Sedentary Work, Low Physical Job Demand, and Obesity in US Workers

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Background *Little is known about the role of low physical activity at work (sedentary work or low physical job demand) in the increasing prevalence of obesity of US workers.*
Methods *This cross-sectional and secondary data analysis included 1,001 male and 1,018 female workers (age range: 32–69) from the National Survey of Midlife Development in the United States (MIDUS) II study (2004–2006). Sedentary work and physical job demand were measured by questionnaire items. Total obesity (based on body mass index) and central obesity (based on waist circumference) were defined using WHO criteria.*
Results *After controlling for covariates (socio-demographic, psychosocial working conditions, health status, and health behaviors), sedentary work, low physical job demand, or their combination increased the risk for total and central obesity in male workers, particularly when they worked longer than 40 hr per week. Sedentary work marginally increased the risk for total and central obesity in female workers.*
Conclusions *Low physical activity at work is a significant risk factor for total and central obesity in middle-aged US male workers.* Am. J. Ind. Med. *© 2010 Wiley-Liss, Inc.*

KEY WORDS: total obesity; central obesity; psychosocial work; health behaviors; work hours

INTRODUCTION

Obesity, an excess of body fat, has been recognized as a serious public health issue in the general population and among workers in the United States (US) since the 1980s [Ford et al., 2003; Caban et al., 2005; Ogden et al., 2007]. Obesity has been well documented as a key risk factor for a wide range of chronic diseases such as hypertension, coronary heart disease, osteoarthritis, dyslipidemia, Type II diabetes, some cancers as well as increased mortality [NIH, 1998; Flegal et al., 2005]. One estimate of the national cost of obesity amounted to 78.5 billion in 1998, which accounted for 9.1% of total US medical expenditures in the same year [Finkelstein et al., 2003].

Experts agree that the obesity epidemic arises from changes in the environment and health behaviors rather than from changes in genes [Prentice and Jebb, 1995; Hill and Peters, 1998; Peters, 2002]. However, there is not a clear consensus on what environmental and behavioral changes have driven the US obesity epidemic [Williamson et al., 1991; Harnack et al., 2000; Helmchen, 2001; Philopson, 2001; Young and Nestle, 2002; Zhang and Wang, 2004; Block et al., 2009].

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One possible explanation is that ''the decline in work-related physical activity seems a prime suspect in the growth of obesity.'' [Philopson, 2001, p. 2]. In fact, there have been substantial changes in technology (e.g., computers), the organization of work (e.g., lean production system) as well as the structure of industries and occupations (e.g., service-driven economy and increased women's labor force participation rate) and labor relations (i.e., decreased union density) in the US since the 1980s [Ashford and Caldart, 1996; Adler et al., 1997; Auto et al., 2001; Freeman, 2007]. Consequently, routine manual tasks at work (within detailed occupations) in the US have been reduced substantially over time by mechanization, automation, or computerization [Auto et al., 2001; Helmchen, 2001]. Strenuous jobs have decreased and sedentary jobs (i.e., sitting most of time) have increased significantly in male workers, albeit not to the same extent in female workers [Lakdawalla and Philipson, 2007]. In addition, work-related, dynamic physical activities have been further restricted due to lean production systems restricting workers, in terms of work space as well as time and motion [Womack et al., 1991; Adler et al., 1997; Leslie and Butz, 1998; Nelson-Peterson and Leppa, 2007].

However, few studies [Jeffery et al., 1991; King et al., 2001; Hu et al., 2003] have investigated the role of low physical activity at work (sedentary work or low physical job demand) in the increasing prevalence of obesity of US workers. In addition, the association between low physical activity at work and obesity has been inconclusive in the few existing studies, as is the case in non-US studies [Haglund, 1987; Pols et al., 1997; Bell et al., 2001; Gutiérrez-Fisac et al., 2002; Ishizaki et al., 2004; Mummery et al., 2005; Ostry et al., 2006; Böckerman et al., 2008].

Physical inactivity at work was associated with total obesity (BMI $\geq 30\,kg/m^2$) in the third National Health and Nutrition Examination Survey (1988–1994), but the finding was not presented separately for male and female workers [King et al., 2001]. Hu et al. [2003] also reported that sedentary work was a risk factor for total obesity in female nurses, although sedentary work was defined broadly in this study to include not only sitting at work, but also sitting away from home or while driving. By contrast, Jeffery et al. [1991] found no association (for men) and a significant, ''positive'' association (for women) between physical job activity and total obesity in the Healthy Worker Project.

These studies have limitations, in particular, that they did not adjust in their analyses for adverse psychosocial working conditions [Jeffery et al., 1991; King et al., 2001; Hu et al., 2003] and/or any energy intake information [King et al., 2001]. In addition, none of the studies [Jeffery et al., 1991; King et al., 2001; Hu et al., 2003] examined central obesity as an outcome, which has been known to be more strongly associated with chronic diseases than BMI [Ford et al., 2003; Vazquez et al., 2007; Lee et al., 2008] and has been a key criterion for clinical diagnosis of the metabolic syndrome [Zimmet et al., 2005].

In this analysis of the MIDUS II data set, we will test whether low physical activity at work (sedentary work or low physical job demand) is associated with total (based on BMI) and central (based on waist circumference) obesity in male and female US workers, after adjustment for various socio-demographic and psychosocial working condition variables, health conditions, and health behaviors (including leisure-time physical activity (LTPA) and stress-induced overeating behavior).

METHODS

Study Population

Data from the National Survey of Midlife Development in the United States (MIDUS) II study [Ryff et al., 2007] were used for this study. Unfortunately, information on physical activity at work, LTPA, and eating behaviors was not available in the MIDUS I study so it was not possible to perform a longitudinal analysis. From 1995 to 1996, the MacArthur Midlife Research Network carried out a national survey (i.e., MIDUS I study) to investigate the role of behavioral, psychological, and social factors in understanding age-related differences in physical and mental health [Ryff et al., 2007]. In the MIDUS I study, 7,108 persons (males, 48% and females, 52%) completed a telephone interview only (n = 783) or both the interview and mailed questionnaires (n = 6,325). All of the participants were non-institutionalized, English-speaking adults, aged 25–74, in the US. They were drawn from four subsamples: (1) a national random-digit-dial (RDD) sample (n = 3,487); (2) oversamples from five metropolitan areas (N = 757); (3) siblings of individuals from the RDD sample (n = 950); and (4) a national RDD sample of twin pairs (n = 1,914). The response rates of the four subsamples ranged from 60% to 70%. The four subsamples were very similar to one another in terms of the distributions of age, education, and gender [Ryff et al., 2007]. The socio-demographic characteristics of the RDD subsample were comparable to those of a US population representative sample, the October 1995 Current Population Survey (http://www.census.gov/cps). However, the RDD subsample relatively underrepresented those who were blacks, young (e.g., aged 25–34), or had less education (i.e., 12 or <12 years of formal education) [Ryff et al., 2007].

