BMJ Open

Patterns of Objectively-Assessed Sedentary Time and Physical Activity among Japanese Workers

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2018-021690
Article Type:	Research
Date Submitted by the Author:	15-Jan-2018
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Title: Patterns of Objectively-Assessed Sedentary Time and Physical Activity among Japanese Workers

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Word count: 3495 words

Key words: descriptive epidemiology, occupational sitting, occupational activity patterns, Asia.

ABSTRACT

Objectives: To examine patterns of sedentary behavior and physical activity, among Japanese workers with differing occupational-activity types.

Methods: Full-time workers aged 40-64 years (n = 345; 55% men) wore an accelerometer for 7 days and completed a socio-demographic and occupational activity-type survey. Mean overall sedentary time, prolonged bouts of sedentary time and light-and moderate-to vigorous-intensity of physical activity (LPA and MVPA) as a proportion of accelerometer wear time, and number of breaks per sedentary hour, were identified for four time periods: working hours; workdays; non-work hours; and, non-work days. These sedentary behavior and physical activity measures in the four time periods were examined among workers with four self-attributed occupational activity types (mainly sitting, standing, walking, physical labor), adjusting for sociodemographic attributes. Diurnal patterns of sedentary behavior, LPA and MVPA were examined.

Results: In working hours, those with a sitting job had significantly more total and prolonged sedentary time along with less LPA and MVPA, and less frequent breaks, compared to those with the three more-active job type. Similar differences by job type were found for the whole working day, but not for prolonged sedentary time and breaks. On non-working hours and days, differences in sedentary and physically- active patterns by job type were not apparent.

Conclusions: Occupational activity type is related to overall sedentary time and patterns on working days, but not to leisure-time sitting and activity patterns, which were similar across the sitting, standing, walking, and physical labor occupational-activity types.

ARTICLE SUMMARY

Strengths and limitations of this study

- This is the first study to report descriptive patterns of objectively measured workers' sedentary behavior comprehensively in non-Western countries, and their relationships with occupational activity types.
- This study was used population-recruited sample and accelerometer-assessed sedentary behavior and physical activity.
- Data were cross-sectional and therefore any causality cannot be inferred.
- Low response late was not completely at random, which may have resulted in selection bias.

INTRODUCTION

Sedentary behavior, defined as any waking behavior characterized by an energy expenditure ≤1.5 METs while in a sitting or reclining posture [1] has distinctive adverse effects on human health [2]. For example, excessive sedentary behavior increases the risk of all-cause mortality [3, 4] and risk of type 2 diabetes, cardiovascular disease, and some cancers [5], with some evidence of dose-response relationships [6]. There are benefits of more-frequent breaks from sedentary time on cardio-metabolic risk biomarkers [7]. Reducing prolonged sedentary behavior is an important public health issue.

Among the Japanese adult population, the worksite is a key setting in which to address sedentary behaviors, since approximately 60% of the total population are employed, and 60 % are full-time workers (>40 hours/week) [8]. Understanding patterns of sedentary behavior (e.g. overall daily time, prolonged time, breaks, diurnal patterns) on working days and non-working days can help to identify the most sedentary segments of the day and whether there is carry-over of those patterns that may influence workers' whole-of-day sedentary time and physical activity. Such insights can inform approaches to sedentary behavior as an emerging occupational-health risk.

Sedentary behavior patterns at work and potentially across the whole day may be influenced by the demands of work – in terms of having to be seated, standing, or physically active for job tasks [9]. Hence, it is important to examine in more depth the relationship between types of occupational activity requirements with overall patterns of physical activity and sedentary behavior, in order to provide evidence that can inform approaches to workplace health promotion through sedentary behavior reduction.

The majority of previous studies examining objectively-measured occupational sedentary patterns has only focused on office-based workers and primarily seated occupational groups [10-16]. Only one previous study conducted in Netherland has examined the pattern of sedentary behavior across different types of occupations including white-collar, office-based workers and blue-collar construction and factory workers [17]. However, there have been no detailed examinations of overall diurnal patterns and the variability between workdays and non-workdays. In addition, while a

small number of studies have examined patterns of sedentary behavior among workers, based on different occupational categories [18] or on types of occupational activity [9, 19], they have used self-report measures of total and/or domain-specific sedentary behavior. Objectively-measured patterns of occupational sedentary behavior have not been examined.

Previous studies on sedentary behaviors among workers have been conducted mainly in Western countries. One international-comparative study found that self-reported sitting time of working adult population in Japan was the longest among 20 countries [20]. Although the Japanese working adult population seems to be at-risk population considered in this international context, patterns of sedentary behavior in Japanese workers have not been examined. Since working environments (e.g. social norms, working spaces and work time) are likely to be different in Japan and other Asian countries compared with Western countries, understanding the sedentary behavior patterns in the Japanese work environment context will be informative.

We examined accelerometer-derived patterns of sedentary behavior (overall sedentary time, sedentary time accumulated in prolonged bouts, breaks from sedentary time and diurnal patterns of sedentary time) and physical activity among Japanese workers, based on occupational-activity types. These behaviors were characterized for four time periods: during work and non-work hours, on work days and on work and non-work days.

METHODS

Study design and procedure

This was a cross-sectional observational study, as a part of a project to investigate the associations between built environment attributes and sedentary behavior among Japanese middle-aged adults. A mail survey was conducted in Matsuyama city in Ehime prefecture (428.9 km^2; 516,000 people) from July to December 2013, and Koto Ward in Tokyo (40.2 km^2; 484,000 people) from April 2014 to February 2015. The study was approved by the Institutional Ethics Committee of Waseda University (2012-269, 2013-264).

The survey procedures were as follows: first, 3,000 potential participants aged 40-64 were extracted randomly from each basic resident register stratified by gender and age (40–49 years/ 50–59 years/ 60–64 years) for Matsuyama city and Koto Ward. Second, invitation letters were mailed to the potential participants and asked to return an enclosed from to indicate their expression of interest to participate in the study. Non-respondents were mailed an additional request to join the study two weeks after the initial invitation letter was sent. Then, those who expressed interest were mailed the informed-consent form of this study, an accelerometer, an activity diary, and a questionnaire. Those who finally agreed to participate were asked to sign the consent form, wear the accelerometer and record the activity diary for 7 days, respond to the questionnaire, and then return all of these within two weeks. Non-respondents were sent a reminder notice up to three times, and those who completed survey were sent thank-you letter with a ¥1,000 book voucher card.

In total, 864 (14.4% of the originally-approached sample) including 437 (14.6%) from Koto Ward and 427 (14.2%) from Matsuyama city agreed to participate: 778 (13.0% of the originally-approached sample) completed the questionnaire and wore the accelerometer. Those who worked either full-time or part-time were included (n=633). Those who had missing or invalid data for occupational activity type (n=38) or insufficient accelerometer data (n=175) were excluded (numbers not mutually exclusive). The final study sample size was 443 (full- time workers: n=345; part-time workers: n= 98).

Assessment of sedentary behavior and physical activity

Participants were asked to wear a triaxial accelerometer, Active style Pro HJA-350IT (Omron Health Care Co., Ltd., Kyoto, Japan) on the left side of the waist for seven days. This accelerometer was reported to be valid and to accurately assess low intensity physical activity including sedentary behavior [21, 22]. A recent comparative study of three activity monitors showed that the Active style Pro HJA-350IT underestimated total sedentary time (-25.6 min/day) and the ActiGraph GT3X overestimated it (+63.7 min/day), compared with the activePAL3 as the criterion [23]. Data were collected in one-minute epochs. In order to obtain the information of work day including work and non-work hours and non-work day, participants were also asked to record the time

when wearing and removing accelerometer as well as starting and finishing a job on 7 days.

Socio-demographic data and occupational activity type

Age and gender were obtained from the basic resident register. Height, weight, educational level (university or further education; high school or less), marital status (currently married; single), employment status (full-time; part-time), occupation and main occupational activity type (sitting; standing; walking; physical labor) were obtained. Body mass index (BMI) was calculated from self-reported height and weight. Occupations were referenced to Japanese standard classification of occupations [24].

Data management

Accelerometer data were processed using Omron health management software BI-LINK for physical activity professional edition ver1.0 and custom software [23]. Valid data for a wear day was defined as ≥10 hours/day excluding ≥60 consecutive minutes of no activity (0.9 or less metabolic equivalents; METs) with allowance for up to 2 min of some limited movement (≤1.0 METs) within these periods and ≥75% wear time of work hours for a work day [12]. Those who had four or more valid days of data including at least three work days and a non-work day were included in the analysis. The data were extracted according to the following four time periods: working-hours (from starting to finishing job on work day), non-working hours (from wearing accelerometer to starting job and from finishing job to taking off accelerometer on work day), working day (a sum of working and non-working hours), and for non-working days (from wearing to taking off accelerometer).

The five measures of sedentary behavior and physical activity were first extracted for each time segments: time spent in all sedentary behavior, prolonged sedentary bouts, number of breaks per sedentary hour., and light-intensity physical activity (LPA) and moderate-to vigorous-intensity physical activity (MVPA). Time spent in sedentary behavior, LPA, and MVPA were defined as all wear time for any activity with an accelerometer-estimated intensity of ≤1.5 METs, 1.6-2.9 METs, and 3.0 or more METs, respectively. Prolonged sedentary bouts were defined as a period of uninterrupted sedentary time lasting ≥ 30 minutes [1]. A break in sedentary time was defined as a

period of non-sedentary bout in between two sedentary bouts [1]. For each of the time segments, daily averages of all sedentary and physically-active measures were calculated over valid work and non-work days. Daily summaries of time spent in all sedentary behavior, prolonged sedentary bouts, LPA, and MVPA for each time segments were also calculated in terms of the percentage of these intensities in worn time (% wear time). Finally, daily average values including work and non-work days of five measures in a week were then computed by weighting for 5 work days and 2 non-work days.

Statistical Analysis

Full-time (n=345) and part-time (n=98) workers were separately analyzed. Comparisons of the sociodemographic characteristics and five sedentary behavior and physical activity measures among the four occupational-activity types were conducted using one-way ANOVA for continuous variables and chi-square test for category variables. Each of the five sedentary and physical activity measures were compared among four occupational activity types in 4 time periods (working hours, non-working hours, working days, non-working days) using Analysis of Covariance (ANCOVA) with Bonferroni post-hoc test, adjusting for sociodemographic variables. For these analyses, those who had missing data for socio-demographic variables were excluded among the full-time workers (n= 4). For part-time workers, only one person was engaged in physical labor tasks. Thus, statistical analyses were not conducted. For describing diurnal patterns, those who had ≥6 h of work time starting morning were included (n=403). Diurnal pattern of sedentary behavior, LPA and MVPA in each hour from 06:00-06:59 to 22:00-22:59 for each occupational activity type on work day and non-work day were illustrated by line graphs. All statistical analyses were performed using STATA 13.0 (Stata Corp., College Station, TX, US) and IBM SPSS Statistics 22 software (IBM Japan Inc., Tokyo, Japan). Significant levels were $p < 0.05$.

RESULTS

The characteristics of participants in full-time work are summarized in Table 1. The mean age and BMI were 50.3(SD 6.9) and 22.8 (3.2), respectively. About a half of them were men and lived in Koto Ward. The majority had completed university or higher education, were married, and worked in mainly-sitting type jobs. Those with job types

involving mainly sitting and physical labor were more likely to be men than those with other two occupational activity types. Those mainly sitting at work were also more likely to live in Koto Ward and completed university or further education than those in three other more active jobs. Mean wearing days and hours of accelerometer were 6.8 (SD=0.9) days and 15.3 (SD=1.1) hours. There were no significant differences in wearing days and hours of accelerometer wear time among the four of occupational-activity types. Those with sitting jobs had proportionally more total and prolonged sedentary time and less MVPA time, compared with those with other three occupational-activity types ($p<0.001$). Additionally, those with sitting jobs had less LPA time in proportion and frequent breaks than those with standing and walking job($p<0.001$). There were no significant differences in any of the sedentary behavior and physical activity measures among those in three physically active job types. The findings remained unchanged after adjusting for sociodemograhic attributes in the sensitivity analyses.

Table 1. Socio-demographic characteristics for participants of full-time jobs

	n (%)					
	All participants	Occupational activity type				
		Sitting	Standing	Walking	physical labor	
N	345	239 (69.3)	47 (13.6)	48 (13.9)	11 (3.2)	
Age, mean(SD)#	50.3(6.9)	50.1(7.0)	50.7(6.8)	50.5(6.7)	52.6(6.7)	
Women	156 (45.2)	99 (41.4)	25 (53.2)	29 (60.4)	3 (27.3)	*
BMI, kg/m² [a], mean (SD)#	22.8 (3.2)	23.0(3.4)	21.9(2.4)	22.3(2.6)	25.5(4.2)	**
Residence area						
Matsuyama city	170 (49.3)	98 (41.0)	37 (78.7)	26 (54.2)	9 (81.8)	***
Koto Ward	175 (50.7)	141 (59.0)	10 (21.3)	22 (45.8)	2 (18.2)	
Education [a]						
High school or less	109 (31.6)	59 (24.8)	23 (48.9)	21 (43.8)	6 (54.5)	***
Greater than high school	235 (68.1)	179 (75.2)	24 (51.1)	27 (56.3)	5 (45.5)	
Marital status[b]						
Single	85 (24.6)	60 (25.4)	11 (23.4)	12 (25.0)	2 (18.2)	
Married	257 (74.5)	176 (74.6)	36 (76.6)	36 (75.0)	9 (81.8)	
Occupation[c]						
Professional and engineering	71 (20.6)	39 (16.5)	13 (28.3)	18 (37.5)	1 (10.0)	
Administrative and managerial	59 (17.1)	56 (23.6)	0 (0)	2 (4.2)	1 (10.0)	
Clerical	114 (33.0)	111 (46.8)	2 (4.3)	1 (2.1)	0 (0.0)	
Sales	17 (4.9)	7 (3.0)	4 (8.7)	6 (12.5)	0 (0.0)	
Service	34 (9.9)	9 (3.8)	17 (37)	8 (16.7)	0 (0.0)	
Security	1 (0.3)	0 (0.0)	1 (2.2)	0 (0.0)	0 (0.0)	
Agricultural, forestry and fishery	4 (1.2)	0 (0.0)	1 (2.2)	3 (6.3)	0 (0.0)	
Transport and machine operation	9 (2.6)	1 (0.4)	0 (0.0)	4 (8.3)	4 (40.0)	
Manufacturing process	14 (4.1)	4 (1.7)	5 (10.9)	1 (2.1)	4 (40.0)	
Others	17 (4.9)	10 (4.2)	2 (4.3)	5 (10.4)	0 (0.0)	
Sedentary behavior and Physical activity measures per day , mean (SD)#						
% of worn time spent						
All sedentary	57.5(12.7)	62.8(9.8)	43.4(10.3)	47.9(10.3)	43.9(9.7)	***
Prolonged sedentary bout	19.1(11.0)	22.5(11.5)	13.3(5.7)	14.4(7.4)	16.7(7.3)	***
LPA	34.8(11.0)	30.5(9.1)	46.9(8.8)	42.2(7.9)	44.4(8.8)	***
MVPA	7.7(4.5)	6.8(3.2)	9.7(6.6)	9.9(5.7)	11.6(3.7)	**
Breaks per sedentary hour	9.4(3.1)	8.6(2.7)	12.1(3.0)	11.1(2.6)	10.1(2.5)	***

[a] 1 missing in sitting; [b] 3 missing in sitting; [c] 2 missing in sitting, 1 missing in standing and physical labor

Asterisks indicate statistical significance of F value of one-way ANOVA

*** <.001, ** <.01, *<.05

The sedentary behavior and physical activity measures on work and non-work days and hours on all and occupational activity types of full-time workers are presented in Table2. Regarding working hours, those with jobs involving sitting had significantly more total and prolonged sedentary time along with less LPA and MVPA in proportion, and less frequent breaks compared with those with three other more active jobs. Similar results were found for the working days, except for the prolonged sedentary time and sedentary breaks variables; there were no significant differences between those in the job types involving sitting and those involving physical labor. The differences in sedentary time between the sitting jobs and the other jobs types on working time and working day were 17.7–26.4, and 28.5-42.0% of wear time, respectively. Among the three non-sitting job types, the order of most total and prolonged sedentary time along with less LPA and MVPA in proportion, and less frequent breaks on both working time and day were descriptively as follows: those with walking, standing and physical labor jobs. However, apparent patterns which reached statistical difference were only found in MVPA: the proportion of MVPA in those with job involving physical labor was significantly higher than those with other two less active jobs on only working hours. As a descriptive feature of non-work hours, the more active jobs in which workers were involved, the more total sedentary time along with less LPA in proportion was reported except those with mostly sitting jobs. In large part, the proportions of total sedentary time and LPA in those with sitting jobs were similar to those with the jobs involving physical labor. The differences reaching statistical significance were as follows: those with standing jobs had proportionally less total sedentary time and more LPA than did those with sitting jobs. There were no descriptive and statistical differences apparent between the four occupational activity types on non-working day.

