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

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## ABSTRACT

**Objectives** To examine patterns of sedentary behaviour 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-workdays. These sedentary behaviour and physical activity measures in the four time periods were examined among workers with four self-attributed occupational activity types (mainly sitting, standing, walking, and physical labour), adjusting for sociodemographic attributes. Diurnal patterns of sedentary behaviour, 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 with 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 labour occupational activity types.

## Strengths and limitations of this study

- ► This is the first study to comprehensively report descriptive patterns of workers' objectively measured sedentary behaviour 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 relatively low and not completely random, which may have resulted in some selection bias.

## INTRODUCTION

Sedentary behaviour, defined as any waking behaviour characterised by an energy expenditure ≤1.5 metabolic equivalent tasks (METs) while in a sitting or reclining posture[1] has distinctive adverse effects on human health.[2] For example, excessive sedentary behaviour 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 cardiometabolic risk biomarkers.[7] Reducing prolonged sedentary behaviour is an important public health issue.

Among the Japanese adult population, the worksite is a key setting, in which to address sedentary behaviours; because 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 behaviour (eg, overall daily time, prolonged time, breaks, and 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 reduce sedentary behaviour, as an emerging occupational health risk.

Sedentary behaviour 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 behaviour, in order to provide evidence that can inform approaches to workplace health promotion through sedentary behaviour 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 the Netherland has examined the pattern of sedentary behaviour across different types of occupations including white-collar, office-based workers, and blue-collar construction and factory workers.[17] However, there were no detailed examinations of overall diurnal patterns and the variability between workdays and non-workdays. Although another previous study conducted in Scotland compared the pattern of total sedentary behaviour 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 behaviour 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 behaviour. Objectively measured patterns of occupational sedentary behaviour have not been examined.

Although there are distinct health consequences of sedentary behaviour, 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 behaviour indicates less time spent in LPA, MVPA, or both indicating that these behaviours are linked. Thus, it may be important to examine patterns of not only sedentary behaviour, but also LPA and MVPA concurrently. A small number of previous studies has simultaneously examined sedentary and active behaviour patterns during working and leisure time.[9 12–15 17 18] However, little is known about how different the patterns or relationships between sedentary behaviours and physical activities during working and leisure time would be between those in types of occupations with different activity requirements.

Previous studies on sedentary behaviours 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 behaviour in Japanese workers have not been examined. Since working environments (eg, social norms, working spaces, worksite design, worksite neighbourhood, and work time) are likely to be different in Japan and other Asian countries compared with Western countries, understanding the sedentary behaviour and physical activity patterns in the Japanese work environment context will be informative.

This study examined accelerometer-derived patterns of sedentary behaviour (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 behaviours were characterised for four time periods: during work and non-work hours, on workdays, and on work and non-workdays.

## METHODS

### Study design and procedure

This was a cross-sectional observational study, as a part of a project to investigate the associations between social and urban design attributes and sedentary behaviour among Japanese middle-aged adults. A mail survey was conducted in Matsuyama city in Ehime prefecture (428.9 km²; 516 000 people) from July to December 2013 and Koto Ward in Tokyo (40.2 km²; 484 000 people) from April 2014 to February 2015.

The survey procedures were as follows: first, 3000 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 2 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 2 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 everyday 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 ¥1000 book voucher.

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 behaviour 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 7 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 behaviour), 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 1 min epochs. In order to obtain the information of workday including work and non-work hours and non-workday, participants were also asked to record the time when wearing and removing accelerometer as well as starting and finishing a job on 7 days.

### Sociodemographic 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), and 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 the 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 four categories: sitting, standing, walking, and physical labour. 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 V.1.0 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 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 workday.[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 workday), non-working hours (from wearing accelerometer to starting job and from finishing job to taking off accelerometer on workday), 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 behaviour 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), LPA (% of wear time), and MVPA (% of wear time). Total sedentary time, LPA, 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 min. A prolonged sedentary bout was defined as a period of uninterrupted sedentary time lasting ≥30 min.[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 behaviour. For each of the time segments, daily averages of all sedentary and physically active measures were calculated over valid work and non-workdays. Daily summaries of time spent in all sedentary behaviour, 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-workdays of five measures in a week were then computed by weighting for five workdays and two non-workdays.

