Research Article

The Correlation between Sedentary Behavior by Time Period and Physical Activity and Health Indicators among Japanese Workers

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Article Information

ABSTRACT

Objectives: In order to reduce the sedentary behavior of workers who remain seated for extended periods of time, the correlation between sedentary behavior by time period and health indicators must be investigated. Thus, the purpose of this study is to investigate the correlation between the sedentary behavior during work hours or per day and the amount of physical activity and health indicator.

Methods: Based on an objective measurement method using an accelerometer and Inbody, the correlation among sedentary behavior, amount of physical activity, body fat percentage, muscle mass, and demographic variables in the survey of 101 Japanese workers was analyzed. For the amount of physical activity, a triaxial accelerometer was used to measure light-intensity lifestyle activity [1.6–2.9 metabolic equivalents (METs)], sedentary time (≤1.5 METs), and vigorous physical activity (3 METs or above), which was evaluated every 10 seconds.

Results: The results reveal that the sedentary behavior by time period is related to gender, age, type of occupation, low-intensity physical activity, and walking time, in which low-intensity physical activity has a greater effect on the sedentary behavior than moderate-intensity or higher physical activity. Specifically, for the sedentary time during work hours, the subjects who perform more low-intensity physical activity had a shorter sedentary time than those who do not (OR = 0.41, 95 % CI = 0.17-0.97), and those who have longer walking times per day had a shorter sedentary time than those who do not (OR = 0.21,95 % CI = 0.62-0.72).

Conclusions: In order to reduce the SB of workers in the future, research on developing a strategic intervention method based on the results of this study should be conducted.

INTRODUCTION

Mechanization and automation at home and in the work environment, which is the result of economic growth, has impacted how people work and provides a wider variety of hobbies to choose from. As a result, our lives have become richer; however, such environmental changes have resulted in a lack of physical movement on a daily basis. As a result, our time spent sitting or lying down has inevitably increased. Hence, studies are being conducted in many countries on the correlation between sedentary time and health. According to one previous study, as sedentary time increases, the risk of diabetes, obesity, heart disease, and cancer, as well as the mortality rate, increases [1].

Until recently, most studies have focused on physical activity, as it is known to improve health; however, a growing number of studies now focus on reducing sedentary behavior (SB). Moreover, when compared to adults with less than 4 hours of sedentary behavior per day, the total risk of death increases by 15% for those with 8-11 hours of SB and 40% for those with more than 11 hours of SB, even if they engage in the amount of physical activity recommended by the

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WHO [2]. In addition, some studies suggest that SB is treated independently from a lack of moderate-vigorous physical activity (MVPA), the recommendations for which are found in physical activity guidelines [3,4]. Specifically, the benefits of regular MVPA would decrease if a person exhibits extensive periods of SB throughout the day.

Workers are a group of people who often experience long periods of sedentary time. Most of the workers' SB is related to work rather than leisure activities, as 60-70% of work hours are spent seated [5]. Due to the nature of work, long periods of SB cannot be easily modified. Furthermore, the correlation between SB and demographic variables varies by country [6]. Japanese workers, for example, have longer periods of sedentary time than workers in many other countries. It has been reported that SB has a negative effect on physical health and reduces the productivity of workers if their sedentary time lengthens during the work hours [7]. Therefore, it is necessary to reduce the SB of workers in Japan.

While the number of studies on SB is rising in other countries, those involving Japanese workers are few. Since the form of SB during work hours and non-work hours varies, time period and place should be taken into account. In one study on elderly individuals, for example, the diurnal pattern of SB was analyzed. The results revealed that sedentary time at night is longer than in the morning and during the day, and sedentary time increased from morning to night [8]. The examination of time periods helps researchers gain a more thorough understanding of the SB.

Most studies on SB have focused on the condition of SB per day; however, it is also important to investigate how SB influences physical activity, personal characteristics, and health outcome to implement an effective intervention plan. Furthermore, the duration of SB depends on the type of work [9], and office workers who are mostly seated have higher total mortality rates and death rates from cancer than production workers or sales workers [10].

