
Primary Eating Time[a]	-.03 (-2.10)**	-0.74 (-2.42)**		-.03 (-2.30)**	-0.66 (-2.46)**	
Secondary Eating Time[a]	-.02 (-3.56)**	-0.96 (-3.06)**		-.03 (-4.40)**	-0.37 (-2.28)*	
Secondary Drinking Time[a]	.01 (2.49)**	2.14 (1.87)*		.01 (2.32)**	0.36 (1.81)*	
Food Preparation Time[a]	-.05 (-3.07)**	0.04 (.35)		-.03 (-2.57)**	-0.17 (-2.75)**	
Physically Active Time[a]	-.01 (-2.11)**	0.02 (.58)		-.02 (-3.88)**	0.37 (.49)	
Sleep Time[a]	-.02 (-4.36)**	-0.14 (-2.48)**		-.00 (0.40)	-0.04 (-.47)	
Television/Video Time[a]	.01 (3.50)**	0.18 (4.23)**		.03 (5.30)**	0.19 (2.05)**	
Age	.01 (1.57)	0.00 (.10)	.09 (5.39)**	.03 (5.10)**	0.05 (2.80)**	.07 (4.36)**
Black	.18 (.92)	-1.56 (-2.38)**	.01 (.06)	2.42 (12.17)**	1.24 (3.45)*	2.35 (11.57)**
Hispanic	.09 (.51)	0.37 (1.80)*	-.18 (-.94)	.76 (3.65)**	1.52 (5.77)**	.76 (3.52)**
Other	-1.04 (-3.80)**	-0.67 (-2.19)**	-.72 (-2.57)**	-.64 (-2.30)**	0.69 (1.84)*	-.51 (-1.77)*
Married / Cohabitating	.69 (4.87)**	1.14 (4.54)**	.22 (1.18)	-.45 (-3.10)**	0.27 (1.04)	-.74 (-4.57)**
Education	-.17 (-6.89)**	0.18 (2.06)**	-.06 (-1.21)	-.34 (-12.22)**	-0.09 (-1.18)	-.23 (-4.54)**
Employed	.47 (2.72)**	1.25 (4.72)**	.44 (2.62)**	.23 (1.52)	0.35 (.64)	.16 (1.07)

Poor Health	2.21 (12.73)**	1.39 (4.83)**	2.27 (13.10)**	3.04 (16.03)**	2.31 (8.60)**	3.15 (16.61)**
Occupation with METs>3.3	-.54 (-3.08)**	-0.43 (-.69)	-.75 (-4.88)**	---	---	---
Number of Kids < Age 6	-.07 (-.72)	0.25 (1.92)*	-.24 (-2.24)**	-.04 (-.36)	0.34 (1.87)*	-.08 (-.70)
Number of Kids Age 6-17	.04 (.69)	0.04 (.53)	.07 (1.10)	.00 (.05)	0.15 (1.00)	.02 (.33)
Weekend			.06 (.52)			-.04 (-.27)
Primary Meal Preparer			-.07 (-.46)			-.71 (-3.73)**
Primary Grocery Shopper			.19 (1.35)			.22 (.94)
Summer			.24 (1.82)*			.10 (.69)
ATUS07			.05 (.45)			-.00 (-.00)
Grocery Price Index			-.03 (-4.69)**			-.03 (-4.50)**
Hourly Opportunity Cost of Time			-.06 (-2.89)**			-.07 (-2.75)**
Ln(Non-Wage Income)			-1.34 (-4.68)**			-.55 (-1.75)**
Adjusted R^2	.05	.05	.05	.11	.11	.11
F-Statistic	23.47**	21.92**	22.19**	67.53**	65.34**	62.22**

[a]Readers interested in the first stage estimates see (Zick, Stevens, and Bryant 2011).

To test for endogeneity, we first estimate the reduced form equations for time use. The residuals from these equations are then included as additional regressors in the structural equations. The Durbin-Wu-Hausman F-statistic assesses if the residuals are statistically significant which would imply that time use and BMI are endogenous (Baum, Schaffer, and Stillman 2003). Our set of seven time use categories have an associated F-statistic of 4.92 (p<.01) for males and 5.01 (p<.01) for females. Thus, we are confident that endogeneity exists.

Shea's partial R^2 statistic can be used to assess the strength of a set of instruments adjusting for their inter-correlations when estimating an OLS regression. However, in our case the censored nature of the dependent variables leads us to estimate the time use equations using tobit rather than OLS. Consequently, we assess instrument strength by estimating the χ^2

associated with the instruments excluded from the second stage estimation and each endogenous regressor. This approach is parallel to an OLS approach suggested by Bound, Jaeger, and Baker (Bound, Jaeger, and Baker 1995). The calculated χ^2 for males ranges from a low of 72 in the case of secondary eating time to a high of 722 for television/video viewing time. For females, the range is 136 (secondary drinking time) to 496 (sleep time). All are far above the critical χ^2 of 21.67, suggesting that our instruments are strong.

Independence of the instruments is assessed by Hansen's J statistic which has a χ^2 distribution with degrees of freedom equal to the number of over-identifying restrictions (Baum, Schaffer, and Stillman 2003). A statistically significant value suggests that the instruments used in the first stage are *not* independent of the second stage error term. In our model, Hansen's J is 3.03 (p=.22) for women and 2.33 (p=.31) for men, indicating the instruments are not associated with the error term in either instance.

Taken altogether, the above statistical tests indicate that there is endogeneity between time use and BMI and that the instruments used in our estimation meet the criteria necessary to rely on the instrumental variables approach. Thus, we highlight the results for the second stage instrumental variables model along with the alternative reduced form estimates.

It is important to note that the time use coefficients estimated in the instrumental variables formulation are always larger than their counterpart estimates in the OLS model. This is not surprising as past research has demonstrated that "small window" measurements of the type provided in a 24-hour time diary are likely biased toward zero in multivariate analyses (Wolfe 1996). In this context, the instrumental variables approach is also preferred as it provides estimates of the relationship between typical time use, rather than a single day's report of time use, and BMI.

For both females and males, an increase in either primary or secondary eating time is associated with a significantly lower BMI while an increase in secondary drinking time translates into a significant increase in BMI. Increases in television/video time are also associated with a statistically significant increase in BMI for both men and women. An increase in sleep time is linked to a significant decline in BMI for men but not women while more time spent in food preparation is associated with a decline in BMI for women but not men. Although time spent being physically active had a significant negative relationship to BMI in the OLS model, this relationship is not present for either women or men in the instrumental variables estimates. We attribute this null finding to the "small window" problem associated with a single 24-hour time diary as physical activity, particularly exercise and sports, may not occur on a daily basis. With the exception of secondary eating time, the signs of all the significant coefficients are in keeping with our hypotheses.

The instrumental variables specification reveals several differences in socio-demographic variables by gender. Age, race/ethnicity, marital status, education, and employment effects all vary by gender. For example, an increase in age is associated with a statistically significant increase in BMI for women but not men. Conversely, married/cohabitating males have significantly higher BMI's than single males, while marriage/cohabitation has no effect on BMI for women, *ceteris paribus*. One of the few socio-demographic variables that do not vary by gender is health status. Being in fair/poor health is associated with a large increase in BMI for both women and men.

The reduced form estimates also demonstrate considerable socio-demographic differences by gender. But, they reveal striking similarities with regard to the economic

variables. For both women and men, increases in grocery prices, opportunity costs of time, and nonwage income are all associated with significantly lower BMI.

Our analyses reveal consistent evidence that primary eating time is inversely related to BMI (Zick, Stevens, and Bryant 2011). We also find that Americans' time spent in primary eating activities has declined by an average of 11 minutes per day for women and 23 minutes per day for men between 1975 and 2006 (Zick and Stevens 2010). Taken together this suggests that the rise in BMI over the past 30+ years may be associated, in part, with changes in Americans' time spent in primary eating activities. Specifically, based on our instrumental variables model, we estimate that an 11-minute decline per day in women's primary eating time may have translated into a .73 increase in BMI for women. Likewise, a 23 minute per day decline in primary eating time over this historical period would translate into 1.70 increase in BMI for men.