A follow-up survey of the participants of the MIDUS I study respondents was conducted from 2004 to 2006. The average follow-up interval was ~9 years later and ranged from 7.8 to 10.4 years. The longitudinal retention rates among the four subsamples ranged from 65% to 78% (on average, 70%). There were no significant ($P < 0.01$) differences between the follow-up participants and non-participants in terms of age and gender. However, in the follow-up,

less-educated persons and non-Whites were relatively more likely to have dropped out of the study. For the MIDUS II study, 4,963 persons (males, 47% and females, 53%) completed a telephone interview only (n = 931) and both the interview and a mailed questionnaires (n = 4,032). For this analysis, we first restricted study subjects to those (n = 2,292) who completed both the interview and mailed questionnaire (n = 4,032), were not pregnant (n = 4,954), were working at a paid-job (at least 1 hr per week at a main job) in the MIDUS II survey (n = 2,469), and were aged <70 years (n = 4,177). Finally 2,019 workers (1,001 males and 1,018 females) who had valid information on the exposure and outcome variables (see below) were chosen for this study.

Exposures—Sedentary Work and Low Physical Job Demand

Several methods of assessing physical activity have been used in epidemiologic research [LaPorte et al., 1985]. Among the methods, self-reported physical activity measures have been shown to be the most practical for large population-based epidemiologic studies [LaPorte et al., 1985; Owen and Bauman, 1992]. In this study, physical activity at work was also estimated by self-reported sedentary work and physical effort.

Sedentary work was measured by one questionnaire item (i.e., ''how often does your job require you to sit for long periods of time during your work-shift?'') having a five-part Likert response set (all, most, some, little of the time, and never). For this analysis, the responses were grouped into high (all and most); middle (some); and low (little and never: the reference group) (Table I). As in this study, sedentary work has been measured in many population-based studies by a single questionnaire item that asks about sitting time at work [Cooper et al., 1990; Brown et al., 2003; Ishizaki et al., 2004; Mummery et al., 2005]. In addition, Miller and Brown [2004] reported that the 1-week test and re-test reliability of a questionnaire item for sedentary work (i.e., the number of hours they spent sitting at work) was excellent (intra-class correlation coefficient = 0.76) and self-reported sitting time at work was significantly associated with pedometer-counted walking steps in a group of Australian male and female workers.

The level of physical job demand was also assessed by a single questionnaire item (i.e., ''how often does your job require a lot of physical effort during your work-shift?'') with the same response set as for the sedentary work question. For this analysis, the responses were trichotomized as for the sedentary work variable. The physical job demand item was highly correlated with two other questionnaire items of detailed physical work activities (lifting 50 or more pounds and crouch/stoop/kneel at job) in the MIDUS II data set: Spearman coefficients, >0.71 for men and >0.57 for women. In a US national study [Lakdawalla and Philipson, 2007], self-reported physical job demand (using the same item as in this study) was significantly correlated with the ''physical demand-strength rating'' of the revised 4th edition Dictionary of Occupational Titles (DOT). The rating was done by job-analysis experts for each detailed occupation and expressed by one of the following five items: sedentary (e.g., involving sitting), light, medium, heavy, and very heavy work (e.g., frequent lifting of objects weighing 50 pounds or more). Also, similar physical effort items have been used in some epidemiological studies about physical job demands and general obesity [Haglund, 1987; Ostry et al., 2006].

A preliminary data analysis revealed a highly negative correlation between the sedentary work and physical job demand variables: Spearman coefficients were −0.53 and −0.48 for men and women, respectively. So a variable combining sedentary work and physical job demand (hereafter called ''physical inactivity at work'') was additionally created to examine a potential interaction effect between sedentary work and physical job demand on obesity. Also, theoretically, these two aspects of physical activity at work are complementary to each other since they are assessing two extreme ends of physical activity at work. The ''physical inactivity at work'' variable was then grouped into three categories: high (high sedentary work and low physical job demand); low (low sedentary work and high physical job demand); and middle (the other combination groups of sedentary work and physical job demand). Spearman correlations of quantitative job demand (see below) with sedentary work and physical job demand were weak (i.e., <0.11) for both men and women.

Despite the same response (e.g., all of the time—*your work-shift*) to the sedentary work and physical job demand items, its meaning (i.e., absolute exposure time) could differ by the length of the ''work-shift'' of the respondents (e.g., 8 hr for a worker who works 8 hr per day vs. 12 hr for a worker who works 12 hr per day). To address this issue, the risks of sedentary work and low physical demand for total and central obesity in the multivariate analyses (see below) were additionally investigated by stratifying the variable, working hours per week of the respondents into ≤40 and >40 hr per week.

As a sensitivity test, two-level definitions of sedentary work and physical job demand (high = all and almost of the time vs. low = some, little, and never) were employed for analysis. Also, an alternative definition of physical inactivity at work based on the aforementioned two-level variables was tested in the analysis.