Accordingly, the SB pattern may vary by subject based on their occupation and depending on their gender, age, and lifestyle. Extended SB during work hours poses a significant problem; thus, a study focusing on the specific time period of workers' SB must be conducted in order to develop an effective intervention method. As such, this study aims to determine the correlation between workers' SB based on time period and physical activity and one's health indicator using an objective measurement method.

METHODS

Study Participants

This cross-sectional study examined 122 full-time workers (aged 30-59: 44.0 ± 8.6) at company R in Japan. Their physical activity and SB were measured by a triaxial accelerometer, the health indicator was measured using Inbody (Inbody 470, Tokyo, Japan), and demographic variables were collected through a survey. After excluding surveys with omitted or invalid data, 101 subjects (82.8%) were selected for analysis. This study was conducted after obtaining approval from the IRB of Sendai University (Approval No. 27-6). Moreover, the purpose, benefits, disadvantages, risks, and disclosure of data associated with the measurements and analyses were explained to the subjects prior to obtaining their consent to participate.

Measurement items

BMI, body fat percentage, and muscle mass were measured using Inbody 470. To evaluate the SB and the amount of physical activity, a triaxial accelerometer (Active Style Pro HJA-750C, Omron Health Care Co., Ltd. Kyoto, Japan) was used. Specifically, the subjects were asked to wear the accelerometer on their waist for 10 working days from the time they awoke to the time they went to sleep, except when showering or swimming. This device memorizes the synthetic acceleration using a measurement range of ±6 G and a resolution of 3 mG. It is also capable of precisely measuring light-intensity activities such as SB [11,12]. In addition, a survey included questions on gender, age, occupation, marital status, and education level.

Statistical processing

For demographic variables, occupation and education were examined. Subjects were divided into two groups based on occupation, including sales workers and office workers. They were also divided into three groups based on education level, including 4-year degree or higher, 2-year degree or equivalent, and high school or less. Regarding measurements, those with a BMI of 24.0 or above were in the high group, while those with a BMI of less than 24.0 were in the low group. Men with body fat percentages of 20% or more and women with body fat percentages of 30% or more were in the high group, and all others were in the low group. Muscle mass was divided into high and low groups based on the median value.

If the accelerometer value remained at 0 for 20 minutes or longer, it was assumed that the subject was not wearing the accelerometer. For the amount of physical activity, the triaxial accelerometer measured light-intensity lifestyle activity [1.6–2.9 metabolic equivalents (METs)], sedentary time (≤1.5 METs), and vigorous physical activity (3 METs or above), which was evaluated every 10 seconds. After dividing the subjects into three groups, their walking time, active time other than walking, and the total amount of physical activity (METs-h/day) were calculated for each group. In terms of physical activity index, the subjects were divided into two groups based on the median. For SB per day, the data was extracted as the subjects wore the accelerometer for 600 minutes or more per day over four days [13]. Work hours at company R are 9:00 - 18:00; thus, the subjects' sedentary time, METs-h/day, and walking were extracted only during those hours.

Sedentary time (in minutes) per day or during work hours

Table 1. Characteristics of the participants.

Demographic and background characteristics	N	%
	101	100
Overall		
Sex		
Men	80	79.2
Women	21	20.8
Age (years)	44.0±8.6	
30-39	33	32.7
40-49	38	37.6
50-59	30	29.7
Employment status		
Office clerk	40	39.6
Sales	61	60.4
Marital status		
Unmarried	66	65.3
Married	35	34.7
Educational level		
4years of university or higher	63	62.4
2years of university or equivalent	21	20.8
High school or junior high school	17	16.8
Health indicators and PA[a] levels	**Mean**	**SD**
BMI(kg/m²)[b]	23.1	3.3
Fat percent(%)	23.4	6.1
Muscle mass(kg)	48.4	8.3
Minutes in LPA[c] per day	230.3	54.3
Minutes in MVPA[d] per day	89.4	24.3
METs-h per day[e]	6.0	2.1
METs-h during work[f]	4.1	1.5
Minutes in steps per day	9164	2868
Minutes in steps during work	6579	2029
Minutes in sedentary time per day	409	72
Percent wear time in sedentary time per day	56.1	7.2
Minutes in sedentary time during work	293	63
Percent wear time in sedentary time during work	61.0	13.1
Wear time of per day	727	86
Wear time of during work	480	-