Table2. Comparison of sedentary behavior and physical activity among four occupational activity types in full-time workers

	Mean (SD)	Marginal mean (95% CI) [a]			
	All	Sitting	Standing	Walking	physical labor
Wear time (h)					
Work day [a]	15.6(1.8)	15.5 (15.3-15.8)	15.8 (15.2-16.3)	15.7 (15.2-16.2)	16.6 (15.6-17.7)
Work hours [b]	9.4(1.8)	9.3 (9.1-9.5)	9.7 (9.2-10.3)	9.7 (9.2-10.2)	9.8(8.8-10.9)
Non-work hours [c]	6.2(2.3)	6.3 (6.0-6.5)	6.0 (5.4-6.6)	6.0 (5.4-6.6)	6.8 (5.5-8.1)
Non-work day [d]	14.3(2.0)	14.4 (14.1-14.7)	14.3 (13.7-14.9)	13.9 (13.3-14.4)	14.4 (13.2-15.6)
All sedentary (%wear time)					
Work day	56.8(15.3)	63.2 (61.8-64.5)	40.6 (37.4-43.7)***	45.5 (42.5-48.5)***	36.8 (30.4-43.2)***
Work hours	58.6(21.9)	68.5 (66.7-70.3)	34.6 (30.4-38.7)***	40.0 (36.0-44.0)***	26.5 (18.1-34.9)***,‡
Non-work hours	53.3(11.9)	54.0 (52.4-55.4)	49.8 (46.3-53.3)*	52.5 (49.2-55.9)	56.5 (49.4-63.6)
Non-work day	59.1(13.8)	59.8 (58.1-61.6)	56.3 (52.3-60.4)	58.2 (54.3-62.1)	60.3 (52.0-68.5)
Prolonged sedentary bouts (% wear time)					
Work day	18.2(12.5)	21.0 (19.5-22.4)	11.7 (8.4-15.0)***	12.4 (9.2-15.5)***	12.0 (5.3-18.7)
Work hours	18.6(18.2)	23.1 (21.1-25.2)	8.5 (3.8-13.2)***	9.0 (4.4-13.5)***	7.0 (-2.5-16.6)**
Non-work hours	16.7(11.1)	16.6 (15.2-18.0)	16.2 (13.0-19.5)	16.5 (13.4-19.7)	20.5 (13.9-27.0)
Non-work day	24.1(15.1)	24.8 (22.9-26.8)	22.3 (17.9-26.7)	23.1 (18.8-27.4)	24.1 (15.2-33.1)
Breaks per sedentary hour					
Work day	9.8(3.6)	8.8 (8.4-9.1)	12.7 (11.8-13.6)***	11.7 (10.8-12.6)***	10.9 (9.1-12.7)
Work hours	10.8(5.7)	8.8 (8.2-9.4)	16.2 (14.9-17.5)***	14.7 (13.4-16.0)***	13.3 (10.6-16.0)**
Non-work hours	10.0(3.7)	10.0 (9.5-10.5)	10.5 (9.4-11.6)	10.0 (8.9-11.0)	9.7 (7.4-11.9)
Non-work day	8.6(3.7)	8.6 (8.1-9.0)	8.9 (7.6-10.0)	8.7 (7.6-9.7)	8.8 (6.5-11.0)
LPA (%wear time)					
Work day	35.1(13.1)	30.3 (29.1-31.5)	48.1 (45.4-50.8)***	42.9 (40.3-45.6)***,†	48.2 (42.6-53.7)***
Work hours	34.6(17.7)	27.4 (25.9-29.0)	53.3 (49.7-56.9)***	47.1 (43.6-50.6)***	54.9 (47.6-62.1)***
Non-work hours	36.2(11.3)	35.3 (33.9-36.6)	40.4 (37.3-43.5)*	37.7 (34.7-40.7)	34.7 (28.4-41.0)
Non-work day	34.2(11.9)	33.7 (32.2-35.2)	35.6 (32.2-39.1)	35.3 (32.0-38.6)	34.6 (27.6-41.5)
MVPA (%wear time)					
Work day	8.2(5.4)	6.5 (5.9-7.2)	11.3 (9.9-12.8)***	11.5 (10.2-12.9)***	15.0 (12.1-17.9)***
Work hours	6.8(7.5)	4.1 (3.3-4.9)	12.2 (10.3-14.0)***	12.9 (11.1-14.6)***	18.6 (14.9-22.4)***,†,‡
Non-work hours	10.5(6.8)	10.8 (10.0-11.6)	9.8 (8.0-11.6)	9.8 (8.0-11.6)	8.8 (5.1-12.5)
Non-work day	6.7(4.6)	6.5 (5.9-7.1)	8.0 (6.6-9.3)	6.5 (5.2-7.8)	5.2 (2.4-7.9)

[a] Marginal mean and 95% CI from ANCOVA adjusted for covariates including gender, age, BMI, residence area, educational attainment, marital status.
Asterisks indicate significant difference from the sitting: *p < 0.05, **p < 0.01, *** <.001
Dagger indicates significant difference from the standing: †p < 0.05

Double dagger indicates significant difference from the walking: ‡p < 0.05

Hourly patterns of sedentary behavior, LPA and MVPA on four occupational activity types are summarized in Figure 1 for full time workers. Overall, time and LPA showed an inverse pattern. On work days, a notable difference was observed in the pattern of sedentary behavior during work hours between those in the sitting jobs and the other three types, while all occupational activity types showed a similar pattern after work, with a linear increase in the sedentary fraction until 22:00-22:59. Those with jobs involving mainly standing, walking and physical labor constantly accounted for a larger fraction of LPA than that of sedentary behavior from 6:00-6:59 throughout almost of all working hours. On non-work days, sedentary behavior in all occupational activity types was mostly dominant from 7:00-7:59 to 18:00-18:59. However, the time differences between sedentary behavior and LPA in those with sitting jobs stayed more constant and larger than those in other more active job from 7:00-7:59 to 18:00-18:59. After 18:00-18:59 on non-work day, all types showed increase in sedentary time as the same with work days. All results of the part-time workers were presented in Table S1,2 and Figure S1.

INSERT FIGURE 1 ABOUT HERE

DISCUSSION

This is the first study to examine accelerometer-measured patterns of sedentary behaviors and physical activity among Japanese workers in their work and non-work contexts, and to examine how these patterns differed by occupational activity type. Among full-time workers, sedentary time comprised more than half of the working day. Overall, those whose jobs involving mainly sitting, who accounted for 70% of this study sample, had higher amount of both total and prolonged sedentary time and less frequent breaks from sitting across the whole day, compared with those in more physically active job types. Previous studies in Western countries have examined the differences in objectively-measured total sedentary behavior only among 19 occupation groups or sectors [18] and self-reported leisure and domain-specific sedentary behaviors among occupational activity types [9, 19]. The present study extends these findings, for the first time in a non-Western country, by examining the differences in additional sedentary behavior measures such as prolonged sedentary behavior and breaks using objective measurements. The present findings suggest that further public health efforts focused on the worksite should be emphasized, especially for office-workers who are a majority of the working adult population in Japan and are an

apparent at-risk subgroup due to high volumes of sitting, not only at work but also in non-work time.

Among those involving mainly sitting jobs of this study sample, 63% of working day (60% of non-work day) were sedentary. Some previous studies conducted in Australia and the UK found that sedentary behavior assessed by Actigraph were 68-70% of working day of office workers (60-63% of non-work day)[12, 14]. Our recent comparative study of activity devices found that total sedentary time assessed by the Active style Pro HJA-350IT were proportionally 11% less time spent in total sedentary behavior than Actigraph [23]. These findings suggest that Japanese office-workers may spend more time in sedentary behavior across whole day compared with those in Western countries, which is similar to the previous international-comparative study examining self-reported sitting time of working adult population [20]. As an at-risk population considered in the international context, promoting effective public health strategies to reduce sedentary behavior on the worksite may be a necessary effort in Japan.

We found significant differences in overall sedentary time and number of breaks from sedentary time in work hours across the occupational activity types that we examined, especially for working hours. Full-time workers with mainly sitting jobs spent most sedentary time and had less breaks from sedentary behavior than those with more active job types: these differences were approximately 20-30% in the proportion (2.5-4 hours) and 5-7 times per sedentary hours. On the other hand, these patterns on non-working hours or days were relatively similar although workers with sitting and physical labor jobs somewhat spent more sedentary along with in less LPA than those with standing and walking jobs. These findings indicate that the occupational activity type, which is commonly determined by job requirements can have the greatest impact on overall sedentary time and patterns in workers' population. These findings are consistent with the only previous study from The Netherlands, which found all white-collar workers from financial service providers and research institutes had significantly greater occupational (30-35%) and total sitting time (10-15%) in proportion than all blue-color workers of construction company [17]. In addition, these findings supported those of previous studies using self-reported data in Australia,

France, and The Netherlands, which showed that workers with higher occupational sitting time did not sit less, rather sat more, on their leisure time [9, 18, 25]. Similar to studies conducted in Western countries, the present findings suggest that further promotion of worksite interventions to reduce office-workers' sedentary time along with increased sedentary breaks should be prioritized on working populations in not only Western countries but also in Japan.

Similar to the average patterns, the analysis of the accelerometer output by hour of the working day showed that the pattern of sedentary behavior, LPA and MVPA were highly dependent on occupational activity types during working hours (except for lunch time), whereas all were similar on the evening time after work. The descriptive features were observed on non-working day, especially during the daytime, across occupational activity types. Even though the average sedentary and activity patterns were not distinct among them, some dips in sedentary behavior along with increases in LPA were found in those with standing, walking, and physical labor job types, whereas the conditions in which sedentary behavior is the most dominant stayed constant throughout a day in those with sitting job types. The pattern of MVPA was stable and independent from those of sedentary behavior and LPA in all occupational activity types. The variations in pattern of sedentary behavior and LPA among occupational activity types could be partly attributed to differences in socio-demographic attributes (especially gender) and sample size. However, in a previous study from the UK examining the diurnal patterns of sedentary behavior and physical activity among office workers grouped into tertiles based on occupational sedentary time, the higher the tertile for occupational sedentary time in which office workers were categorized, the more pronounced and stable the difference between sedentary behavior and LPA (less crossing and reversing time points in a graph between them) became throughout a non-working day [14]. These results imply that routine diurnal occupational sedentary and LPA patterns, which were repeated 5 days a week, on working day may carry over their leisure-time behavioral patterns as a habit. Similarly, the previous study in French working adults using self-reported questionnaire found that occupational activity level workers involved as job were negatively associated with averaged time spent sedentary in leisure-time on both working and non-working day [19]. Future intervention studies are necessary to

clarify spreading effects whether promoting breaking behavior by LPA on working-hour this may transfer to leisure-time behavior and activity.

This is the first study to report descriptive patterns of objectively measured Japanese workers' sedentary behavior comprehensively, and their relationships with occupational activity types. Other strengths of this study were use of population-recruited sample and accelerometer -assessed sedentary behavior and physical activity. There are also some limitations in this study. First, data were cross-sectional and therefore any causality cannot be inferred. Second, the present samples were selected from only two cities in Japan although central and average-sized local cities were chosen. Thus, the results may differ in other cities and areas. Third, the response rate was relatively low.

CONCLUSION

In summary, full-time workers involved in mostly sitting jobs had a higher volume of sedentary behavior with prolonged bouts on workdays, compared with other occupational-activity job types. The differences in sedentary patterns mainly occurred during work hours. There may be carry-over of sedentary and physical activity patters in working time, which could influence leisure time and whole of day time spent sedentary, with potential for adverse health consequences. Therefore, intervention for to reduce workers' sedentary behaviors are needed, especially for those in office-based workplace where prolonged periods of sitting are required.

AUTHORS' CONTRIBUTION

Kurita and Shibata conceived the study, analyzed the data, and drafted the manuscript. Koohsari and Owen assisted with analyzing data and drafting manuscript. Ishii and Oka were involved in the development and implementation of this study. All authors contributed to study design, interpretation of the results, and manuscript preparation. All authors have read and approved the final manuscript.

FUNDING

This study was supported by a Grant-in-Aid for Scientific Research (No. 26242070) from the Japan Society for the Promotion of Science, MEXT-Supported Program for the

Strategic Research Foundation at Private Universities (S1511017). Koohsari was supported by a JSPS Postdoctoral Fellowship for Research in Japan (#17716) from the Japan Society for the Promotion of Science. Owen was supported by a National Health and Medical Research Council of Australia Senior Principal Research Fellowship and Program Grant, and by an Australian Academy of Sciences/Japan Society for the Promotion of Science Visiting Fellowship to Waseda University.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA SHARING STATEMENT

Requests for access to data should be addressed to the corresponding author.

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Figure1. Hourly pattern of sedentary behavior, LPA and MVPA of four task types among full-time workers

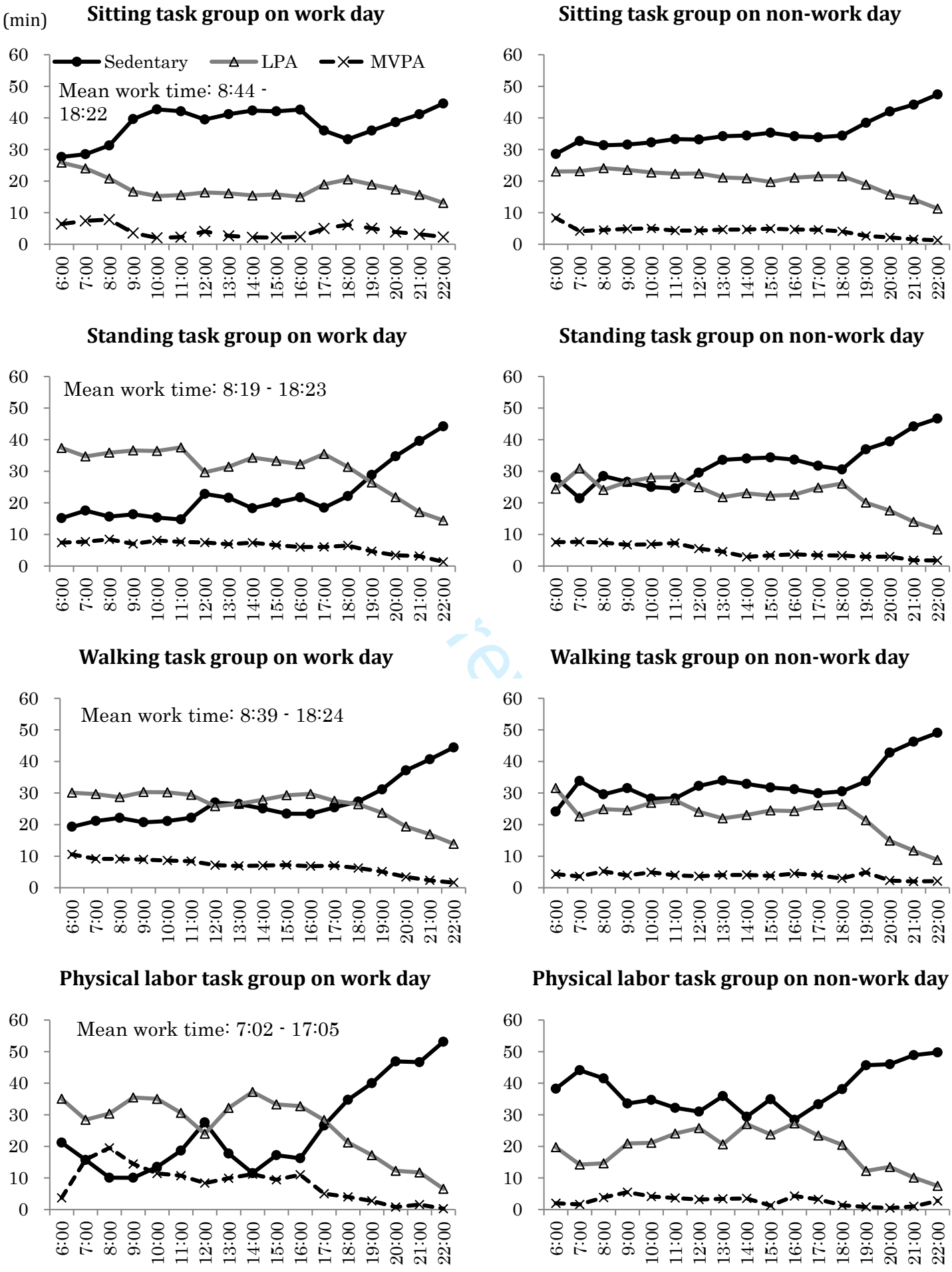

Figure1. Hourly pattern of sedentary behavior, LPA and MVPA of four task types among full-time workers

