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Effects of a multicomponent physical activity promoting program on sedentary behavior, physical activity and body measures: a longitudinal study in different office types

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Objectives The aim of this study was to investigate effects of a multicomponent program promoting physical activity on sedentary behavior, physical activity, and body measures, when relocating from cell offices to either a flex or cell office.

Methods The Active Office Design (AOD) study is a longitudinal non-randomized controlled study performed in a municipality in northern Sweden. A subsample of 86 participants were randomly recruited from the AOD study to objectively measure sedentary behavior and physical activity, using ActivPAL and ActiGraph, before and after relocation to the two different office types. The multicomponent program promoting physical activity was performed in both offices. Data were analyzed using linear mixed models.

Results Eighteen months after relocation, the total number of steps per work day increased by 21% in the flex office and 3% in the cell office group, compared to baseline. Moderate and vigorous physical activity (MVPA) during work hours increased by 42% in the flex office group and 19% in the cell office group. No changes were seen regarding sitting time at work. Small additive effects for walking and MVPA were seen for both groups during non-work time. Weight increased in the flex office group.

Conclusions This long-term study shows that a multicomponent workplace intervention can lead to increased walking time, steps, and MVPA in a flex compared to a cell office. Small additive increases of physical activity were seen during non-work time in both groups. More long-term controlled studies are needed to confirm these results.

Key terms activity-based work; flex office; health promotion; intervention; occupational health; office worker; sitting; workplace.

Work life has changed rapidly during the last decades, with an increase in the percent of individuals working with sedentary work tasks in the service sector (1). Office workers usually spend 62–78% of their time at work sitting (2–5). Excessive sedentary behavior (SB), defined as any waking behavior with an energy expenditure ≤1.5 metabolic equivalents (MET) while in a sitting, lying, or reclining posture (6), has been proposed as an independent risk factor for type 2 diabetes, cardiovascular diseases, cancer, and overall mortality, even when reaching recommendations for physical activity (PA) at moderate-to-vigorous intensity (MVPA) (7–10). There is therefore a need for interventions using objective measurements to verify putative effects (11, 12).

The most common office types are cell offices and open landscapes with fixed workstations, but in recent years flex offices with activity-based working have increased in popularity (13). The main reasons for relocating to a flex office are to reduce facility costs and enhance social interaction and teamwork within the organization (14). In a flex office with activity-based work there are no fixed workstations, but instead various spaces in the office which are designed to support the performance of different work tasks. In addition to

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traditional workstations in open landscape areas, rooms for meetings, lounge areas, and temporary individual rooms are available. Depending on work tasks and personal needs, employees are expected to move between these different workstations and locations in the office. Earlier studies on the effects of flex offices have shown conflicting results regarding sitting and walking. A recent study, investigating occupational sitting patterns in a governmental state organization, where four office sites relocated from cell to flex offices, showed limited overall effects for sedentary patterns, while walking time increased significantly in the flex offices. The results differed between sites though, indicating contextual and site-specific complexity (15). In a study by Foley et al (16), SB and PA were investigated after relocation to a flex office with activity-based work. While self-reported sitting time decreased, no changes were observed for objectively measured sedentary time, sedentary breaks, or step counts. Research and policy documents suggest that health-promotive interventions in the workplace should include organizational, environmental, and individual components for successful results (17–19), and a participatory approach has been advocated in occupational health interventions (20).

The flex office with activity-based working could theoretically provide environmental as well as organizational conditions for increased PA at work. Controlled studies with long-term follow-up and objective measurements are now needed to determine whether office design affects SB and PA in office environments. The addition of PA-promoting programs at the workplace would probably also stimulate employees to increase PA at work. To our knowledge, no previous studies have evaluated the effects of a multicomponent PA intervention program in flex offices. The aim of this controlled longitudinal study was to investigate the effects on objectively measured SB, PA, and body measures after a PA-promoting program, when relocating to either a flex or cell office. We hypothesized that both groups would reduce total sitting time, increase the frequency of sedentary breaks, increase time in standing and light PA (LPA) during working hours. These changes were expected to be greater in the flex office. No changes in MVPA or body measures were expected.