[a]Physical activity; [b]Body mass index; [c]Light phsysical activity; [d]Moderate-to-vigorous physical activity; [e]Metabolic equivalent task-hours per day; [f]Metabolic equivalen task-hours during work.

obtained from the accelerometer were calculated against the total ratio in which the subjects were divided into high or low groups based on the median. The difference in demographic variables was analyzed using a chi-square test. The variables in the amount of physical activity and health outcome were compared using a t-test. Furthermore, in order to examine the correlation between sedentary time by time period and the physical activity or health-related factors, the sedentary time for two time periods was set as a dependent variable while other variables were set as independent variables to perform binary and multinomial logistic regression analysis by statistically controlling the effects of the variables; the odds ratio and a 95% confidence interval were also calculated. A statistical significance level of less than 5% was used for all sides, and SPSS 25.v was used.

RESULTS

The general characteristics of the subjects are shown in Table 1. Out of the 101 subjects, 79.2% were male, and the average age was 44.0 ± 8.6. Of the total, 39.6% were office workers, 65.3% were married, and 62.4% had 4-year degree or higher educational level. In terms of health indicators, the averages for BMI was 23.1 ± 3.3, body fat percentage was 23.4 ± 6.1%, and that of muscle mass was 48.4 ± 8.3kg. In terms of the amount of physical activity, low-intensity physical activity of 1.6-2.9 METs was 230.3 ± 54.3 minutes, MVPA of 3 METs or higher was 89.4 ± 24.3 minutes, METs per day was 6.0 ± 2.1, METs during work hours was 4.1 ± 1.5, steps per day were 9164 ± 2868 , steps during work hours was 6579 ± 2028, sedentary time per day was 408 ± 71 minutes, the ratio of sedentary time during the day was 56.1 ± 7.2, time spent seated while working was 292 ± 63 minutes, and the ratio of sedentary time during work hours was 61 ± 13.

The difference in SB by time period and demographic variables, body fat percentage, BMI, muscle mass, or the amount of physical activity are shown in Table 2. With respect to the ratio of sedentary time categorized based on the median and the demographic variables, one's gender, age, and occupation had a significant impact on sedentary time per day; conversely, only gender had a significant impact on sedentary time during work hours. More specifically, sedentary time for women was longer than men for both sedentary time per day and during work hours. The subjects in the older age group and office workers had a longer sedentary time than those in the younger age group and sales workers, respectively, for sedentary time per day.

Muscle mass and BMI had a significant impact on the sedentary time by time period and health indicators. The average BMI was high in the group with a shorter sedentary time during work hours, and the muscle mass was higher in the group with a shorter sedentary time per day and during work hours. Moreover, low-intensity physical activity, MVPA, and METs-h per day and during work hours demonstrated a significant difference in the amount of physical activity performed. Specifically, in the group with a shorter sedentary time per day and during work hours, the average values of low-intensity physical activity, MVPA, and METs-h per day and during work hours were higher.

Table 3 displays the results of the binary and multinomial logistic regression analysis in which the sedentary time is a dependent variable and the demographic variables, health indicators, amount of physical activity, and effects between each variables are adjusted. The results indicate that gender, age, occupation, and low-intensity physical activity had a significant correlation with the sedentary time per day. Specifically, women had a longer sedentary time per day than men (OR = 6.33, 95 % CI = 1.61-24.89), and the subjects in their 50s had a longer sedentary time per day than those in their 30s (OR = 7.70, 95% CI = 2.09-28.36). Sales workers had a significantly shorter sedentary time than officer workers (OR = 0.28, 95% CI = 0.10-0.78), while the subjects who perform more low-intensity physical activity

Table 2. Difference in sedentary behavior by time period and each variable.

