体力研究 BULLETIN OF THE PHYSICAL FITNESS RESEARCH INSTITUTE
No.117 pp.1～7 Apr., 2019

Association of the usage of height-adjustable desks with physical activity and sitting behavior in employees

Takashi Jindo[1)], Mitsuru Makishima[2)], Naruki Kitano[1)], Kyosuke Wakaba[1)], and Yuko Kai[1)]

SUMMARY

Installation of height-adjustable desks (HAD) are recommended to reduce sitting behaviors in the workplace. However, it is still unclear whether standing desk work using the HAD could decrease sitting time and increase physical activity (PA) during in-office working hours. This study aims to investigate the association of the usage of HADs with objectively measured sitting behaviors, or PA, among Japanese employees.

This study was conducted in Tokyo in November 2018 at a single office of an office furniture manufacturing and sales company. Participants included 90 employees that completed a self-reported questionnaire survey and wore a tri-axial accelerometer to measure PA and sitting time (ST). In the target office, electric HADs were installed on hot-desking spaces, and fixed seats which were available for all employees. Participants were divided into two groups of users or non-users of HADs based on their responses to the questionnaire. Independent t-tests were applied to examine the differences in ST and PA between HAD users and non-users for participants stratified by job type (sales work or other office work).

Among the office workers, users showed less ST and greater PA (ST: 377.4 ± 51.7, PA: 142.6 ± 51.7 min/8.67-hours) than non-users during working hours (ST: 412.0 ± 42.6, PA: 108.0 ± 42.6 min/8.67-hours), and greater non-locomotive activities (99.7 ± 45.1 min/8.67-hours) than non-users (67.1 ± 29.1 min/8.67-hours). HAD users showed fewer bouts of prolonged ST (consecutive ST for 30 minutes or longer) than non-users (1.2 ± 0.8 vs. 1.8 ± 0.6 time/8.67-hours). There were no significant differences observed between the two sales groups.

These results suggest that working in a standing position using an HAD effectively improves ST in office workers. On the other hand, using an HAD might enhance non-locomotive activities, such as standing or posture adjustments at or around the desk, but it may not enhance locomotive activities.

Key words: sit-stand desk, office environment, occupational health, locomotive activities.

Introduction

Previous studies have reported that too much sitting is associated with deterioration of physical and mental health[6,11,16)], and office workers are known to sit for more than half of their working hours[10,14)]. Therefore, improving sitting behaviors is an important issue for modern company management. As a strategy to improve sitting time (ST) at workplace, the installation of height-adjustable desks (HADs) in offices is recommended[2)]. Previous systematic review of workplace intervention strategies reported that HAD installation effectively reduced ST by around 73 minutes per 8-hour workday, and that the effectiveness of an HAD intervention on ST was greater than other educational or behavioral interventions[3)].

Limiting ST at an office by using an HAD results in an increase in time spent standing, which is considered

1) Physical Fitness Research Institute, Meiji Yasuda Life Foundation of Health and Welfare, Tokyo, Japan.
2) Workstyle Research Laboratory, Okamura Corporation, Tokyo, Japan.

to be non-locomotive physical activity (PA). Moreover, by standing more often in an office environment, employees may increase their walking activity in the office, which is also considered locomotive PA. A previous study[12] investigated the differences in self-reported duration of walking at work between three groups of monthly, weekly, and daily HAD users, and reported that daily HAD users seemed to have longer walking time (3.2 hours/week) than monthly or weekly users (2.2 to 2.3 hours/week). However, a systematic review of seven studies (one subjective and six objective activity measurement) reported that there was no significant effect of the installation of an HAD on walking time in office workers. The contradicting results of these previous studies suggest that further research on the effects of the installation of HADs on ST and PA is needed. Since locomotive activities have larger health impacts and may relate to the increased likelihood of communication between employees at workplaces than just standing, investigating whether HADs play a role in additional walking is helpful in the understanding and creation of workplace.

Most of the above sited studies were conducted in western countries. There are currently no reports on this issue with Japanese workers, who show the longest ST in the world[1]. Additionally, environment, culture, workplace atmosphere, and workstyle in Japan are different from those in their Western counterparts. Therefore, it is unclear whether standing desk work using an HAD could decrease ST and increase PA during working hours in Japanese office workers. Accordingly, the purpose of this study was to examine the differences in objectively measured ST and PA of the HAD usage of Japanese employees.

