Association Between Sedentary Work and BMI in a U.S. National Longitudinal Survey

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Introduction: Technological advancements have made life and work more sedentary, and long hours of sitting are known to be associated with many health concerns. Several studies have reported an association between prolonged sitting time at work and weight gain, but the results are inconsistent. This study examined the relationship between sitting time at work and BMI using data from a large prospective cohort of U.S. men and women from 2002 to 2010. Initial analyses were performed in 2013, with additional analyses in 2014 and 2015.

Methods: The sample size at the base year (2002) was 5,285 and the age range 38–45 years. The outcome, BMI, was based on self-reported measures of height and weight. Estimates of workplace sitting time were linked from an external database (Occupational Information Network), and the occupation-wide rating for sitting time was linked to survey participants by occupation. Fixed-effects models controlling for time-invariant effects of all time-invariant characteristics were employed to examine the association, controlling for age, education, work hours, and hours of vigorous and light/moderate physical activities.

Results: Longer sitting time was significantly associated with higher BMI for the overall sample ($\beta = 0.054; p < 0.05$) and men ($\beta = 0.086; p < 0.01$). For women, the association was not statistically significant.

Conclusions: The findings provide further support for initiatives to reduce workplace sitting time as a means of reducing the risk of weight gain and related health conditions.

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relationship. The associations reported by cross-sectional studies may include both causal effect of prolonged sitting and selection bias; obese people tend to increase sedentary behaviors and potentially may pre-select themselves into more sedentary jobs.

A few prospective studies have investigated this topic, but their results were inconsistent. Four of these studies did not find a prospective association, one study found a positive relationship among female nurses but another showed that occupational physical activities were correlated with overweight (only among its female participants), indicating a negative association. These studies, though innovative, were not without limitations. One used samples from a single occupational group (nurses) and the other contained government workers only; it is unclear whether their results are generalizable to workers of other occupations or the broader workforce. Another was based on a cohort living in a municipality well above the Arctic circle, so the lifestyle of the residents might not be comparable to those living in the continental U.S. or other temperate regions. Several other studies from Nordic countries used samples consisting of workers of varying occupations. Nonetheless, the data may be dated; none of these studies had a follow-up later than 1995, and the results may not be reflective of the circumstances faced by the contemporary U.S. workforce.

The relationship between sedentary work and weight gain warrants further analysis with a more representative sample, a study design that ensures temporal precedence of exposure, robust statistical methods, and data that are more contemporary. Sedentary behavior refers to activities that do not increase energy expenditure substantially above the resting level. As sitting appears to be the most common workplace sedentary behavior, it was hypothesized that longer sitting time at work would contribute to weight gain.

Methods

Study Sample

This study’s primary data source was the National Longitudinal Survey of Youth 1979 (NLSY79), an ongoing prospective study that began in 1979 with a nationally representative sample of 12,686 U.S. men and women then aged 14–22 years. Although a primary focus of the survey is labor force behavior, the survey’s content is considerably broader, including obesity and occupational injury. The interview was conducted biannually after 1991. Detailed information on sampling and data collection is published elsewhere.

The NLSY data were analyzed from 2002 to 2010, the latest publicly available data at the initiation of the study, and 2002 was selected as the starting year because of the substantial differences between the occupational codes used by NLSY79 prior to 2002 and the exposure measure from another source (see Measures section). From 1991 onward, the number of NLSY79 respondents eligible for interview was actually 9,964. Figure 1 details the selection process for the participants at the 2002 base year. The data were an unbalanced panel. Those who had missing values in the base year were included in later years if they had valid data in those years. The number of observations in 2002, 2004, 2006, 2008, and 2010 was 5,285, 5,003, 5,062, 5,029, and 4,717, respectively.

Despite 30 years of follow-up, the NLSY79 has a relatively low degree of sample attrition and has maintained a good response rate. Retention rate, defined as the percentage of base year respondents remaining eligible who were interviewed in a given survey year, was 78.1% in 2002 and 75.3% in 2010; most sample attrition was due to elimination of subsamples by design in the program. Response rate, defined as the percentage of respondents remaining eligible and alive who were interviewed in a given survey year, was 80.3% in 2002 and 80.6% in 2010.