Outcome—Obesity (Body Mass Index and Waist Circumference)

General obesity was defined by the body mass indexes (≥30 kg/m^2) [WHO, 2000], based on self-reported height

TABLE I. Total and Central Obesity Prevalence for the Variables for This Study in 1,001 Male and 1,018 Female US Workers

Major variable category	Minor variable category	Subcategory	Frequency (%)		Total obesity, % (based on BMI)		Central obesity, % (based on WC)	
			Men	Women	Men	Women	Men	Women
Data source	Subsamples	National random	42.1	41.7	29.7	24.3	35.9	40.1
		City	10.7	7.8	35.5	27.8	34.6	39.2
		Siblings	16.1	16.5	26.7	28.0	31.1	42.3
		Twin	31.2	34.1	26.6	28.5	30.1	44.4
Socio-demographic	Age (years old)	<40	10.2	13.3	22.5	28.9	22.5[a]	38.5
		40–49	34.0	35.6	27.6	28.2	30.3[a]	43.4
		50–59	37.9	35.1	31.7	26.3	36.7[a]	38.7
		≥ 60	18.0	16.1	28.9	22.0	37.2[a]	48.2
	Marital status	Married	79.1	68.7	29.3	25.5	34.7[a]	40.6
		Non-married	20.9	31.3	27.3	29.2	27.3[a]	44.5
	Race	White	93.5	91.9	28.3	25.0[c]	32.5	40.7[a]
		Others	6.5	8.1	36.9	45.1[c]	43.1	54.9[a]
	Education	High school or less	24.0	26.7	37.1[b]	30.9[b]	39.2[a]	48.2[b]
		Some college	26.1	31.5	31.0[b]	29.6[b]	36.0[a]	43.9[b]
		University or more	50.0	41.7	23.8[b]	21.6[b]	28.8[a]	36.2[b]
	Annual household income	$<$\$60,000	27.5	37.8	29.5	28.8	34.5	46.0[b]
		\$60,000 to \$99,999	35.7	30.6	32.5	27.3	35.0	44.7[b]
		$\geq$\$100,000	36.9	31.6	24.9	23.3	30.4	34.2[b]
	Any children, aged 0–6 years	No	88.6	90.9	29.4	26.3	33.7	41.8
		Yes	11.4	9.1	24.6	30.1	28.9	41.9
Working conditions	Sedentary work (S)	Low	34.4	35.8	26.7	25.0[a]	29.1	42.3[a]
		Middle	22.5	22.3	30.7	21.6[a]	33.8	34.8[a]
		High	43.2	41.9	29.6	30.7[a]	36.1	45.2[a]
	Physical job demand (P)	Low	53.6	59.1	27.7	27.9	34.3	42.0
		Middle	25.0	22.3	31.2	23.3	33.6	39.6
		High	21.4	18.6	29.0	26.5	29.9	43.9
	Physical inactivity at work ($=S+P$)	Low	14.6	13.9	25.3	28.4[a]	26.0	46.8[a]
		Middle	50.6	51.5	30.4	23.1[a]	34.1	38.0[a]
		High	34.8	34.7	28.2	31.2[a]	34.8	45.6[a]
	Job control	Low	46.0	53.3	30.0	29.5[a]	33.5	46.4[b]
		High	54.0	46.7	27.9	23.4[a]	32.9	36.6[b]
	Quantitative job demands	Low	41.7	42.4	30.2	25.8	35.7	42.2
		High	58.3	57.6	27.9	27.3	31.3	41.6
	Supervisor support	Low	43.3	39.9	30.5	27.8	31.6	43.8

		High	37.1	48.5	27.8	27.1	33.2	42.5
		No immediate supervisors	19.7	11.6	27.4	20.3	36.5	32.2
	Coworker support	Low	50.0	45.8	30.5	31.1[a]	32.3	45.0
		High	40.5	44.5	27.9	22.5[a]	34.8	39.3
		No coworkers	9.5	9.7	24.2	25.3[a]	30.5	39.4
	Hours of work per week at a main job	40 or less	47.5	77.8	29.7	25.4	35.4	41.5
		>40	52.5	22.2	28.1	31.0	31.2	42.9
	Any other (second) paid jobs	No	84.7	85.0	28.5	26.7	33.0	42.4
		Yes	15.3	15.0	30.7	26.1	34.0	38.6
Health status	Any chronic diseases	No	50.0	47.1	24.6[b]	21.9[b]	27.3[c]	34.2[c]
		Yes	50.0	52.9	33.2[b]	30.8[b]	39.0[c]	48.6[c]
	Major depression	No	95.7	88.7	29.5[a]	25.5[a]	33.6	40.5[a]
		Yes	4.3	11.3	14.0[a]	35.7[a]	23.3	52.2[a]
Health behaviors	Leisure-time physical activity	Non-active	55.2	55.6	32.7[b]	32.0[c]	37.8[b]	49.3[c]
		Active	44.8	44.4	24.1[b]	19.9[c]	27.5[b]	32.5[c]
	Stress-induced overeating	No	80.7	61.2	22.9[c]	17.3[c]	28.5[c]	31.3[c]
		Yes	19.3	38.8	53.9[c]	41.3[c]	52.8[c]	58.5[c]
	Current smoker	No	85.4	83.4	29.2	28.4[b]	34.0	42.6
		Yes	14.6	17.8	26.7	17.8[b]	28.1	37.9
	Alcohol consumption	No	30.4	36.5	34.2[a]	37.4[c]	38.2	51.9[c]
		Moderate	66.8	61.6	27.1[a]	20.6[c]	31.2	35.9[c]
		Heavy	2.8	1.9	14.3[a]	15.8[c]	25.0	42.1[c]
Obesity	Total obesity (BMI, $\geq$30 kg/m^2)		28.9	26.6				
	Central obesity (WC)		33.2	41.8				

BMI, body mass index; WC, waist circumference; >40 in. for men and >35 in. for women.
[a]$P < 0.05$, [b]$P < 0.01$, and [c]$P < 0.001$ at chi-square tests.

and weight information. There were strong correlations between self-reported and measured values of BMI in a subsample (n = 464) of the MIDUS II participants [Block et al., 2009]: Pearson correlation coefficients were 0.93 in men and 0.92 in women. Central obesity was defined by the self-reported waist circumferences (>40 in. for men; >35 in. for women) [WHO, 2000].