Methods

A. Participants and ethical procedure

Participants recruited for this study were employees working at the Okamura Corporation in Tokyo, which is one of the leading office furniture manufacture and sales companies in Japan. One hundred thirty-one participants out of 150 employees in a single office responded to the self-reported questionnaire and accelerometer measurements disseminated in November of 2018.

To ensure ethicality, the company researchers and the office superior explained the aim and procedure of the study to the participants using printed material given to employees. Participants were asked to read the instruction of the study, which explained the usage of personal information, how to leave the study, and that the results of the investigation would never affect company performance appraisal. Every participant provided a signed letter of informed consent. This study was approved by the Ethical Committee of Meiji Yasuda Life Foundation of Health and Welfare (Approval number: 29001).

B. Measures

1. Usage of height-adjustable desk

Electric HADs were installed on hot-desking spaces (so-called "free-address" desks) and fixed seats at the target office. Every employee in this office was permitted to use the HADs during working hours. Since all employees of the target office had transferred from other offices in January of 2018, they had access to available HADs for around 10 months.

Usage of the HADs during working hours was assessed using the following question: "On average, how long do you usually perform standing desk work using an HAD during working hours?" The participants selected their potential response from the following options: 0 min/day (never use an HAD in standing position), shorter than 10 min/day, 10 to 30 min/day, 30 to 60 min/day, and longer than 60 min/day (whereby participants were required to write their actual duration). Based on the response, participants were divided into following two groups: non-users (0 min) and users (comprised "shorter than 10 min" or longer use). Since participants who used HADs were required to respond to this question, the 21 participants who did

not respond to the question were presumed to have never used an HAD, and were subsequently coded as non-users.

2. Physical activity and sedentary behavior

PA and ST were measured using a tri-axial accelerometer, a device with a high accuracy (r = 0.88) for estimating total energy expenditure (Active Style Pro HJA-750C; Omron Healthcare Co. Ltd., Kyoto, Japan). Using correlation analysis, total energy expenditure was measured using the doubly labeled water method in the free-living condition[7]. This method can accurately classify (95.5–100% accuracy for correct discrimination) the type of PA as either locomotive (various speed walking/jogging) or non-locomotive activities (household activities such as laundry, dishwashing, moving small load, and vacuuming) using its algorism[8,9]. The output data of the device is measured in Metabolic Equivalents (METs) per minute, and each MET value has label of locomotive or non-locomotive activity. Since this study was conducted at an office environment, general walking was defined as the locomotive activity, and possible other body movements at work (e.g. standing work, sit-stand movements, and moving small loads) were defined as non-locomotive activities.

Participants were instructed to wear the tri-axial accelerometer for a period of 2 weeks on their waist during all waking hours, except while swimming or bathing. Non-wear time was defined as an interval of at least 20 consecutive minutes of no detectable intensity of the accelerometer, and a valid day was defined as a day that the participants had 10 hours or more wear-time per day[5]. The data from participants who had four or more valid days per work week were treated as valid data[15]. Of the valid data, activity recorded during the standard working hours (8:40-17:20) in the company on weekdays were used. Variables of the ST (≦ 1.5 METs) and PA (≧ 1.6 METs) were included in the analysis, and these variables converted into units of min/8.67-hours per workday using the following formula; min/8.67-hours = observed duration / wearing time * standard working hours (8.67-hours). Total PA was analyzed separately by locomotive and non-locomotive activities. Moreover, bouts of prolonged ST, which was defined as consecutive ST for 30 minutes or longer, were included in the analysis.

3. Demographic variables

Age, gender, body mass index (BMI), body pain, and job type (sales, sales support, design, research, and office clerk) were investigated as demographic variables. Body pain was evaluated using a 10-point Likert scale for each the neck, shoulder, back, and knee. BMI was calculated using self-reported height and weight of each participant. Type of desk ownership (hot-desking or fixed-seat) was documented for analysis.

C. Statistical analysis

Participants with missing questionnaire data (n = 24) or who did not have valid accelerometer data (n = 17) were excluded from the analysis. Thus, data of 90 participants were used in the final analysis.