Characteristics	Percent wear time in sedentary time per day[a]				Percent wear time in sedentary time during work[a]			
	Low=50 N (%)	High=51 N (%)	X^2	p-value	Low=50 N (%)	High=51 N (%)	X^2	p-value
Sex								
Men	45 (56.3)	35 (43.8)	7.003	0.013	47 (58.8)	33 (41.3)	13.156	<0.001
Women	5 (23.8)	16 (76.2)			3 (14.3)	18 (85.7)		
Age, years								
30-39	23 (69.7)	10 (30.3)	11.646	0.003	13 (39.4)	20 (60.6)	2.114	0.348
40-49	19 (50.0)	19 (50.0)			20 (52.6)	18 (47.7)		
50-59	8 (26.7)	22 (73.3)			17 (56.7)	13 (43.3)		
Employment status								
Office clerk	10 (25.0)	30 (75.0)	15.910	<0.001	15 (37.5)	25 (62.5)	3.818	0.067
Sales	40 (65.6)	21 (34.4)			35 (57.4)	26 (42.6)		
Marital status								
Unmarried	32 (48.5)	34 (51.5)	0.079	0.836	30 (45.5)	36 (57.1)	1.250	0.300
Married	18 (51.4)	17 (48.6)			20 (57.1)	15 (42.9)		
Educational level								
4 years of university or higher	35 (55.6)	28 (44.4)	3.160	0.206	33 (52.4)	30 (47.6)	1.382	0.501
2 years of university or equivalent	7 (33.3)	14 (66.7)			8 (38.1)	13 (61.9)		
High school or junior high school	8 (47.1)	9 (52.9)			9 (52.9)	8 (47.1)		
Health indicators and PA[b] levels	Low=50 Mean±SD	High=51 Mean±SD	t	p-value	Low=50 Mean±SD	High=51 Mean±SD	t	p-value
BMI(kg/m²)[c]	23.8±3.6	22.6±2.8	1.894	0.061	24.1±3.5	22.3±2.7	3.063	0.003
Fat percent(%)	22.3±6.3	24.4±5.8	-1.716	0.089	23.5±6.0	23.3±6.3	0.189	0.851
Muscle mass(kg)	51.5±7.7	45.4±7.8	3.923	0.001	50.9±7.4	45.8±8.4	3.217	0.002
Minutes in LPA[d] per day	260.7±46.8	200.4±43.7	6.691	<0.001	241.8±54.0	218.9±52.6	2.159	0.033
Minutes in MVPA[e] per day	97.1±28.6	81.8±16.3	3.306	0.001	95.5±27.9	83.4±18.6	2.571	0.012
METs-h per day[f]	6.6±2.5	5.5±1.6	2.668	0.009	6.5±2.4	5.6±1.7	2.096	0.039
METs-h during work[g]	4.5±1.7	3.7±1.1	2.807	0.006	4.4±1.6	3.7±1.3	2.364	0.040
Minutes in steps per day	9350±3388	8982±2265	0.644	0.521	9669±3003	8670±2665	1.769	0.080
Minutes in steps during work	6816±2333	6346±1669	1.165	0.247	6958±2095	6206±1909	1.887	0.062

[a]The percent wear time of sedentary time categorized based on the median; [b]Physical activity; [c]Body mass index; [d]Light phsysical activity; [e]Moderate-to-vigorous physical activity; [f]Metabolic equivalent task-hours per day; [g]Metabolic equivalen task-hours during work.

had a shorter sedentary time than those who perform less low-intensity physical (OR = 0.56, 95% CI = 0.02-0.17).

For the sedentary time during work hours, a significant correlation was observed in gender, age, low-intensity physical activity, and steps per day. Specifically, women had a longer sedentary time per day than men (OR = 6.16, 95% CI = 1.21-31.33), and men in their 40s had a longer sedentary time per day than men in their 30s (OR = 4.64, 95% CI = 1.18-18.25). The subjects who perform more low-intensity physical activity had a shorter sedentary time than those who do not (OR = 0.41, 95% CI = 0.17-0.97), and those who have longer walking times per day had a shorter sedentary time than those who do not (OR = 0.21, 95% CI = 0.62-0.72).

DISCUSSION

This study investigated how SB by time period is correlated with demographic variables, obesity, health outcome, and physical activity by objectively evaluating specific time periods during the regular work hours of Japanese workers. SB per day and during work hours had a significant correlation with gender, age, and low-intensity physical activity. For SB

per day, only the occupation, and for SB during work hours, only the walking time per day, exhibited a correlation. However, no correlation between SB and obesity was observed during any time period.