While time spent in primary eating activities has declined, our descriptive trend analyses of time diary data show that secondary eating and drinking time has risen from an average of 20 minutes per day for women in 1975 to 80 minutes per day in 2006-07. Similarly, men's secondary eating and drinking time has risen from an average of 25 minutes per day to 70 minutes per day over that same historical period (Zick and Stevens 2010). Surprisingly, in our instrumental variables model, secondary eating time is associated with a significantly lower BMI for both men ($p<.05$) and women ($p<.10$). But, secondary drinking time is associated with higher men's and women's BMIs ($p<.10$). In the ATUS06-07 data, secondary drinking time makes up approximately three-quarters of all time spent in secondary eating and drinking activities. Past studies have found a positive relationship between secondary eating and drinking time and BMI for women (Bellisle and Dalix 2001; Bertrand and Schanzenbach 2009) while others (Hamermesh 2010) find little evidence of secondary eating/drinking effects on BMI. Ours

is the first to parse out secondary eating and drinking time. As such, it sheds some light on the mixed findings in the literature, pointing the finger to increases in secondary drinking time (rather than secondary eating time) as a possible contributing factor to rising BMIs. Future work should examine secondary eating time more closely as the negative sign we observed was counter to what we had hypothesized. In addition, researchers need to gain a better understanding of the inverse relationship between primary eating time and BMI as it would be important to know if individuals who linger over meals are consuming fewer calories.

Findings regarding the role that food preparation time plays in BMI are intriguing. For women, the more time spent in food preparation and clean-up, the lower their BMIs. Presumably, more time spent in food preparation and clean-up is associated with using more primary foods and fewer prepared foods when cooking. It may also be associated with smaller serving sizes relative to those found in prepared meals. Since 83 percent of women but only 39 percent of the men identify themselves as the primary meal preparer in their households, it is not surprising that we do not observe the same relationship for the men. It would be interesting to investigate whether more time spent preparing meals by women translate into lower BMIs for other members of their households as well. Unfortunately, this question cannot be addressed with the ATUS data as only one member of each household in the sample provides time diary and BMI information.

While we did not find support for a link between physical activity and BMI, we found strong support for a link between physical *inactivity* – as measured by television/video viewing time – and BMI. This finding is consistent with past research (Bowman 2006; Tucker and Bagwell 1991; Bowman 2006) and with public health programs that encourage individuals to spend less time watching television/videos and more time being physically active (Centers for

Disease Control and Prevention 2011). In the future, researchers may want to explore the role of other sedentary activities as they relate to BMI (e.g., computer screen time).

While our 24-hour diary may be too short to capture typical time spent being physically active each day, this is not true for television/video viewing time which is sufficiently prevalent to be adequately measured with a single, 24-hour diary. Indeed, it may be that television/viewing time is a more general marker for a sedentary lifestyle that could be used in place of the more infrequent physical activity time when analyzing 24-hour time diary data.

Our reduced form model estimates provide some insights regarding the role that changing prices, opportunity costs, and nonwage income may be playing in the rising overweight/obesity epidemic. Clearly, these economic factors matter. In the case of opportunity costs, we show that an increase in the hourly opportunity cost of time is associated with a significantly lower BMI for both women and men. It suggests that the recent economic recession, which precipitated a decline in workers' opportunity costs, may lead to more weight gain for Americans. And, this may be especially true for newly unemployed individuals who are drawing down on their savings that historically was a source of interest (i.e., nonwage) income. Indeed, it would appear that rising wage rates are not just good for the economy. They may also be good for Americans' weight management.

Finally, The BMI analyses illustrate that grocery prices also matter. This is consistent with past research that has linked the historical drop in prices for energy-rich, processed foods to rising BMI in the United States (Drewnowski 2004; Christian and Rashad 2009). It also suggests a dilemma for policy makers. Lower food prices may increase food access, but at the same time they may also be serving to fuel greater caloric intake.

Further details regarding the analyses done to answer question 1 can be found at (Zick, Stevens, and Bryant 2011).

Question 2: Does Food Stamp Program Participation Affect Energy Balance-Related Time Use?

In searching for possible explanations for Americans' growing overweight/obesity risk, a number of scholars have examined the relationship between low income individuals' participation in the food stamp program (FSP)[1] and their BMI (Chen, Yen, and Eastwood 2005; Gibson 2003, 2006; Kaushal 2007; Meyerhoefer and Pylypchuk 2008; Ver Ploeg et al. 2007; Ver Ploeg and Ralston 2008; Baum 2011). The picture that emerges is fairly consistent given the differences in the sample restrictions, time frame, and estimation approaches used. First, FSP participation is associated with BMI and obesity risk for women but not typically for men. Second, the magnitude of this association is smaller if statistical controls for FSP participation endogeneity are included in the model. Third, the association may not hold for specific racial/ethnic sub-groups (e.g., recent immigrants) and it may be dissipating over time.

Researchers who relate FSP participation to BMI are less consistent in the ex-post speculations they make regarding why FSP participation and BMI might be related. Sometimes they propose that it may be a function of the structure of the benefit program (e.g., the gender neutral calculation of the benefit, the frequency of the benefit receipt). At other times, the authors speculate on possible differences in the types of foods purchased with food stamps. Only a couple of authors allude to possible differences in time use related to energy intake and/or energy expenditures (Gibson 2003; Ver Ploeg et al. 2007).

[1] In 2008, the Food Stamp Program (FSP) name was changed to the Supplemental Nutrition Assistance Program (SNAP). However, the data used in this study come from 2006-07, and thus we use the label FSP rather than SNAP throughout this paper.

The ATUS06-07 is the only one of the four data sets used in this research project that contains information on FSP participation. Thus, we use it to assess the differences in energy balance-related time use by FSP status with the goal of shedding some light on the processes that may underlie the observed link between FSP participation and BMI. Building on the findings of earlier studies that examine the relationship between FSP participation and BMI (Chen, Yen, and Eastwood 2005; Meyerhoefer and Pylypchuk 2008), our analyses make use of propensity score methods to account for the potential endogeneity between FSP participation and time use.

In the ATUS06-07, food stamp eligibility is determined by the household's needs adjusted income for the prior month. Although the FSP eligibility involves an asset test as well as an income test, the ATUS0607 Eating and Health Module does not contain asset information. Thus, identification of our sample based on income adjusted for needs alone may result in the inclusion of some households that are not eligible to participate in the food stamp program based on the asset test. To further insure that we are not categorizing people as FSP eligible when they are not, we eliminate all respondents who report their household income for the past 12 months as being in excess of $40,000. Within the 25-64 age restriction, there are 2,053 respondents in the ATUS06-07 who meet the eligibility criteria. FSP participation information comes from the respondent's answer to the question, "In the past 30 days, did you or anyone in your household get food stamp benefits?"

Analysis Approach

Recall that in its simplest formulation, the household production framework suggests that each individual combines his/her time spent in food-related activities, and physical activities, and a vector of market goods to produce her/his BMI, given a set of predetermined variables that

influence an individual's technical ability to produce energy balance (e.g., gender, age). The decision to participate in the FSP alters both the income constraint and the time constraint that the individual faces as the FSP benefit adds to income but it constrains the individuals as to where they can use the benefits to make food purchases (e.g., one cannot use food stamps to purchase food from fast food or full service restaurants). Indeed, research shows that food stamp recipients are less likely to eat out and have a smaller share of food-away-from-home expenditures than otherwise similar non-recipients (Pan and Jensen 2008). We hypothesize that these shifts in resource constraints will in turn affect the choices participants make about how to allocate both their money and time resources.