Statistical analysis was stratified by participant job type (sales or other office work), because work style or working activity is different among job types. The results of descriptive statistics were shown using mean ± standard deviation for the proportional and interval variables, and with numbers and percentages for nominal variables. Independent t-test, chi-square test, and Fisher's Exact Test were adopted to compare the differences in PA, ST, and demographic variables between the two groups of HAD usage (non-users vs. users). IBM SPSS Statistics 24 for windows was used for the analysis, and the level of statistical significance was set at $P < 0.05$.

Results

Table 1 presents participant demographics, job type, and desk type in each HAD usage group of office workers and sales workers. In the office worker group, a significant difference was found in desk type

between the HAD user groups, in that HAD user desk types were evenly mixed (hot-desking versus fixed-seat), but most non-users (95%) owned hot-desks. No significant difference was found between sales workers and groups of usage, and every worker in each usage group used hot-desking.

Table 2 showed the differences in PA and ST between the groups of HAD usage within job type. It

Table 1. Participants' characteristics by height-adjustable desk usages.

Variables	Office workers			Sales workers		
	Non-users (n = 20)	Users (n = 19)	*P*-value	Non-users (n = 14)	Users (n = 37)	*P*-value
Age, mean ± SD	40.3 ± 10.6	40.8 ± 13.2	0.899	44.7 ± 11.4	42.3 ± 11.1	0.498
Gender, n (%)						
Male	11 (55.0)	9 (47.4)	0.752	13 (92.9)	35 (94.6)	1.000
Female	9 (45.0)	10 (52.6)		1 (7.1)	2 (5.4)	
Body mass index, mean ± SD	22.7 ± 4.1	22.2 ± 3.6	0.741	22.4 ± 1.7	23.3 ± 2.7	0.271
Body pain, mean ± SD						
Neck and shoulder	4.8 ± 2.9	4.5 ± 2.7	0.805	3.4 ± 2.5	3.8 ± 2.7	0.569
Back	3.6 ± 3.0	4.1 ± 2.3	0.605	2.8 ± 2.4	3.5 ± 2.5	0.350
Knee	1.7 ± 2.7	1.0 ± 1.6	0.367	2.1 ± 2.0	2.5 ± 2.7	0.653
Job type						
Sales	NA			14 (100.0)	37 (100.0)	–
Sales support	8 (40.0)	3 (15.8)	0.002	NA		
Design	0 (0.0)	9 (47.4)				
Research	6 (30.0)	6 (31.6)				
Office clerk	6 (30.0)	1 (5.3)				
Desk ownership, n (%)						
Fixed-seat	1 (5.0)	10 (52.6)	0.001	0 (0.0)	0 (0.0)	–
Hot-desking	19 (95.0)	9 (47.4)		14 (100.0)	37 (100.0)	
Duration of standing desk work by using HAD, n (%)						
Shorter than 10 min/day	NA	6 (31.6)	–	NA	11 (29.7)	–
10 to 30 min/day		2 (10.5)			18 (48.6)	
30 to 60 min/day		5 (26.3)			5 (13.5)	
Longer than 60 min/day		6 (31.6)			3 (8.1)	

SD; standard deviation, NA; not applicable, HAD; height-adjustable desk.

Table 2. Differences in PA and ST between the usages of height-adjustable desk.

Variables	Office workers			Sales workers		
	Non-users (n = 20)	Users (n = 19)	*P*-value	Non-users (n = 14)	Users (n = 37)	*P*-value
Sitting time, min/8.67-hours	412.0 ± 42.6	377.4 ± 51.7	0.028	347.0 ± 42.3	346.2 ± 35.6	0.943
Physical activity, min/8.67-hours	108.0 ± 42.6	142.6 ± 51.7	0.028	173.0 ± 42.3	173.8 ± 35.6	0.943
Locomotive physical activity, min/8.67-hours	41.0 ± 17.9	42.9 ± 21.3	0.759	81.6 ± 29.8	77.4 ± 18.8	0.551
Non-locomotive physical activity, min/8.67-hours	67.1 ± 29.1	99.7 ± 45.1	0.010	91.4 ± 28.2	96.4 ± 29.2	0.581
Frequency of prolonged sitting time, time/8.67-hours	1.8 ± 0.6	1.2 ± 0.8	0.008	1.1 ± 0.6	1.2 ± 0.7	0.721