Table S1. Socio-demographic characteristics for participants of part-time workers

	n (%)				
	All participants	Occupational task group			
		Sitting	Standing	Walking	Physical labor
n	98	35 (35.7)	35 (35.7)	27 (27.6)	1 (1.0)
Age, mean(SD)	51.1(7.3)	50.4 (6.8)	52.7(8.0)	49.9(6.8)	54.0
Women	94 (95.9)	34 (97.1)	33 (94.3)	26 (96.3)	1 (100)
BMI (kg/m^2)[a], mean(SD)	21.1(2.2)	21.2 (2.3)	20.9(2.1)	21.3(2.2)	18.8
Residence area					
Matsuyama city	44 (44.9)	15 (42.9)	23 (65.7)	16 (59.3)	0 (0.0)
Koto Ward	54 (55.1)	20 (57.1)	12 (34.3)	11 (40.7)	1 (100)
Education					
High school or less	44 (44.9)	11 (31.4)	22 (62.9)	11 (40.7)	0 (0.0)
Greater than high school	54 (55.1)	24 (68.6)	13 (37.1)	16 (59.3)	1 (100)
Marital status[b]					
Single	12 (12.2)	4 (11.4)	4 (11.4)	4 (15.4)	0 (0.0)
Married	85 (86.7)	31 (88.6)	31 (88.6)	22 (84.6)	1 (100.0)
Occupation[c]					
Professional and engineering	17 (17.5)	6 (17.6)	4 (11.4)	7 (25.9)	0 (0.0)
Administrative and managerial	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Clerical	23 (23.7)	21 (61.8)	2 (5.7)	0 (0.0)	0 (0.0)
Sales	7 (7.2)	1 (2.9)	5 (14.3)	1 (3.7)	0 (0.0)
Service	33 (34)	3 (8.8)	18 (51.4)	11 (40.7)	1 (100)
Security	1 (1.0)	0 (0.0)	1 (2.9)	0 (0.0)	0 (0.0)
Agricultural, forestry and fishery	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Transport and machine operation	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Manufacturing process	5 (5.2)	1 (2.9)	3 (8.6)	1 (3.7)	0 (0.0)
Others	10 (10.3)	1 (2.9)	2 (5.7)	7 (25.9)	0 (0.0)
Sedentary behavior and Physical activity measures per day , mean (SD)					
% of worn time spent	15.7(1.44)	15.7(1.4)	15.5(1.5)	16.1(1.5)	16.4
All sedentary	47.6(9.8)	53.9(7.7)	44.7(10.3)	43.6(7.7)	41.8
Prolonged sedentary bout	14.4(7.6)	15.1(8.0)	15.0(8.0)	12.7(6.4)	14.7
LPA	44.2(8.4)	39.2(6.9)	47.5(8.5)	46.3(7.2)	44.2
MVPA	8.1(3.9)	6.9(2.5)	15.6(3.4)	10.0(5.2)	14.0
Breaks per sedentary hour	10.8(2.3)	10.1(1.9)	11.1(2.7)	11.2(2.2)	10.2

a 1 missing in standing task group
b 1 missing in walking task group
c 1 missing in sitting task group

Table S2 Comparison of sedentary behavior and physical activity among four occupational activity types in part-time workers

	Mean(SD)				
	All	**Sitting**	**Standing**	**Walking**	**Physical labor**
Wear time (h)					
Work day	16.0(1.6)	15.9(1.7)	15.8(1.6)	16.3(1.7)	16.6
Work hours	6.2(2.4)	6.4(2.2)	5.9(2.5)	6.5(2.5)	7.0
Non-work hours	9.7(3.0)	9.5(2.8)	9.8(2.8)	9.9(3.7)	9.6
Non-work day	15.1(1.6)	15.0(1.2)	14.7(1.9)	15.6(1.6)	15.8
Sedentary (%wear time)					
Work day	45.1(11.3)	54.2 (7.9)	40.1 (10.9)	40.3 (8.4)	35.0
Work hours	36.6(23.4)	59.9 (12.6)	24.4 (19.4)	23.4 (14.3)	8.5
Non-work hours	49.8(9.7)	50.2 (8.9)	49.5 (10.8)	49.7 (9.9)	54.5
Non-work day	53.9(12.7)	53.1 (12.0)	56.4 (14.6)	51.8 (11.2)	58.8
Prolonged sedentary bouts of sedentary (%wear time)					
Work day	12.2(7.1)	14.0 (8.1)	11.4 (6.6)	10.7 (6.3)	14.0
Work hours	6.8(11.3)	12.5 (14.4)	4.3 (9.5)	2.7 (3.9)	0.0
Non-work hours	15.8(9.1)	15.4 (9.0)	15.8 (8.7)	15.8 (9.8)	24.3
Non-work day	20.0(14.3)	18.0 (13.4)	24.0 (16.4)	17.5 (12.1)	16.7
Breaks per sedentary hour					
Work day	11.3(2.6)	10.3 (2.2)	12 (2.9)	11.7 (2.6)	10.5
Work hours	19.4(11.7)	11.6 (4.8)	24.3 (12.5)	23.1 (12.3)	26.0
Non-work hours	9.9(2.5)	9.7 (2.2)	10.2 (2.4)	9.9 (2.9)	8.8
Non-work day	9.5(3.7)	9.8 (3.6)	8.9 (4.4)	9.8 (3.1)	9.5
LPA (%wear time)					
Work day	46.0(10.0)	38.6 (7.5)	51.5 (9.1)	48.6 (8.2)	47.6
Work hours	53.0(19.4)	35.3 (11.7)	65.4 (16.3)	59.6 (14.3)	57.6
Non-work hours	41.7(9.0)	40.4 (8.3)	42.8 (9.9)	42.1 (8.9)	40.3
Non-work day	39.7(10.2)	41 (10.4)	37.5 (11.3)	41 (8.3)	35.5
MVPA (%wear time)					
Work day	8.8(4.6)	7.2 (2.8)	8.4 (3.8)	11.1 (6.1)	17.3
Work hours	10.4(11.1)	4.8 (3.2)	10.2 (7.2)	17 (16.3)	33.9
Non-work hours	8.4(4.2)	9.4 (4.4)	7.7 (4.3)	8.2 (3.8)	5.2
Non-work day	6.4(4.8)	5.9 (2.8)	6.2 (4.9)	7.2 (6.6)	5.7

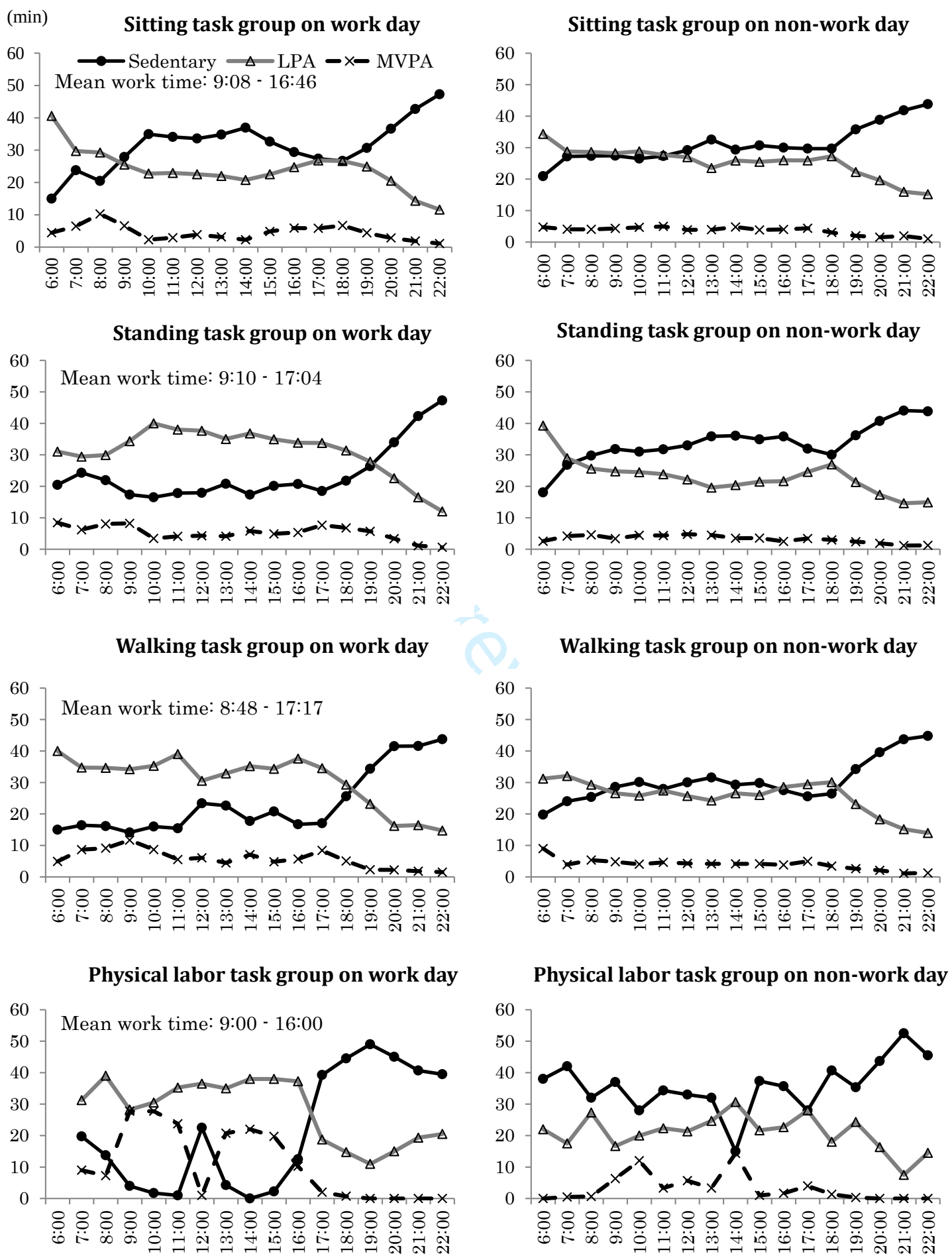

Figure S1. Hourly pattern of sedentary behavior, LPA and MVPA of four task types among part-time workers

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	16
Study size	10	Explain how the study size was arrived at	N/A
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	8
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6 8-9
		(b) Give reasons for non-participation at each stage	8-9
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-9
		(b) Indicate number of participants with missing data for each variable of interest	6,8
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	N/A
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	9-10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11-12
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	13
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16-17

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Patterns of Objectively-Assessed Sedentary Time and Physical Activity among Japanese Workers: Cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2018-021690.R1
Article Type:	Research
Date Submitted by the Author:	10-Jul-2018
Complete List of Authors:	Kurita, Satoshi; Waseda University, Graduate School of Sport Sciences Shibata, Ai; University of Tsukuba, Faculty of Health and Sport Scineces; University of Tsukuba, Faculty of Health and Sport Sciences Ishii, Kaori; Waseda University, Faculty of Sport Sciences Koohsari, Javad; Waseda University, Faculty of Sport Sciences; Australian Catholic University, Institute for Health and Ageing Owen, Neville; Baker Heart & Diabetes Institute; Swinburne University of Technology, Health Sciences OKA, Koichiro; Waseda University, Faculty of Sport Sciences
Primary Subject Heading:	Public health
Secondary Subject Heading:	Epidemiology, Sports and exercise medicine
Keywords:	descriptive epidemiology, occupational sitting, occupational activity patterns, Asia

Title: Patterns of Objectively-Assessed Sedentary Time and Physical Activity among Japanese Workers: Cross-sectional study

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Word count: 3596 words

Key words: descriptive epidemiology, occupational sitting, occupational activity patterns, Asia.

ABSTRACT

Objectives: To examine patterns of sedentary behavior and physical activity, among Japanese workers with differing occupational-activity types.

Methods: Full-time workers aged 40-64 years (n = 345; 55% men) wore an accelerometer for 7 days and completed a socio-demographic and occupational activity-type survey. Mean overall sedentary time, prolonged bouts of sedentary time and light-and moderate-to vigorous-intensity of physical activity (LPA and MVPA) as a proportion of accelerometer wear time, and number of breaks per sedentary hour, were identified for four time periods: working hours; workdays; non-work hours; and, non-work days. These sedentary behavior and physical activity measures in the four time periods were examined among workers with four self-attributed occupational activity types (mainly sitting, standing, walking, physical labor), adjusting for sociodemographic attributes. Diurnal patterns of sedentary behavior, LPA and MVPA were examined.

Results: In working hours, those with a sitting job had significantly more total and prolonged sedentary time along with less LPA and MVPA, and less frequent breaks, compared to those with the three more-active job type. Similar differences by job type were found for the whole working day, but not for prolonged sedentary time and breaks. On non-working hours and days, differences in sedentary and physically- active patterns by job type were not apparent.

Conclusions: Occupational activity type is related to overall sedentary time and patterns on working days, but not to leisure-time sitting and activity patterns, which were similar across the sitting, standing, walking, and physical labor occupational-activity types.

ARTICLE SUMMARY

Strengths and limitations of this study

- This is the first study to report descriptive patterns of objectively measured workers' sedentary behavior comprehensively in non-Western countries, and their relationships with occupational activity types.
- This study was used population-recruited sample and accelerometer-assessed sedentary behavior and physical activity.
- Examination of hourly patterns of sedentary behavior and physical activity was novel.
- Data were cross-sectional and therefore any causality cannot be inferred.
- Low response late was not completely at random, which may have resulted in selection bias.

INTRODUCTION

Sedentary behavior, defined as any waking behavior characterized by an energy expenditure ≤1.5 METs while in a sitting or reclining posture [1] has distinctive adverse effects on human health [2]. For example, excessive sedentary behavior increases the risk of all-cause mortality [3, 4] and risk of type 2 diabetes, cardiovascular disease, and some cancers [5], with some evidence of dose-response relationships [6]. There are benefits of more-frequent breaks from sedentary time on cardio-metabolic risk biomarkers [7]. Reducing prolonged sedentary behavior is an important public health issue.

Among the Japanese adult population, the worksite is a key setting in which to address sedentary behaviors and, since approximately 60% of the total population are employed, and 60 % of those employed are full-time workers (>40 hours/week) [8]. Understanding patterns of sedentary behavior (e.g. overall daily time, prolonged time, breaks, diurnal patterns) on working days and non-working days can help to identify the most sedentary segments of the day and whether there is carry-over of those patterns that may influence workers' whole-of-day sedentary time and physical activity. Such insights can inform approaches to sedentary behavior and as emerging occupational-health risks.

Sedentary behavior patterns at work and potentially across the whole day may be influenced by the demands of work – in terms of having to be seated, standing, or physically active for job tasks [9]. Hence, it is important to examine in more depth the relationship between types of occupational activity requirements with overall patterns of sedentary behavior, in order to provide evidence that can inform approaches to workplace health promotion through sedentary behavior reduction.

The majority of previous studies examining objectively-measured occupational sedentary patterns has only focused on office-based workers and primarily seated occupational groups [10-16]. One previous study conducted in Netherland has examined the pattern of sedentary behavior across different types of occupations including white-collar, office-based workers and blue-collar construction and factory workers [17]. However, there have been no detailed examinations of overall diurnal patterns and the variability between workdays and non-workdays. Although another previous study

conducted in Scotland has compared the pattern of total sedentary behavior between delivery and office staffs across workdays and non-workdays, further in-depth examinations of sedentary patterns in larger sample size and across various occupational types may more needed [18]. In addition, while a small number of studies have examined patterns of sedentary behavior among workers, based on different occupational categories [19] or on types of occupational activity [9, 20], they have used self-report measures of total and/or domain-specific sedentary behavior. Objectively-measured patterns of occupational sedentary behavior have not been examined.

Although there are distinct health consequences of sedentary behavior, light-intensity physical activity (LPA), and moderate-to-vigorous intensity physical activity (MVPA) [21,22], the time available for each of them in a day is finite. More time spent in sedentary behavior indicates less time spent in LPA, MVPA, or both, indicating that these behaviors are linked. Thus, it may be important to examine patterns of not only sedentary behavior, but also LPA and MVPA concurrently. A small number of previous studies has simultaneously examined sedentary and active behavior patterns during working and leisure-time [9, 12-15, 17, 18]. However, little is known about how different the patterns or relationships between sedentary behaviors and physical activities during working and leisure-time would be between those in types of occupations with different activity requirements.

Previous studies on sedentary behaviors among workers have been conducted mainly in Western countries. One international-comparative study found that self-reported sitting time of working adult population in Japan was the longest among 20 countries [23]. Although the Japanese working adult population seems to be at-risk population considered in this international context, patterns of sedentary behavior in Japanese workers have not been examined. Since working environments (e.g. social norms, working spaces and work time) are likely to be different in Japan and other Asian countries compared with Western countries, understanding the sedentary behavior and physical activity patterns in the Japanese work environment context will be informative.

We examined accelerometer-derived patterns of sedentary behavior (total sedentary

time, sedentary time accumulated in prolonged bouts, sedentary breaks and diurnal patterns of sedentary time) and physical activity among Japanese workers, based on occupational-activity types. These behaviors were characterized for four time periods: during work and non-work hours, on work days and on work and non-work days.