An added feature of the framework is that the decision to participate in the FSP may not be independent of an individual's preferences. For instance, low-income individuals who have small children in the home may have an added incentive to apply for food stamps relative to otherwise similar individuals who do not have any small children and at the same time, the presence of small children may influence the parents' time use. Thus, the framework suggests that our empirical model must somehow correct for the possible endogeneity of the food stamp participation decision in the estimation of time use and BMI.

Concern about the endogeneity would disappear if eligible households were randomly assigned to the FSP. But, they are not. Past research that has adjusted for the possible endogeneity of FSP participation and BMI has generally done so through the estimation of a recursive system, estimation of an instrumental variables model, or the estimation of a simultaneous system of equations. Yet, these approaches are limited by the functional form that is chosen, the inability to control for unobservable characteristics related to the decision to participate in the FSP, and by the reality that such methods may hide the fact that some in the

"treated" sample have no counterfactual in the non-treated sample (i.e., there is a lack of common support) (Black and Smith 2004; Gibson-Davis and Foster 2006).

Rosenbaum and Rubin (Rosenbaum and Rubin 1983, 1984) propose the use of the propensity score method which approaches the endogenity problem by balancing the treatment group (i.e., food stamp participant households) with the control group (i.e., food stamp eligible households that do not participate in the program) with regard to their covariates. Essentially, the propensity score adjusts for the bias that is caused by the self-selection into the program by creating matches between members of the treatment and control groups rather than through the random assignment that is used in true experiments. As such, the propensity score approach addresses concerns about functional form and the need to use only those observations in the common support reason. Like all statistical modeling approaches that attempt to correct for endogeneity when using non-experimental data, propensity scores do *not* correct for self-selection based on unobservable characteristics.

The propensity score approach relies on first estimating a logit equation where the dependent variable is FSP participation (1=yes, 0=no). The independent variables in this logit model include all observable factors that might affect the participation decision as well as those factors that might affect the substantive outcome of interest (i.e., time use). From the logit estimates, the predicted probabilities of participating in the FSP are generated for all respondents. These predicted probabilities become the features on which treatment respondents are matched to controls.

Based on the logit equation (available in (Zick and Stevens 2011c)), we check to see if the outcome is independent of the treatment selection also known as the conditional independence assumption (CIA). In our case, this means that participation in the FSP should be

random once we control for the covariates. In an attempt to meet the CIA, we include race/ethnicity, age, marital status, presence/absence of minor children, education level, employment status, region of residence, citizenship status (i.e., legal non-citizen versus citizen), income level and the price of groceries among our covariates as these have been found in past studies to be associated with FSP participation (Black and Smith 2004; Chen, Yen, and Eastwood 2005; Gibson-Davis and Foster 2006; Meyerhoefer and Pylypchuk 2008). In addition, we include information about states' FSP structure that may affect their residents' participation (i.e., Is the value of a resident's automobile used in calculating eligibility in 2006? Were food stamp application forms available online in 2006?).

Matching begins by assessing the extent to which the estimated probabilities of participation for the treatment group overlap with the estimated probabilities of participation for the control group (Caliendo and Kopeinig 2008; Imbens 2004; Smith and Todd 2005). Observations that are outside of this common support area (i.e., the probability area where both treatment and control observations are found) are discarded. Next, members of the treatment group are matched to members of the control group based on their estimated probabilities of participating in the FSP taken from the logit equation. A number of matching methods are used in the literature (Gibson-Davis and Foster 2006). Given that there is no conceptual guidance on the choice of matching methods, we use nearest neighbor with replacement, kernel, and radius caliper matching. The results are robust across these three approaches. For reasons of parsimony, we present only the radius caliper matching results.

After the matching is done, t-tests are conducted to ascertain if statistically significant differences exist between the treatments and the controls. This involves estimating the average treatment effect for the treated (ATT) which is defined to be the expected value of the outcome

for those who participate in the treatment (e.g., FSP) minus the expected value for those same individuals if they did not participate in the treatment (Guo and Fraser 2010). In analyzing the impact of policies like the FSP, the ATT is preferred as it provides information as to how the program affects those who elect to participate in it rather than comparing the mean difference between the treated and the non-treated group (Heckman 2005). ATT estimates are net of all of the covariates that are used in estimating the propensity score. That is, the ATT nets out the influence of the socio-demographic and economic variables used in the logit estimation (Guo and Fraser 2010). If the propensity score model is properly specified and if the ATT is statistically significant, then one can conclude that the effect was caused by the policy in question. Our propensity score analyses are conducted using psmatch2 in Stata 9.0 (Leuven and Sianesi 2003).

We draw on our findings from our BMI and time use analyses to inform the time use categories that are examined here. These categories include: (1) primary eating time, (2) secondary eating time, (3) secondary drinking time, (4) food preparation and clean-up time, (5) 10+ minute spells of physical activity time that generates 3.3 or more METs, (6) television/video viewing time, and (7) time spent sleeping.

Results

Table 4 contains the results of our propensity score modeling. Focus first on the BMI numbers. In the full sample, the average BMI of women whose households participate in the FSP is just over 30 which is also the BMI threshold for obesity (Centers for Disease Control and Prevention 2007). This translates into a weight of 175 pounds for a woman who is 5 ‘ 4” tall. We find that prior to the matching, FSP participating females have significantly higher BMIs than their non-participating counterparts while males’ BMIs appear to not differ by FSP status.

After adjusting for the propensity score matching, women participating in the FSP continue to have significantly higher BMIs than they would have had if they were not in the FSP, which is consistent with past research (Chen, Yen, and Eastwood 2005; Meyerhoefer and Pylypchuk 2008). The 1.52 BMI difference for the full sample translates into about a 9 pound weight difference for the average American adult female who is 5' 4" tall. When we strict the sample to mothers with at least one minor child in the home, the 1.65 BMI difference equates with about a 10 pound difference for a woman who is the same height.

To gain some understanding of the underling time use mechanisms that may be responsible for any link between BMI and FSP participation, we examine the respondents' total time spent in the seven energy balance related activities. These results also appear in Table 2. Although we present results for both the women and men, we will focus on the results for the women as they have significant BMI differences even after adjusting for the propensity score while the men do not. The unadjusted means reveal several statistically significant differences in FSP participants' time use. Specifically, FSP participant females appear to spend relatively less time in primary eating activities, and relatively more time engaged in secondary drinking, watching television/videos, and sleeping. But, once we control for the likelihood that an individual is participating in the FSP, many of these time-use related differences disappear.

Table 4. Food Stamp Program Participants and Non-Participants BMI and Mean Minutes per Day Spent in Energy Balance Related Activities: Unmatched and Average Treatment Effect on the Treated (ATT)[a]

		All Females (*N*=1,391)			Females with Minor Children (*N*=904)			All Males (*N*=662)		
Variable		FSP=1	FSP=0	T-Test	FSP=1	FSP=0	T-Test	FSP=1	FSP=0	T-Test
BMI	Unmatched	30.45	28.79	4.06**	29.93	28.38	3.22**	28.64	28.22	0.77
	ATT	30.43	28.91	2.74**	29.90	28.25	2.41**	28.74	28.83	-0.13
Primary Time Spent Eating (min.)	Unmatched	50.39	56.42	-2.45**	47.53	54.57	-2.71**	55.19	62.02	-1.40
	ATT	50.66	50.06	0.18	47.85	48.47	-0.17	55.11	59.18	-0.63
Secondary Time Spent Eating (min.)	Unmatched	18.11	18.61	-0.13	17.66	19.06	-0.30	23.36	14.45	1.44
	ATT	17.23	18.56	-0.25	18.87	16.01	0.37	28.83	14.30	1.35
Secondary Time Spent Drinking (min.)	Unmatched	64.74	47.50	1.85*	67.43	51.21	1.36	65.50	37.88	2.04**
	ATT	68.20	47.47	1.61*	72.97	35.04	2.26**	73.09	70.34	0.12
Food Preparation / Clean-up Time (min.)	Unmatched	57.41	55.10	0.63	62.80	66.65	-0.84	35.25	19.79	3.95**
	ATT	56.20	53.28	0.58	61.03	50.05	1.62*	36.59	19.40	2.80**
Physical Activity Time (min.)	Unmatched	66.00	70.21	-0.41	67.69	60.48	0.60	73.68	112.03	-1.88*
	ATT	63.75	58.63	0.37	70.32	50.26	1.16	77.89	103.89	-0.86
Television / Video Time (min.)	Unmatched	204.63	176.59	2.75**	173.66	151.05	2.13**	282.46	243.39	1.99**
	ATT	206.74	189.28	1.26	173.01	165.08	0.52	283.99	234.78	1.69*
Sleep Time (min.)	Unmatched	570.43	547.36	2.77**	570.14	545.98	2.44**	571.57	561.17	0.74
	ATT	568.67	549.81	1.65*	568.62	548.56	1.40	566.24	570.12	-0.18

$^{+}p<.10$ *p<.05 **p<.01

[a] Obtained using propensity scores and radius matching estimated in STATA.

