Examining Sedentary Work and BMI Prospectively: Evidence from the National Longitudinal Survey of Youth 1979 (NLSY79)

Authors: Tin-chi Lin[1,2] PhD, Theodore K. Courtney[1,2] MS, CSP, David A. Lombardi[1,2], Santosh K. Verma[1,3] MD, ScD

1. Center for Injury Epidemiology, Liberty Mutual Research Institute for Safety, Hopkinton, MA, USA

2. Environmental and Occupational Medicine and Epidemiology Program, Department of Environmental Health, Harvard School of Public Health, Boston, MA, USA

3. Department of Family Medicine and Community Health, University of Massachusetts Medical School, Worcester, MA, USA

Correspondence to: Tin-chi Lin, Center for Injury Epidemiology, Liberty Mutual Research Institute for Safety, Hopkinton, MA 01748, USA. [Email: tin-chi.lin@LibertyMutual.com ; fax: +1(508)435-0482]

ABSTRACT

We examined workplace sitting time and body mass index (BMI) prospectively using the National Longitudinal Survey of Youth 1979 (NLSY79). The outcome, BMI, was based on self-reported height and weight. Sitting time was extracted from the Occupational Information Network and linked to NLSY79 participants. We used fixed-effects models and conducted a series of sensitivity analyses.

Longer sitting time was significantly associated with higher BMI ($p < 0.05$) for the overall sample. However, the results differed substantially when analyzed by gender. For men, long sitting time was significantly associated with higher BMI ($p < 0.01$). For women, the association was not statistically significant.

Ours is the first prospective study in an occupationally diverse cohort to document an association between BMI and workplace sitting time among men. Our findings provide further support for initiatives to reduce workplace sitting time as a means of reducing the risk of obesity and related health conditions.

EXTENDED ABSTRACT

INTRODUCTION

Individually and societally, we have benefited from many technological advancements; more output can be generated with less input. But the pursuit for efficiency and maximization of output bears its cost: people's body weight may have increased as a side effect of technological progress (1, 2). Work has become less strenuous, and studies have shown that energy expenditure due to work has declined steadily over the previous decades (3).

Whether sedentariness at work leads to weight gain has received some attention (3, 4, 5, 6, 7, 8, 9). However, as review articles (10, 11, 12) point out, most previous research has used a cross-sectional design. Associations reported by cross-sectional studies lack temporal precedence between sedentary work and BMI and may not reflect a causal effect of sedentary work, because obese people tend to increase sedentary behaviors, and potentially, pre-select themselves into more sedentary jobs.

We are aware of only two prospective studies that have investigated this topic (13, 14) to date, but their results were inconsistent. Also, similar to the cross-sectional research studies, the two prospective studies used samples from a single occupational group or sector (American nurses and British government workers); so it is difficult to determine whether their results were driven by occupation or sector-specific factors or are generalizable to the entire workforce.

The relationship between sedentary work and obesity warrants further analysis with a broadly representative sample, a study design which ensures temporal precedence of exposure, and robust statistical methods. To this end, we used the National Longitudinal Survey of Youth 1979 (NLSY79) as our primary dataset.

METHOD

Our primary data source was the National Longitudinal Survey of Youth 1979 (NLSY79), an ongoing prospective longitudinal study which began in 1979 with a nationally representative sample of 12,686 U.S. men and women then aged 14-22. The survey interviewed participants each year from 1979 to 1994 and every other year since then. Detailed information on sampling and data collection of the NLSY79 survey is published elsewhere (15, 16).

We used BMI (body mass index) as the outcome, based on self-reported height and weight from NLSY79 participants. We controlled for participants' age (centered at 40), education (in years), reported weekly frequencies of moderate and vigorous leisure-time exercise, and total weekly work hours.

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. O*NET is an online database developed for the U.S. Department of Labor(17); it collects occupational information such as skills required for a job. O*NET has been used

extensively for research in industrial psychology (18) and economics (19), and for occupational exposures in health-related studies (20). Below is the O*NET question that was used:

Element id 4.C.2.d.1.a: *"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). Table 1 and 2 show the most and least sedentary jobs based on O*NET; the data value shown is the average of responses within a given occupation.

We analyzed the NLSY79 data from 2002 to 2010 (the latest publicly available data at the initiation of our study). We selected 2002 as the starting year, because preliminary analysis indicated that over 30% of the pre-2000 NLSY79 observations could not be matched with O*NET. To ensure the temporal precedence of our exposure variable (i.e. time spent sitting at work), we used NLSY79's considerable employment history data (21). With the employment history available, we could determine which job(s) a participant held at any given time prior to the interview as well their occupation(s). O*NET data for sitting time was then linked to the NLSY79 participants through the occupations identified for the given time period using a crosswalk developed by the Bureau of Labor Statistics (22). For hypothesis testing, we constructed the exposure using the job(s) reported six months prior to the interview. The choice of six months was arbitrary; we went on to crosscheck the results using job(s) held at 3, 9, 12, 15, and 18 months before interview.