For demographic variables, the sedentary time per day and during work hours had a correlation with gender and age; however, no correlation was found with marital status and education level. Gender did not reveal a correlation in the study results; however, most women were office workers while most men were sales workers. Since women spent more time seated during work hours, the total amount of SB time per day increased for women, thus creating the difference in gender. In terms of age, the subjects in their 50s had a longer sedentary time than those in their 30s.

The subjects in their 40s had a longer sedentary time than those in their 30s during work hours, and there was a difference in SB by time period. A previous study reported that the people in the older age groups have a longer sedentary time as they generally spend a long time watching TV [6]. Among the employed individuals, the older employees primarily held managerial positions, which increased their sedentary time. In contrast, younger workers in their 30s mainly held sales positions with higher amounts of physi-

Table 3. Adjusted odds ratios for factors related to sedentary behavior by time period.

	Sedentary behavior	
	Percent wear time in sedentary time per day	Percent wear time in sedentary time during work
	OR (95%CI)	OR (95%CI)
Sex		
Women (ref: men)	6.33 (1.61-24.89)*	6.16 (1.21-31.33)*
Age group (ref: 30 years)		
40-49 years	2.32 (0.69-8.08)	4.64 (1.18-18.25)*
50-59 years	7.70 (2.09-28.36)**	3.02 (0.91-9.99)
Employment status		
Sales(ref: office clerk)	0.28 (0.10-0.78)**	0.49 (0.18-1.34)
Marital status		
Unmarried(ref: married)	1.16 (0.25-5.21)	0.38 (0.14-1.04)
Educational status(ref: ≥college graduate)		
2 years college or equivalent	0.57 (0.19-1.64)	1.08 (0.15-7.56)
<high school graduate	0.29 (0.04-2.12)	0.37 (0.03-4.93)
BMI (ref: no-obese, BMI>24)	0.40 (0.70-2.20)	0.83 (0.28-2.49)
Fat percent(ref: low)	1.91 (0.39-9.37)	0.42 (0.12-1.49)
Muscle mass (ref: low)	1.56 (0.26-9.43)	0.37 (0.16-1.17)
Minutes in LPA per day(ref: low)	0.56 (0.02-0.17)*	0.41 (0.17-0.97)*
Minutes in MVPA per day(ref: low)	0.46 (0.85-2.46)	1.89 (0.45-7.19)
METs-h per day (ref: low)	1.28 (0.15-10.70)	0.92 (0.20-4.17)
METs-h during work (ref: low)	0.37 (0.72-1.39)	0.59 (0.17-1.99)
Minutes in steps per day(ref: low)	0.33 (0.08-1.38)	0.21 (0.62-0.72)**
Minutes in steps during work (ref: low)	1.45 (0.29-7.20)	1.48 (0.32-6.83)

Abbreviation: ref, referent group; Adjusted for sex, age, employment status, marital status, and education status; **p<0.01, *p<0.05.

cal activity; thus, sedentary time increased with age. Based on the results of this study, it is necessary to reduce SB for workers in their 50s, as they had the longest sedentary time per day, and for workers in their 40s, as they had the longest sedentary time during work hours.

With respect to the correlation between sedentary time per day and occupation, many studies have reported that SB influences occupation in terms of the sedentary time during work hours and walking [6, 14]. In general, desk workers or drivers spend most of their work hours seated, and it is difficult to reduce their sedentary time. While there was a difference in the sedentary time per day among different occupations in this study, no difference was observed during work hours. When compared to office workers, sales workers had less SB not only during their work hours but also during commute and leisure time. This indicates that the type of work may influence an individual's daily lifestyle.

Moreover, the subjects' steps per day decreased as their sedentary time during work hours increased. This is so because a worker's SB is generally longer during work hours than during leisure time, as 60-70% of work hours could be spent with SB [5]. As such, 60% of the subjects in this study were sales workers, and their sedentary time was less than that of office workers; this corresponds with the findings of previous studies. Sales workers have a shorter sedentary time, as they spend most of the work hours walking. Hence, measures should be taken to reduce the SB of office workers. In some studies that examined effective intervention methods, using a work station or standing desk that can adjust the height or change the position of the workers was highly recommended for companies in which most of their office workers were seated for long periods of time.