The ATT estimates reveal no significant differences in eating time, or physical activity time. We do observe some evidence that secondary drinking time and food preparation and clean-up time (females with minor children only) are both higher because of participation in the FSP. In addition, sleep time is marginally higher for women because of FSP participation in the full sample only but not in the sample that is restricted to mothers with minor children.

It is somewhat noteworthy that we find that in the cases of participating women (with minor children) and participating men, food preparation and clean-up time is significantly higher than it would otherwise be. Indeed, for the men the relative increase in time is over 17 minutes per day which is larger than it is for women. Our finding of more time being spent in food preparation because of participating in the FSP is consistent with earlier work (Davis and You 2010; Rose 2007) and thus reinforces concerns about the time costs imposed on FSP participants.

Our findings confirm those of earlier studies where the observed relationship between FSP participation and BMI remains for women even after we control for the endogeneity of FSP participation. In an attempt to uncover factors that might shed light on the process behind women's FSP-BMI relationship, we looked at the energy balance-related time use patterns of both FSP recipients and compared them to our estimates of what they would have been had these individuals not been participating in the FSP. We find little evidence that FSP participants are making different energy balance-related time use choices because of the FSP.

Further details regarding the analyses done to answer question 2 can be found at (Zick and Stevens 2011c).

Question 3: How has the composition of Americans' energy balance-related time use changed over the past 30+ years and what socio-demographic and economic factors are linked to observed shifts?

We use data from all four nationally representative surveys to create a description of changes in time use from 1975-76 to 2006-07. Sample sizes for these analyses vary considerably across the four surveys. There are 1,728 respondents who meet our age restrictions in the TUESA75-76. For the ATUS85, the number is somewhat larger with 3,110 respondents. The FISCT98-99 has the smallest sample size with 795 respondents in the 25-64 age range. Finally, the ATUS06-07 has the largest sample with 17,789 respondents between the ages of 25 to 64.

Unfortunately, the ATUS85 did not ask any questions about secondary eating/drinking activities. The TUESA75-76 and the FISCT98-99 collected information on secondary eating/drinking but did not ask separate questions about the two. In the ATUS06-07, questions about secondary eating were asked separately from questions about secondary beverage drinking activities, and all of these questions were asked at the end of the diary interview rather than concurrently with each primary activity identified by the respondent as was done in the TUESA75-76 and the FISCT98-99. Thus, the reader should note that we must group secondary eating and drinking together for the descriptive analyses and the differences in the way the questions were asked across the three surveys may affect the validity of any conclusions we draw about trends over time.

Descriptive graphs of mean time spent in the five energy balance-related activities are presented separately for women and men in Figures 1-5. Clear patterns that are similar for both women and men emerge from these graphs. The figures suggest that over the 30+ years covered

by these surveys, Americans decreased their time spent in primary eating/drinking activities. Women have decreased the time and men have moderately increased the time they spend in food preparation and clean-up activities. Both women and men increased their time spent in secondary eating/drinking activities and physical activities that generate 3.3+ METs. In contrast, there has been little change in sleep time or television/video viewing time with the exception, perhaps, of a recent uptick in television/video viewing time between 1998-09 and 2006-07.

Figure 1. Trends in Mean Time Spent Eating and Drinking

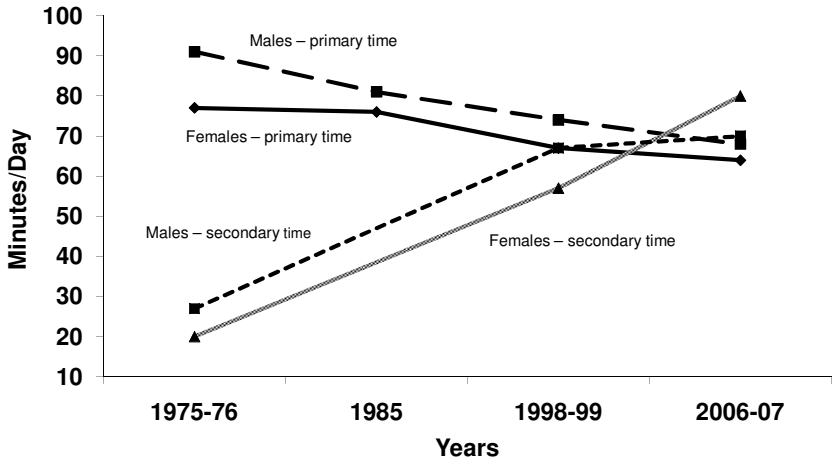


Figure 2. Trends in Mean Food Preparation and Clean-Up Time

Figure 3. Trends Physical Activity Time (10+ minute spells summed)