METHODS

Study design and procedure

This was a cross-sectional observational study, as a part of a project to investigate the associations between built environment attributes and sedentary behavior among Japanese middle-aged adults. A mail survey was conducted in Matsuyama city in Ehime prefecture (428.9 km^2; 516,000 people) from July to December 2013, and Koto Ward in Tokyo (40.2 km^2; 484,000 people) from April 2014 to February 2015. The study was approved by the Institutional Ethics Committee of Waseda University (2012-269, 2013-264).

The survey procedures were as follows: first, 3,000 potential participants aged 40-64 were extracted randomly from each basic resident register stratified by gender and age (40–49 years/ 50–59 years/ 60–64 years) for Matsuyama city and Koto Ward. Second, invitation letters were mailed to the potential participants and asked to return an enclosed from to indicate their expression of interest to participate in the study. Non-respondents were mailed an additional request to join the study two weeks after the initial invitation letter was sent. Then, those who expressed interest were mailed the informed-consent form of this study, an accelerometer, an activity diary, and a questionnaire. Those who finally agreed to participate were asked to sign the consent form, wear the accelerometer and record the activity diary for 7 days, respond to the questionnaire, and then return all of these within two weeks. Participants were guided to wear the accelerometers during waking time (put it on straight after waking up) and to remove it during sleeping (take it off just before going to bed) and during water-based activities such as bathing or swimming. In addition, participants were asked to record for every day during the period of accelerometer wear, their time getting up, putting on the accelerometer, leaving home to travel to their workplace, starting their job, finishing their job, arriving at home, taking off the accelerometer, and going to bed. Non-respondents were sent a reminder notice up to three times, and those who

completed survey were sent thank-you letter with a ¥1,000 book voucher card.

In total, 864 (14.4% of the originally-approached sample) including 437 (14.6%) from Koto Ward and 427 (14.2%) from Matsuyama city agreed to participate: 778 (13.0% of the originally-approached sample) completed the questionnaire and wore the accelerometer. Those who worked either full-time or part-time were included (n=633). Those who had missing or invalid data for occupational activity type (n=38) or insufficient accelerometer data (n=175) were excluded (numbers not mutually exclusive). The final study sample size was 443 (full- time workers: n=345; part-time workers: n= 98).

Assessment of sedentary behavior and physical activity

Participants were asked to wear a triaxial accelerometer, Active style Pro HJA-350IT (Omron Health Care Co., Ltd., Kyoto, Japan) on the left side of the waist for seven days. This accelerometer device has been reported to be valid and to accurately assess not only MVPA, but also low-intensity physical activity (including sedentary behavior), in comparison to indirect calorimetry [24, 25]. A recent comparative study of three activity monitors showed that the Active style Pro HJA-350IT underestimated total sedentary time (-25.6 min/day) and the ActiGraph GT3X overestimated it (+63.7 min/day), compared with the activePAL3 as the criterion [26]. Data were collected in one-minute epochs. In order to obtain the information of work day including work and non-work hours and non-work day, participants were also asked to record the time when wearing and removing accelerometer as well as starting and finishing a job on 7 days.

Socio-demographic data and occupational activity type

Age and gender were obtained from the basic resident register. Height, weight, educational level (university or further education; high school or less), marital status (currently married; single), employment status (full-time; part-time), occupation (professional and engineering; administrative and managerial; clerical; sales; service; security; agricultural, forestry and fishery; transport and machine operation; manufacturing process; others) were self-reported in questionnaire. Main occupational activity type was also self-reported. Participants were asked to choose the occupational activity type that most accurately described their work from the following 4 categories:

sitting, standing, walking, and physical labor. Body mass index (BMI) was calculated from self-reported height and weight. Occupations were referenced to Japanese standard classification of occupations [27].

Data management

Accelerometer data were processed using Omron health management software BI-LINK for physical activity professional edition ver1.0 and custom software [26]. Valid data for a wear day was defined as ≥10 hours/day excluding ≥60 consecutive minutes of no activity (0.9 or less metabolic equivalents; METs) with allowance for up to 2 min of some limited movement (≤1.0 METs) within these periods and ≥75% wear time of work hours for a work day [12]. Those who had four or more valid days of data including at least three work days and a non-work day were included in the analysis. The data were extracted according to the following four time periods: working-hours (from starting to finishing job on work day), non-working hours (from wearing accelerometer to starting job and from finishing job to taking off accelerometer on work day), working day (a sum of working and non-working hours), and for non-working days (from wearing to taking off accelerometer). Work-hours were obtained from the activity diary.

The five measures of sedentary behavior and physical activity were first extracted for each time segments: total sedentary time (min/day; % of wear time), sedentary time accumulated in prolonged sedentary bouts (% of wear time), number of sedentary breaks (times/sedentary hour), and LPA (% of wear time) and MVPA (% of wear time). Total sedentary time, LPA time, and MVPA time were defined as all wear time for any activity with an accelerometer-estimated intensity of ≤1.5 METs, 1.5< and <3.0 METs, and 3.0 or more METs, respectively. A sedentary bout was defined as a period of uninterrupted sedentary time [1]. Total sedentary time was calculated by a sum of uninterrupted sedentary time lasting ≥ 1 minutes. A prolonged sedentary bout was defined as a period of uninterrupted sedentary time lasting ≥ 30 minutes [1]. Sedentary time accumulated in prolonged bouts was calculated as the sum of prolonged sedentary bouts (% of wear time). A sedentary break was defined as a non-sedentary bout in between two sedentary bouts [1]. The number of sedentary breaks was calculated by the total number of sedentary breaks divided by time spent in all sedentary behavior. For each of the time segments, daily averages of all sedentary and physically-active

measures were calculated over valid work and non-work days. Daily summaries of time spent in all sedentary behavior, prolonged sedentary bouts, LPA, and MVPA for each time segments were also calculated in terms of the percentage of these intensities in worn time (% wear time). Finally, daily average values including work and non-work days of five measures in a week were then computed by weighting for 5 work days and 2 non-work days.

Statistical Analysis

Full-time (n=345) and part-time (n=98) workers were separately analyzed. Comparisons of the sociodemographic characteristics and five sedentary behavior and physical activity measures among four occupational activity types were conducted using one-way ANOVA for continuous variables and chi-square test for category variables. Each of the five sedentary and physical activity measures were compared among four occupational activity types in four time periods (working hours, non-working hours, working days, non-working days) using Analysis of Covariance (ANCOVA) with Bonferroni post-hoc test, adjusting for gender, age, residential area, educational level, marital status, and BMI. For these analyses, those who had missing data for these covariates were excluded among the full-time workers (n= 4). For part-time workers, only one person was engaged in physical labor tasks and thus their data were excluded from the analyses. For describing diurnal patterns, those who had ≥6 h of work time starting morning were included (n=403). Diurnal pattern of sedentary behavior, LPA and MVPA in each hour from 06:00-06:59 to 22:00-22:59 for each occupational activity type on work day and non-work day were illustrated by line graphs. All statistical analyses were performed using STATA 13.0 (Stata Corp., College Station, TX, US) and IBM SPSS Statistics 22 software (IBM Japan Inc., Tokyo, Japan). Significant levels were $p < 0.05$.

RESULTS

The characteristics of participants in full-time work are summarized in Table 1. The mean age and BMI were 50.3(SD 6.9) and 22.8 (3.2), respectively. About a half of them were men and lived in Koto Ward. The majority had completed university or higher education, were married, and worked in mainly-sitting type jobs. Those with sitting and physical labor jobs were more likely to be men than those with other two occupational

activity types. Those with sitting jobs were also more likely to live in Koto Ward and completed university or further education than those in three other more active jobs.

Table 1. Basic characteristics for participants of full-time jobs (N=345)

	All participants	Occupational activity type				Group differences‡
		Sitting [a]	Standing [b]	Walking [c]	physical labor [d]	
N	345	239 (69.3)	47 (13.6)	48 (13.9)	11 (3.2)	
Age, mean (SD)	50.3(6.9)	50.1(7.0)	50.7(6.8)	50.5(6.7)	52.6(6.7)	
Women, n (%)	156 (45.2)	99 (41.4)	25 (53.2)	29 (60.4)	3 (27.3)	a,d<c
BMI, kg/m²†, mean (SD)	22.8 (3.2)	23.0(3.4)	21.9(2.4)	22.3(2.6)	25.5(4.2)	b,c<d
Residence area, n (%)						
Matsuyama city	170 (49.3)	98 (41.0)	37 (78.7)	26 (54.2)	9 (81.8)	a< b,d b<c
Koto Ward	175 (50.7)	141 (59.0)	10 (21.3)	22 (45.8)	2 (18.2)	
Education [a], n (%)						
High school or less	109 (31.6)	59 (24.8)	23 (48.9)	21 (43.8)	6 (54.5)	a<b,c,d
Greater than high school	235 (68.1)	179 (75.2)	24 (51.1)	27 (56.3)	5 (45.5)	
Marital status††, n (%)						
Single	85 (24.6)	60 (25.4)	11 (23.4)	12 (25.0)	2 (18.2)	
Married	257 (74.5)	176 (74.6)	36 (76.6)	36 (75.0)	9 (81.8)	
Occupation†††, n (%)						
Professional and engineering	71 (20.6)	39 (16.5)	13 (28.3)	18 (37.5)	1 (10.0)	
Administrative and managerial	59 (17.1)	56 (23.6)	0 (0)	2 (4.2)	1 (10.0)	
Clerical	114 (33.0)	111 (46.8)	2 (4.3)	1 (2.1)	0 (0.0)	
Sales	17 (4.9)	7 (3.0)	4 (8.7)	6 (12.5)	0 (0.0)	
Service	34 (9.9)	9 (3.8)	17 (37)	8 (16.7)	0 (0.0)	
Security	1 (0.3)	0 (0.0)	1 (2.2)	0 (0.0)	0 (0.0)	
Agricultural, forestry and fishery	4 (1.2)	0 (0.0)	1 (2.2)	3 (6.3)	0 (0.0)	
Transport and machine operation	9 (2.6)	1 (0.4)	0 (0.0)	4 (8.3)	4 (40.0)	
Manufacturing process	14 (4.1)	4 (1.7)	5 (10.9)	1 (2.1)	4 (40.0)	
Others	17 (4.9)	10 (4.2)	2 (4.3)	5 (10.4)	0 (0.0)	

†:1 missing in sitting group; ††:3 missing in sitting group; †††: 2 missing in sitting group, 1 missing in both standing group and physical labor group

‡: significant differences between 4 occupational activity types with one-way ANOVA for continuous variables; chi-square test for category variables; a= sitting, b=standing, c=walking; d=physical labor

The sedentary behavior and physical activity measures in all days, work and non-work contexts on all and occupational activity types of full-time workers are presented in Table 2. In all days, mean wearing days and hours of accelerometer were 6.8 (SD: 0.9) days and 15.3 (SD: 1.1) hours. There were no significant differences in wearing days and hours of accelerometer wear time among the four of

occupational-activity types. In all days, those with sitting jobs had proportionally more total and prolonged sedentary time and less LPA and MVPA time in proportion, compared with those with other three occupational-activity types ($p<0.001$). Additionally, those with sitting jobs had more frequent breaks than those with standing and walking jobs ($p<0.001$). There were no significant differences in any of the sedentary behavior and physical activity measures among those in three physically active job types.

Regarding working hours, those with sitting jobs had significantly more total and prolonged sedentary time along with less LPA and MVPA in proportion, and less frequent breaks compared with those with three other more active jobs ($p<0.01$). The differences in sedentary time between the sitting jobs and the other jobs types on working hours were 17.7–26.4% of wear time. In addition, those with walking jobs had significantly more total sedentary time in proportion than those with physical labor jobs ($p<0.05$). Also, those with physical labor jobs had significantly more MVPA time in proportion than those with standing and walking jobs ($p<0.05$).

As a descriptive feature of non-work hours, the more active the jobs in which workers were involved, the more was their proportion of total sedentary time and the less their LPA, except for those with mostly sitting jobs. In large part, the proportions of total sedentary time and LPA in those with sitting jobs were similar to those with the jobs involving physical labor. The differences reaching statistical significance were as follow: those with standing jobs had proportionally less total sedentary time and more LPA than those with sitting jobs ($p<0.05$).

Results similar to working hours were found for the total for working days, except for the prolonged sedentary time and sedentary breaks variables; there were no significant differences between those with sitting job and physical labor. The differences in sedentary time between the sitting jobs and the other jobs types on working days were 28.5-42.0% of wear time, respectively. In addition, those with standing job had significantly more LPA time in proportion than those with walking jobs ($p<0.05$).

On non-work days, there were no significant differences apparent between the four occupational activity types.

Table2. Comparison of sedentary behavior and physical activity among four occupational activity types in full-time workers

	All	Occupational activity type			
	Mean (SD)	Marginal mean (95% CI) [a]			
		Sitting	Standing	Walking	Physical labor
Wear time (hours)					
All day	15.3 (1.1)	15.2 (15.0-15.4)	15.3 (14.9-15.8)	15.2 (14.7-15.6)	16.0 (15.0-16.9)
Work day [a]	15.6(1.8)	15.5 (15.3-15.8)	15.8 (15.2-16.3)	15.7 (15.2-16.2)	16.6 (15.6-17.7)
Work hours [b]	9.4(1.8)	9.3 (9.1-9.5)	9.7 (9.2-10.3)	9.7 (9.2-10.2)	9.8(8.8-10.9)
Non-work hours [c]	6.2(2.3)	6.3 (6.0-6.5)	6.0 (5.4-6.6)	6.0 (5.4-6.6)	6.8 (5.5-8.1)
Non-work day [d]	14.3(2.0)	14.4 (14.1-14.7)	14.3 (13.7-14.9)	13.9 (13.3-14.4)	14.4 (13.2-15.6)
Total sedentary (%wear time)					
All day	57.5(12.7)	62.2 (61.0-63.5)	45.1 (42.2-47.9)***	49.1 (46.4-51.9)***	43.5 (37.7-49.3)***
Work day	56.8(15.3)	63.2 (61.8-64.5)	40.6 (37.4-43.7)***	45.5 (42.5-48.5)***	36.8 (30.4-43.2)***
Work hours	58.6(21.9)	68.5 (66.7-70.3)	34.6 (30.4-38.7)***	40.0 (36.0-44.0)***	26.5 (18.1-34.9)***,‡
Non-work hours	53.3(11.9)	54.0 (52.4-55.4)	49.8 (46.3-53.3)*	52.5 (49.2-55.9)	56.5 (49.4-63.6)
Non-work day	59.1(13.8)	59.8 (58.1-61.6)	56.3 (52.3-60.4)	58.2 (54.3-62.1)	60.3 (52.0-68.5)
Prolonged sedentary bouts (% wear time)					
All day	19.1(11.0)	22.1(20.8-23.4)	14.8(11.8-17.7)***	15.4(12.6-18.3)***	15.5(9.4-21.5)
Work day	18.2(12.5)	21.0 (19.5-22.4)	11.7 (8.4-15.0)***	12.4 (9.2-15.5)***	12.0 (5.3-18.7)
Work hours	18.6(18.2)	23.1 (21.1-25.2)	8.5 (3.8-13.2)***	9.0 (4.4-13.5)***	7.0 (-2.5-16.6)**
Non-work hours	16.7(11.1)	16.6 (15.2-18.0)	16.2 (13.0-19.5)	16.5 (13.4-19.7)	20.5 (13.9-27.0)
Non-work day	24.1(15.1)	24.8 (22.9-26.8)	22.3 (17.9-26.7)	23.1 (18.8-27.4)	24.1 (15.2-33.1)
Breaks per sedentary hour					
All day	9.4(3.1)	8.7 (8.4-9.1)	11.6 (10.8-12.4)***	10.8 (10.1-11.6)***	10.3 (8.7-11.9)
Work day	9.8(3.6)	8.8 (8.4-9.1)	12.7 (11.8-13.6)***	11.7 (10.8-12.6)***	10.9 (9.1-12.7)
Work hours	10.8(5.7)	8.8 (8.2-9.4)	16.2 (14.9-17.5)***	14.7 (13.4-16.0)***	13.3 (10.6-16.0)**
Non-work hours	10.0(3.7)	10.0 (9.5-10.5)	10.5 (9.4-11.6)	10.0 (8.9-11.0)	9.7 (7.4-11.9)
Non-work day	8.6(3.7)	8.6 (8.1-9.0)	8.9 (7.6-10.0)	8.7 (7.6-9.7)	8.8 (6.5-11.0)
LPA (%wear time)					
All day	34.8(11.0)	31.3 (30.2-32.3)	44.5 (42.1-47.0)***	40.8 (38.4-43.1)***	44.3 (39.3-49.2)***
Work day	35.1(13.1)	30.3 (29.1-31.5)	48.1 (45.4-50.8)***	42.9 (40.3-45.6)***,†	48.2 (42.6-53.7)***
Work hours	34.6(17.7)	27.4 (25.9-29.0)	53.3 (49.7-56.9)***	47.1 (43.6-50.6)***	54.9 (47.6-62.1)***
Non-work hours	36.2(11.3)	35.3 (33.9-36.6)	40.4 (37.3-43.5)*	37.7 (34.7-40.7)	34.7 (28.4-41.0)
Non-work day	34.2(11.9)	33.7 (32.2-35.2)	35.6 (32.2-39.1)	35.3 (32.0-38.6)	34.6 (27.6-41.5)
MVPA (%wear time)					
All day	7.7(4.5)	6.5 (6.0-7.1)	10.4 (9.1-11.6)***	10.1 (8.9-11.3)***	12.2 (9.7-14.7)***
Work day	8.2(5.4)	6.5 (5.9-7.2)	11.3 (9.9-12.8)***	11.5 (10.2-12.9)***	15.0 (12.1-17.9)***
Work hours	6.8(7.5)	4.1 (3.3-4.9)	12.2 (10.3-14.0)***	12.9 (11.1-14.6)***	18.6 (14.9-22.4)***,†,‡
Non-work hours	10.5(6.8)	10.8 (10.0-11.6)	9.8 (8.0-11.6)	9.8 (8.0-11.6)	8.8 (5.1-12.5)
Non-work day	6.7(4.6)	6.5 (5.9-7.1)	8.0 (6.6-9.3)	6.5 (5.2-7.8)	5.2 (2.4-7.9)

[a] Marginal mean and 95% CI from ANCOVA adjusted for covariates including gender, age, BMI, residence area, educational level, marital status.
Asterisks indicate significant difference from the sitting: *p < 0.05, **p < 0.01, *** <.001
Dagger indicates significant difference from the standing: †p < 0.05
Double dagger indicates significant difference from the walking: ‡p < 0.05

Hourly patterns of sedentary behavior, LPA and MVPA on four occupational activity types are summarized in Figure 1 for full time workers. Overall, sedentary time and LPA showed an inverse pattern. On work days, a notable difference was observed in the pattern of sedentary behavior during work hours between those with the sitting jobs and the other three types, while all occupational activity types showed a similar pattern after work, with a linear increase in the sedentary fraction until 22:00-22:59. Those with standing, walking and physical labor jobs constantly accounted for a larger fraction of LPA than that of sedentary behavior from 6:00-6:59 throughout almost of all working hours. On non-work days, sedentary behavior in all occupational activity types was mostly dominant from 7:00-7:59 to 18:00-18:59. However, the time differences between sedentary behavior and LPA in those with sitting jobs stayed more constant and larger than those in other more active jobs from 7:00-7:59 to 18:00-18:59. After 18:00-18:59 on non-work day, all types showed increase in sedentary time as the same with work days. All results of the part-time workers were presented in Table S1,2 and Figure S1.