Prolonged sitting time was defined as sitting time consecutive for 30 minutes or longer.

was found that office workers had significantly different ST and PA time between the users and non-users, with the exception of locomotive PA during working hours. Specifically, the ST in non-users (412.0 ± 42.6 min/8.67-hours) was significantly longer than that of users (377.4 ± 51.7 min/8.67-hours). PA in total and non-locomotive activities were significantly different between the groups of HAD usage, in that users showed greater total PA (142.6 ± 51.7 min/8.67-hours) and non-locomotive PA (99.7 ± 45.1 min/8.67-hours) than non-users (PA: 108.0 ± 42.6, non-locomotive PA: 67.1 ± 29.1 min/8.67-hours). Users showed significantly smaller bouts of prolonged ST (1.2 ± 0.8 time/8.67-hours) than non-users (1.8 ± 0.6 time/8.67-hours). No significant difference was found between sales workers and the usage groups in either variable.

Discussion

This is the first study to examine the difference in objectively measured ST and PA through the use of HADs in Japanese employees. The results of this study indicate that the office workers using HADs showed less ST as well as less prolonged ST during working-hours. In addition, greater non-locomotive PA were found in HAD users over locomotive PA in office workers. Since previous studies only provide data from Western countries, the knowledge gained from the scope of this study was beneficial for Japanese companies.

Differences in ST and PA between the groups of non-users and users in office workers was 34.6 min/working hours in this study. This difference was accounted for by the difference in non-locomotive activity between the groups. These findings suggested that HAD users changed their position from sitting to standing more frequently than non-users during working hours. These changes in ST and non-locomotive PA, however, did not have a significant effect on locomotive PA during working hours. It was speculated that if standing posture increased in response to HAD usage, locomotive PA, such as walking in the office, would increase. This is because it is easier for a worker to move out of a standing position rather than a seated position in order to communicate with coworkers around the office.

The findings of this study suggest that introduction of HADs to offices is not enough to promote locomotive PA during working hours. Therefore, other strategies to increase locomotive activities at work appear to be necessary. For example, providing information about the benefits of enhanced PA over the replacement of ST to standing work, setting step count goal during working hours, and arranging the layout of HADs to create walkable offices may be effective.

Moreover, the frequency of prolonged ST was fewer in the HAD user group than in the non-users. This finding seemed to be important effect of using HADs, because prolonged ST for 30 minutes or longer is a reported risk factor for future health deterioration[4]. These results support prior knowledge from a systematic review[13], and suggested that introducing of HADs to offices promotes future well-being by reducing prolonged ST.

On the other hand, PA and ST showed no difference in sales workers between HAD usage. The reason for this might be that the duration of standing desk work was shorter than that of office workers, and that they might be active both inside and outside the office regardless of HAD usage. It is suggested that HAD usability is different for every job type, and we should consider how we can utilize HAD in a practical setting by taking into account the appropriate postures (i.e. sitting, standing, or walking) for various job tasks.

This study has several limitations. First, the assessments of HAD usage were conducted using self-reported questionnaire, which was not examined for its reliability and validity. Therefore, it is not clear whether the self-reported data of HAD usage was exact. In this study, however, the data of HAD usage was only used to divide the participants into users and non-users

based on the duration of HAD usage. With this in mind, a potential error of group classification appears small. Second, multivariate analysis was not used to examine the difference in ST or PA between the groups of HAD usage due to a small sample size. Thus, demographic variables and other confounders should be included in analysis for adjustment. There were, however, no significant differences in demographic variables and the two groups of HAD usage in this study. The results of this study seemed to exhibit the relationships between HAD usage and ST or PA during working hours. Third, since this study was conducted at a single office of a single company, one should be careful not to generalize the findings in this study.

Conclusions

Overall, standing desk work using HADs correlated with less ST, greater PA, and fewer prolonged ST during working hours in office workers. Using HADs in offices would increase the PA of non-locomotive activities, such as standing desk work or sit-stand movements, but it would not increase locomotive activities.

Conflicts of interest statement

The authors declare that there are no conflicts of interest.

References

1) Bauman, A., Ainsworth, B.E., Sallis, J.F., Hagstromer, M., Craig, C.L., Bull, F.C., Pratt, M., Venugopal, K., Chau, J., Sjostrom, M., and Group, I.P.S.(2011): The descriptive epidemiology of sitting. A 20-country comparison using the International Physical Activity Questionnaire(IPAQ). Am. J. Prev. Med., **41**, 228－235.