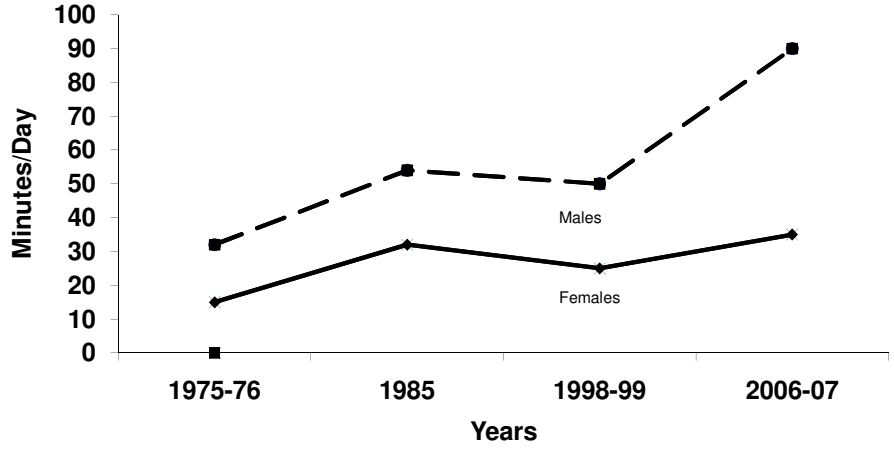


Figure 4. Trends in Television/Video Viewing Time

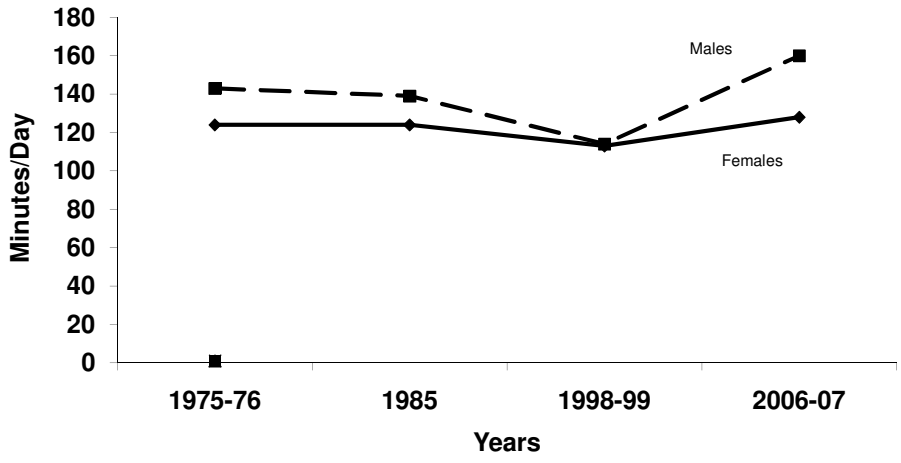
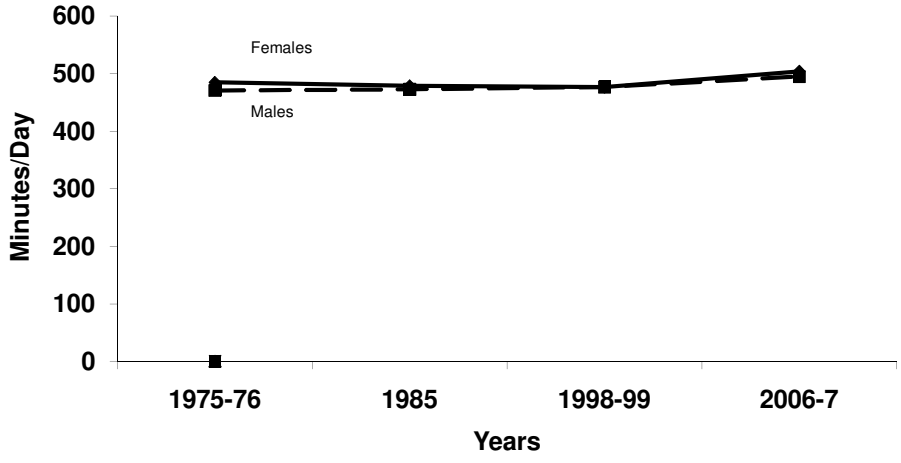


Figure 5. Trends in Sleep Time



Recall that cross-sectional analyses done with the ATUS06-07 link increases in primary eating/drinking time, food preparation time (women only), and sleep time (men only) to decreases in BMI. In contrast, increases in television/video viewing time and secondary drinking

time were associated with increases in BMI. If the relationships between time use and BMI observed in 2006-07 also held in earlier years, it would appear that some of the upward trend in BMI that has occurred may be attributable to Americans' shifting food preparation and eating patterns. In addition, more recent increases in sedentary television/video viewing time may be playing a role.

To gain a sense of whether these shifting patterns of time use are age related, we construct graphs for the TUESA75-76 data and the ATUS06-07 data by age. The results appear in Figures 6-11. Several patterns are quite clear in these graphs. At any given age, Americans are spending less time in primary eating/drinking activities in 2006-07 than their 1975-76 same age counterparts did. They are spending more time in secondary eating/drinking and more time sleeping. Males are spending more time in food preparation and clean-up while females are spending less time in these activities than their same age contemporaries did in the mid-1970s. However, the age related story is more complicated in the case of physical activity. Finally, we observe very little change in age-related television/video viewing time across this 30+ year period. These descriptive analyses are suggestive of period effects (i.e., structural changes in the relationships between respondent characteristics other than age) in the case of eating, food preparation and sleeping behaviors.