Methods

Design and recruitment

This study is a part of the Active Office Design (AOD) research project, which is a natural experiment with a longitudinal follow-up with a comparison group. The AOD study was conducted among white-collar workers performing public workplace administration in a municipality (Örnsköldsvik Municipality) with 56 000 inhabitants in Northern Sweden. The overarching aim of the project was to evaluate the effects of different office types on perceived work environment, productivity, health, PA, and well-being. Before the relocation most of the employees had permanent individual workstations in cell offices or shared rooms. The relocation resulted in 219 employees (59%) – including departments for economy, human resources, urban planning, education and politicians – moving to a flex office with activity-based work, and 152 employees (41%) – including the welfare office and social workers – moving to traditional cell offices. The researchers were not involved in the allocation of employees to the two office types. The organization provided the researchers with lists of employees involved in the relocation process, and all these employees were invited in the AOD study to answer a questionnaire about experienced working conditions, health, self-assessed productivity, and PA 6 months before, and 6 and 18 months after the relocation (21). All participants signed informed consent to participate in the study.

Participants in this study, with repeated measurements of SB, PA, and body measures, were recruited from the two groups moving to different office types. Using the lists of employees provided by the organization, a researcher with no other involvement in the trial prepared a computer-generated list of random numbers within each office type. Following this, the selected employees got an e-mail invitation with a description of the study and information on its purpose. The e-mail was followed by a phone interview to assess eligibility according to inclusion criteria: (i) age 18–63 years, (ii) working ≥75, (iii) spending >60% of work hours inside the office, and (iv) not planning to retire or relocate to another worksite during the study period. Recruitment was performed between September and December 2014, and all participants signed an informed consent. The Regional Ethical Committee in Umeå, Sweden, granted ethical approval (No: 2014/226-31). The study design with timeline for recruitment, data collection, and PA promoting activities is shown in figure 1.

Sample size and power calculations

The power calculations were based on data from earlier studies (5, 22–24). These studies report standard deviation (SD) of 35.3–100.0 minutes, and our calculations were based on a SD of 55 minutes with a power of 0.80. We assumed an estimated dropout rate of 20% and that group size and SD within groups were equal for sitting time. To achieve a power of 80% (α=0.05), with possibility to detect a difference of ≥30 minutes of sitting per day between groups, a sample size of totally 84 individuals was needed in a repeated measures Anova between factors design.

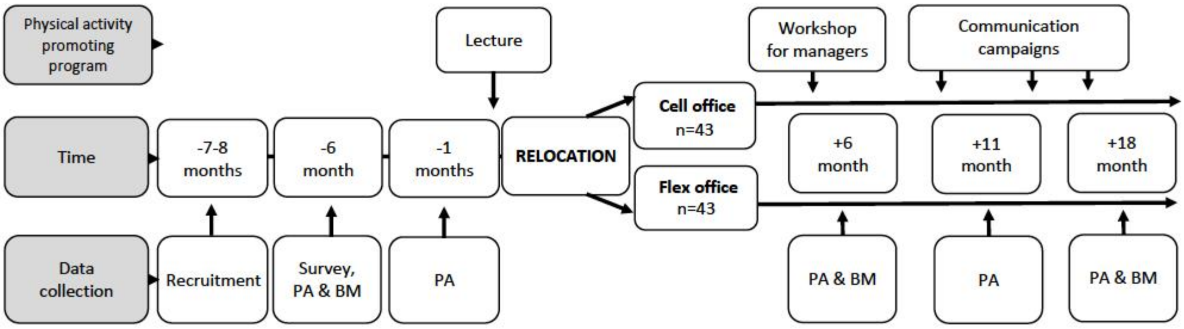

Figure 1. Flowchart for recruiment, data collection and the physical activity promoting program. [PA=physical activity measurements; BM=body measurements],

Interventions

Environmental factors in the two office-types. The flex office building had three floors. The center of the building comprised a roofed atrium surrounded by open office areas and balconies. The interior design was equipped with sit–stand tables in some meeting rooms, touch down stations with mainly standing tables, and 16 treadmills at individual workstations, both in cell offices and open areas. Seven shared waste-paper bins were deployed at each floor. The shared break spaces had both sitting and standing tables. Employees had assigned areas in the building where their break spaces and personal cabinets were located, although they were encouraged to use the whole office area for work.

The cell office building also had three floors. Each floor had double corridors with cell offices along the outer walls and shared areas like meeting rooms, break spaces, and archives in the middle. All office rooms were deployed with a waste-paper bin. All employees in both groups had sit–stand tables at their workplaces both before and after the relocation. More detailed information of organizational and architectural features is found in supplementary table S1 (www.sjweh.fi/show_abstract.php?abstract_id=3808).