2) Buckley, J.P., Hedge, A., Yates, T., Copeland, R.J., Loosemore, M., Hamer, M., Bradley, G., and Dunstan, D.W.(2015): The sedentary office: an expert statement on the growing case for change towards better health and productivity. Br. J. Sports Med., **49**, 1357－1362.

3) Chu, A.H.Y., Ng, S.H.X., Tan, C.S., Win, A.M., Koh, D., and Müller-Riemenschneider, F.(2016): A systematic review and meta-analysis of workplace intervention strategies to reduce sedentary time in white-collar workers. Obes. Rev., **17**, 467－481.

4) Honda, T., Chen, S., Yonemoto, K., Kishimoto, H., Chen, T., Narazaki, K., Haeuchi, Y., and Kumagai, S.(2016): Sedentary bout durations and metabolic syndrome among working adults: a prospective cohort study. BMC Public Health, **16**, 888.

5) Masse, L.C., Fuemmeler, B.F., Anderson, C.B., Matthews, C.E., Trost, S.G., Catellier, D.J., and Treuth, M.(2005): Accelerometer data reduction: a comparison of four reduction algorithms on select outcome variables. Med. Sci. Sports Exerc., **37**, S544－ S554.

6) Munir, F., Houdmont, J., Clemes, S., Wilson, K., Kerr, R., and Addley, K.(2015): Work engagement and its association with occupational sitting time: results from the Stormont study. BMC Public Health, **15**, 30.

7) Murakami, H., Kawakami, R., Nakae, S., Nakata, Y., Ishikawa-Takata, K., Tanaka, S., and Miyachi, M.(2016): Accuracy of wearable devices for estimating total energy expenditure: comparison with metabolic chamber and doubly labeled water method. JAMA Intern. Med., **176**, 702－703.

8) Ohkawara, K., Oshima, Y., Hikihara, Y., Ishikawa-Takata, K., Tabata, I., and Tanaka, S.(2011): Real-time estimation of daily physical activity intensity by a triaxial accelerometer and a gravity-removal classification algorithm. Br. J. Nutr., **105**, 1681－1691.

9) Oshima, Y., Kawaguchi, K., Tanaka, S., Ohkawara, K., Hikihara, Y., Ishikawa-Takata, K., and Tabata, I.(2010): Classifying household and locomotive activities using a triaxial accelerometer. Gait Posture, **31**, 370－374.

10) Parry, S. and Straker, L.J.B.P.H.(2013): The contribution of office work to sedentary behaviour associated risk. BMC Public Health, **13**, 296.

11) Patterson, R., McNamara, E., Tainio, M., de Sá, T.H., Smith, A.D., Sharp, S.J., Edwards, P., Woodcock, J., Brage, S., and Wijndaele, K.(2018): Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis. Eur. J. Epidemiol., **33**, 811－829.

12) Renaud, L., Huysmans, M., van der Ploeg, H., Speklé, E., and van der Beek, A.(2018): Long-term access to sit-stand workstations in a large office population: user profiles reveal differences in sitting time and perceptions. Int. J. Environ. Res. Public Health, **15**, 2019.

13) Shrestha, N., Kukkonen-Harjula, K.T., Verbeek, J.H., Ijaz, S., Hermans, V., and Pedisic, Z.(2018): Workplace interventions for reducing sitting at work. Cochrane Database Syst. Rev., **6**, CD010912.

14） Thorp, A.A., Healy, G.N., Winkler, E., Clark, B.K., Gardiner, P.A., Owen, N., and Dunstan, D.W.（2012）: Prolonged sedentary time and physical activity in workplace and non-work contexts: a cross-sectional study of office, customer service and call centre employees. Int. J. Behav. Nutr. Phys. Act., **9**, 128.

15） Trost, S.G., McIver, K.L., and Pate, R.R.（2005）: Conducting accelerometer-based activity assessments in field-based research. Med. Sci. Sports Exerc., **37**, S531－S543.

16） Zhai, L., Zhang, Y., and Zhang, D.（2015）: Sedentary behaviour and the risk of depression: a meta-analysis. Br. J. Sports Med., **49**, 705－709.