Figure 6. Primary Eating/Drinking Time

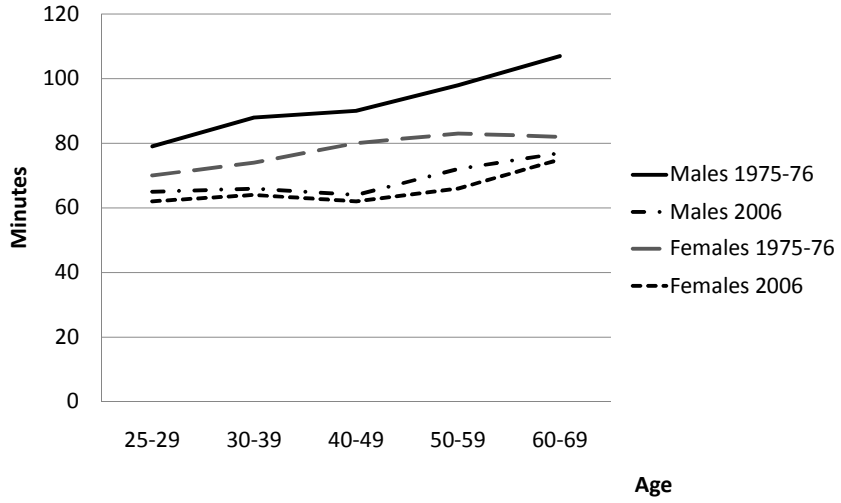


Figure 7. Secondary Eating/Drinking Time

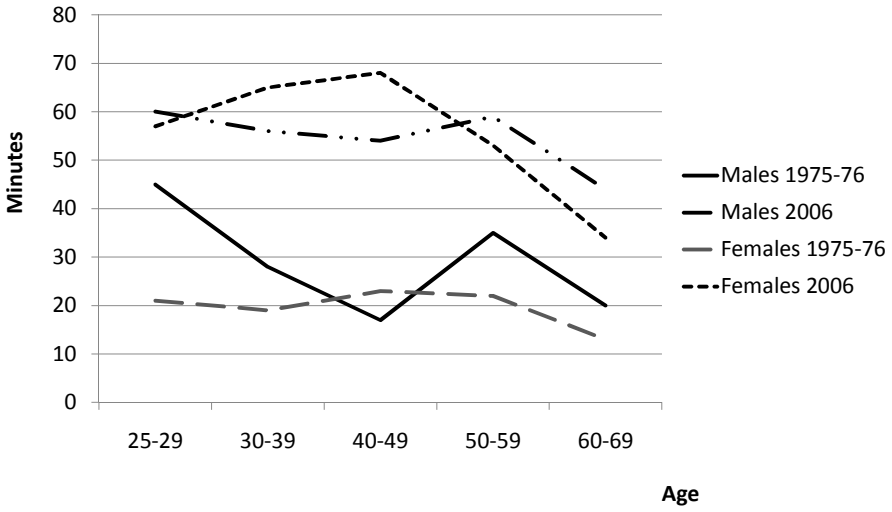


Figure 8. Food Preparation and Clean-Up

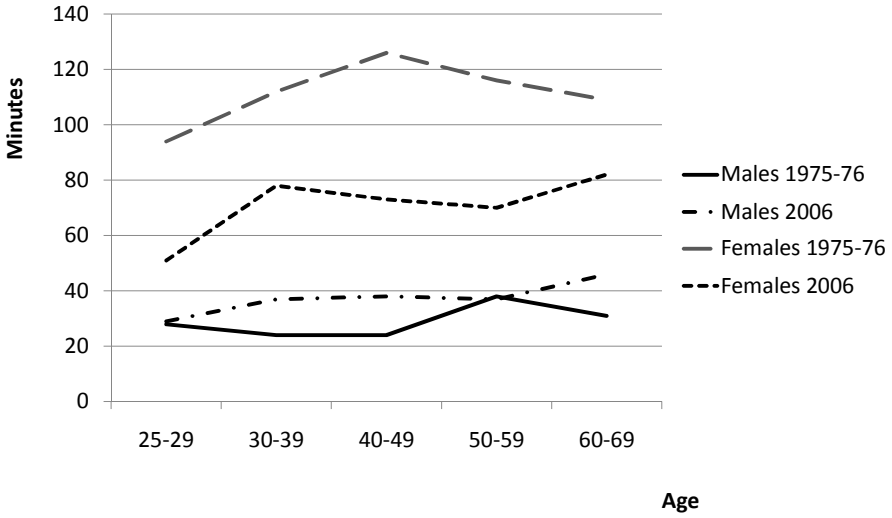


Figure 9. Primary Physical Activity Time

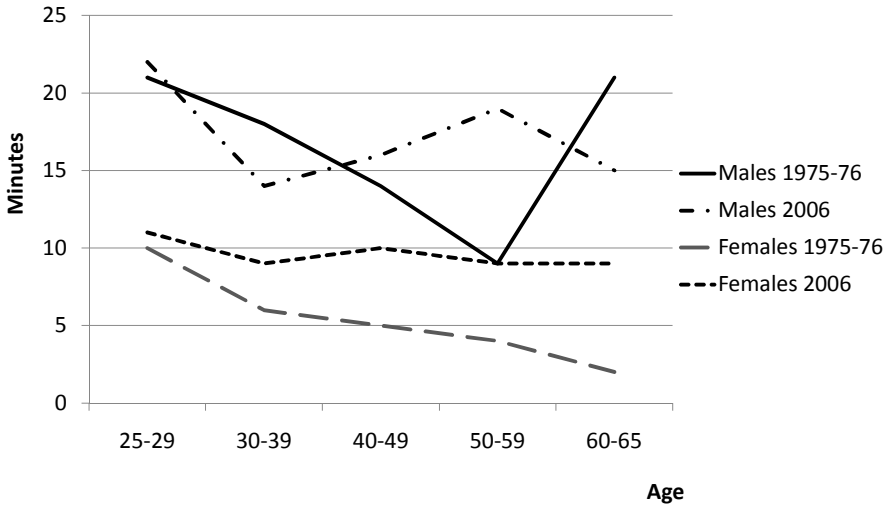


Figure 10. Television/Video Viewing Time

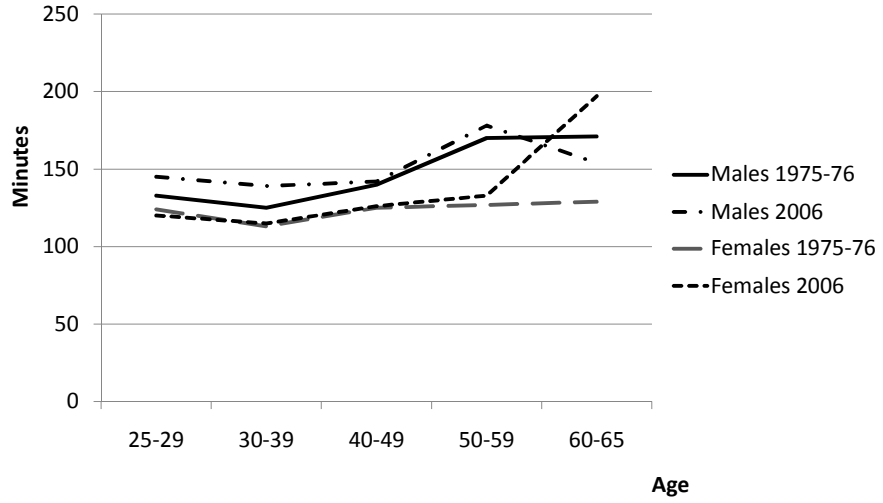
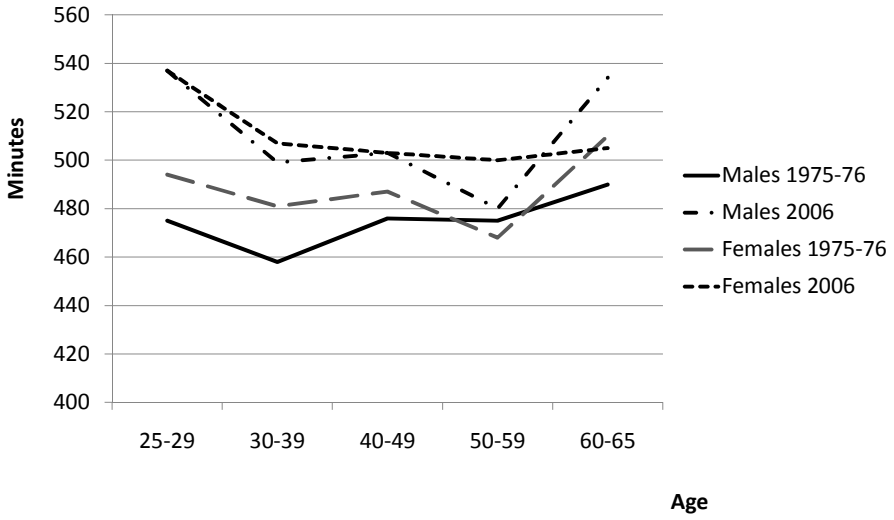


Figure 11. Sleeping Time



Multivariate Results

Data from the TUESA75-76 and the ATUS06-07 are used to undertake an analysis that focuses on the overall shifts in time use and how the influence of socio-demographic and

economic factors have or have not changed over this historical period. For our analyses, we use the 1,728 respondents in the TUESA75-76 and the 17,789 respondents in the ATUS06-07 who meet our 25-64 age restriction. Our covariates are limited to those variables that are common to both data sets. These include: the respondent's years of education, race (black vs. non-black), marital status, age, employment status, and estimated hourly opportunity cost of time. Household characteristics are limited to the number of children under age 18 in the home. We also include a control variable for whether the diary came from a weekend day or a weekday.

Table 5 contains descriptive information on the two samples. The men and women in these two samples generally reflect the socio-demographic and economic characteristics of the U.S. adult population at the times these surveys were undertaken. In moving from 1975-76 to 2006-07, we see that both American males and females became slightly more educated, older, and more racially diverse. Both men and women were also less likely to be married in 2006-07 than in 1975-76 and the number of minor children in the home declined over this period. In addition, the percentage of males who were employed declined while the percentage of females who were employed grew substantially. Finally, the estimated hourly opportunity costs rose in real terms for both men and women but the percentage gain was greater for women.

Table5. Weighted Descriptive Statistics for the 1975-76 and 2006-07 Survey Respondents

	Males		**Females**	
Variables	**1975-76**	**2006-07**	**1975-76**	**2006-07**
Education (yrs.)	12.40	13.62	12.16	13.70
Black (1=yes)	.06	.11	.11	.13
Married (1=yes)	.81	.66	.71	.66
Age (yrs)	42.14	43.58	42.74	43.88
Employed (1=yes)	.89	.83	.51	.70
Opportunity Costs/hr. (2006 $)	18.17	19.49	11.25	15.96
Number of Children in the Home	1.14	.83	1.22	.94
Weekend Diary (1=yes)	.28	.29	.25	.29
N	787	7,801	941	9,988

Table 6 contains information about the fraction of respondents who participated in each of the four time use categories that are the focus of the multivariate analyses. We select these categories based on the results of the multivariate analyses that linked time use to BMI. We exclude secondary eating and drinking time because the inability to separate secondary eating from secondary drinking in the TUESA75-76 data makes it impossible to assess changes over this 30+ year period in these two components of time use.

Table 6. Participation Rates in Six Energy Balance-Related Time Use Categories in 1975-76 and 2006-07

	Males		Females	
Activities	**1975-76**	**2006-07**	**1975-76**	**2006-07**
Primary Eating/Drinking	.98	.96	.98	.95
Food Preparation and Clean-Up	.55	.66	.94	.85
Television/Video Watching	.80	.81	.77	.76
Sleep	.99	.99	.99	.99

The figures in Table 6 re-affirm the upward trend for males and the downward trend for females in food preparation and clean-up as measured by the percentages of individuals who engage in these activities in 1975-76 versus 2006-07. Methodologically, they also suggest that while distributions of the dependent variables are not highly censored in the case of primary eating time, women's food preparation time, television/video viewing time, and sleep time, there are potential concerns in the case of men's food preparation time. Estimation of this latter time use category using a tobit routine that corrects for censoring (available upon request), did not change any of the substantive findings. Thus, for ease of exposition, ordinary least squares (OLS) multivariate estimates are presented for all of the equations.