Theoretical background and development of physical-activity-promoting program. To fit the intervention to the organizational context, development of the PA-promoting program was made in collaboration among the researchers and the senior leadership, the office relocation steering group, and workplace representatives. The PA-promoting program was influenced by the following models: (i) model for preventive health at the workplace (18); (ii) social ecologic model of influences on physical activity (25); and (iii) social cognitive theory (26). The main focus in the program was to replace sitting with standing or walking and break up prolonged sitting while working, but other everyday PA eg, active commuting, stair use, and walking meetings were also included. The program activities targeted all employees in both offices, with the same procedures for both groups over a period of 18 months. More details on the intervention program are described in the supplementary information (www.sjweh.fi/show_abstract.php?abstract_id=3808).

Content of program promoting physical activity

Lecture. All employees were invited to a 45-minute lecture approximately one month before the office relocation. The aim of the lecture was to increase awareness of the relationship between SB, PA, and health and to inspire the employees to reflect and discuss how they could make behavioral changes.

Workshop for managers. A seminar for managers was held about five months after relocation, aiming to repeat the importance of breaking up sitting and moving in the workplace, discuss culture and norms, and share ideas on how managers could lead by example.

Communication campaigns. Three campaigns were developed in collaboration with voluntary employees from the organization. The campaigns were launched 10–17 months after the relocation. Posters, table signs in the meeting- and coffee rooms, posts on the workplace intranet, and information via managers at workplace meetings were used for communication. The first campaign focused on breaking up prolonged sitting, the second highlighted the importance of everyday PA, and the third focused on taking the stairs and/or using treadmill workstations if available at the workplace. The campaigns also aimed to encourage reflection and individual goal-setting regarding behaviors for everyday PA, both at work and during leisure time.

Other factors of influence for physical activity at work

During the course of the study, employees were offered access to a computer program that provided reminders to take active breaks. The organization had a policy (common in Sweden) that all employees could exercise one hour a week during working hours if their work so permitted. The health and wellness hour could be distributed across the week. Subsidized gym fees were offered, bicycles and electric bicycles were provided for transport to meetings outside the office, and showers were available at the workplace. Both groups had about the same distance from the parking lot to the office, both before and after the relocation. The organization also performed their usual health-promoting program, ie, a one-month step competition once a year, for both groups.

Data collection, data processing, and outcome variables

Sedentary behavior and physical activity. Objective measurements were performed at five time points, at two baseline measurements (6 months and 4 weeks before relocation) and at three follow-ups, approximately 6, 11, and 18 months after relocation. Each measurement period was performed over seven consecutive days. The participants wore ActivPAL3 or ActivPAL3 micro activity monitor (PAL Technologies, Glasgow, Scotland, UK) and ActiGraph wGT3x-BT activity monitor (ActiGraph, Pensacola, Florida, USA). The two devices register different aspects of SB and PA. ActivPAL provides valid, reliable, and sensitive measurements on changes in body postures and motion (27, 28). ActiGraph is valid for measuring duration, frequency, and intensity of PA at different intensity levels (29). Participants noted in a logbook what time they got up, went to bed, started and finished work, whether it was a work or non-work day, and periods of non-wear time, and this was used to distinguish between work time, leisure time on work days, and total time on non-work-days. Any adverse events related to the measurements could be reported in an open question in the logbook. Outcomes for SB and PA are analyzed for work time, leisure time on work days, time on non-work days, and total week time. For a measurement period to be eligible for analysis, it had to include ≥3 work days and ≥1 non-work-day. To be included ≥10 hours of measurements in total were needed per day, and for analysis of work time ≥4 hours was required (30). Activity outcomes for leisure time on workdays for both ActivPAL and ActiGraph were calculated by subtracting work time values from total time values.

ActivPAL was worn on the right thigh for 24 hours per day (PAL Technologies Limited, Glasgow, UK; default settings). Data from ActivPAL were processed using a custom-made excel macro (HSC PAL analysis software v2.19s). ActiGraph was worn with an elastic belt around the waist during waking hours. The raw data were collected at 30 Hz and downloaded with 60-second epoch length in the Actilife software v.6.13.3. To define wear and non-wear time, we used a modified version of the Choi algorithm, with 60 minutes of consecutive zero counts, no tolerance for spikes, and a small 1-minute window length, using vector magnitude (29). For workdays, time filters based on the logbooks were manually entered in the Actilife software. To define PA levels, a modified version of the Freedson Adult VM3 algorithm based on vector magnitude was used (31). Light PA was defined as 201–2689 counts per minute (cpm) and MVPA as ≥2690 cpm. The lower cut-off point for LPA was based on a small pilot experiment (32). More details about collection and processing of data are described in the supplementary information on methods (www.sjweh.fi/show_abstract.php?abstract_id=3808).