Measures

The outcome was BMI, based on self-reported height and weight from NLSY79 participants. Between 2002 and 2010, a total of 268 observations reporting a BMI < 14 or > 50 kg/m2 were considered implausible and were set to missing. Sensitivity analyses indicated that setting different cut-off points for implausible values did not influence the study results.

The primary explanatory variable was “time spent sitting at work,” extracted from the Occupational Information Network (O*NET) and then linked to the main NLSY data by occupation.
Using a data source external to (and then linking it back to) the NLSY to evaluate exposure was necessary, as no U.S. national longitudinal survey documents both participants’ body weight and time spent sitting at work.

The O*NET is a database developed for the U.S. Department of Labor that comprehensively describes occupations and is provided to the public and private sectors at no cost. It collects a wide range of jobs characteristics such as abilities, skills, and personal attributes required for a job, as well as activities performed in a job and working conditions. Data are collected for > 800 different jobs through national surveys or by occupational experts. The program is designed for career planning and workforce developments, but is also used by government agencies for administrative purposes. Version 15.1 of the O*NET database, based on data collected and updated gradually between 2002 and 2010, was used for this study.

Below is the O*NET question (extracted from Question 34 of the Work Context questionnaire) used for the analysis:

**How much time in your current job do you spend sitting?**

There were five possible responses: 1 (never), 2 (less than half of the time), 3 (about half of the time), 4 (more than half of the time), and 5 (continuously or almost continuously). The data value from the database is an average of individual ratings (not actual hours spent sitting) sampled from an occupation; Table 1 lists the ratings for the most and least sedentary jobs.

The O*NET data value (a constant for a given occupation) was assigned to NLSY participants in each survey year by occupation. O*NET and the NLSY used different occupational taxonomies, and a crosswalk was used to convert the occupational codes of one to the other. To ensure the temporal precedence of the exposure, the O*NET measurement was matched to the job(s) that the respondent held 6 months prior to the interview. The job information was extracted from NLSY79’s employment data. Then, the repeated measurement for the exposure (6 months prior to the interview) was used to predict BMI in each wave from 2002 to 2010. The choice of 6 months was made to allow enough time for observing weight change.

Each analysis controlled for participants’ age (centered at 40 years), education (in years), weekly work hours of all jobs, and hours of vigorous and light/moderate physical activity (PA) per week based on self-reported frequency and duration of the activities, respectively. Further analysis suggested that a non-negligible proportion of the PA measurements had exceedingly high data values. To reduce the impact of extreme values, an upper limit was placed for both PA measures. For all observations whose original data values were greater than the threshold, their data values were replaced with this upper limit. After the primary analyses, sensitivity analyses were performed by conducting the analysis for the upper limit set at the 80th, 85th, and 95th percentiles, respectively.

**Statistical Analysis**

Fixed-effects longitudinal models were used to examine the association between sitting time and BMI, because they can control for the time-invariant effects of all time-invariant factors (e.g., ethnicity). Additional analysis was performed using random-effects models to investigate the potential interaction effect between gender and sitting time on BMI. Because men and women differ in labor market activities and body metabolism, the fixed-effect model was run first for the overall sample, and then for women and men respectively. All data analyses were performed using Stata, version 13; the command “xtreg, fe” was used to run fixed-effects models, and a p-value of < 0.05 was considered statistically significant. Initial analyses were performed in 2013, with additional analyses in 2014 and 2015. The New England IRB determined that this study was exempt from review.

**Results**

Table 2 presents characteristics of the participants in the base year, 2002. The demographic profile of these 5,285
participants was similar to the U.S. population of the same age range in 2002, except that the working data set had a higher proportion of men than the national average (53.3% vs 50.4%), presumably because employment history was required for a participant to be included in the analyses. On average, at the baseline the participants were aged 41.5 years, had completed 13.7 years of education, and performed vigorous and light/moderate PA 3.0 and 4.7 hours a week, respectively. They spent 41.1 hours working for all jobs, and the average rating of workplace sitting time was 3.0 (about half of the time), both evaluated at 6 months prior to the 2002 interview. The body weight of the cohort increased with time: The average BMI increased from 27.68 kg/m² in 2002 to 28.45 kg/m² in 2010, equivalent of a weight gain of 4.9 pounds (2.28 kg) for a 5 foot, 7 inch–tall person (172.7 cm).