Tables 7 and 8 contain the OLS parameter estimates for males and females, respectively. Regressions that group both data sets together and interact a data set dummy with all of the independent variables are estimated to test for differences in the structural relationships between

the socio-demographic and economic variables and time use. But, for ease of exposition, we present the parameter estimates generated separately for the TUESA75-76 and the ATUS06-07 data sets and bold and italicize the coefficients that are statistically different from one another based on the interaction model. The full set of interaction parameter estimates is available upon request.

Table 7. Weighted Parameter Estimates of the Energy Balance-Related Time Use Equations: Males (*t* ratios in parentheses)[a]

	1975-76				2006-07			
Independent Variables	**Primary Eat/Drink**	**Food Prep/Clean Up**	**TV/Video**	**Sleep**	**Primary Eat/Drink**	**Food Prep/Clean Up**	**TV/Video**	**Sleep**
Constant	49.21 (3.08)**	27.56 (2.06)**	238.58 (5.78)**	***525.04 (17.24)***	28.59 (7.23)**	11.84 (2.63)**	320.49 (26.15)**	***606.61 (58.32)***
Education (yrs)	.77 (1.06)	.82 (1.36)	-6.09 (-3.27)**	-3.12 (-2.27)**	2.12 (9.68)**	1.15 (4.60)**	-10.41 (-15.31)**	-4.51 (-7.82)**
Black (1=yes)	-23.57 (-3.02)**	-3.06 (-.47)	26.71 (1.33)	-31.31 (-2.11)**	-19.46 (-10.87)**	-3.05 (-1.50)	20.66 (3.72)**	-6.59 (-1.40)
Married (1=yes)	-.45 (-.09)	-9.96 (-2.35)**	-3.93 (-.30)	***5.01 (.52)***	6.02 (4.58)**	-4.33 (-2.89)**	-12.91 (-3.17)**	***-18.21 (-5.27)***
Age (yrs)	***.74 (3.91)***	.35 (2.20)**	.62 (1.26)	-.12 (-.35)	***.17 (3.02)***	.24 (3.68)**	.92 (5.18)**	-.55 (-3.71)**
Employed (1=yes)	4.07 (.66)	-19.01 (-3.66)**	-74.37 (-4.65)**	-56.70 (-4.80)**	-1.12 (-.73)	-6.45 (-3.70)**	-81.00 (-17.08)**	-37.69 (-9.36)**
Ln(Wage) in 2006 $	.37 (.15)	.72 (.35)	1.63 (.26)	8.19 (1.75)*	.37 (.45)	.73 (.78)	1.70 (.66)	.65 (.30)
# of Children at Home	-2.02 (-1.40)	-.59 (-.49)	-2.78 (-.75)	-1.86 (-.68)	-.93 (-1.75)*	1.62 (2.66)**	-11.07 (-6.69)**	-2.98 (-2.12)**
Weekend Diary (1=yes)	2.82 (.69)	***-.59 (-.17)***	70.83 (6.68)**	61.42 (7.85)**	5.79 (4.82)**	***14.22 (10.40)***	67.76 (18.21)**	66.14 (20.94)**
Adjusted-R^2	.03	.03	.11	.11	.04	.02	.14	.08
F Statistic	4.42**	4.30**	12.60**	12.59**	44.41**	21.48**	163.50**	90.32**

*p<.05 **p<.01

[a]Bolded and italicized coefficients are significantly different across years.

Table 8. Weighted Parameter Estimates of the Energy Balance-Related Time Use Equations: Females (*t* ratios in parentheses)[a]

	1975-76				2006-07			
Independent Variables	**Primary Eat/Drink**	**Food Prep/Clean Up**	**TV/Video**	**Sleep**	**Primary Eat/Drink**	**Food Prep/Clean Up**	**TV/Video**	**Sleep**
Constant	***53.08 (4.83)*****	***111.37 (5.46)*****	221.57 (7.08)**	***535.06 (21.14)*****	***40.00 (10.67)*****	***69.64 (12.26)*****	264.72 (25.53)**	***619.23 (61.59)*****
Education (yrs)	1.30 (2.56)**	***.03 (.03)***	***-5.37 (-3.71)*****	***-2.23 (-1.90)****	1.68 (8.40)**	***-2.06 (-6.79)*****	***-8.32 (-14.99)*****	***-4.32 (-8.02)*****
Black (1=yes)	***-27.87 (-6.24)*****	***-15.24 (-1.84)****	19.77 (1.56)	20.45 (1.99)**	***-11.75 (-8.14)*****	***-8.85 (-4.05)*****	24.52 (6.14)**	11.66 (3.01)**
Married (1=yes)	-.25 (-.08)	***30.11 (5.31)*****	***8.80 (1.01)***	.41 (.06)	5.15 (4.99)**	***17.65 (11.29)*****	***-13.24 (-4.64)*****	-8.23 (-2.97)**
Age (yrs)	.36 (2.67)**	.69 (2.73)**	***-.52 (-1.35)***	***-.36 (-1.14)***	.08 (1.76)*	.47 (6.44)**	***.57 (4.30)*****	***-1.21 (-9.43)*****
Employed (1=yes)	-.82 (-.30)	***-43.13 (-8.45)*****	-54.77 (-7.00)**	-17.40 (-2.75)**	-5.39 (-5.11)**	***-22.64 (-14.18)*****	-48.78 (-16.74)**	-24.86 (-8.79)**
Ln(Wage) in 2006 $	-2.06 (-.95)	***-14.75 (-3.67)*****	7.65 (1.24)	-3.50 (-.70)	-.43 (-.62)	***.76 (.73)***	-3.16 (-1.64)	1.77 (.95)
# of Children at Home	-.81 (-.78)	10.07 (5.17)**	-11.14 (-3.73)**	-3.41 (-1.42)	-2.04 (-4.58)**	9.99 (14.78)**	-10.37 (-8.41)**	-4.15 (-3.47)**
Weekend Diary (1=yes)	8.40 (2.73)**	***-5.46 (-.95)***	***16.27 (1.86)****	***42.51 (6.00)*****	8.31 (8.10)**	***11.39 (7.32)*****	***34.79 (12.24)*****	***59.58 (21.62)*****
Adjusted-R^2	.07	.16	.08	.06	.03	.09	.10	.07
F Statistic	9.53**	23.39**	11.13**	7.35**	41.23**	120.89**	136.21**	94.15**

*p<.05 **p<.01

[a]Bolded and italicized coefficients are significantly different across years.

For males there are very few changes in the estimated structural relationships between 1975-76 and 2006-07. And, with the exception of the shift in the parameter estimates associated with food preparation/clean-up, the magnitudes of the estimated relationships change very little across the two sets of equations. Nevertheless, the estimated coefficients provide us with some insights about how socio-demographic factors that are linked to energy balance-related time use may have operated to shift American males' time use choices over this historical period. In the discussion that follows, the focus is on primary eating time, television/video viewing time, and sleep time as these are the time use categories that were found to be statistically linked to men's BMI when answering question #1.

Recall that between 1975-76 and 2006-07, American males became slightly more educated, more racially diverse, less likely to be married, less likely to be employed, and less likely to have minor children in the home. The analyses suggest that in the case of primary eating time, shifts in the racial composition, employment status, and marital status of American men may have served to dampen primary eating/drinking time as the magnitudes of these coefficients are quite large in 2006-07. It would appear that these socio-demographic shifts had even larger effects on males' sedentary television/video viewing time. While education gains reduced men's television/video viewing time somewhat, the change in racial composition, marital status, employment status, and number of minors in the home are all linked to large increases in television/video viewing time. Finally, look at the sleep time equation estimates where the evidence of socio-demographic shifts is more complex. Changes in men's marital status, employment status, and the number of minor children in the home are all linked to gains in sleep (which in turn is associated with lower BMI). But, the increase in men's years of schooling and age, and the shift in racial composition that has occurred over this 30+ year period are all linked to declines in sleeping time.