Body measures

Body measurements were performed at the workplace 6 months before and 6 and 18 months after relocation. The participants wore underwear during the measurements, which the same observer performed at all time points using standardized methods (33). Body height was measured to the nearest 0.1 cm with a wall-mounted stadiometer (Hyssna 4146, Hyssna Measuring Equipment AB, Hyssna, Sweden), body weight to the nearest 0.1 kg using a calibrated electronic digital scale (Tanita BWB-800 MA; Umedico AB, Rosersberg, Sweden), and waist and hip circumference to the nearest 0.5 cm. Waist circumference was measured with a measuring tape midway between the top of the iliac crest and the lower margin of the last palpable rib, and hip circumference was measured over the most prominent part of trochanter major.

Background characteristics

Information on background variables was obtained from the baseline questionnaire in the AOD study, distributed to all employees involved in the relocation process 6 months prior to the relocation. Questions about age, sex, managing position, extent of employment, self-rated health (one question from SF-36) (34), hours of computer work per day, and self- reported exercise were used. The question for self-reported exercise was formulated "how many days during the past 3 months have you exercised in workout clothes, with the purpose of improving your fitness and/or to feel good?" (35).

Data collection took place between November 2014 and March 2017. The flex office relocated 6 months before the cell office, which means that the measurements were carried out with a seasonal difference between the groups.

Outcome variables

The primary outcome variable was sitting time at work, measured by the ActivPAL. Secondary outcomes from

ActivPAL were (i) time in standing and walking, (ii) time spent in prolonged sitting bouts of >30 minutes, (iii) number of breaks per sedentary hour, and (iv) total number of steps at work. Secondary outcomes from ActiGraph were daily LPA, MVPA, and time in MVPA bouts of >10 minutes at work. Additional secondary outcomes were body measures [weight, body mass index (BMI), waist circumference, and waist-hip ratio]. For work time and leisure time on work days, outcomes for SB and PA were standardized and presented as 8 hours per day and, for non-work days and total week time, as 16 hours per day. Outcomes for SB and PA from ActivPAL and ActiGraph during leisure time on workdays, non-work days, and total week time are exploratory in order to study compensatory effects.

Feedback to participants

After the baseline period, the participants received feedback based on the ActivPAL data via e-mail. The feedback described crude results on group means from the first baseline measurements for time in sitting/lying, standing, walking, and number of steps per day. The aim of this feedback was to motivate to continued participation in the study. When all data collection was completed, participants received individual feedback on the same outcomes from all measurement periods.

Statistical analyses

Statistical analyses were carried out using SPSS software v.24 (IBM Corp, Armonk, NY, USA). Baseline differences between groups were determined using paired t-tests or Chi^2 tests. Linear mixed models with model parameters estimated through restricted maximum likelihood (REML) were used to examine the differences between the two groups over time (the sums of square were calculated using type III ANOVA). Within-group effects were analyzed using the estimated marginal means of the fitted models, where the comparisons of main effects were performed using the outcome at baseline as reference. The confidence interval (CI) adjustment was set to least-significant distance for all tests. The models for SB and PA data were constructed with group (two levels: flex and cell office), time [four levels: baseline (reference), 6, 11, and 18 months], and the interaction (group × time) as fixed factors. The two baseline measurements were weighted to a give a balanced value. Between- and within-group analyses were performed both unadjusted and adjusted with covariates for age, BMI, self-reported exercise habits and self-reported health at baseline in the model. All participants with baseline data were included in the models, and missing data at follow-up were considered missing at random.

In a similar way, the models for body measurements were constructed with group (two levels: flex and cell office), time [three levels: baseline (reference), 6 and 18 months], and the interaction (group × time) as fixed factors. Random intercepts for participants were used in all models. For all analyses, significance level was set at $\alpha=0.05$, two-tailed. Bonferroni corrections were performed for significant results. Since we did 35 relevant significant tests, the Bonferroni-corrected significance level was 0.05/35=0.0014.

Results

Baseline characteristics

We recruited 43 individuals from each office group for this study. Baseline characteristics are presented in table 1 (see supplementary figure S1 for recruitment, drop-

Table 1. Characteristics of participants at baseline 1. [SD=standard deviation.]