INSERT FIGURE 1 ABOUT HERE

DISCUSSION

This is the first study to examine accelerometer-measured patterns of sedentary behaviors and physical activity among Japanese workers in their work and non-work contexts, and to examine how these patterns differed by occupational activity type. Among full-time workers, sedentary time comprised more than half of the working day. Overall, those with sitting jobs, who accounted for 70% of this study sample, had higher amount of both total and prolonged sedentary time and less frequent breaks from sitting across the whole day, compared with those in more physically active job types. Previous studies in Western countries have examined the differences in objectively-measured total sedentary behavior among 2-19 occupation groups or sectors [18, 19] and self-reported leisure and domain-specific sedentary behaviors among occupational activity types [9, 20]. The present study extends these findings, for the first time in a non-Western country, by examining the differences in additional sedentary behavior measures such as prolonged sedentary behavior and breaks using objective measurements. The present findings suggest that further public health efforts focused on the worksite should be emphasized, especially for office-workers who are a majority of the working adult population in Japan and are an apparent at-risk subgroup due to high volumes of sitting, not only at work but also in non-work time.

Among those with sitting jobs of this study sample, 63% of working day (60% of non-work day) were sedentary. Some previous studies conducted in Australia and the UK found that sedentary behavior assessed by Actigraph were 68-70% of working day of office workers (60-63% of non-work day)[12, 14]. Our recent comparative study of activity devices found that total sedentary time assessed by the Active style Pro HJA-350IT were proportionally 11% less time spent in total sedentary behavior than Actigraph [26]. These findings suggest that Japanese office-workers may spend more time in sedentary behavior across whole day compared with those in Western countries, which is similar to the previous international-comparative study examining self-reported sitting time of working adult population [23]. As an at-risk population considered in the international context, promoting effective public health strategies to reduce sedentary behavior on the worksite may be a necessary effort in Japan.

We found significant differences in overall sedentary time and number of breaks from sedentary time in work hours across the occupational activity types that we examined, especially for working hours. Full-time workers with sitting jobs spent most sedentary time and had less breaks from sedentary behavior than those with more active job types: these differences were approximately 20-30% in the proportion (2.5-4 hours) and 5-7 times per sedentary hours. On the other hand, these patterns on non-working hours or days were relatively similar although workers with sitting and physical labor jobs somewhat spent more sedentary along with in less LPA than those with standing and walking jobs. These findings may indicate that the occupational activity type, which is commonly determined by job requirements can have the greatest impact on overall sedentary time and patterns in workers' population. These findings are consistent with the only previous study from The Netherlands, which found all white-collar workers from financial service providers and research institutes had significantly greater occupational (30-35%) and total sitting time (10-15%) in proportion than all blue-color workers of construction company [17]. In addition, these findings supported those of previous studies in Australia, France, Scotland, and the Netherlands, which showed that workers with higher occupational sitting time did not sit less, rather sat more, on their leisure time [9, 18, 19, 28]. Similar to studies conducted in Western countries, the present findings suggest that further promotion of

worksite interventions to reduce office-workers' sedentary time along with increased sedentary breaks should be prioritized on working populations in not only Western countries but also in Japan.

Similar to the average patterns, the analysis of the accelerometer output by hour of the working day showed that the pattern of sedentary behavior, LPA and MVPA were highly dependent on occupational activity types during working hours (except for lunch time), whereas all were similar on the evening time after work. The descriptive features were observed on non-working day, especially during the daytime, across occupational activity types. Even though the average sedentary and activity patterns were not distinct among them, some dips in sedentary behavior along with increases in LPA were found in those with standing, walking, and physical labor jobs, whereas the conditions in which sedentary behavior is the most dominant stayed constant throughout a day in those with sitting jobs on non-working day. The pattern of MVPA was stable and independent from those of sedentary behavior and LPA in all occupational activity types. The variations in pattern of sedentary behavior and LPA among occupational activity types could be partly attributed to differences in socio-demographic attributes (especially gender) and sample size. However, in a previous study from the UK examining the diurnal patterns of sedentary behavior and physical activity among office workers grouped into tertiles based on occupational sedentary time, the higher the tertile for occupational sedentary time in which office workers were categorized, the more pronounced and stable the difference between sedentary behavior and LPA (less crossing and reversing time points in a graph between them) became throughout a non-working day [14]. These results imply that routine diurnal occupational sedentary and LPA patterns, which were repeated 5 days a week, on working day may carry over their leisure-time behavioral patterns as a habit. Similarly, the previous study in French working adults using a self-report questionnaire found that the occupational activity levels involved in jobs were negatively associated with leisure time spent sedentary, on both working and non-working days [20]. Future intervention studies could help to clarify whether promoting breaks from sedentary time by more LPA during working hours may influence leisure-time sedentary behavior and physical activity. The hourly patterns for LPA and MVPA would also be useful to consider in relation to the timing of workplace physical activity interventions, which is fruitful as a future research topic.

This is the first study to report descriptive patterns of objectively measured Japanese workers' sedentary behavior comprehensively, and their relationships with occupational activity types. Other strengths of this study were use of population-recruited sample and accelerometer -assessed sedentary behavior and physical activity. There are also some limitations in this study. First, data were cross-sectional and therefore any causality cannot be inferred. Second, the present samples were selected from only two cities in Japan although central and average-sized local cities were chosen. Thus, the results may differ in other cities and areas. Third, the response rate was relatively low. Our middle-aged participants were recruited initially by random sampling, which may have introduced some sampling bias; only 10 were recruited whose jobs involved physical labor. Therefore, the findings may not be generalizable to the broader middle-aged worker population, in particular to those whose jobs involve physical labor. Fourth, accelerometers were unable to accurately differentiate sitting and very-static standing postures, and they cannot detect some types of physical activity such as cycling and water activity.

CONCLUSION

In summary, full-time workers involved in mostly sitting jobs had a higher volume of sedentary behavior with prolonged bouts on workdays, compared with other occupational-activity job types. The differences in sedentary patterns mainly occurred during work hours. There may be carry-over of sedentary and physical activity patters in working time, which could influence leisure time and whole of day time spent sedentary, with potential for adverse health consequences. Therefore, intervention for to reduce workers' sedentary behaviors are needed, especially for those in office-based workplace where prolonged periods of sitting are required.

AUTHORS' CONTRIBUTION

Kurita and Shibata conceived the study, analyzed the data, and drafted the manuscript. Koohsari and Owen assisted with analyzing data and drafting manuscript. Ishii and Oka were involved in the development and implementation of this study. All authors contributed to study design, interpretation of the results, and manuscript preparation. All authors have read and approved the final manuscript.

FUNDING

This study was supported by a Grant-in-Aid for Scientific Research (No. 26242070) from the Japan Society for the Promotion of Science, MEXT-Supported Program for the Strategic Research Foundation at Private Universities (S1511017). Koohsari was supported by a JSPS Postdoctoral Fellowship for Research in Japan (#17716) from the Japan Society for the Promotion of Science. Owen was supported by a National Health and Medical Research Council of Australia Senior Principal Research Fellowship and Program Grant, and by an Australian Academy of Sciences/Japan Society for the Promotion of Science Visiting Fellowship to Waseda University.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA SHARING STATEMENT

Requests for access to data should be addressed to the corresponding author.

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Figure1. Hourly pattern of sedentary behavior, LPA and MVPA of four task types among full-time workers

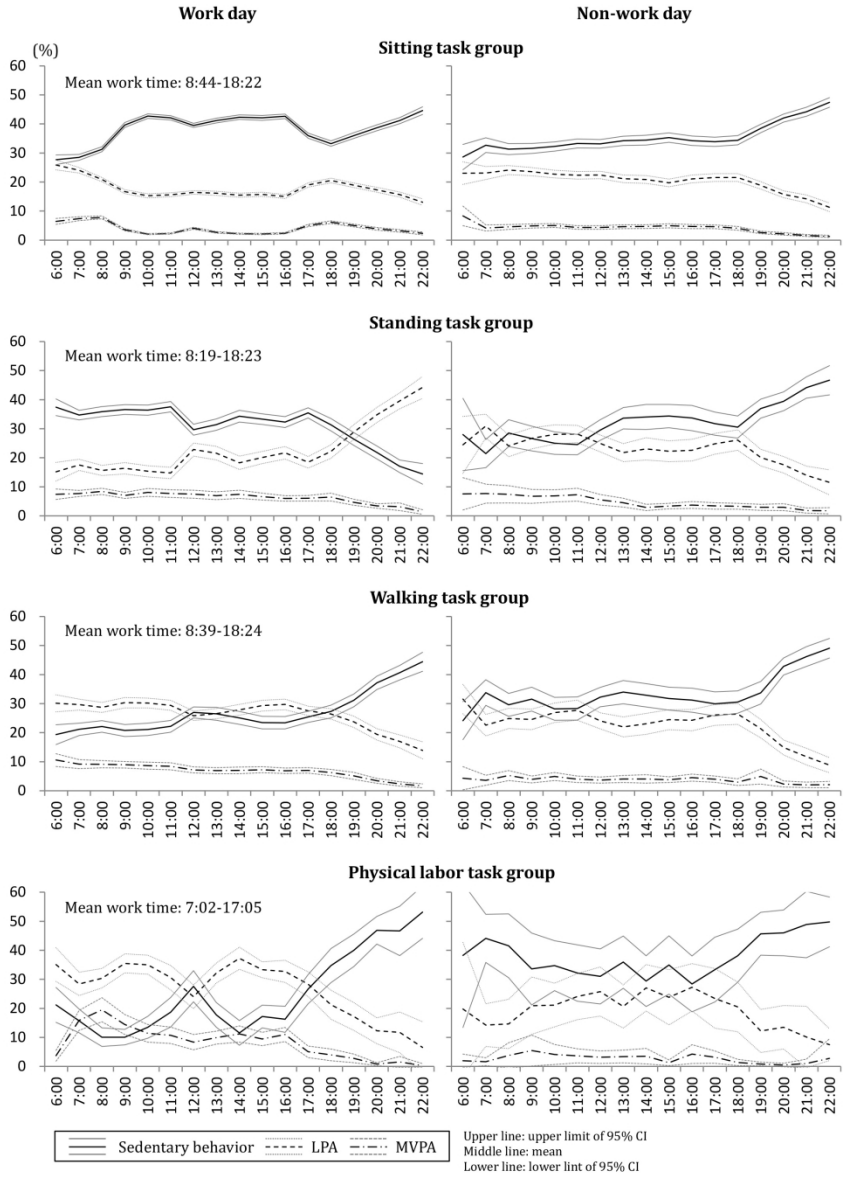

Figure 1. Hourly pattern of sedentary behavior, LPA and MVPA of four task types among full-time workers

183x259mm (300 x 300 DPI)

Table S1. Basic characteristics for participants of part-time workers

	All participants	Occupational task group		
		Sitting	Standing	Walking
n	98	35 (35.7)	35 (35.7)	27 (27.6)
Age, mean(SD)	51.1(7.3)	50.4 (6.8)	52.7(8.0)	49.9(6.8)
Women, n (%)	94 (95.9)	34 (97.1)	33 (94.3)	26 (96.3)
BMI (kg/m^2)[a], mean(SD)	21.1(2.2)	21.2 (2.3)	20.9(2.1)	21.3(2.2)
Residence area, n (%)				
Matsuyama city	44 (44.9)	15 (42.9)	23 (65.7)	16 (59.3)
Koto Ward	54 (55.1)	20 (57.1)	12 (34.3)	11 (40.7)
Education, n (%)				
High school or less	44 (44.9)	11 (31.4)	22 (62.9)	11 (40.7)
Greater than high school	54 (55.1)	24 (68.6)	13 (37.1)	16 (59.3)
Marital status[b], n (%)				
Single	12 (12.2)	4 (11.4)	4 (11.4)	4 (15.4)
Married	85 (86.7)	31 (88.6)	31 (88.6)	22 (84.6)
Occupation[c], n (%)				
Professional and engineering	17 (17.5)	6 (17.6)	4 (11.4)	7 (25.9)
Administrative and managerial	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Clerical	23 (23.7)	21 (61.8)	2 (5.7)	0 (0.0)
Sales	7 (7.2)	1 (2.9)	5 (14.3)	1 (3.7)
Service	33 (34)	3 (8.8)	18 (51.4)	11 (40.7)
Security	1 (1.0)	0 (0.0)	1 (2.9)	0 (0.0)
Agricultural, forestry and fishery	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Transport and machine operation	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Manufacturing process	5 (5.2)	1 (2.9)	3 (8.6)	1 (3.7)
Others	10 (10.3)	1 (2.9)	2 (5.7)	7 (25.9)

a 1 missing in standing task group
b 1 missing in walking task group
c 1 missing in sitting task group

Table S2 Comparison of sedentary behavior and physical activity among three occupational activity types in part-time workers