Covariates

Various potential covariates were considered in the analysis: data sources, socio-demographic [Ford et al., 2003; Zhang and Wang, 2004; Ogden et al., 2007], psychosocial working conditions [Rosmond et al., 1996; Shields, 2002; Brunner et al., 2007; Ishizaki et al., 2008; Block et al., 2009], health status, and health behaviors [van Strien et al., 1986; Williamson et al., 1991; Rosmond and Bjorntorp, 1999; Brunner et al., 2007]. Specifically, four data sources: city; siblings; and twin subsamples (vs. the national random subsample), age (<40; 40–49; 50–59; and ≥60 years old), sex, marital status (married and non-married), any children aged 0–6 years at home, race (Whites and others), annual household income (<$60,000; $60,000 to $99,999; and ≥$100,000), and education (high—university/graduate school graduate; middle—some college education, but unfinished; and low—high school graduate and lower education). Several psychosocial working conditions were measured by questionnaire items (see Appendix I): job control (skill discretion plus decision authority, five items), quantitative job demands (three items), coworker (two items) and immediate supervisor (two items) support, and no coworkers (two items) and immediate supervisors (two items). Job control, quantitative job demands, coworker support, and supervisor support were dichotomized into high and low at their median values. In addition, hours of work per week at a main job (≤40 and >40 hr per week) and other paid jobs (yes vs. no) were also self-reported.

The following health status and health behaviors were measured: major depression assessed by the telephone interview, based on the Diagnostic and Statistical Manual of Mental Disorders III-R [APA, 1987]; chronic diseases (those who have experienced or been treated for any of the following during the past 12 months: arthritis, sciatica, recurring stomach trouble or diarrhea, persistent foot troubles, trouble with varicose veins, multiple sclerosis, stroke, and hernia; or those who have ever had heart problems or ever had cancer); smoking (current smokers vs. non-smokers); alcohol consumption (moderate drinking—up to two drinks per day for men and one drink per day for women [USDHHS and USDA, 2005] during the past month and heavy drinking—more than moderate drinking vs. no drinking); active LTPA (i.e., vigorous or moderate physical activity long enough to work up a sweat, several times a week or more during the summer or the winter); and stress-induced overeating (those who endorsed either of the following two items about "how you respond when you are confronted with difficult or stressful events in your life": "I eat more than I usually do" and "I eat more of my favorite foods to make myself feel better").

Statistic Analyses

Descriptive statistics of obesity and physical activity at work were first conducted. The distributions of physical activity at work by education and occupation (nine major groups, see Table II, and detailed three-digit 1990 US census occupational classification codes) were also examined. The univariate associations of the study variables (including sedentary work, low physical job demand, and physical inactivity at work) with total and central obesity were examined through chi square tests (Table I). The associations of sedentary work, low physical job demand, and physical inactivity at work with total and central obesity were also investigated through a series of multivariate logistic regression models (Tables III–V), for men and women separately: Model 1—only one variable (sedentary work, physical job demand, or their combination variable, physical inactivity at work); Model 2—additionally with data sources, psychosocial working conditions, and socio-demographic variables; and Model 3—additionally with data sources, psychosocial working conditions, socio-demographic variables, health status, and health behavior variables. The multivariate analyses were replicated with stratification for working hours per week (≤40 and >40 hr per week) in order to examine whether the length of a person's work shift could modify the apparent effects of the sedentary work and low physical job demand items (Table V). Due to space limitations, the odds ratios (ORs) in the multivariate analyses were presented in Tables III and IV only for the covariates which were significant ($P < 0.05$) in the univariate analyses or in Model 3.

RESULTS

Descriptive Statistics of Total and Central Obesity

The means and standard deviations of BMI were 28.4 kg/m^2 and 4.9 for men, and 27.2 kg/m^2 and 6.2 for women, respectively. The medians of BMI were 27.6 for men and 25.8 for women. Total obesity percentages were 28.9% and 26.6% for male and female workers, respectively. The means and standard deviations of waist circumference were 39.2 in. and 4.8 for men, and 34.8 in. and 5.8 for women, respectively. The medians of waist circumferences were 38.0 in. for men and 34.0 in. for women. Central obesity percentages were 33.2% and 41.8% for male and female workers, respectively.

TABLE II. Percentages of High Sedentary Work (HS), Low Physical Job Demand (LPD), and High Physical Inactivity at Work (HPI) in Three Education Levels and Nine Major Occupation Groups of 1,001 Male and 1,018 Female US Workers

			Physical activity at work (%)		
Sex	**Category**	**Subcategory (%, frequency)**	**HS**	**LPD**	**HPI (HS and LPD)**
Men	Education	University or more (50.0)	58.0	73.6	51.6
		Some college (26.1)	30.7	41.8	22.6
		High school or less (24.0)	25.8	25.0	12.9
	Occupation	Executive, administrative, and managerial (28.8)	53.4	67.5	45.6
		Professional specialty (20.3)	60.3	83.9	54.8
		Technician and related support (3.7)	44.4	63.9	38.9
		Sales occupation (9.6)	43.6	61.7	36.2
		Administrative support including clerical (5.9)	46.6	46.6	36.2
		Service occupation (5.5)	24.1	31.5	14.8
		Farming, forestry, and fishing (2.4)	20.8	4.2	0.0
		Precision production, crafts, and repair (14.3)	10.7	13.6	5.7
		Operator, laborer, and military (9.6)	35.1	25.5	17.0
Women	Education	University or more (41.7)	44.7	67.8	37.9
		Some college (31.5)	42.1	55.8	34.6
		High school or less (26.7)	37.5	49.6	29.8
	Occupation	Executive, administrative, and managerial (18.6)	71.7	79.1	64.2
		Professional specialty (27.7)	28.0	57.0	22.2
		Technician and related support (4.5)	35.6	62.2	31.1
		Sales occupation (8.6)	26.4	59.8	23.0
		Administrative support including clerical (23.1)	64.4	73.8	54.5
		Service occupation (11.3)	7.0	26.3	3.5
		Farming, forestry, and fishing (0.9)	11.1	0.0	0.0
		Precision production, crafts, and repair (1.6)	31.3	25.0	12.5
		Operator, laborer, and military (3.8)	26.3	13.2	5.3

Spearman correlations between continuous body mass indexes and waist circumferences were 0.82 ($P < 0.001$) for men and 0.84 ($P < 0.001$) for women. The kappa values between total obesity and central obesity were 0.69 ($P < 0.001$) for men and 0.57 ($P < 0.001$) for women.