### Statistical analysis

Full-time (n=345) and part-time (n=98) workers were separately analysed. Comparisons of the sociodemographic characteristics and five sedentary behaviour and physical activity measures among four occupational activity types were conducted using one-way analysis of variance for continuous variables and $X^2$ 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, and 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 labour tasks and thus their data were excluded from the analyses. For describing diurnal patterns, those who had ≥6 hour of work time starting morning were included (n=403). Diurnal pattern of sedentary behaviour, LPA and MVPA in each hour from 06:00–06:59 to 22:00–22:59 for each occupational activity type on workday and non-workday were illustrated by line graphs. All statistical analyses were performed using STATA V.13.0 and IBM SPSS Statistics V.22 software. Significant levels were p<0.05.

### Patients and public involvement

Patients or public were not involved in the design or planning of the study.

## RESULTS

The characteristics of participants in full-time work are summarised 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 labour 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.

The sedentary behaviour and physical activity measures in all days, work and non-work contexts on all and occupational activity types of full-time workers are presented

**Table 1** Basic characteristics for participants of full-time jobs (n=345)

| | | Occupational activity type | | | | |
|---|---|---|---|---|---|---|
| | All participants | Sitting [a] | Standing [b] | Walking[c] | Physical labour[d] | Group differences* |
| 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 |
| Body mass index, kg/m$^2$†, 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†, 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) | |

*Significant differences between four occupational activity types with one-way analysis of variance for continuous variables; $X^2$ test for category variables.
†One missing in sitting group.
‡Three missing in sitting group.
§Two missing in sitting group, one missing in both standing group and physical labour group.
a= sitting; b=standing, c=walking; d=physical labour.

Table 2 Comparison of sedentary behaviour and physical activity among four occupational activity types in full-time workers

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

Asterisks indicate significant difference from the sitting: *p<0.05, **p<0.01, ***p<0.001.
Dagger indicates significant difference from the standing: †p<0.05.
Double dagger indicates significant difference from the walking: ‡p<0.05.
§Marginal mean and 95% CI from analysis of covariance adjusted for covariates including gender, age, body mass index , residence area, educational level, marital status.

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 behaviour 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 labour jobs (p<0.05). Additionally, those with physical labour 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 labour. The differences reaching statistical significance were as follows: 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 labour. 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-workdays, there were no significant differences apparent between the four occupational activity types.

Hourly patterns of sedentary behaviour, LPA, and MVPA on four occupational activity types are summarised in figure 1 for full-time workers. Overall, sedentary time and LPA showed an inverse pattern. On workdays, a notable difference was observed in the pattern of sedentary behaviour 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 labour jobs constantly accounted for a larger fraction of LPA than that of sedentary behaviour from 6:00–6:59 throughout almost of all working hours. On non-workdays, sedentary behaviour in all occupational activity types was mostly dominant from 7:00–7:59 to 18:00–18:59. However, the time differences between sedentary behaviour 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-working day, all types showed increase in sedentary time as the same with workdays. All results of the part-time workers were presented in the online supplementary tables S1 and S2 and figure S1.

## DISCUSSION

This is the first study to examine accelerometer-measured patterns of sedentary behaviours 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 behaviour among occupation groups or sectors[18 19] and self-reported leisure and domain-specific sedentary behaviours 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 behaviour measures such as prolonged sedentary behaviour and breaks using objective measurements. The present findings suggest that further public health efforts focused on the worksite should be emphasised, especially for office workers who are the majority of the working adult population in Japan and an apparent at-risk subgroup due to high volumes of sitting, not only at work but also during non-work time.

Among those with sitting jobs of this study sample, 63% of working day (60% of non-workday) were sedentary. Some previous studies conducted in Australia and the UK found that sedentary behaviour assessed by Actigraph were 68%–70% of working day of office workers (60%–63% of non-workday).[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 behaviour than Actigraph.[26] These findings suggest that Japanese office workers may spend more time in sedentary behaviour 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 behaviour 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 behaviour than those with more active job