	All	Occupational activity types		
		Sitting	Standing	Walking
	Mean (SD)			
Wear time (hours)				
All days	15.7(1.44)	15.7(1.4)	15.5(1.5)	16.1(1.5)
Work day	16.0(1.6)	15.9(1.7)	15.8(1.6)	16.3(1.7)
Work hours	6.2(2.4)	6.4(2.2)	5.9(2.5)	6.5(2.5)
Non-work hours	9.7(3.0)	9.5(2.8)	9.8(2.8)	9.9(3.7)
Non-work day	15.1(1.6)	15.0(1.2)	14.7(1.9)	15.6(1.6)
Total sedentary (%wear time)				
All days	47.6(9.8)	53.9(7.7)	44.7(10.3)	43.6(7.7)
Work day	45.1(11.3)	54.2 (7.9)	40.1 (10.9)	40.3 (8.4)
Work hours	36.6(23.4)	59.9 (12.6)	24.4 (19.4)	23.4 (14.3)
Non-work hours	49.8(9.7)	50.2 (8.9)	49.5 (10.8)	49.7 (9.9)
Non-work day	53.9(12.7)	53.1 (12.0)	56.4 (14.6)	51.8 (11.2)
Prolonged sedentary bouts (%wear time)				
All days	14.4(7.6)	15.1(8.0)	15.0(8.0)	12.7(6.4)
Work day	12.2(7.1)	14.0 (8.1)	11.4 (6.6)	10.7 (6.3)
Work hours	6.8(11.3)	12.5 (14.4)	4.3 (9.5)	2.7 (3.9)
Non-work hours	15.8(9.1)	15.4 (9.0)	15.8 (8.7)	15.8 (9.8)
Non-work day	20.0(14.3)	18.0 (13.4)	24.0 (16.4)	17.5 (12.1)
Breaks per sedentary hour				
All days	10.8(2.3)	10.1(1.9)	11.1(2.7)	11.2(2.2)
Work day	11.3(2.6)	10.3 (2.2)	12 (2.9)	11.7 (2.6)
Work hours	19.4(11.7)	11.6 (4.8)	24.3 (12.5)	23.1 (12.3)
Non-work hours	9.9(2.5)	9.7 (2.2)	10.2 (2.4)	9.9 (2.9)
Non-work day	9.5(3.7)	9.8 (3.6)	8.9 (4.4)	9.8 (3.1)
LPA (%wear time)				
All days	44.2(8.4)	39.2(6.9)	47.5(8.5)	46.3(7.2)
Work day	46.0(10.0)	38.6 (7.5)	51.5 (9.1)	48.6 (8.2)
Work hours	53.0(19.4)	35.3 (11.7)	65.4 (16.3)	59.6 (14.3)
Non-work hours	41.7(9.0)	40.4 (8.3)	42.8 (9.9)	42.1 (8.9)
Non-work day	39.7(10.2)	41 (10.4)	37.5 (11.3)	41 (8.3)
MVPA (%wear time)				
All days	8.1(3.9)	6.9(2.5)	15.6(3.4)	10.0(5.2)
Work day	8.8(4.6)	7.2 (2.8)	8.4 (3.8)	11.1 (6.1)
Work hours	10.4(11.1)	4.8 (3.2)	10.2 (7.2)	17 (16.3)
Non-work hours	8.4(4.2)	9.4 (4.4)	7.7 (4.3)	8.2 (3.8)
Non-work day	6.4(4.8)	5.9 (2.8)	6.2 (4.9)	7.2 (6.6)

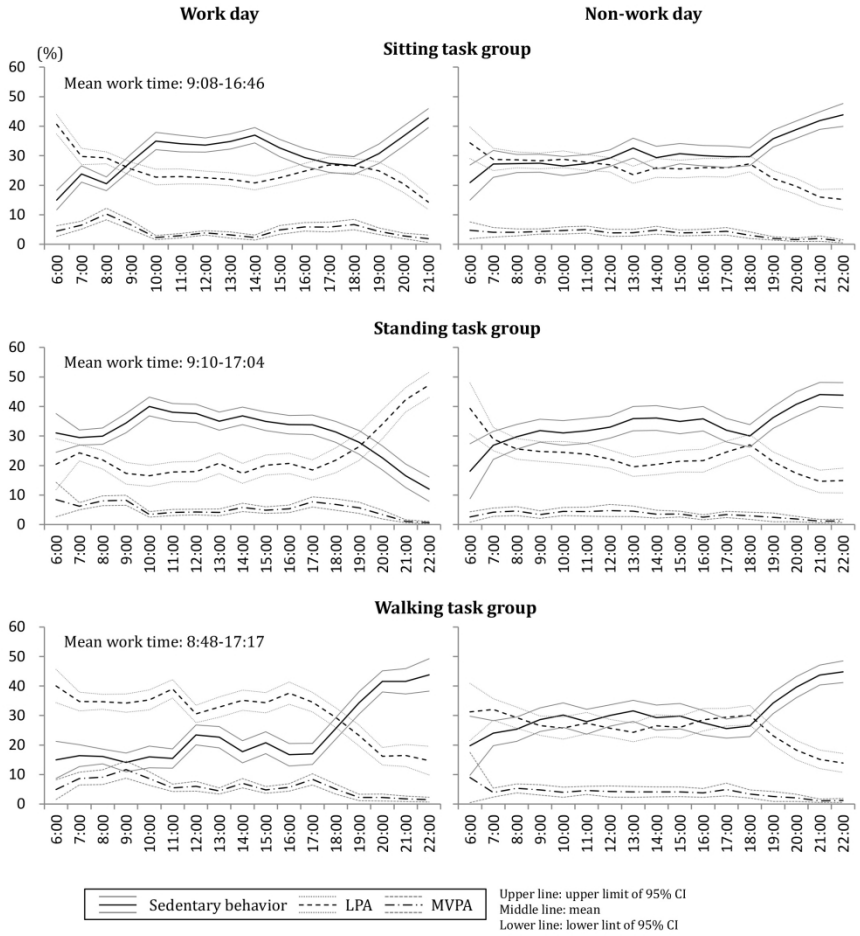

Figure S1. Hourly pattern of sedentary behavior, LPA and MVPA of three task types among part-time workers

183x255mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study design	4	Present key elements of study design early in the paper	5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-9
Bias	9	Describe any efforts to address potential sources of bias	16-18
Study size	10	Explain how the study size was arrived at	N/A
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	9
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7 8-9
		(b) Give reasons for non-participation at each stage	8-9
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	7,9
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	N/A
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	9-10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11-13
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	14
Discussion			
Key results	18	Summarise key results with reference to study objectives	14-16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17
Generalisability	21	Discuss the generalisability (external validity) of the study results	17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Patterns of objectively-assessed sedentary time and physical activity among Japanese workers: a cross-sectional observational study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2018-021690.R2
Article Type:	Research
Date Submitted by the Author:	13-Oct-2018
Complete List of Authors:	Kurita, Satoshi; Waseda University, Graduate School of Sport Sciences Shibata, Ai; University of Tsukuba, Faculty of Health and Sport Scineces; University of Tsukuba, Faculty of Health and Sport Sciences Ishii, Kaori; Waseda University, Faculty of Sport Sciences Koohsari, Javad; Waseda University, Faculty of Sport Sciences; Australian Catholic University, Institute for Health and Ageing Owen, Neville; Baker Heart & Diabetes Institute; Swinburne University of Technology, Health Sciences OKA, Koichiro; Waseda University, Faculty of Sport Sciences
Primary Subject Heading:	Public health
Secondary Subject Heading:	Epidemiology, Sports and exercise medicine
Keywords:	descriptive epidemiology, occupational sitting, occupational activity patterns, Asia

Title: Patterns of objectively-assessed sedentary time and physical activity among Japanese workers: a cross-sectional observational study

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Word count: 4057 words

Key words: descriptive epidemiology, occupational sitting, occupational activity patterns, Asia.

ABSTRACT

Objectives: To examine patterns of sedentary behavior and physical activity, among Japanese workers with differing occupational-activity types.

Design: A cross-sectional observational study in 2013-2015.

Setting: Two local communities in Japan

Participants: Full-time workers aged 40-64 years (n = 345; 55% men) and who lived in two cities.

Main outcome measures: From accelerometer data for 7 days, mean overall sedentary time, prolonged bouts of sedentary time and light-and moderate-to vigorous-intensity of physical activity (LPA and MVPA) as a proportion of accelerometer wear time, and number of breaks per sedentary hour, were identified for four time periods: working hours; workdays; non-work hours; and, non-work days. These sedentary behavior and physical activity measures in the four time periods were examined among workers with four self-attributed occupational activity types (mainly sitting, standing, walking, physical labor), adjusting for sociodemographic attributes. Diurnal patterns of sedentary behavior, LPA and MVPA were examined.

Results: In working hours, those with a sitting job had significantly more total and prolonged sedentary time (total: $p<0.001$; prolonged: $p<0.01$) along with less LPA ($p<0.001$) and MVPA ($p<0.001$), and less frequent breaks ($p<0.01$), compared to those with the three more-active job type. Similar differences by job type were found for the whole working day, but not for prolonged sedentary time and breaks. On non-working hours and days, differences in sedentary and physically- active patterns by job type were not apparent.

Conclusions: Occupational activity type is related to overall sedentary time and patterns on working days, but not to leisure-time sitting and activity patterns, which were similar across the sitting, standing, walking, and physical labor occupational-activity types.

ARTICLE SUMMARY

Strengths and limitations of this study

- This is the first study to comprehensively report descriptive patterns of workers' objectively-measured sedentary behavior in a non-Western country, and relationships with occupational activity types.
- This study used a population-recruited sample and objectively (accelerometer)-assessed sedentary and physically-active time
- Distinct examination of work and leisure-time patterns of sedentary and physically-active time was novel.
- Since the study design was cross-sectional, causality cannot be inferred.
- The response rate was low and not completely random, which may have resulted in some selection bias.

INTRODUCTION

Sedentary behavior, defined as any waking behavior characterized by an energy expenditure ≤1.5 METs while in a sitting or reclining posture [1] has distinctive adverse effects on human health [2]. For example, excessive sedentary behavior increases the risk of all-cause mortality [3, 4] and risk of type 2 diabetes, cardiovascular disease, and some cancers [5], with some evidence of dose-response relationships [6]. There are benefits of more-frequent breaks from sedentary time on cardio-metabolic risk biomarkers [7]. Reducing prolonged sedentary behavior is an important public health issue.

Among the Japanese adult population, the worksite is a key setting in which to address sedentary behaviors and, since approximately 60% of the total population are employed, and 60 % of those employed are full-time workers (>40 hours/week) [8]. Understanding patterns of sedentary behavior (e.g. overall daily time, prolonged time, breaks, diurnal patterns) on working days and non-working days can help to identify the most sedentary segments of the day and whether there is carry-over of those patterns that may influence workers' whole-of-day sedentary time and physical activity. Such insights can inform approaches to sedentary behavior and as emerging occupational-health risks.

Sedentary behavior patterns at work and potentially across the whole day may be influenced by the demands of work – in terms of having to be seated, standing, or physically active for job tasks [9]. Hence, it is important to examine in more depth the relationship between types of occupational activity requirements with overall patterns of sedentary behavior, in order to provide evidence that can inform approaches to workplace health promotion through sedentary behavior reduction.

The majority of previous studies examining objectively-measured occupational sedentary patterns has only focused on office-based workers and primarily seated occupational groups [10-16]. One previous study conducted in Netherland has examined the pattern of sedentary behavior across different types of occupations including white-collar, office-based workers and blue-collar construction and factory workers [17]. However, there have been no detailed examinations of overall diurnal patterns and the variability between workdays and non-workdays. Although another previous study

conducted in Scotland has compared the pattern of total sedentary behavior between delivery and office staffs across workdays and non-workdays, further in-depth examinations of sedentary patterns in larger sample size and across various occupational types may more needed [18]. In addition, while a small number of studies have examined patterns of sedentary behavior among workers, based on different occupational categories [19] or on types of occupational activity [9, 20], they have used self-report measures of total and/or domain-specific sedentary behavior. Objectively-measured patterns of occupational sedentary behavior have not been examined.

Although there are distinct health consequences of sedentary behavior, light-intensity physical activity (LPA), and moderate-to-vigorous intensity physical activity (MVPA) [21,22], the time available for each of them in a day is finite. More time spent in sedentary behavior indicates less time spent in LPA, MVPA, or both, indicating that these behaviors are linked. Thus, it may be important to examine patterns of not only sedentary behavior, but also LPA and MVPA concurrently. A small number of previous studies has simultaneously examined sedentary and active behavior patterns during working and leisure-time [9, 12-15, 17, 18]. However, little is known about how different the patterns or relationships between sedentary behaviors and physical activities during working and leisure-time would be between those in types of occupations with different activity requirements.

Previous studies on sedentary behaviors among workers have been conducted mainly in Western countries. One international-comparative study found that self-reported sitting time of working adult population in Japan was the longest among 20 countries [23]. Although the Japanese working adult population seems to be at-risk population considered in this international context, patterns of sedentary behavior in Japanese workers have not been examined. Since working environments (e.g. social norms, working spaces and work time) are likely to be different in Japan and other Asian countries compared with Western countries, understanding the sedentary behavior and physical activity patterns in the Japanese work environment context will be informative.

We examined accelerometer-derived patterns of sedentary behavior (total sedentary time, sedentary time accumulated in prolonged bouts, sedentary breaks and diurnal patterns of sedentary time) and physical activity among Japanese workers, based on occupational-activity types. These behaviors were characterized for four time periods: during work and non-work hours, on work days and on work and non-work days.

METHODS

Study design and procedure

This was a cross-sectional observational study, as a part of a project to investigate the associations between built environment attributes and sedentary behavior among Japanese middle-aged adults. A mail survey was conducted in Matsuyama city in Ehime prefecture (428.9 km^2; 516,000 people) from July to December 2013, and Koto Ward in Tokyo (40.2 km^2; 484,000 people) from April 2014 to February 2015. The study was approved by the Institutional Ethics Committee of Waseda University (2012-269, 2013-264).

The survey procedures were as follows: first, 3,000 potential participants aged 40-64 were extracted randomly from each basic resident register stratified by gender and age (40–49 years/ 50–59 years/ 60–64 years) for Matsuyama city and Koto Ward. Second, invitation letters were mailed to the potential participants and asked to return an enclosed from to indicate their expression of interest to participate in the study. Non-respondents were mailed an additional request to join the study two weeks after the initial invitation letter was sent. Then, those who expressed interest were mailed the informed-consent form of this study, an accelerometer, an activity diary, and a questionnaire. Those who finally agreed to participate were asked to sign the consent form, wear the accelerometer and record the activity diary for 7 days, respond to the questionnaire, and then return all of these within two weeks. Participants were guided to wear the accelerometers during waking time (put it on straight after waking up) and to remove it during sleeping (take it off just before going to bed) and during water-based activities such as bathing or swimming. In addition, participants were asked to record for every day during the period of accelerometer wear, their time getting up, putting on the accelerometer, leaving home to

travel to their workplace, starting their job, finishing their job, arriving at home, taking off the accelerometer, and going to bed. Non-respondents were sent a reminder notice up to three times, and those who completed survey were sent thank-you letter with a ¥1,000 book voucher card.

In total, 864 (14.4% of the originally-approached sample) including 437 (14.6%) from Koto Ward and 427 (14.2%) from Matsuyama city agreed to participate: 778 (13.0% of the originally-approached sample) completed the questionnaire and wore the accelerometer. Those who worked either full-time or part-time were included (n=633). Those who had missing or invalid data for occupational activity type (n=38) or insufficient accelerometer data (n=175) were excluded (numbers not mutually exclusive). The final study sample size was 443 (full- time workers: n=345; part-time workers: n= 98).

Assessment of sedentary behavior and physical activity

Participants were asked to wear a triaxial accelerometer, Active style Pro HJA-350IT (Omron Health Care Co., Ltd., Kyoto, Japan) on the left side of the waist for seven days. This accelerometer device has been reported to be valid and to accurately assess not only MVPA, but also low-intensity physical activity (including sedentary behavior), in comparison to indirect calorimetry [24, 25]. A recent comparative study of three activity monitors showed that the Active style Pro HJA-350IT underestimated total sedentary time (-25.6 min/day) and the ActiGraph GT3X overestimated it (+63.7 min/day), compared with the activePAL3 as the criterion [26]. Data were collected in one-minute epochs. In order to obtain the information of work day including work and non-work hours and non-work day, participants were also asked to record the time when wearing and removing accelerometer as well as starting and finishing a job on 7 days.

Socio-demographic data and occupational activity type

Age and gender were obtained from the basic resident register. Height, weight, educational level (university or further education; high school or less), marital status (currently married; single), employment status (full-time; part-time), occupation (professional and engineering; administrative and managerial; clerical; sales; service; security; agricultural,

forestry and fishery; transport and machine operation; manufacturing process; others) were self-reported in questionnaire. Main occupational activity type was also self-reported. Participants were asked to choose the occupational activity type that most accurately described their work from the following 4 categories: sitting, standing, walking, and physical labor. Body mass index (BMI) was calculated from self-reported height and weight. Occupations were referenced to Japanese standard classification of occupations [27].

Data management

Accelerometer data were processed using Omron health management software BI-LINK for physical activity professional edition ver1.0 and custom software [26]. Valid data for a wear day was defined as ≥10 hours/day excluding ≥60 consecutive minutes of no activity (0.9 or less metabolic equivalents; METs) with allowance for up to 2 min of some limited movement (≤1.0 METs) within these periods and ≥75% wear time of work hours for a work day [12]. Those who had four or more valid days of data including at least three work days and a non-work day were included in the analysis. The data were extracted according to the following four time periods: working-hours (from starting to finishing job on work day), non-working hours (from wearing accelerometer to starting job and from finishing job to taking off accelerometer on work day), working day (a sum of working and non-working hours), and for non-working days (from wearing to taking off accelerometer). Work-hours were obtained from the activity diary.