Descriptive Statistics of Sedentary Work and Physical Job Demand

The distributions of sedentary work, physical job demand, and physical inactivity at work in male workers were very similar to those in female workers (Table I). For instance, 34.8% of male workers and 34.7% of female workers reported high physical inactivity at work. As expected, high sedentary work and low physical job demand were most prevalent in the high education group (Table II). As a result, the percentages of high physical inactivity at work were highest in the high education group and followed by the middle and low education groups in both men and women. The educational gradient of physical inactivity at work was steeper in men than in women.

In addition, as expected, high sedentary work, low physical job demand, and high physical inactivity at work in male workers were most prevalent in executive, administrative, managerial, and professional occupations, while they were least prevalent in service occupations and manual workers (farming, forestry, and fishing; precision production, crafts, and repair; and operator, laborer, and military occupations) (Table II). In female workers, similar occupational distributions of the physical activity at work variables were observed. However, the percentages of high sedentary work and high physical inactivity at work were much higher in female clerical occupations and lower in female professional occupations than in male clerical and professional occupations, respectively. The distribution patterns of detailed occupations (based on the 1990 US census three-digit codes) in professional occupations were quite different between men and women, for example, ''lawyers'' was the most frequent occupation title for men and ''nurses'' was for women. Nonetheless, one occupation—''teachers, secondary school''—had comparable sample sizes in both men ($n = 17$; the second most frequent occupation in men) and women ($n = 25$; the third most frequent occupation in

TABLE III. Odds Ratios (95% Confidence Intervals) of Sedentary Work for Total Obesity (BMI, $\geq$30 kg/m^2) in US Male (n = 1,001) and Female (n = 1,018) Workers

Sex	Variables	Model 1	Model 2[a]	Model 3[b]
Men	Sedentary work (middle)	1.21 (0.84–1.76)	1.35 (0.91–1.99)	1.54 (1.02–2.33)
	Sedentary work (high)	1.15 (0.84–1.58)	1.48 (1.04–2.11)	1.44 (0.99–2.08)
	Education (middle)		1.54 (1.08–2.20)	1.57 (1.07–2.29)
	Education (low)		2.09 (1.44–3.04)	2.19 (1.46–3.28)
	Any chronic diseases			1.50 (1.11–2.04)
	Major depression			0.28 (0.11–0.72)
	Active leisure-time physical activity			0.68 (0.49–0.93)
	Stress-induced overeating			4.48 (3.15–6.39)
	Moderate alcohol consumption			0.78 (0.56–1.08)
	Heavy alcohol consumption			0.39 (0.12–1.21)
Women	Sedentary work (middle)	0.83 (0.56–1.23)	0.87 (0.58–1.32)	1.03 (0.66–1.60)
	Sedentary work (high)	1.33 (0.97–1.82)	1.31 (0.93–1.83)	1.38 (0.95–1.99)
	Job control (low)		1.24 (0.92–1.69)	0.97 (0.69–1.34)
	Coworker support (low)		1.52 (1.10–2.08)	1.46 (1.04–2.06)
	Working hours (>40 hr per week)		1.53 (1.07–2.18)	1.66 (1.12–2.44)
	Race (non-Whites)		2.48 (1.53–4.02)	2.60 (1.53–4.41)
	Education (middle)		1.57 (1.10–2.25)	1.60 (1.09–2.36)
	Education (low)		1.64 (1.12–2.40)	1.68 (1.09–2.57)
	Any chronic diseases			1.66 (1.21–2.30)
	Major depression			1.01 (0.63–1.64)
	Active leisure-time physical activity			0.59 (0.42–0.81)
	Stress-induced overeating			3.19 (2.32–4.40)
	Smoking			0.40 (0.25–0.66)
	Moderate alcohol consumption			0.45 (0.33–0.63)
	Heavy alcohol consumption			0.40 (0.11–1.54)

[a]Sources of subsamples, socio-demographic variables (age, marital status, race, education, annual household income, and any children, aged 0–6 years), and working conditions (job control, quantitative job demands, supervisor and coworker support, hours of work per week at a major job, and any other paid jobs) were controlled for.
[b]Covariates in Model 2 plus health status (any chronic diseases and major depression) and health behaviors (leisure-time physical activity, stress-induced overeating, current smoker, and alcohol consumption) were additionally controlled for. Due to space limitations, the odds ratios in the multivariate analyses were presented only for the covariates which were significant ($P < 0.05$) in the univariate analyses or in Model 3.

women). The percentages of high sedentary work, low physical job demand, and high physical inactivity at work were similar between the male and female teachers: 11.8%, 76.5%, and 5.9% for men and 0.0%, 72.0%, and 0.0% for women, respectively.

Univariate Associations With Total and Central Obesity

In the univariate analysis, sedentary work, physical job demand, and physical inactivity at work were not significantly ($P < 0.05$) associated with total and central obesity in male workers, although total and central obesity were more prevalent at the high or middle levels of sedentary work and physical inactivity at work than at the low levels (Table I). The prevalence of total and central obesity was lowest at the middle levels of sedentary work, physical job demand, and physical inactivity at work in female workers when compared to those at low or high levels, although total and central obesity were more prevalent at the high level of sedentary work than at the middle or low levels.

On the other hand, lower levels of education, lack of LTPA, stress-induced overeating, less alcohol consumption, and any chronic diseases were strongly associated with total and central obesity in both men and women. Subsamples, any children aged 0–6 years, quantitative job demands, supervisor support at work, hours of work per week at a main job, and any other paid jobs were not associated with total or central obesity in both men and women. Age and being married were associated with central obesity in male workers. Race (non-Whites), low job control, and major depression were associated with total and central obesity in female workers. Lower annual household income was associated only with central obesity while low coworker support and being a non-smoker were associated only with total obesity in female workers.