Table 3 presents coefficient estimates for the relationship between sitting time at work and BMI from fixed-effects models; longer sitting time was significantly associated with higher BMI ($\beta=0.054$, $p<0.05$) for the overall sample. Thus, if one’s sitting time at work were to change from never (1 rating) to continuously or almost continuously (5 rating), BMI would increase by 0.216. But the results differed substantially by gender. For men, the association was statistically significant ($\beta=0.086$, $p<0.01$); for women, the coefficient of sitting time was not statistically different from zero. Gender differences in the association were consistent when the upper limit for the PA measures was set at different levels (Appendix Table 1, available online); the estimated association was significant among men, but no significant associations were found among women.

### Table 2. Characteristics of NLSY79 Respondents in Working Dataset in Base Year, 2002 (N=5,285)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (weighted)</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>46.7%</td>
<td></td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Age</td>
<td>41.5</td>
<td>2.28</td>
<td>38</td>
<td>45</td>
</tr>
<tr>
<td>Black</td>
<td>13.4%</td>
<td></td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Hispanic</td>
<td>6.5%</td>
<td></td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Education (in years)</td>
<td>13.7</td>
<td>2.49</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>BMI</td>
<td>27.7</td>
<td>5.42</td>
<td>15.5</td>
<td>49.9</td>
</tr>
<tr>
<td>Ratings of workplace sitting time, 6 months prior to interview</td>
<td>3.0</td>
<td>1.13</td>
<td>0</td>
<td>5.0</td>
</tr>
<tr>
<td>Work hours (all jobs), 6 months prior to interview</td>
<td>41.1</td>
<td>14.11</td>
<td>0</td>
<td>105</td>
</tr>
<tr>
<td>Hours of vigorous physical activities per week</td>
<td>3.0</td>
<td>4.34</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>Hours of light/moderate physical activities per week</td>
<td>4.7</td>
<td>6.81</td>
<td>0</td>
<td>21</td>
</tr>
</tbody>
</table>

### Table 3. Fixed-Effects Regression Assessing the Association Between Workplace Sitting Time and BMI, National Longitudinal Survey of Youth 1979 (NLSY79) in 2002–2010

<table>
<thead>
<tr>
<th></th>
<th>All (N=25,096)</th>
<th></th>
<th>Male (n=12,625)</th>
<th></th>
<th>Female (n=12,471)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef.</td>
<td>SE</td>
<td>Coef.</td>
<td>SE</td>
<td>Coef.</td>
<td>SE</td>
</tr>
<tr>
<td>Age (centered at 40 years)</td>
<td>0.099***</td>
<td>0.005</td>
<td>0.090***</td>
<td>0.006</td>
<td>0.109***</td>
<td>0.008</td>
</tr>
<tr>
<td>Education (in years)</td>
<td>0.002</td>
<td>0.049</td>
<td>-0.024</td>
<td>0.075</td>
<td>0.003</td>
<td>0.067</td>
</tr>
<tr>
<td>Workplace sitting time</td>
<td>0.054*</td>
<td>0.025</td>
<td>0.086**</td>
<td>0.032</td>
<td>0.025</td>
<td>0.038</td>
</tr>
<tr>
<td>Work hours, all jobs</td>
<td>0.002</td>
<td>0.001</td>
<td>0.003</td>
<td>0.002</td>
<td>0.001</td>
<td>0.002</td>
</tr>
<tr>
<td>Hours of vigorous physical activities</td>
<td>-0.009</td>
<td>0.005</td>
<td>-0.002</td>
<td>0.005</td>
<td>-0.024*</td>
<td>0.009</td>
</tr>
<tr>
<td>Hours of light/moderate physical activities</td>
<td>-0.008*</td>
<td>0.003</td>
<td>-0.009*</td>
<td>0.004</td>
<td>-0.007</td>
<td>0.006</td>
</tr>
<tr>
<td>Constant</td>
<td>27.755***</td>
<td>0.665</td>
<td>28.257***</td>
<td>1.005</td>
<td>27.599***</td>
<td>0.917</td>
</tr>
</tbody>
</table>

Note: Boldface indicates statistical significance (*$p<0.05$; **$p<0.01$; ***$p<0.001$). Coef, coefficient.
Consistent with the fixed-effects model, the random-effects model (Model 1 of Appendix Table 2, available online) showed that the association between workplace sitting time and BMI was significant for the overall sample ($\beta=0.056, p<0.05$). Model 2 indicated that gender and sitting time interacted in their relationship with BMI ($\beta=-0.112, p<0.05$), and the association was significant for men ($\beta=0.120, p<0.001$) but not for women ($\beta=0.007, p=0.82$).