	Flex office (N=43)		Cell office (N=43)	
	Mean (SD)	N (%)	Mean (SD)	N (%)
Demography, health and lifestyle				
Age at baseline	48.3 (10.3)		48.5 (9.8)	
Body measures				
Weight, kg	74.7 (13.5)		71.9 (13.2)	
Body mass index	2.1 (4.2)		25.6 (3.5)	
Waist circumference, cm	88.3 (10.5)		87.8 (10.6)	
Waist/hip ratio	0.85 (0.8)		0.85 (0.8)	
Sex (women)		32 (74)		42 (98)
Self-rated general health [a]				
Very good or excellent		30 (70)		19 (44)
Good and fair		13 (23)		23 (54)
Bad		0 (0)		0 (0)
Physical exercise [a]				
No exercise		1 (2)		7 (16)
Occasionally – not regular		7 (16)		10 (23)
Once a week		7 (16)		10 (23)
2–3 times a week		18 (42)		11 (26)
>3 times per week		10 (23)		4 (9)
Work characteristics				
Managers		10 (23)		3 (7)
Office type before relocation				
Cell office (1 person)		32 (74)		31 (72)
Shared room (2–3 persons)		5 (12)		12 (28)
Landscape with personal work station (small or medium size)		6 (14)		0 (0)
Employment degree (%)				
100		40 (93)		34 (79)
75–99		3 (7)		9 (21)
Computer work per work-day (hours) [a]				
2–4		3 (7)		5 (12)
4–6		16 (37)		22 (51)
6–8		24 (56)		15 (35)
Meetings outside the office [a]				
0 to 3–4 times per week		32 (74)		30 (70)
1–2 times per week to daily		11 (26)		12 (28)

[a] Missing data from one participant in cell office group.

outs, and completion of data collection,(www.sjweh.fi/show_abstract.php?abstract_id=3808).

There were no significant differences between the two groups at baseline regarding age, body measurements, self-reported exercise, employment degree, time of computer work per day or number of meetings outside the office (table 1). However, the groups differed in proportion of sex (P=0.002), proportion of managers (P=0.035), self-rated general health (P=0.022), and what office type they worked in before relocation (P= 0.019). Baseline characteristics to illustrate representativeness of the recruited study sample versus the total office population in the AOD study are shown in supplementary table S2 (www.sjweh.fi/show_abstract.php?abstract_id=3808). For results on separate outcomes of the two baseline measurements, see supplementary table S3 (www.sjweh.fi/show_abstract.php?abstract_id=3808).

After the baseline period, the organization decided to relocate managers and project leaders in the cell office group to a flex office, on a separate floor, thus we only used the baseline data for those four participants in the cell office group. In the flex office, 70% (N=31) of the recruited participants completed the entire study compared to 67% (N=30) in the cell office. The drop-outs had significant lower ratings for self-rated general health but were otherwise similar to participants still in the study at the third follow-up (data not shown).

Outcomes of sedentary behavior and physical activity

Work time. At baseline, 53% of time was spent sitting in the flex office and 50% in the cell office group. There were no significant group effects or changes within the groups for total sitting or prolonged sitting time during the study time (table 2). A group effect was observed in number of breaks per sitting hour, driven by an increase in mean sitting duration and a decrease in number of breaks in the cell office group. At the third follow-up, the flex office had 7.3 and the cell office group 6.5 breaks per sitting hour (table 2).

At baseline, 39% of time was spent standing in the flex office and 41% in the cell office group. There was no significant group effect for standing, although standing time decreased within the flex office group at all follow ups, from 189 minutes a day at baseline to 175 minutes a day at follow-up 3 (table 2). Number of steps at work increased within both groups, but there was a significant group effect with the flex office group increasing their number of steps with 744 and the cell office group with 116 per workday at the third follow-up compared to baseline. Under the course of the study, time spent in LPA at work decreased at all follow-up time points in the flex office group, with a decrease of 10 minutes per day at third follow-up compared to baseline (table 2). The cell office group had a significant within group decrease

Table 2. Results for sedentary behavior and physical activity at work in the two office groups presented as estimated means (EM) with confidence intervals (CI). Pairwise comparisons within groups compared to baseline and model effects for group by time interactions are presented. EM are calculated with group and time interaction in the linear mixed model. [Prolonged sitting=sitting >30 minutes; LPA=light physical activity; MVPA=moderate-to-vigorous physical activity; MVPA bout=time spent in MVPA >10 minutes]. **Bold indicates statistically significant.**