TABLE IV. Odds Ratios (95% Confidence Intervals) of Sedentary Work for Central Obesity (Waist Circumference, >40 in. for Men and >35 in. for Women) in US Male (n = 1,001) and Female (n = 1,018) Workers

Sex	Variables	Model 1	Model 2[a]	Model 3[b]
Men	Sedentary work (middle)	1.25 (0.87–1.79)	1.39 (0.95–2.57)	1.52 (1.02–2.26)
	Sedentary work (high)	1.38 (1.02–1.87)	1.82 (1.29–2.57)	1.78 (1.24–2.53)
	Age (40–49 years)		1.66 (0.96–2.88)	1.46 (0.83–2.59)
	Age (50–59 years)		2.09 (1.19–3.67)	1.75 (0.98–3.14)
	Age (60 or more years)		1.96 (1.05–3.65)	1.39 (0.72–2.69)
	Marital status (vs. married)		0.66 (0.46–0.96)	0.67 (0.45–0.99)
	Education (middle)		1.60 (1.14–2.27)	1.61 (1.12–2.31)
	Education (low)		1.82 (1.26–2.62)	1.85 (1.25–2.72)
	Any chronic diseases			1.57 (1.17–2.10)
	Active leisure-time physical activity			0.64 (0.48–0.87)
	Stress-induced overeating			3.11 (2.20–4.40)
Women	Sedentary work (middle)	0.73 (0.52–1.03)	0.79 (0.55–1.13)	0.86 (0.59–1.26)
	Sedentary work (high)	1.13 (0.85–1.49)	1.22 (0.90–1.66)	1.28 (0.92–1.78)
	Job control (low)		1.31 (1.00–1.72)	1.08 (0.81–1.45)
	Race (others vs. White)		1.85 (1.15–2.97)	1.85 (1.11–3.07)
	Income (middle)		1.54 (1.10–2.17)	1.49 (1.04–2.15)
	Income (low)		1.48 (1.01–2.15)	1.38 (0.92–2.08)
	Education (middle)		1.29 (0.94–1.76)	1.24 (0.88–1.75)
	Education (low)		1.39 (0.99–1.95)	1.31 (0.90–1.90)
	Any chronic diseases			1.75 (1.32–2.32)
	Major depression			1.14 (0.73–1.79)
	Active leisure-time physical activity			0.55 (0.41–0.74)
	Stress-induced overeating			3.11 (2.33–4.15)
	Smoking			0.64 (0.43–0.96)
	Moderate alcohol consumption			0.61 (0.46–0.82)
	Heavy alcohol consumption			0.91 (0.33–2.56)

[a]Sources of subsamples, socio-demographic variables (age, marital status, race, education, annual household income, and any children, aged 0–6 years), and working conditions (job control, quantitative job demands, supervisor and coworker support, hours of work per week at a major job, and any other paid jobs) were controlled for.
[b]Covariates in Model 2 plus health status (any chronic diseases and major depression) and health behaviors (leisure-time physical activity, stress-induced overeating, current smoker, and alcohol consumption) were additionally controlled for. Due to space limitations, the odds ratios in the multivariate analyses were presented only for the covariates which were significant ($P < 0.05$) in the univariate analyses or in Model 3.

Multivariate Associations With Total Obesity

In the multivariate analyses, both physical job demand and physical inactivity at work were not associated with total obesity in both men and women (data not shown). However, high and middle levels of sedentary work increased the risk for total obesity in male workers, when compared to the low level of sedentary work: their ORs for total obesity (95% confidence intervals (CIs) were 1.44 (0.99–2.08) and 1.54 (1.02–2.33), respectively (Table III). Although such significant risk increases were not observed in female workers, the risk of sedentary work for total obesity was still higher at the high level than at the low and middle level as expected: OR (95% CI) = 1.38 (0.95–1.99), $P = 0.09$.

In both men and women, lower levels of education, any chronic diseases, and stress-induced overeating were risk factors for total obesity, while active LTPA and alcohol consumption were inversely associated with total obesity as in the univariate analyses (Table III). In male workers, major depression was associated with a decreased risk for total obesity. In female workers, race (non-Whites), low coworker support, and long working hours per week increased the risk for total obesity, while smoking decreased the risk. Major depression and low job control were not associated with total obesity in female workers in multivariate models.

Multivariate Associations With Central Obesity

After controlling for all of the covariates, sedentary work, low physical job demand, and high physical inactivity at work were associated with central obesity in male workers. Increased risk was observed in both high and middle levels of

TABLE V. Odds Ratios (95% Confidence Intervals) of Sedentary Work, Physical Job Demand, and Physical Inactivity at Work for Total (Body Mass Index) and Central Obesity (Waist Circumference, >40 in. for Men and >35 in. for Women) in US Male (n = 526) Workers Who Worked More Than 40 hr per Week

		Total obesity			Central obesity		
Variables	Frequency (%)	Model 1	Model 2[a]	Model 3[b]	Model 1	Model 2[a]	Model 3[b]
Sedentary work (low)	29.5	1.00	1.00	1.00	1.00	1.00	1.00
Sedentary work (middle)	23.8	1.35 (0.80–2.28)	1.81 (1.03–2.90)	2.22 (1.21–4.09)	1.27 (0.76–2.12)	1.49 (0.86–2.61)	1.72 (0.96–3.11)
Sedentary work (high)	46.8	1.10 (0.70–1.73)	1.73 (1.02–2.94)	1.60 (0.91–2.81)	1.35 (0.86–2.09)	1.82 (1.10–3.02)	1.72 (1.00–2.94)
Physical job demand (low)	55.7	1.00	1.00	1.00	1.00	1.00	1.00
Physical job demand (middle)	24.9	1.55 (0.99–2.41)	1.08 (0.65–1.80)	1.19 (0.68–2.07)	0.99 (0.64–1.53)	0.64 (0.38–1.07)	0.66 (0.38–1.14)
Physical job demand (high)	19.4	0.98 (0.58–1.64)	0.65 (0.35–1.21)	0.83 (0.42–1.62)	0.51 (0.30–0.87)	0.31 (0.16–0.60)	0.36 (0.18–0.71)
Physical inactivity at work (low)	12.0	1.00	1.00	1.00	1.00	1.00	1.00
Physical inactivity at work (middle)	50.6	1.62 (0.85–3.09)	2.02 (1.01–4.05)	1.69 (0.81–3.55)	2.70 (1.29–5.49)	3.20 (1.50–6.84)	2.78 (1.26–6.16)
Physical inactivity at work (high)	37.5	1.19 (0.61–2.34)	2.10 (0.96–4.55)	1.51 (0.66–3.47)	2.61 (1.25–5.46)	4.31 (1.89–9.83)	3.37 (1.41–8.03)