Fixed-effects models (23) were used to examine the association between sitting time and BMI. Although less efficient than methods such as random-effects models, fixed-effects models have unique advantages in obtaining unbiased estimates: they can control for the effects of all stable factors (e.g. ethnicity) that do not change over time. Since body weight could be influenced by many factors that may or may not be assessed by a survey, considerations for reducing bias due to omitted variables outweighed achieving statistical efficiency. Because men and women differ fundamentally in labor market activities (24), we ran the model first for the overall sample, and then for females and males respectively.

RESULTS

Table 3 presents characteristics of the participants in the base year, 2002. The demographic profile of these 5,305 participants was similar to the U.S. population of the same age range in 2002 (25), except that our working data set had a higher proportion of males than the national average (53.3% vs. 50.4%), presumably because employment history was required for a participant to be included in our analysis. On average, at the baseline the participants were 41.5 years old, had completed 13.7 years of education, and did moderate and vigorous exercise 7 and 4 times 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 grew steadily; the average BMI

increased from 27.7 kg/m2 in 2002 to 28.4 in 2010, equivalent of a weight gain of 4.6 pounds (2.1 kg) for a 5 foot, 7 inch tall person (172.7cm).

Table 4 presents coefficient estimates for the relationship between sitting time and work and BMI from fixed-effects models, controlling for age, education, work hours, and weekly frequencies of leisure time exercise. The analysis suggested that that longer sitting time was significantly associated with higher BMI ($p < 0.05$) when we ran regression for the overall sample. However, the results differed substantially when assessed by gender. For men the association was statistically significant ($p < 0.01$); but for women, the coefficient of sitting time was not statistically different from zero.

Sensitivity analyses produced a similar pattern. Table 5 shows the association between sitting time and BMI using exposure evaluated at 3, 9, 12, 15, and 18 months prior to the interview with the same control variables; longer sitting time was significantly associated with higher BMI only among men, as long as the exposure was evaluated within 6-12 months prior to the interview.

DISCUSSION

An earlier study (26) showed that American adults spent more than half of their waking time in sedentary behaviors. In an increasingly automated economy, jobs are growing more sedentary, and the overall level of sedentary time in a working day could increase further. Prolonged sitting time is found to be linked with mortality (27) and many diseases, such as colon cancer (28) or type-2 diabetes (13), independent of physical activity level. Ours is the first prospective study to document a significant gain in weight associated with sitting time at work among males, using a large, occupationally diversified sample with a series of robustness checks.

In our study, the coefficient estimates for sitting time differed substantially by gender; the coefficients were not statistically significant for females (Table 4 and 5), with the magnitude being smaller and standard errors larger than males. We do not think this difference suggests distinct biological mechanisms between men and women, and potential explanations include: (a) females' selection into occupation due to weight difference (29), which then attenuates the coefficient estimate, and (b) the fact that females' workplace sitting time (as reported by O*NET) was less evenly distributed across occupations than males.

Our results differed from one of the few prospective studies (13), which demonstrated that longer occupational sitting time (including driving) was significantly correlated with onset of obesity among female nurses. In that study the baseline sample consisted of a single occupation (nurses). Because the participants were occupationally homogeneous, the aforementioned selection bias, which would not be evident unless the sample consisted of workers of different skills and physical traits, would be less likely to affect their analyses.

There are several opportunities for future research suggested by our analysis. Whenever possible objective measures of exposure and outcomes should be used to improve upon self-reported measures (30). Future research should include off-work physical activities and if possible, dietary information. In addition, fundamental biophysical research should be

encouraged to study the mechanism. For example, recent research (31) indicated that sitting may distort the intracellular environment which in turn may result in an increase in fat content in the body. Intervention studies should be also be conducted. For example, options to reduce sitting time could be considered such as replacing the conventional workstation with one that permits alternating between sitting and standing (32), or work processes could be redesigned to reduce sitting for extended periods.

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TABLES

Table 1. The Most Sedentary Jobs

Ranking	Occupation	How much time do you spend sitting (min = 1, max = 5)?
1	Telephone operators	4.98
2	Insurance underwriters	4.92
3	Tax preparers	4.91
4	Telemarketers	4.90
5	Statisticians	4.87
6	Computer programmers	4.86
7	Atmospheric and space scientists	4.85
8	Technical writers	4.81
9	Editors	4.81
10	Budget analysts	4.79
11	Actuaries	4.79
12	Operations research analysts	4.75
13	Bill and account collectors	4.74
14	Mathematicians	4.74
15	Loan counselors and officers	4.73
16	Computer software engineers	4.72
17	Proofreaders and copy markers	4.72
18	Insurance claims and policy processing clerks	4.71
19	Market and survey researchers	4.70
20	Database administrators	4.69
21	Switchboard operators, including answering service	4.68
22	Credit authorizers, checkers, and clerks	4.67
23	Credit analysts	4.67
24	Personal financial advisors	4.66
25	Word processors and typists	4.65