For example, one study introduced a work station by Ergotron in order to reduce sedentary time [15]. The amount of sedentary time was reduced by two hours per day, and the effect lasted for more than three months. In addition, the HDL cholesterol level of the subjects increased. Further, in a study that used the same type of work station [16], the amount of sedentary time was reduced by one hour during work hours, and the subjects' subjective well-being in terms of back pain, neck pain, and mood also improved. Most of these studies are being conducted in other countries, but it is expected that similar studies will soon be introduced in Japan as well.

For the correlation between SB and the amount of physical activity, low-intensity physical activity was correlated with both SB per day and SB during work hours. MVPA is more closely associated with leisure activities than with work [17], and the results of this study did not exhibit a correlation between SB and MVPA.

That is, in terms of SB during work hours, low-intensity physical activities related to work were performed more during work hours than non-work hours, and the tasks performed while standing up entailed more physical activity than those done while seated. Compared to other countries, it has been reported that the workers in Japan have the longest work hours [18], sedentary time and low-intensity physical activity are related to the incidence of metabolic

syndrome [19], and most of the activities are moderate-intensity or less during daily life and work hours, which greatly contributes to burning calories throughout the day [20].

As seen in previous studies, low-intensity physical activity is more crucial in reducing SB than MVPA. In addition, it is important to recognize how to reduce SB and increase low-intensity physical activity in order to prevent lifestyle diseases. More specifically, it is recommended that sedentary time be reduced by two hours during work hours, and the amount of low-intensity physical activity (such as standing up and taking a walk) should be increased [20]. It is also emphasized that the time spent seated during work hours should be reduced by 2 - 4 hours. Thus, using a standing desk or work station is recommended. The total SB time per day and during work hours did not have any correlation with MVPA or the METs-h/d. Hence, it can be confirmed that the SB for any time period is not directly related to MVPA, unlike low-intensity physical activity such as walking, and that it functions independently. Even if MVPA is performed in order to reduce SB, the effect of reducing SB was not significant.

Moreover, no correlation between SB and health indicators was observed during any time period. Many previous studies have reported that SB is closely related to the incidence of type 2 diabetes and other health-related factors [21], but this did not correspond with the findings of this study. It can be inferred that most of the subjects in this study had an average body type with low obesity rates because the group had a high amount of physical activity with 42 METs/h on average, which is higher than 23 METs/h per week as suggested in the guidelines, when their weekday work hours were converted to a weekly basis. Furthermore, in terms of muscle mass, muscular contractions due to physical activity promote the oxidation of fat through a myokine and improve insulin sensitivity for lipolysis to prevent chronic diseases [22].

Nonetheless, SB that does not involve muscular contractions cannot create the same effect. However, the average difference in calories burned between sitting and standing is 0.15 kcal/min or 9 kcal/hr [23]; hence, the reduction in SB may contribute to burning more calories.

This study was original in that it objectively examined the workers' SB by time period and its correlation with other variables; however, there are certain limitations. The subjects of this study were selected from one company in one city in Japan. Therefore, appropriate caution should be taken with interpretation, as the results may vary in another company or city.

Moreover, the patterns of SB during work hours, commute, and leisure time were not examined separately; thus, the correlation between the pattern of SB and demographic variables or health-related factors cannot be confirmed. Additionally, the accelerometer used in this study, Active Style Pro 750C, measured the total time seated to be 6.5 minutes/day per day and 10.5 min/day less during work hours when compared to the model HJA-350IT [24]. Lastly, there are limitations in being unable to detect certain physical activities such as riding a bicycle or participating in water sports.

CONCLUSIONS

In total, 60% of the work hours involved SB for Japanese workers. The workers with the most sedentary time per day are women, those in their 50s, and those with low amounts of low-intensity physical activity such as office workers. The workers with the most sedentary time during work hours are women, those in their 40s, and those with low amount of low-intensity physical activity and walking time. There was a difference in SB by time period for occupation and walking time per day. In terms of walking time per day, the SB during work hours is influenced by the SB during commute or leisure time, and low-intensity physical activity has greater effects on SB than MVPA.

In order to reduce the SB of workers in the future, research on developing a strategic intervention method based on the results of this study should be conducted. In addition, the correlation between SB and physical activity or productivity, as well as the effect of a reduction in SB, must be further examined.

Conflicts of Interest

The authors declare no conflict of interest.

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