[a]Sources of subsamples, socio-demographic variables (age, marital status, race, education, annual household income, and any children, aged 0–6 years), and working conditions (job control, quantitative job demands, supervisor and coworker support, hours of work per week at a major job, and any other paid jobs) were controlled for.
[b]Covariates in Model 2 plus health status (any chronic diseases and major depression) and health behaviors (leisure-time physical activity, stress-induced overeating, current smoker, and alcohol consumption) were additionally controlled for.

sedentary work in male workers, with ORs (95% CIs) of 1.78 (1.24–2.53) and 1.52 (1.02–2.26), respectively (Table IV). Similarly, high and middle levels of physical job demand were inversely associated with central obesity in male workers, with ORs (95% CIs) of 0.64 (0.42–0.97) and 0.74 (0.51–1.06), respectively. Finally, the combined variable (physical inactivity at work) was also associated with even stronger associations with central obesity: OR of 1.78 (1.24–2.53) for the high level of physical inactivity at work and 1.52 (1.02–2.26) for the middle level. However, these variables were not significantly associated with central obesity in female workers, although the risk of sedentary work for central obesity was still higher at the high level than at the low and middle level as expected: OR (95% CI) = 1.28 (0.92–1.78), $P = 0.14$.

In both men and women, any chronic diseases and stress-induced overeating increased the risk for central obesity, while active LTPA decreased the risk for central obesity (Table IV). Being married and low education increased the risk for central obesity in male workers. In female workers, race (non-Whites), the middle level of annual household income, and smoking increased the risk for central obesity, while moderate alcohol consumption decreased the risk for central obesity. Age for men and major depression and low job control for women were not significantly associated with central obesity. Interestingly, the risk of low job control for central obesity in female workers substantially decreased after controlling for health behaviors in Model 3.

Stratified Analyses by Working Hours per Week

The above multivariate analyses for total and central obesity were replicated when the analysis was stratified by hours worked per week. The risks of physical job demand and physical inactivity at work for total obesity did not vary greatly within strata of hours of work in male workers. However, the risk of middle level of sedentary work for total obesity was significantly higher in male workers (n = 526) who worked longer (i.e., >40 hr per week) (Table V) than in male workers (n = 475) who worked shorter (i.e., 40 hr per week or less). The risk of high levels of sedentary work for central obesity did not change much by the hours of work. However, the risks of physical job demand and physical inactivity at work for central obesity increased substantially and were significant in the group of men working >40 hr per week. For example, the OR of high physical inactivity at work for central obesity was 3.37 (95% CI, 1.41–8.03), which was greater than the risks of non-active LPTA and stress-induced overeating in the male group: 1.67 (1.08–2.56) and 3.29 (2.01–5.40), respectively. There were no effect modifications by working hours per week in female workers.

Effects of Alternative Definitions of the Physical Activity at Work Variables on the Multivariate Analyses

Generally, the associations between high sedentary work, low physical job demand, and high physical inactivity at work based on two-level measures (high = all and almost of the time vs. low = some, little, and never) and obesity were stronger for female workers, than for male workers for the three-level measures. Some noticeable changes were as follows: no association between sedentary work (based on the two-level definition) and total obesity in male workers: ORs (95% CIs) = 1.07 (0.81–1.41), $P = 0.65$, in Model 1, 1.30 (0.96–1.76), $P = 0.09$, in Model 2, and 1.19

(0.86–1.63), $P = 0.30$, in Model 3 (Table III); a borderline-significant association between sedentary work (based on the two-level definition) and total obesity in female workers: ORs (95% CIs) = 1.43 (1.08–1.89), $P = 0.01$, in Model 1, 1.38 (1.02–1.86), $P = 0.04$, in Model 2, and 1.36 (0.98–1.88), $P = 0.06$, in Model 3 (Table III); and a significant association between sedentary work (based on the two-level definition) and central obesity in female workers: ORs (95% CIs) = 1.27 (0.98–1.63), $P = 0.07$, in Model 1, 1.34 (1.03–1.76), $P = 0.03$, in Model 2, and 1.36 (1.02–1.82), $P = 0.04$, in Model 3 (Table IV).

DISCUSSION

There were significant associations between low physical activity at work (sedentary work, low physical job demand, or their combination) and both total and central obesity among US male workers participating in the MIDUS II study, particularly those who worked longer than 40 hr per week. Positive associations of sedentary work with total and central obesity were also observed in female workers though of borderline statistical significance. These findings provide some support to the hypothesis that low levels of work-related physical activity may be contributing to the current obesity epidemic in the US and conversely that increasing opportunities for physical activity at work could possibly contribute to obesity prevention in US workers.

Comparisons With Other Studies

Only very few studies have reported an association of low physical activity at work (sedentary work or low physical job demand) with central obesity in male workers. Our MIDUS II study findings are consistent with a Japanese study at a metal manufacturing factory [Ishizaki et al., 2004]. Our study is also relatively unique in controlling for other key risk factors for obesity (e.g., low socio-economic status, adverse psychosocial working conditions, non-active LTPA, and overeating behavior) in assessing the association between low physical activity at work and total obesity in male workers, although several studies have observed such an association [Bell et al., 2001; Ishizaki et al., 2004; Mummery et al., 2005; Ostry et al., 2006; Böckerman et al., 2008].

However, this study is not consistent with one US cross-sectional study [Jeffery et al., 1991] and two non-US cross-sectional studies [Haglund, 1987; Gutiérrez-Fisac et al., 2002] reporting no associations between work-related physical activity and total obesity in male workers. Differences in measurement of physical activity at work might explain the inconsistency of this study with the other US study [Jeffery et al., 1991] which measured ''occupational physical activity'' using one questionnaire item about the degree of ''manual labor'' [Blair et al., 1985]. That measure did not assess the extent of sedentary (i.e., sitting) work, which in this study appeared to be a more sensitive measure for total obesity (but not necessarily for central obesity) than the physical demand (''physical effort'') measure in both men and women. We cannot rule out socio-cultural differences in obesity etiology [Swinburn, 2008], which may explain differences between this study and non-US studies [Haglund, 1987; Gutiérrez-Fisac et al., 2002].