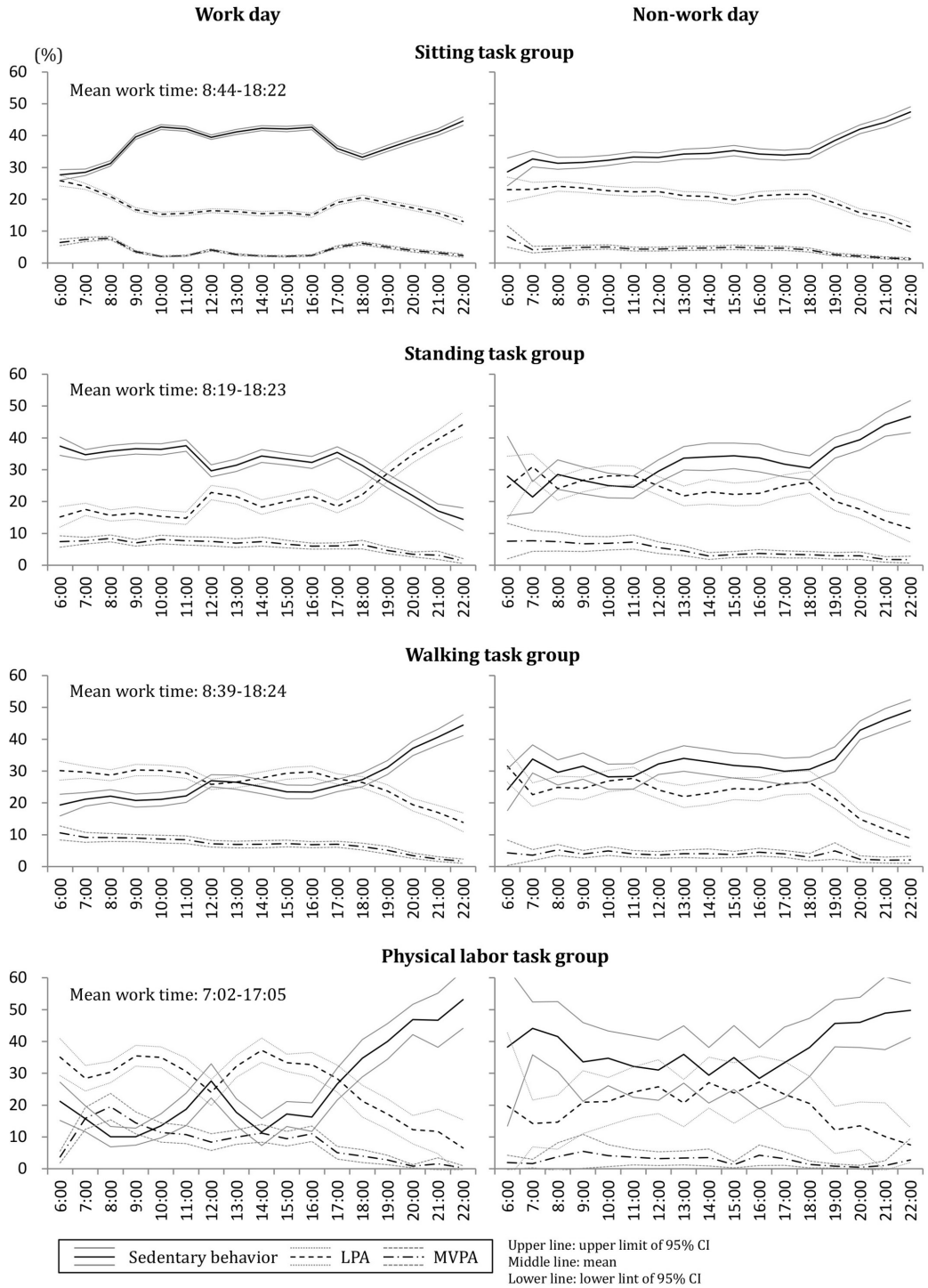


**Figure 1** Hourly pattern of sedentary behaviour, LPA, and MVPA of four task types among full-time workers. LPA, light-intensity physical activity; MVPA, moderate-to-vigorous intensity physical activity.

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 labour 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-colour 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 prioritised on working populations not only in 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 behaviour, 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 behaviour along with increases in LPA were found in those with standing, walking, and physical labour jobs, whereas the conditions in which sedentary behaviour 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 behaviour and LPA in all occupational activity types. The variations in pattern of sedentary behaviour and LPA among occupational activity types could be partly attributed to differences in sociodemographic attributes (especially gender) and sample size. However, in a previous study from the UK examining the diurnal patterns of sedentary behaviour 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 categorised, the more pronounced and stable the difference between sedentary behaviour 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 behavioural 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 behaviour 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 behaviour comprehensively and their relationships with occupational activity types. Other strengths of this study were use of population-recruited sample and accelerometer-assessed sedentary behaviour 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 initially recruited by random sampling, which may have introduced some sampling bias; only 10 were recruited whose jobs involved physical labour. Therefore, the findings may not be generalisable to the broader middle-aged worker population, in particular to those whose jobs involve physical labour. In other words, the relatively small sample size for those with physical-labour job types limits our capacity to generalise 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 behaviour 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 reducing workers' sedentary behaviours are needed, especially for those in office-based workplace where prolonged periods of sitting are required.

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