Table 2. The Least Sedentary Jobs

Ranking	Occupation	How much time do you spend sitting (min = 1, max = 5)?
-1	Manufactured building and mobile home installers	1.09
-2	Bakers	1.12
-3	Tire builders	1.15
-4	Drywall installers, ceiling tile installers, and tapers	1.18
-5	Brickmasons, blockmasons, and stonemasons	1.18
-6	Pressers, textile, garment, and related materials	1.20
-7	Cabinetmakers and bench carpenters	1.21
-8	Maids and housekeeping cleaners	1.26
-9	Textile knitting and weaving machine setters, operators, and tenders	1.26
-10	Bartenders	1.27
-11	Butchers and other meat, poultry, and fish processing workers	1.28
-12	Woodworking machine setters, operators, and tenders, except sawing	1.28
-13	Crossing guards	1.30
-14	Combined food preparation and serving workers, including fast food	1.30
-15	Dishwashers	1.30
-16	Hairdressers, hairstylists, and cosmetologists	1.30
-17	Upholsterers	1.32
-18	Counter attendants, cafeteria, food concession, and coffee shop	1.34
-19	Hosts and hostesses, restaurant, lounge, and coffee shop	1.34
-20	Cutting workers	1.35
-21	Plating and coating machine setters, operators, and tenders, metal and plastic	1.35
-22	Cashiers	1.36
-23	Cement masons, concrete finishers, and terrazzo workers	1.38
-24	Food preparation workers	1.38
-25	Fence erectors	1.39

Table 3. Characteristics of NLSY79 Respondents in the Working Dataset in the Base Year, 2002 (N = 5,305)

Variable	Mean (weighted)	Standard Error	Min	Max
Female	46.7%	0.50	0	1
Age	41.5	2.28	38	45
Black	13.3%	0.34	0	1
Hispanic	6.5%	0.25	0	1
Education (in year)	13.7	2.49	0	20
Body Mass Index (BMI)	27.7	5.42	15.5	49.9
Ratings of Workplace sitting time, 6 months prior to interview	3.0	1.13	0	5
Work hours (all jobs), 6 months prior to interview	41.1	14.10	0	105
Weekly frequency of vigorous off-work exercise	4.2	6.51	0	28
Weekly frequency of moderate off-work exercise	7.0	10.57	0	42

Table 4. Main Results: Fixed-effects Regression for All, Male, and Female Sample Members, National Longitudinal Survey of Youth 1979 (NLSY79) in 2002-2010.

	All (N = 25,248)			Men (N = 12,727)			Women (N = 12,521)		
	Coef.	S.E.	*p-value*	Coef.	S.E.	*p-value*	Coef.	S.E.	*p-value*
Workplace sitting time	0.055	0.025	*	0.089	0.032	**	0.024	0.038	
Age (centered at 40)	0.101	0.005	***	0.092	0.006	***	0.110	0.007	***
Education (in year)	0.003	0.049		-0.026	0.075		0.007	0.067	
Work hours, all jobs	0.002	0.001		0.003	0.002		0.001	0.002	
Weekly freq. of off-work vigorous exercise	-0.007	0.003	*	-0.006	0.003	*	-0.011	0.005	*
Weekly freq. of off-work moderate exercise	-0.001	0.002		0.001	0.002		-0.003	0.003	
Constant	27.697	0.663	***	28.231	1.002	***	27.524	0.915	***

Note: Coef. = coefficient; S.E. = standard errors; *: p< 0.05, **: p< 0.01, ***: p< 0.001

Table 5. Sensitivity Analysis: Running Fixed-effects Models Using the Original O*NET Variable on Sitting Time at 3, 6, 9, 12, 15, and 18 Months prior to Interview, Respectively.

			At what time was the exposure evaluated (number of months prior to interview)?					
	Sample		3 mon.	6 mon.	9 mon.	12 mon.	15 mon.	18 mon.
Using original O*NET variable for workplace sitting time	All	coef.	0.043	0.055*	0.063*	0.054*	0.031	0.005
		S.E.	(0.025)	(0.025)	(0.025)	(0.024)	(0.024)	(0.024)
	Men	coef.	0.058	0.089**	0.097**	0.089**	0.048	0.015
		S.E.	(0.032)	(0.032)	(0.032)	(0.031)	(0.030)	(0.030)
	Women	coef.	0.029	0.024	0.033	0.022	0.016	-0.003
		S.E.	(0.038)	(0.038)	(0.038)	(0.038)	(0.037)	(0.036)

Note: Coef. = coefficient; S.E. = standard errors; *: p< 0.05, **: p< 0.01, ***: p< 0.001. All regression models controlled for age, education, work hours (all jobs), weekly frequencies of vigorous and moderate exercise in leisure time, as the primary analysis did.