Turn now to Table 8 and the coefficient estimates for females. Here the picture that emerges is more complex. We observe numerous changes in the structural relationships between socio-demographic characteristics over the historical period studied. Sometimes these structural shifts appear to re-enforce the shifts in socio-demographic characteristics of American women as they relate to energy balance-related time use while at other times they appear to work in opposition. In the discussion that follows, the focus is on primary eating time, food preparation and clean-up time, and television/video viewing time, as these are the time use categories that were found to be statistically linked to women's BMI when answering question #1.

Again, recall that between 1975-76 and 2006-07, American women became somewhat more educated and ethnically diverse, they were less likely to be married and to have minor children in the home, and they were more likely to be employed. At the same time, it would appear that educational and day-of-the-week links to energy balance-related time use became stronger while the structural relationships between race, marital status, and employment status and energy balance-related time use softened somewhat. For example, the fact that a smaller percentage of women are married in 2006-07 relative to 1975-76, coupled with the statistically significant change in the sign and magnitude of the coefficient associated with marital status in the television/video viewing equation, suggests that both effects were associated with greater women's television/video viewing in 2006-07 compared to 1975-76. In contrast, the magnitude of the estimated effect of being married on food preparation and clean-up time declines between 1975-76 and 2006-07, although both are positive. Thus, the drop in the fraction of women who are married still contributes to the decline in food preparation time but not to the extent that it would had the structural relationship between marital status and food preparation/clean-up remained constant over this historical period. This same phenomena appears to hold for employment status, education, and racial composition effects. Only in the case of weekend effects are the structural shifts, when they occur, uniformly positive. On weekends in 2006-07, American women chose to do more food preparation and clean-up, more television/video viewing, and more sleeping, than did their otherwise similar counterparts in 1975-76.

Further details regarding the analyses done to answer question 3 can be found at (Zick and Stevens 2010, 2011a, 2011b).

Summary and Conclusions

Using nationally representative data from the ATUS06-07, we find that cross-sectional analyses that do not adjust for endogeneity likely under-estimate the true relationship between time use and BMI. We also conclude that Americans' time use decisions have important implications for their BMIs. The analyses suggest that both eating and beverage drinking time and context matters. In the case of women only, time spent in food preparation is inversely related to BMI while for men only, time spent sleeping is inversely related to BMI. For both men and women, sedentary time, as measured by television/video viewing time is also linked to a higher BMI. In addition, the reduced form models suggest that shifts in grocery prices, opportunity costs, and non-wage income may be contributing to the rise in Americans' BMI. We observed statistically significant inverse relationships between all three economic variables and BMI. Thus, changes in economic factors over the past 30+ years (e.g., the decline in men's real earnings and real food prices), may also be linked to Americans' weight gain.

When we turn our focus to low-income food stamp-eligible individuals in the ATUS06-07, like other researchers, we observe an association between FSP participation and BMI for women even after we control for the endogeneity of BMI and the participation decision. We conclude that there is little evidence that FSP participation alters low-income women's physical (in)activity or eating patterns, with the exception of secondary time spent drinking liquids. The absence of evidence regarding shifts in energy balance-related time use associated with FSP participation suggests that researchers may want to examine other possible explanations for the female FSP participants' relatively higher BMIs.

In taking a closer descriptive look at four different nationally representative time use data sets, we observe that between 1975-76 and 2006-07, American women and men made considerable changes in how they chose to allocate their energy balance-related time. Time

spent in primary eating/drinking activities declined, secondary eating/drinking time rose, physical activity time rose, and food preparation and clean-up time declined substantially for women while it increased modestly for men. In contrast, television/video viewing time increased only modestly while sleep time remained relatively constant. Examination of age-related differences between 1975-76 and 2006-07 suggest that structural changes in respondent characteristics – other than simple age effects – may be responsible for the observed shifts.

Multivariate analyses reveal that there have not been significant structural changes in the case of men's energy balance-related time use between 1975-76 and 2006-07. Instead, men's observed time use shifts appear to be the result of shifting socio-demographic characteristics (e.g., decline in the fraction of men who are married). In contrast, the story appears to be more complicated for women as we find both changes in the structural relationships and changes in socio-demographic relationships are associated with time use changes that may have led to weight gain.

Our research results must be tempered with a couple of caveats. First, our analyses present a cautionary tale regarding the use of "small window" measures of physical activity time that are available in a single 24-hour time diary. Recall that we do not find evidence of an inverse relationship between time spent in physical activity and BMI. This is counter to a number of past studies (Ching et al. 1996; DiPietro 1995; Gordon-Larsen, Adair, and Popkin 2002; Dunton et al. 2009) but not surprising given that our estimates of physical activity time are likely biased toward zero. The Centers for Disease Control recommends that adults age 18-64 spend 150 minutes *per week* engaged in moderate intensity aerobic activity, or that they spend 75 minutes *per week* in vigorous aerobic activity (Centers for Disease Control and Prevention 2008). Thus, even those who do follow these recommendations might not have been exercising

on the randomly chosen diary day. Although it would be costly, future time-diary data gathering efforts should consider expanding the number of time diaries gathered for each respondent and/or asking additional questions about the usual time the respondent spends each week in certain infrequent, but potentially important activities.

Second, our analyses were somewhat hampered by data limitations. The sample size for the TUESA75-76 limits the power of multivariate analyses that make use of it. In addition, the ATUS06-07 and the TUESA75-76 have very few common socio-demographic measures that can be used when we examining structural changes over time. For instance, while the TUESA75-76 contains information on both spouses' time use in married couple households, the ATUS06-07 has information on only one spouse's time use. The absence of spouse information prevented us from examining the question of how spouses' time use choices may interact to affect BMI. As another example, the ATUS06-07 contains information on the respondent's self-reported health status that would have been quite useful to control for in the time use trends analysis but this information was not gathered in the TUESA75-76. Suffice it to say that given budget constraints, survey sponsors must always make trade-offs between sample size and the amount of information gathered. Nevertheless, if we are to gain a better understanding of Americans' energy balance-related time use choices, it would be very helpful to get time diary information on both spouses in married couple households. This would allow researchers to gain a better understanding of potentially important time-use "spillover effects" within households (e.g., How does time spent in food preparation by one spouse affect the BMI of the other spouse? Do spouses who have sit-down dinners together have lower BMIs than spouses who eat separately while "on the run?").

Counterbalancing the above limitations are several research strengths in this study. First, we use repeated cross-sectional data to gain an understanding of how Americans' energy balance-related time use has changed over the past 30+ years. We also give careful attention to building comparable measures of both time spent in energy intake activities *and* energy expenditure activities so that we might better understand how time use has changed during a historical period where BMI has been rising.

Taken together, our findings regarding trends in primary eating time, secondary drinking time, and time spent in food preparation and clean-up (by women) and their relationship to BMI serve to reinforce nutritional educators' emphasis on preparing meals and setting aside time where eating is one's primary focus. The role of secondary eating in healthy eating behaviors remains an open question, however. In addition, it is unlikely that time use choices play a large role in the elevated obesity risk observed among female food stamp recipients. On the physical activity side of the balance sheet, our analyses suggest that public health directives aimed at getting people to turn off their television may also be key to shifting Americans' energy balance toward healthy body weights. Analyses of time use trends suggest that socio-demographic shifts, especially the decline in the fraction of adults who are married with minor children in the home, the decline in men's employment and the rise in women's employment, may be contributing to less healthy time use choices. For women, structural changes over time in the relationships between socio-demographic characteristics and time use choices complicate the picture. Nevertheless, this research also provides some insights about those groups (e.g., single adults, individuals with less education, those who are not employed), that might be targeted for nutritional and physical activity public education efforts.

Future research should take a careful look at primary eating time, secondary eating time and caloric intake so that we might gain some understanding of the processes that underlie the inverse relationship between eating time and BMI that was observed in this study. In addition, it may be instructive to examine the role of a wider range of sedentary activities (e.g., computer screen time), as they relate to BMI. Such studies could inform additional intervention efforts that might help reverse Americans' weight gain over the past 30 years.

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