Worktime	Flex Office		Cell Office		P-value for group×time effect
	EM	95% CI	EM	95% CI	
Sitting (min/8 hr)					0.326
Baseline	252	230–275	242	219–265	
Follow-up 1	264	241–287	238	214–263	
Follow-up 2	265	242–288	254	230–278	
Follow-up 3	258	234–281	250	226–274	
Standing (min/8 hr)					0.131
Baseline	189	167–211	197	175–220	
Follow-up 1	**168** [b]	**146–190**	198	175–222	
Follow-up 2	**169** [a]	**147–192**	**182** [a]	**158–205**	
Follow-up 3	**175** [a]	**152–198**	189	166–213	
Walking (min/8 hr)					0.001
Baseline	39	35–43	42	38–46	
Follow-up 1	**48** [c]	**42–50**	44	40–49	
Follow-up 2	**46** [c]	**42–51**	**45** [a]	**41–49**	
Follow-up 3	**47** [c]	**44–52**	41	40–46	
Number of steps/8 hr					0.018
Baseline	3602	3220–3984	3757	3365–4149	
Follow-up 1	**4570** [c]	**4180–4961**	**4178** [a]	**3572–4604**	
Follow-up 2	**4331** [c]	**3930–4731**	**4300** [c]	**3879–4721**	
Follow-up 3	**4346** [c]	**3934–4758**	3873	3448–4297	
Time in prolonged sitting (min/8 hr)					0.411
Baseline	110	93–126	99	82–116	
Follow-up 1	111	94–128	93	75–112	
Follow-up 2	116	99–134	98	80–117	
Follow-up 3	110	90–126	106	88–125	
Mean sitting duration (minutes)					0.350
Baseline	8.1	3.2-13.0	10.5	5.3-15.6	
Follow-up 1	10.0	4.9-15.1	13.0	7.0-19.0	
Follow-up 2	9.5	4.1-14.9	13.1	7.3-18.9	
Follow-up 3	9.6	3.8-13.0	**20.4** [a]	**14.5-26.3**	
Number of breaks/ sitting hour					0.001
Baseline	6.7	5.7–7.7	7.9	6.9–9.0	
Follow-up 1	6.8	5.7–7.8	7.3	6.2–8.4	
Follow-up 2	6.5	5.4–7.5	**6.5** [c]	**5.4–7.6**	
Follow-up 3	7.3	6.3–8.4	**6.5** [c]	**5.4–7.5**	
Time in LPA (min/8 hr)					<0.001
Baseline	148	137–158	157	146–168	
Follow-up 1	**136** [c]	**125–146**	**147** [b]	**135–158**	
Follow-up 2	**128** [c]	**117–139**	155	144–167	
Follow-up 3	**138** [b]	**127–149**	151	140–163	
Time in MVPA (min/8 hr)					<0.001
Baseline	19	15–22	16	13–19	
Follow-up 1	**22** [a]	**19–25**	18	14–21	
Follow-up 2	**22** [a]	**19–25**	**22** [c]	**19–26**	
Follow-up 3	**27** [c]	**23–30**	**19** [a]	**15–22**	
Time in MVPA-bouts (min/8 hr)					0.930
Baseline	5.4	2.8–8.0	3.9	1.2–6.6	
Follow-up 1	6.6	3.9–9.2	5.5	2.6–8.4	
Follow-up 2	6.4	3.6–9.1	**7.5** [b]	**4.6–10.4**	
Follow-up 3	8.8	5.9–11.6	5.6	2.7–8.5	

[a] P-value <0.05.
[b] P-value <0.01.
[c] P-value <0.001.

in LPA only at follow-up one, which led to a significant group effect for LPA. Time spent in MVPA increased at all follow-ups in the flex office and at the second and third follow-up in the cell office group compared to baseline. For MVPA, there was a significant group effect, and a significant difference between the groups at third follow-up. Between baseline and third follow-up, time spent in MVPA at work increased by 8 minutes per day in the flex office group and 3 minutes per day in the cell office group (table 2 and supplementary figure S2). Supplementary table S4 shows the adjusted results for SB and PA for work time (www.sjweh.fi/show_abstract.php?abstract_id=3808).

In total, 16 treadmills were installed in the flex office, but at the last follow-up only 6 of them were in use. In the studied subsample, 10% (N=3) reported that they used the treadmills to some extent. In the total flex office population 14% used the treadmills.

Leisure time on work days

There were significant group effects for sitting and standing during leisure time on work days, with the cell office group increasing sitting time by 13 minutes at third follow-up compared to baseline, and the flex office only increasing sitting at leisure by one minute per day (supplementary table S5, add www.sjweh.fi/show_abstract.php?abstract_id=3808). There were also differences in group effects for time spent walking and MVPA during leisure time on work days, mostly due to an increase in the cell office group at the second follow-up, where walking time increased by 11 minutes (table S5). Supplementary table S6 shows the adjusted results for SB and PA leisure time on workdays and time at non-work days (www.sjweh.fi/show_abstract.php?abstract_id=3808).