The five measures of sedentary behavior and physical activity were first extracted for each time segments: total sedentary time (min/day; % of wear time), sedentary time accumulated in prolonged sedentary bouts (% of wear time), number of sedentary breaks (times/sedentary hour), and LPA (% of wear time) and MVPA (% of wear time). Total sedentary time, LPA time, and MVPA time were defined as all wear time for any activity with an accelerometer-estimated intensity of ≤1.5 METs, 1.5< and <3.0 METs, and 3.0 or more METs, respectively. A sedentary bout was defined as a period of uninterrupted sedentary time [1]. Total sedentary time was calculated by a sum of uninterrupted sedentary time lasting ≥ 1 minutes. A prolonged sedentary bout was defined as a period of

uninterrupted sedentary time lasting ≥ 30 minutes [1]. Sedentary time accumulated in prolonged bouts was calculated as the sum of prolonged sedentary bouts (% of wear time). A sedentary break was defined as a non-sedentary bout in between two sedentary bouts [1]. The number of sedentary breaks was calculated by the total number of sedentary breaks divided by time spent in all sedentary behavior. For each of the time segments, daily averages of all sedentary and physically-active measures were calculated over valid work and non-work days. Daily summaries of time spent in all sedentary behavior, prolonged sedentary bouts, LPA, and MVPA for each time segments were also calculated in terms of the percentage of these intensities in worn time (% wear time). Finally, daily average values including work and non-work days of five measures in a week were then computed by weighting for 5 work days and 2 non-work days.

Statistical analysis

Full-time (n=345) and part-time (n=98) workers were separately analyzed. Comparisons of the sociodemographic characteristics and five sedentary behavior and physical activity measures among four occupational activity types were conducted using one-way ANOVA for continuous variables and chi-square test for category variables. Each of the five sedentary and physical activity measures were compared among four occupational activity types in four time periods (working hours, non-working hours, working days, non-working days) using Analysis of Covariance (ANCOVA) with Bonferroni post-hoc test, adjusting for gender, age, residential area, educational level, marital status, and BMI. For these analyses, those who had missing data for these covariates were excluded among the full-time workers (n= 4). For part-time workers, only one person was engaged in physical labor tasks and thus their data were excluded from the analyses. For describing diurnal patterns, those who had ≥6 h of work time starting morning were included (n=403). Diurnal pattern of sedentary behavior, LPA and MVPA in each hour from 06:00-06:59 to 22:00-22:59 for each occupational activity type on work day and non-work day were illustrated by line graphs. All statistical analyses were performed using STATA 13.0 (Stata Corp., College Station, TX, US) and IBM SPSS Statistics 22 software (IBM Japan Inc., Tokyo, Japan). Significant levels were $p < 0.05$.

Patients and public involvement

Patients or public were not involved in this study.

RESULTS

The characteristics of participants in full-time work are summarized in Table 1. The mean age and BMI were 50.3(SD 6.9) and 22.8 (3.2), respectively. About a half of them were men and lived in Koto Ward. The majority had completed university or higher education, were married, and worked in mainly-sitting type jobs. Those with sitting and physical labor jobs were more likely to be men than those with other two occupational activity types. Those with sitting jobs were also more likely to live in Koto Ward and completed university or further education than those in three other more active jobs.

Table 1. Basic characteristics for participants of full-time jobs (N=345)

	All participants	Occupational activity type				Group differences‡
		Sitting [a]	Standing [b]	Walking [c]	physical labor [d]	
N	345	239 (69.3)	47 (13.6)	48 (13.9)	11 (3.2)	
Age, mean (SD)	50.3(6.9)	50.1(7.0)	50.7(6.8)	50.5(6.7)	52.6(6.7)	
Women, n (%)	156 (45.2)	99 (41.4)	25 (53.2)	29 (60.4)	3 (27.3)	a,d<c
BMI, kg/m²†, mean (SD)	22.8 (3.2)	23.0(3.4)	21.9(2.4)	22.3(2.6)	25.5(4.2)	b,c<d
Residence area, n (%)						
Matsuyama city	170 (49.3)	98 (41.0)	37 (78.7)	26 (54.2)	9 (81.8)	a< b,d b<c
Koto Ward	175 (50.7)	141 (59.0)	10 (21.3)	22 (45.8)	2 (18.2)	
Education [a], n (%)						
High school or less	109 (31.6)	59 (24.8)	23 (48.9)	21 (43.8)	6 (54.5)	a<b,c,d
Greater than high school	235 (68.1)	179 (75.2)	24 (51.1)	27 (56.3)	5 (45.5)	
Marital status††, n (%)						
Single	85 (24.6)	60 (25.4)	11 (23.4)	12 (25.0)	2 (18.2)	
Married	257 (74.5)	176 (74.6)	36 (76.6)	36 (75.0)	9 (81.8)	
Occupation†††, n (%)						
Professional and engineering	71 (20.6)	39 (16.5)	13 (28.3)	18 (37.5)	1 (10.0)	
Administrative and managerial	59 (17.1)	56 (23.6)	0 (0)	2 (4.2)	1 (10.0)	
Clerical	114 (33.0)	111 (46.8)	2 (4.3)	1 (2.1)	0 (0.0)	
Sales	17 (4.9)	7 (3.0)	4 (8.7)	6 (12.5)	0 (0.0)	
Service	34 (9.9)	9 (3.8)	17 (37)	8 (16.7)	0 (0.0)	
Security	1 (0.3)	0 (0.0)	1 (2.2)	0 (0.0)	0 (0.0)	
Agricultural, forestry and fishery	4 (1.2)	0 (0.0)	1 (2.2)	3 (6.3)	0 (0.0)	
Transport and machine operation	9 (2.6)	1 (0.4)	0 (0.0)	4 (8.3)	4 (40.0)	
Manufacturing process	14 (4.1)	4 (1.7)	5 (10.9)	1 (2.1)	4 (40.0)	
Others	17 (4.9)	10 (4.2)	2 (4.3)	5 (10.4)	0 (0.0)	

†:1 missing in sitting group; ††:3 missing in sitting group; †††: 2 missing in sitting group, 1 missing in both standing group and physical labor group

‡: significant differences between 4 occupational activity types with one-way ANOVA for continuous variables; chi-square test for category variables; a= sitting, b=standing, c=walking; d=physical labor

The sedentary behavior and physical activity measures in all days, work and non-work contexts on all and occupational activity types of full-time workers are presented in Table 2. In all days, mean wearing days and hours of accelerometer were 6.8 (SD: 0.9) days and

15.3 (SD: 1.1) hours. There were no significant differences in wearing days and hours of accelerometer wear time among the four of occupational-activity types. In all days, those with sitting jobs had proportionally more total and prolonged sedentary time and less LPA and MVPA time in proportion, compared with those with other three occupational-activity types ($p<0.001$). Additionally, those with sitting jobs had more frequent breaks than those with standing and walking jobs ($p<0.001$). There were no significant differences in any of the sedentary behavior and physical activity measures among those in three physically active job types.

Regarding working hours, those with sitting jobs had significantly more total and prolonged sedentary time along with less LPA and MVPA in proportion, and less frequent breaks compared with those with three other more active jobs ($p<0.01$). The differences in sedentary time between the sitting jobs and the other jobs types on working hours were 17.7–26.4% of wear time. In addition, those with walking jobs had significantly more total sedentary time in proportion than those with physical labor jobs ($p<0.05$). Also, those with physical labor jobs had significantly more MVPA time in proportion than those with standing and walking jobs ($p<0.05$).

As a descriptive feature of non-work hours, the more active the jobs in which workers were involved, the more was their proportion of total sedentary time and the less their LPA, except for those with mostly sitting jobs. In large part, the proportions of total sedentary time and LPA in those with sitting jobs were similar to those with the jobs involving physical labor. The differences reaching statistical significance were as follow: those with standing jobs had proportionally less total sedentary time and more LPA than those with sitting jobs ($p<0.05$).

Results similar to working hours were found for the total for working days, except for the prolonged sedentary time and sedentary breaks variables; there were no significant differences between those with sitting job and physical labor. The differences in sedentary time between the sitting jobs and the other jobs types on working days were 28.5-42.0% of wear time, respectively. In addition, those with standing job had significantly more LPA time in proportion than those with walking jobs ($p<0.05$).

On non-work days, there were no significant differences apparent between the four occupational activity types.

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Table2. Comparison of sedentary behavior and physical activity among four occupational activity types in full-time workers

	All	Occupational activity type			
	Mean (SD)	Marginal mean (95% CI) [a]			
		Sitting	Standing	Walking	Physical labor
Wear time (hours)					
All day	15.3 (1.1)	15.2 (15.0-15.4)	15.3 (14.9-15.8)	15.2 (14.7-15.6)	16.0 (15.0-16.9)
Work day [a]	15.6(1.8)	15.5 (15.3-15.8)	15.8 (15.2-16.3)	15.7 (15.2-16.2)	16.6 (15.6-17.7)
Work hours [b]	9.4(1.8)	9.3 (9.1-9.5)	9.7 (9.2-10.3)	9.7 (9.2-10.2)	9.8(8.8-10.9)
Non-work hours [c]	6.2(2.3)	6.3 (6.0-6.5)	6.0 (5.4-6.6)	6.0 (5.4-6.6)	6.8 (5.5-8.1)
Non-work day [d]	14.3(2.0)	14.4 (14.1-14.7)	14.3 (13.7-14.9)	13.9 (13.3-14.4)	14.4 (13.2-15.6)
Total sedentary (%wear time)					
All day	57.5(12.7)	62.2 (61.0-63.5)	45.1 (42.2-47.9)***	49.1 (46.4-51.9) ***	43.5 (37.7-49.3) ***
Work day	56.8(15.3)	63.2 (61.8-64.5)	40.6 (37.4-43.7)***	45.5 (42.5-48.5)***	36.8 (30.4-43.2)***
Work hours	58.6(21.9)	68.5 (66.7-70.3)	34.6 (30.4-38.7)***	40.0 (36.0-44.0)***	26.5 (18.1-34.9)***, ‡
Non-work hours	53.3(11.9)	54.0 (52.4-55.4)	49.8 (46.3-53.3)*	52.5 (49.2-55.9)	56.5 (49.4-63.6)
Non-work day	59.1(13.8)	59.8 (58.1-61.6)	56.3 (52.3-60.4)	58.2 (54.3-62.1)	60.3 (52.0-68.5)
Prolonged sedentary bouts (% wear time)					
All day	19.1(11.0)	22.1(20.8-23.4)	14.8(11.8-17.7)***	15.4(12.6-18.3)***	15.5(9.4-21.5)
Work day	18.2(12.5)	21.0 (19.5-22.4)	11.7 (8.4-15.0)***	12.4 (9.2-15.5)***	12.0 (5.3-18.7)
Work hours	18.6(18.2)	23.1 (21.1-25.2)	8.5 (3.8-13.2)***	9.0 (4.4-13.5)***	7.0 (-2.5-16.6)**
Non-work hours	16.7(11.1)	16.6 (15.2-18.0)	16.2 (13.0-19.5)	16.5 (13.4-19.7)	20.5 (13.9-27.0)
Non-work day	24.1(15.1)	24.8 (22.9-26.8)	22.3 (17.9-26.7)	23.1 (18.8-27.4)	24.1 (15.2-33.1)
Breaks per sedentary hour					
All day	9.4(3.1)	8.7 (8.4-9.1)	11.6 (10.8-12.4)***	10.8 (10.1-11.6)***	10.3 (8.7-11.9)
Work day	9.8(3.6)	8.8 (8.4-9.1)	12.7 (11.8-13.6)***	11.7 (10.8-12.6)***	10.9 (9.1-12.7)
Work hours	10.8(5.7)	8.8 (8.2-9.4)	16.2 (14.9-17.5)***	14.7 (13.4-16.0)***	13.3 (10.6-16.0)**
Non-work hours	10.0(3.7)	10.0 (9.5-10.5)	10.5 (9.4-11.6)	10.0 (8.9-11.0)	9.7 (7.4-11.9)
Non-work day	8.6(3.7)	8.6 (8.1-9.0)	8.9 (7.6-10.0)	8.7 (7.6-9.7)	8.8 (6.5-11.0)
LPA (%wear time)					
All day	34.8(11.0)	31.3 (30.2-32.3)	44.5 (42.1-47.0)***	40.8 (38.4-43.1)***	44.3 (39.3-49.2)***
Work day	35.1(13.1)	30.3 (29.1-31.5)	48.1 (45.4-50.8)***	42.9 (40.3-45.6)***, †	48.2 (42.6-53.7)***
Work hours	34.6(17.7)	27.4 (25.9-29.0)	53.3 (49.7-56.9)***	47.1 (43.6-50.6)***	54.9 (47.6-62.1)***
Non-work hours	36.2(11.3)	35.3 (33.9-36.6)	40.4 (37.3-43.5)*	37.7 (34.7-40.7)	34.7 (28.4-41.0)
Non-work day	34.2(11.9)	33.7 (32.2-35.2)	35.6 (32.2-39.1)	35.3 (32.0-38.6)	34.6 (27.6-41.5)
MVPA (%wear time)					
All day	7.7(4.5)	6.5 (6.0-7.1)	10.4 (9.1-11.6)***	10.1 (8.9-11.3)***	12.2 (9.7-14.7)***
Work day	8.2(5.4)	6.5 (5.9-7.2)	11.3 (9.9-12.8)***	11.5 (10.2-12.9)***	15.0 (12.1-17.9)***
Work hours	6.8(7.5)	4.1 (3.3-4.9)	12.2 (10.3-14.0)***	12.9 (11.1-14.6)***	18.6 (14.9-22.4)***, †, ‡
Non-work hours	10.5(6.8)	10.8 (10.0-11.6)	9.8 (8.0-11.6)	9.8 (8.0-11.6)	8.8 (5.1-12.5)
Non-work day	6.7(4.6)	6.5 (5.9-7.1)	8.0 (6.6-9.3)	6.5 (5.2-7.8)	5.2 (2.4-7.9)

[a] Marginal mean and 95% CI from ANCOVA adjusted for covariates including gender, age, BMI, residence area, educational level, marital status.

Asterisks indicate significant difference from the sitting: *p < 0.05, **p < 0.01, *** <.001
Dagger indicates significant difference from the standing: †p < 0.05
Double dagger indicates significant difference from the walking: ‡p < 0.05

Hourly patterns of sedentary behavior, LPA and MVPA on four occupational activity types are summarized in Figure 1 for full time workers. Overall, sedentary time and LPA showed an inverse pattern. On work days, a notable difference was observed in the pattern of sedentary behavior during work hours between those with the sitting jobs and the other three types, while all occupational activity types showed a similar pattern after work, with a linear increase in the sedentary fraction until 22:00-22:59. Those with standing, walking and physical labor jobs constantly accounted for a larger fraction of LPA than that of sedentary behavior from 6:00-6:59 throughout almost of all working hours. On non-work days, sedentary behavior in all occupational activity types was mostly dominant from 7:00-7:59 to 18:00-18:59. However, the time differences between sedentary behavior and LPA in those with sitting jobs stayed more constant and larger than those in other more active jobs from 7:00-7:59 to 18:00-18:59. After 18:00-18:59 on non-work day, all types showed increase in sedentary time as the same with work days. All results of the part-time workers were presented in Table S1,2 and Figure S1.

INSERT FIGURE 1 ABOUT HERE

DISCUSSION

This is the first study to examine accelerometer-measured patterns of sedentary behaviors and physical activity among Japanese workers in their work and non-work contexts, and to examine how these patterns differed by occupational activity type. Among full-time workers, sedentary time comprised more than half of the working day. Overall, those with sitting jobs, who accounted for 70% of this study sample, had higher amount of both total and prolonged sedentary time and less frequent breaks from sitting across the whole day, compared with those in more physically active job types. Previous studies in Western countries have examined the differences in objectively-measured total sedentary behavior among 2-19 occupation groups or sectors [18, 19] and self-reported leisure and domain-specific sedentary behaviors among occupational activity types [9, 20]. The present study extends these findings, for the first time in a non-Western country, by examining the differences in additional sedentary behavior measures such as prolonged sedentary behavior and breaks using objective measurements. The present findings suggest that further public health efforts focused on the worksite should be emphasized, especially for office-workers who are a majority of the working adult population in Japan and are an

apparent at-risk subgroup due to high volumes of sitting, not only at work but also in non-work time.

Among those with sitting jobs of this study sample, 63% of working day (60% of non-work day) were sedentary. Some previous studies conducted in Australia and the UK found that sedentary behavior assessed by Actigraph were 68-70% of working day of office workers (60-63% of non-work day)[12, 14]. Our recent comparative study of activity devices found that total sedentary time assessed by the Active style Pro HJA-350IT were proportionally 11% less time spent in total sedentary behavior than Actigraph [26]. These findings suggest that Japanese office-workers may spend more time in sedentary behavior across whole day compared with those in Western countries, which is similar to the previous international-comparative study examining self-reported sitting time of working adult population [23]. As an at-risk population considered in the international context, promoting effective public health strategies to reduce sedentary behavior on the worksite may be a necessary effort in Japan.