In female workers, we found borderline significant associations of sedentary work with total and central obesity. But low physical job demand and physical inactivity at work were not risk factors for total and central obesity. The association between sedentary work and total obesity has been found previously to be weaker in female workers than in male workers among several cross-sectional studies [Bell et al., 2001; Ishizaki et al., 2004; Mummery et al., 2005; Böckerman et al., 2008], which is in line with the findings of our study, although the positive association between sedentary work and central obesity was supported in both men and women in the Japanese study by Ishizaki et al. [2004].

The association between sedentary work and obesity while not statistically significant means that we cannot ignore the possibility of sedentary work as a risk factor for total and central obesity in US female workers. The comparatively stronger association of the two-level definition of sedentary work with obesity in female workers may indicate an exposure misclassification between the low and middle levels of sedentary work (but not with the high level) in female workers. However, it was not objectively testable in this secondary data analysis study.

Policy Perspectives: Increasing Physical Activity at Work

This study highlights the importance of physical activity at work for obesity prevention in US workers. In this study, the risk of high physical inactivity at work (combination of sedentary work and low physical job demand) for central obesity was greater than those of either lack of LTPA or stress-induced overeating, especially in male workers who work longer than 40 hr per week. Our findings suggest that increasing opportunities for physical activity at work as well as in leisure time and/or reducing long working hours per week should be major components of a public health policy for obesity prevention. Such policies should be helpful in counteracting the current positive energy imbalance of the US population: increased average total energy intake [Nielsen et al., 2002; Briefel and Johnson, 2004] and stable LTPA [CDC, 2008] since the 1980s.

Enacting such policies may not be easy. Only about 20% of US workplaces conduct a worksite weight management or physical activity program [Linnan et al., 2008]. Stairs in US

buildings are usually hidden from entrances and the use of stairs is not recommended as a way of increasing physical activity at work [Mansi et al., 2009]. Perhaps, most problematic is that reduction of dynamic physical activity at work associated with enhanced technology and automation is often seen as a key component of increased efficiency and productivity [Nelson-Peterson and Leppa, 2007]. Increasing physical activity at work, through health promotion programs, physical workspace design, or by not physically constricting work activities [Carnethon et al., 2009], seems to be contingent on how much our society is willing to view dynamic physical activity at work as a social value-adding (i.e., health promoting) activity and to include this perspective in designing technology and organizing work. A recent study [Healy et al., 2008] suggested that it might be possible to increase physical activity at work without sacrificing productivity: frequent micro-breaks in sedentary work, independent of the total sedentary time, was inversely associated with total and central obesity. The impact of increasing physical activity at work on obesity prevention would presumably be greatest in male high-status workers who are mostly subjected to high physical inactivity at work (Table II).

Limitations of This Study

This study has several limitations. First, despite the consistent findings of this study with other studies, because it is a cross-sectional study, we cannot draw definitive causal inferences about the effect of low physical activity at work on obesity in US workers. Second, although the MIDUS II was a national study, with participants recruited from diverse occupations and industries across the US, it is not necessarily representative of the entire US working population. The data set under-represents minorities (e.g., blacks) and people with low levels of education. If such groups had been represented in the study relative to their proportion in the US population, the prevalence of obesity in this study would have been higher. The risks of race (non-Whites) and low education for obesity in this study might be underestimated. Third, interpretations about the associations of other exposures with obesity should be made carefully because they were not the main focus of this study. For example, in this study, despite some expected associations of psychosocial working conditions (e.g., low job control) with obesity in female workers, there were no such associations in male workers. Such null associations mean no ''direct'' effects of psychosocial working conditions on obesity, which does not exclude the possibility of ''indirect'' impacts of psychosocial working conditions on obesity via health behaviors (not addressed in this study). Fourth, self-reported measures of sedentary work and waist circumference could be vulnerable to self-report bias. However, the occupational distribution of high sedentary work (Table II) in both men and women of this study was very similar to the occupational distribution of low and high physical activity that King et al. [2001] created with reference to the occupational descriptions of the US Department of Labor. Nonetheless, as aforementioned, the low and middle levels of sedentary work might be misclassified in female workers of this study. Also, we cannot rule out the possibility that obese people may overestimate their physical activity level [Brown and Werner, 2008]. On the other hand, although some studies [Roberts et al., 1997; Spencer et al., 2004] reported that self-reported waist circumference values were highly (i.e., $\geq$0.80) correlated with technician-measured ones, there is a possibility that obese people underreport their waist circumference values [Spencer et al., 2004]. However, if such self-reporting biases (i.e., differential misclassification) in relation to sedentary work and waist circumference occurred in this study, the biases would be toward the null hypothesis (underestimation of the associations between sedentary work and obesity). It would be desirable to employ more objective measures of physical activity at work (e.g., observations, accelerometers, and pedometers) and obesity in future studies. Also prospective studies are needed to better test the hypothesis that reductions in physical activity at work contribute to the current obesity epidemic in US male and female workers.

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Appendix I: Psychosocial Working Condition Variables

Skill discretion (two items, response set: all of the time (1) to never (5))

- How often does your job provide you with a variety of things that interest you?
- How often do you learn new things at work?

Decision authority (three items, response set: all of the time (1) to never (5))

- How often do you have a choice in deciding how you do your tasks at work?
- How often do you have a choice in deciding what tasks you do at work?
- How often do you have a say in decisions about your work?

Job control = skill discretion + decision authority

Quantitative job demands (three items, response set: all of the time (1) to never (5))

- How often do you have to work very intensively—that is, you are very busy trying to get things done?
- (How often) you have too many demands made on you.
- (How often) you have enough time to get everything done. (Reversed for scoring)

Coworker support (two items, all of the time (1) to never (5))

- How often do you get help and support from your coworkers?
- How often are your coworkers willing to listen to your work-related problems?

No coworker (''does not apply'' (6) response in the above coworker support items)

Immediate supervisor support (two items, all of the time (1) to never (5))

- How often do you get help and support from your immediate supervisor?
- How often is your immediate supervisor willing to listen to your work-related problems?

No immediate supervisor support (''does not apply'' (6) response in the above supervisor support items)