Time at non-work days

There was a significant decrease in sitting time within the flex office group at non-work days, with 34 minutes less sitting at third follow-up compared to baseline (table S5). The cell office group did not change their sitting time on non-work days, which led to a significant group effect. Concomitantly the flex office group had a major increase in walking time at all follow-ups (up by 24, 26, and 20 minutes, respectively) compared to baseline, resulting in a significant group effect. No group effects were seen for time in LPA and MVPA at non-work days, even though MVPA had increased within the flex office group at all follow-up time points, compared to baseline (table S5).

Total week time

Supplementary table S7 (www.sjweh.fi/show_abstract.php?abstract_id=3808) shows data of SB and PA for total week time (workdays and non-work-days, reported as 16 hours per day). There were no significant group effects for sitting or standing time, only for walking time and time spent in MVPA (figure 2). The flex office group increased their walking time at all follow-ups and by 14 minutes a day at the third follow-up compared to baseline. The cell office group increased walking by 12 minutes at the second follow-up compared to baseline, but at third follow-up there was no change from baseline (table S7). At baseline, the flex office group spent 371 minutes (53×7), and the cell office group 343 minutes (49×7) per week in MVPA. Compared to baseline, the flex office group increased MVPA by 77 (11×7) minutes per week and the cell office group by 35 (5×7) minutes at the third follow-up (figure 2). Within this increase, 21 versus 28 minutes was spent in MVPA bouts of >10 minutes in the flex and cell office group, respectively.

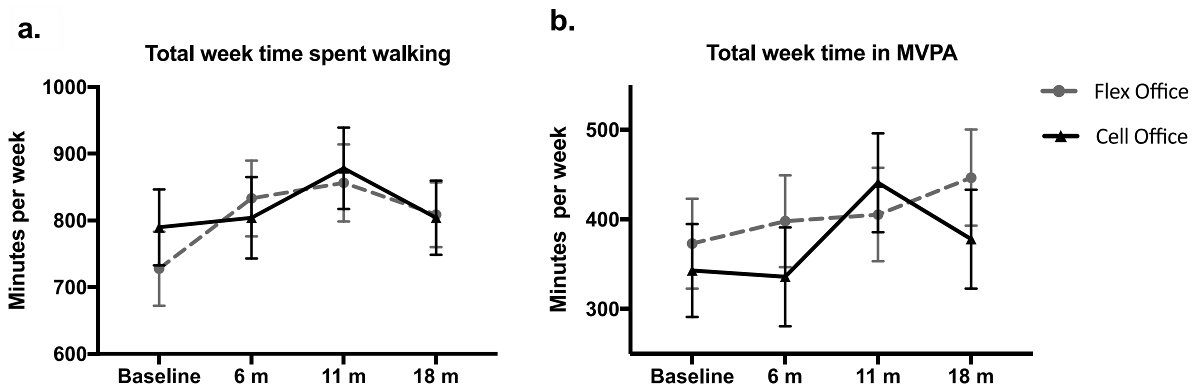

Figure 2. Results with estimated means and confidence intervals for total week time spent walking and in moderate-to-vigorous activity (MVPA). Significant group effects were found for walking (P=0.018) and MVPA (P=0.001)

Supplementary table S8 (www.sjweh.fi/show_abstract.php?abstract_id=3808) shows the adjusted results for SB and PA for total week time.

There were no statistical differences in interaction effect between men and women or manager versus non-manager for activity outcomes in the flex office group during the study, and the results were unaltered when adjusted for season of data collection (data not shown). No adverse events were reported.

Body measures

There was a significant group effect regarding weight change, with the flex office group increasing 1.1 kg in weight between baseline and third follow-up. Waist circumference in the cell office group decreased by 1.6 cm between baseline and third follow-up, which led to a difference in group effect (table 3).

Results after Bonferroni corrections

After Bonferroni corrections, significant differences between groups (group×time interaction) remained for time spent walking, number of breaks per sitting hour, time in LPA and MVPA at work, sitting and standing time at non-work days, as well as time in MVPA for total time.