We found significant differences in overall sedentary time and number of breaks from sedentary time in work hours across the occupational activity types that we examined, especially for working hours. Full-time workers with sitting jobs spent most sedentary time and had less breaks from sedentary behavior than those with more active job types: these differences were approximately 20-30% in the proportion (2.5-4 hours) and 5-7 times per sedentary hours. On the other hand, these patterns on non-working hours or days were relatively similar although workers with sitting and physical labor jobs somewhat spent more sedentary along with in less LPA than those with standing and walking jobs. These findings may indicate that the occupational activity type, which is commonly determined by job requirements can have the greatest impact on overall sedentary time and patterns in workers' population. These findings are consistent with the only previous study from the Netherlands, which found all white-collar workers from financial service providers and research institutes had significantly greater occupational (30-35%) and total sitting time (10-15%) in proportion than all blue-color workers of construction company [17]. In addition, these findings supported those of previous studies in Australia, France, Scotland,

and the Netherlands, which showed that workers with higher occupational sitting time did not sit less, rather sat more, on their leisure time [9, 18, 19, 28]. Similar to studies conducted in Western countries, the present findings suggest that further promotion of worksite interventions to reduce office-workers' sedentary time along with increased sedentary breaks should be prioritized on working populations in not only Western countries but also in Japan.

Similar to the average patterns, the analysis of the accelerometer output by hour of the working day showed that the pattern of sedentary behavior, LPA and MVPA were highly dependent on occupational activity types during working hours (except for lunch time), whereas all were similar on the evening time after work. The descriptive features were observed on non-working day, especially during the daytime, across occupational activity types. Even though the average sedentary and activity patterns were not distinct among them, some dips in sedentary behavior along with increases in LPA were found in those with standing, walking, and physical labor jobs, whereas the conditions in which sedentary behavior is the most dominant stayed constant throughout a day in those with sitting jobs on non-working day. The pattern of MVPA was stable and independent from those of sedentary behavior and LPA in all occupational activity types. The variations in pattern of sedentary behavior and LPA among occupational activity types could be partly attributed to differences in socio-demographic attributes (especially gender) and sample size. However, in a previous study from the UK examining the diurnal patterns of sedentary behavior and physical activity among office workers grouped into tertiles based on occupational sedentary time, the higher the tertile for occupational sedentary time in which office workers were categorized, the more pronounced and stable the difference between sedentary behavior and LPA (less crossing and reversing time points in a graph between them) became throughout a non-working day [14]. These results imply that routine diurnal occupational sedentary and LPA patterns, which were repeated 5 days a week, on working day may carry over their leisure-time behavioral patterns as a habit. Similarly, the previous study in French working adults using a self-report questionnaire found that the occupational activity levels involved in jobs were negatively associated with leisure time spent sedentary, on both working and non-working days [20]. Future intervention studies could help to clarify

whether promoting breaks from sedentary time by more LPA during working hours may influence leisure-time sedentary behavior and physical activity. The hourly patterns for LPA and MVPA would also be useful to consider in relation to the timing of workplace physical activity interventions, which is fruitful as a future research topic.

This is the first study to report descriptive patterns of objectively measured Japanese workers' sedentary behavior comprehensively, and their relationships with occupational activity types. Other strengths of this study were use of population-recruited sample and accelerometer -assessed sedentary behavior and physical activity. There are also some limitations in this study. First, data were cross-sectional and therefore any causality cannot be inferred. Second, the present samples were selected from only two cities in Japan although central and average-sized local cities were chosen. Thus, the results may differ in other cities and areas. Third, the response rate was relatively low. Our middle-aged participants were recruited initially by random sampling, which may have introduced some sampling bias; only 10 were recruited whose jobs involved physical labor. Therefore, the findings may not be generalizable to the broader middle-aged worker population, in particular to those whose jobs involve physical labor. In other words, the relatively small sample size for those with physical-labor job types limits our capacity to generalize from those findings. Finally, accelerometers were unable to accurately differentiate sitting and very-static standing postures, and they cannot detect some types of physical activity such as cycling and water activity.

CONCLUSION

In summary, full-time workers involved in mostly sitting jobs had a higher volume of sedentary behavior with prolonged bouts on workdays, compared with other occupational-activity job types. The differences in sedentary patterns mainly occurred during work hours. There may be carry-over of sedentary and physical activity patters in working time, which could influence leisure time and whole of day time spent sedentary, with potential for adverse health consequences. Therefore, intervention for to reduce workers' sedentary behaviors are needed, especially for those in office-based workplace where prolonged periods of sitting are required.

AUTHORS' CONTRIBUTION

Kurita and Shibata conceived the study, analyzed the data, and drafted the manuscript. Koohsari and Owen assisted with analyzing data and drafting the manuscript. Ishii and Oka were involved in the development and implementation of this study. All authors contributed to the study design, interpretation of the results, and manuscript preparation. All authors have read and approved the final manuscript.

FUNDING

Koohsari was supported by a JSPS Postdoctoral Fellowship for Research in Japan (#17716) from the Japan Society for the Promotion of Science. Owen was supported by a National Health and Medical Research Council of Australia Senior Principal Research Fellowship and Program Grant, and by an Australian Academy of Sciences/Japan Society for the Promotion of Science Visiting Fellowship to Waseda University. Oka was supported by a Grant-in-Aid for Scientific Research (No. 26242070) from the Japan Society for the Promotion of Science, MEXT-Supported Program for the Strategic Research Foundation at Private Universities (S1511017).

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA SHARING STATEMENT

Requests for access to data should be addressed to the corresponding author.

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Figure1. Hourly pattern of sedentary behavior, LPA and MVPA of four task types among full-time workers

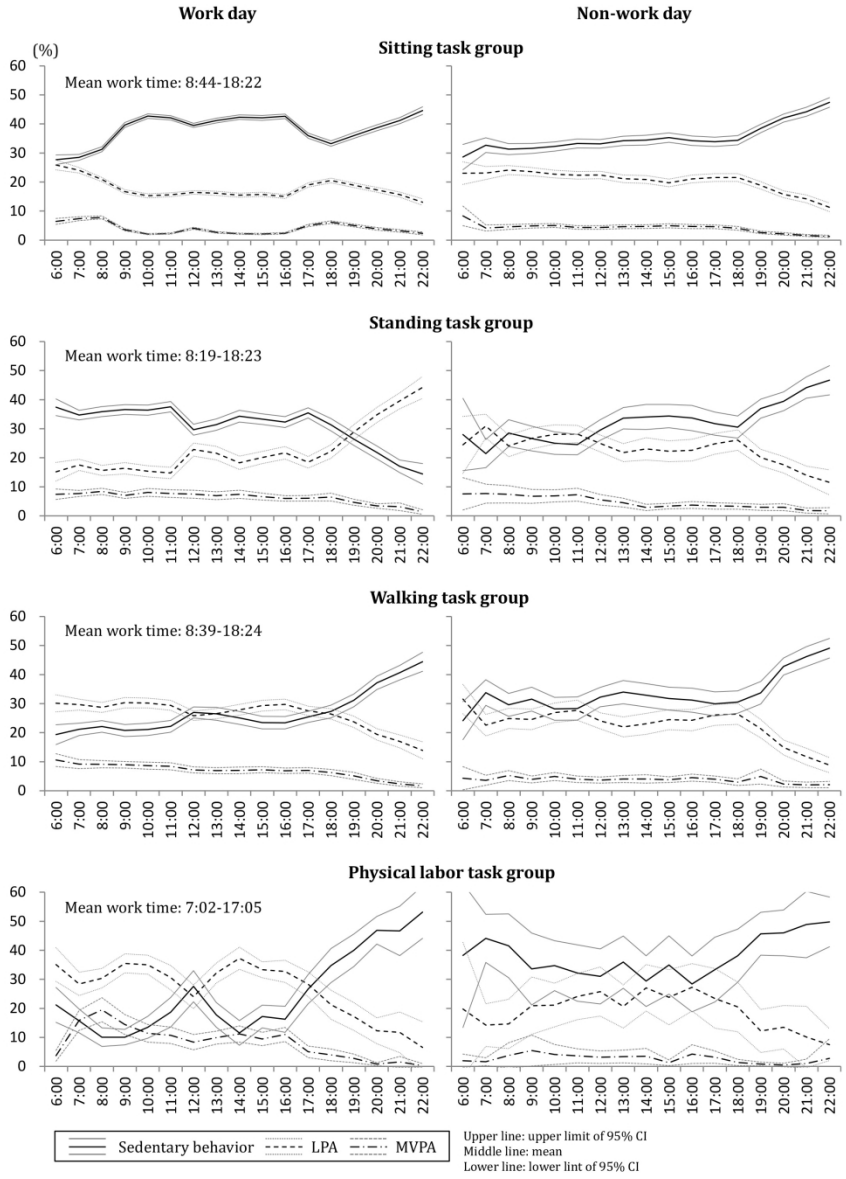

Figure 1. Hourly pattern of sedentary behavior, LPA and MVPA of four task types among full-time workers

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Table S1. Basic characteristics for participants of part-time workers

	All participants	Occupational task group		
		Sitting	Standing	Walking
n	98	35 (35.7)	35 (35.7)	27 (27.6)
Age, mean(SD)	51.1(7.3)	50.4 (6.8)	52.7(8.0)	49.9(6.8)
Women, n (%)	94 (95.9)	34 (97.1)	33 (94.3)	26 (96.3)
BMI (kg/m^2)[a], mean(SD)	21.1(2.2)	21.2 (2.3)	20.9(2.1)	21.3(2.2)
Residence area, n (%)				
Matsuyama city	44 (44.9)	15 (42.9)	23 (65.7)	16 (59.3)
Koto Ward	54 (55.1)	20 (57.1)	12 (34.3)	11 (40.7)
Education, n (%)				
High school or less	44 (44.9)	11 (31.4)	22 (62.9)	11 (40.7)
Greater than high school	54 (55.1)	24 (68.6)	13 (37.1)	16 (59.3)
Marital status[b], n (%)				
Single	12 (12.2)	4 (11.4)	4 (11.4)	4 (15.4)
Married	85 (86.7)	31 (88.6)	31 (88.6)	22 (84.6)
Occupation[c], n (%)				
Professional and engineering	17 (17.5)	6 (17.6)	4 (11.4)	7 (25.9)
Administrative and managerial	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Clerical	23 (23.7)	21 (61.8)	2 (5.7)	0 (0.0)
Sales	7 (7.2)	1 (2.9)	5 (14.3)	1 (3.7)
Service	33 (34)	3 (8.8)	18 (51.4)	11 (40.7)
Security	1 (1.0)	0 (0.0)	1 (2.9)	0 (0.0)
Agricultural, forestry and fishery	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Transport and machine operation	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Manufacturing process	5 (5.2)	1 (2.9)	3 (8.6)	1 (3.7)
Others	10 (10.3)	1 (2.9)	2 (5.7)	7 (25.9)

a 1 missing in standing task group
b 1 missing in walking task group
c 1 missing in sitting task group

Table S2 Comparison of sedentary behavior and physical activity among three occupational activity types in part-time workers

	All	Occupational activity types		
		Sitting	Standing	Walking
	Mean (SD)			
Wear time (hours)				
All days	15.7(1.44)	15.7(1.4)	15.5(1.5)	16.1(1.5)
Work day	16.0(1.6)	15.9(1.7)	15.8(1.6)	16.3(1.7)
Work hours	6.2(2.4)	6.4(2.2)	5.9(2.5)	6.5(2.5)
Non-work hours	9.7(3.0)	9.5(2.8)	9.8(2.8)	9.9(3.7)
Non-work day	15.1(1.6)	15.0(1.2)	14.7(1.9)	15.6(1.6)
Total sedentary (%wear time)				
All days	47.6(9.8)	53.9(7.7)	44.7(10.3)	43.6(7.7)
Work day	45.1(11.3)	54.2 (7.9)	40.1 (10.9)	40.3 (8.4)
Work hours	36.6(23.4)	59.9 (12.6)	24.4 (19.4)	23.4 (14.3)
Non-work hours	49.8(9.7)	50.2 (8.9)	49.5 (10.8)	49.7 (9.9)
Non-work day	53.9(12.7)	53.1 (12.0)	56.4 (14.6)	51.8 (11.2)
Prolonged sedentary bouts (%wear time)				
All days	14.4(7.6)	15.1(8.0)	15.0(8.0)	12.7(6.4)
Work day	12.2(7.1)	14.0 (8.1)	11.4 (6.6)	10.7 (6.3)
Work hours	6.8(11.3)	12.5 (14.4)	4.3 (9.5)	2.7 (3.9)
Non-work hours	15.8(9.1)	15.4 (9.0)	15.8 (8.7)	15.8 (9.8)
Non-work day	20.0(14.3)	18.0 (13.4)	24.0 (16.4)	17.5 (12.1)
Breaks per sedentary hour				
All days	10.8(2.3)	10.1(1.9)	11.1(2.7)	11.2(2.2)
Work day	11.3(2.6)	10.3 (2.2)	12 (2.9)	11.7 (2.6)
Work hours	19.4(11.7)	11.6 (4.8)	24.3 (12.5)	23.1 (12.3)
Non-work hours	9.9(2.5)	9.7 (2.2)	10.2 (2.4)	9.9 (2.9)
Non-work day	9.5(3.7)	9.8 (3.6)	8.9 (4.4)	9.8 (3.1)
LPA (%wear time)				
All days	44.2(8.4)	39.2(6.9)	47.5(8.5)	46.3(7.2)
Work day	46.0(10.0)	38.6 (7.5)	51.5 (9.1)	48.6 (8.2)
Work hours	53.0(19.4)	35.3 (11.7)	65.4 (16.3)	59.6 (14.3)
Non-work hours	41.7(9.0)	40.4 (8.3)	42.8 (9.9)	42.1 (8.9)
Non-work day	39.7(10.2)	41 (10.4)	37.5 (11.3)	41 (8.3)
MVPA (%wear time)				
All days	8.1(3.9)	6.9(2.5)	15.6(3.4)	10.0(5.2)
Work day	8.8(4.6)	7.2 (2.8)	8.4 (3.8)	11.1 (6.1)
Work hours	10.4(11.1)	4.8 (3.2)	10.2 (7.2)	17 (16.3)
Non-work hours	8.4(4.2)	9.4 (4.4)	7.7 (4.3)	8.2 (3.8)
Non-work day	6.4(4.8)	5.9 (2.8)	6.2 (4.9)	7.2 (6.6)

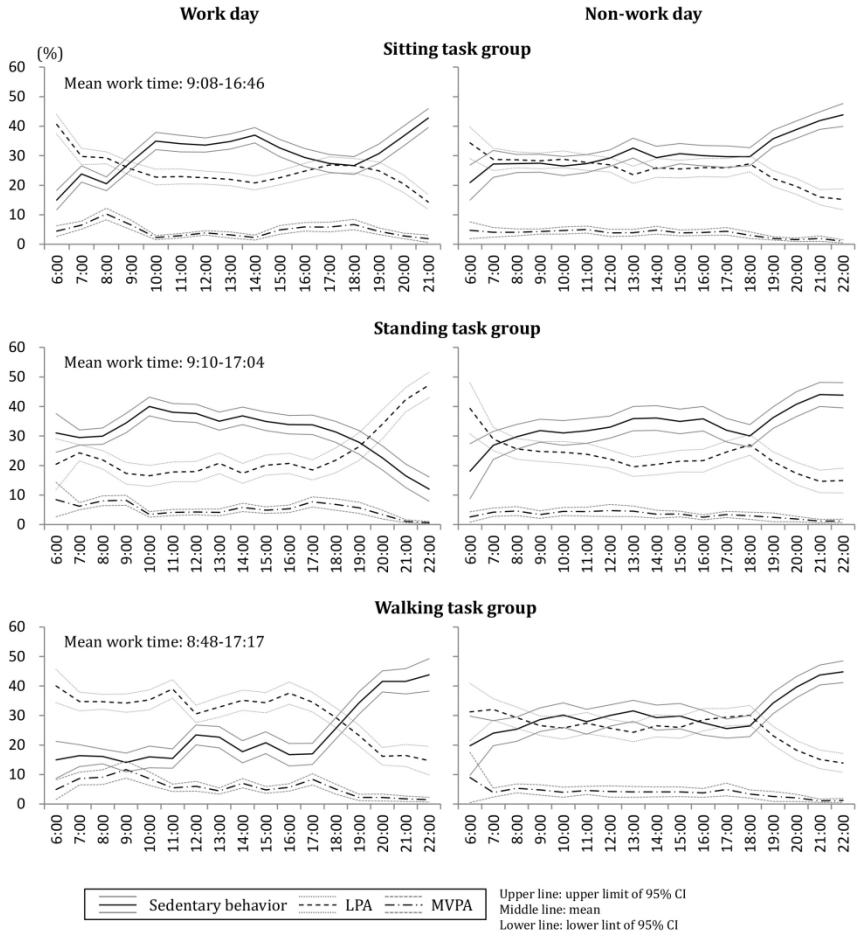

Figure S1. Hourly pattern of sedentary behavior, LPA and MVPA of three task types among part-time workers

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study design	4	Present key elements of study design early in the paper	5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-9
Bias	9	Describe any efforts to address potential sources of bias	16-18
Study size	10	Explain how the study size was arrived at	N/A
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	9
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7 8-9
		(b) Give reasons for non-participation at each stage	8-9
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	7,9
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	N/A
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	9-10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11-13
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	14
Discussion			
Key results	18	Summarise key results with reference to study objectives	14-16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17
Generalisability	21	Discuss the generalisability (external validity) of the study results	17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.