**Discussion**

Data from NLSY79 and O*NET were used to examine the association between sedentary work and BMI. The results showed that longer sitting time at work was significantly associated with higher BMI for the overall sample and for men. For women, the association was not statistically significant. Gender differences in coefficient estimates have been reported by at least two previous studies. The findings corroborated a 2003 Australian cross-sectional study, but contrasted with a Norwegian cohort study that did not find a prospective association among men. Neither of these studies provided detailed explanations for the observed gender differences.

For the present study, the difference in coefficient estimates is not believed to suggest distinct biological mechanisms between men and women, but rather potential residual confounding and selection bias. The NLSY79 did not comprehensively document participants’ PA and did not record participants’ diet. These unmeasured factors may differ between men and women, which may have contributed to the observed gender difference. Selection bias might confound the coefficient estimates for women. People tend to spend less time sitting at work in general if their jobs have higher physical demands, and three previous studies showed that women with higher BMIs were more frequently employed in jobs requiring a higher level of physical demand. This indicates a (counterintuitive) relationship between higher BMI and physically strenuous jobs among female workers. A strong selection bias at work would attenuate the coefficient estimates, as the coefficient would be influenced by the causal effect of long sitting time on BMI (a positive association) and selection bias (a negative association).

**Limitations**

One limitation of this study was the fact that O*NET data value for a given occupation was a constant, preventing the authors from assessing within-occupational changes in sitting time even though people may have increasingly spent more time sitting at work without changing their occupation. Misclassification of sitting time is possible, especially for occupations with a highly diversified job content; for example, the rating for “physicians” may be too high for those working in emergency rooms but low for those who spend most of their time in research. Still, O*NET is one of the few data sources that have comprehensively evaluated job characteristics using national samples. Despite its limitations, many studies have used it to assess the association between job content and a variety of health conditions.

In addition, the study has other limitations. The NLSY79 did not comprehensively record participants’ energy expenditures of varying intensity (e.g., time spent driving or sedentary behaviors off work). The observed association might be attributable to those unmeasured factors and the possibility of residual confounding cannot be ruled out. A non-negligible proportion of the PA measures had data values too high to be realistic. However, imposing a threshold for these extreme values or excluding them from the analyses yielded similar results. BMI is not a perfect measure for body adiposity, and factors other than increasing body fat could contribute to heightened BMI, such as developing muscle mass. Missing data in the sample survey could also introduce bias. However, missing data owing to death (3.7% and 6% of eligible participants in 2002 and 2010, respectively), participant non-response (18.2% of all eligible observations), and item non-response (16.8% of all observations in the working subpopulation) was relatively small, and therefore it does not appear that the resulting loss of information would change the results dramatically.

The study has several strengths. First, the analyses are based on a large and ongoing national cohort survey; the sample resembles the national demographic profile and consists of diverse occupational groups, instead of a single occupation. The NLSY79 cohort has a relatively high participation rate and low sample attrition. The longitudinal nature and employment history information of NLSY79 allowed the authors to construct an exposure that ensured temporal precedence. Lastly, fixed-effects models have particular strengths in reducing omitted-variable bias, and robustness checks yielded similar results.

**Conclusions**

American adults spend more than half of their waking time in sedentary behaviors. Prolonged sitting time is linked with mortality and many chronic diseases, independent of PA level. The results of the study showed that longer sitting time at work was significantly associated with higher BMI for the overall sample and for men. The results provide support for measures to reduce the
duration of sitting in the workplace. Future studies should measure sitting time with objective measures\(^2\)\(^5\) and investigate the underlying biological mechanisms.\(^3\)\(^4\) Given the deleterious consequences of sedentary behavior and its potential contribution to weight gain, the public health community should promote interventions to reduce time spent sitting both during and outside of work.

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References


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Appendix

Supplementary data

Supplementary data associated with this article can be found at, http://dx.doi.org/10.1016/j.amepre.2015.07.024.