Table 3. Results of body measures in the two office groups presented as estimated means (EM) with confidence intervals (CI). Pairwise comparisons within groups compared to baseline and model effects for group by time interactions are presented. EM are calculated with group and time interaction in the linear mixed model. The model for interaction effects is adjusted for age and self-reported physical exercise at baseline. [BMI=body mass index. **Bold indicates statistically significant.**

	Flex Office		Cell Office		P-value for group×time effect
	EM	95% CI	EM	95% CI	
Weight, kg					0.011
Baseline	74.0	69.8–78.2	72.1	67.9–76.3	
Follow-up 1	74.3	70.0–78.5	72.1	67.9–76.3	
Follow-up 3	**75.1** [a]	**70.9–79.3**	71.5	67.3–75.8	
BMI					0.079
Baseline	25.7	24.5–27.0	25.7	24.4–27.0	
Follow-up 1	25.9	24.6–27.2	25.3	23.9–26.7	
Follow-up 3	**26.2** [a]	**24.8–27.6**	24.6	23.3–26.0	
Waist circumference, cm					0.021
Baseline	87.8	84.5–91.0	88.5	85.2–91.7	
Follow-up 1	**86.8** [a]	**83.5–90.1**	**87.3** [a]	**83.9–90.6**	
Follow-up 3	87.8	84.5–91.1	**86.9** [b]	**83.6–90.2**	
Waist/hip ratio					0.540
Baseline	0.85	0.83–0.88	0.86	0.84–0.89	
Follow-up 1	**0.84** [c]	**0.82–0.87**	0.85	0.83–0.88	
Follow-up 3	0.85	0.83–0.88	**0.85** [b]	**0.83–0.88**	

[a] P-value <0.05.
[b] P-value <0.01.
[c] P-value <0.001.

Discussion

We hypothesized that both groups would reduce total sitting time, increase the frequency of sedentary breaks and increase standing time during working hours. These changes were expected to be greater in the flex office. We found no changes in total or prolonged sitting time, but increased walking time and number of steps in both groups and significantly larger increases in the flex office compared to the cell office were identified. Notably, in comparison with earlier studies, time spent sitting and prolonged sitting time at work was lower and standing time higher already at baseline in our study (4, 15, 36, 37), which might be due to the availability of sit–stand tables already at baseline. Sit–stand tables are common in many office environments in Sweden (38), but even when comparing recent Swedish studies, time spent sitting at baseline was lower in this study than previously shown (3, 15). Differences in sample sizes in previous studies, associated with a wide range of standard deviations, made it difficult to calculate the sample size, and there is thus a risk that our study was underpowered. Notably, Hallman et al (15), who also investigated SB in flex offices found similar results to our study, not observing any changes in sedentary time after relocation to flex offices. The stability in sitting and prolonged sitting time throughout this study, might reflect a ceiling effect for further decreases due to individual factors, work tasks, and technical equipment.

We also hypothesized that LPA would increase and no changes for MVPA were expected during work hours. In contrast to our hypothesis, we found that time in MVPA increased and LPA decreased in the flex office. As both groups already at baseline had low proportions of sitting time and quite high proportions of standing time, it might not have been possible to further increase LPA. The response to the PA program in both groups might thus have been achieved by taking a walk during lunch or increased utilization of the health and wellness hour.

Importantly we found an increase in walking time and MVPA also during leisure time implying an additive rather than compensatory effect. MVPA increased during leisure time on workdays within the cell office group and during non-work-days within the flex office group. Previous studies have found conflicting results regarding compensatory effects during non-work time. Pesola et al's study (39) targeted sedentary time both at work and leisure but showed reduced SB and increased PA only during leisure time. A multicomponent workplace intervention study, focusing on decreasing SB and increasing PA at work, resulted in decreased sedentary time at work but compensatory effects with decreased PA during leisure (2). Similar results were also seen in a study by Mansoubi et al (40), where sit–stand workstations was implemented at the office. These variable results regarding compensatory effects indicate the importance of including intervention components targeting both work and leisure time, and measuring and evaluating effects during leisure time in future workplace intervention studies. In our study, the mean increase for total week time of MVPA by 77 minutes per week in the flex office group and 35 minutes in the cell office group most likely represents a clinically meaningful effect. A recent Swedish study, with objectively assessed PA, showed reduced risks for all-cause mortality and cardiovascular disease when replacing sedentary time with LPA or MVPA (41). In a pooled cohort study on self-reported leisure time PA, the hazard ratio for mortality decreased by 31% when MVPA increased from 0 to 150 minutes per week. A further continuous but declining risk reduction of 39% was observed up to the threshold of 750 minutes of MVPA per week, which is five times the PA guideline (42).

The increase in steps at work was more pronounced in the flex compared to the cell office, and this was probably due to differences in office design and the absence of fixed workstations in the former, since the PA-promoting program was performed in both office types. In Hallman et al's study (15), the results differed between different flex office sites, and the authors discussed the possible influence of contextual factors such as office size and availability of workstations. Jancey et al (43) observed an increased number of steps among employees after relocation to a new, purpose-built building, where the office building had a centralized staircase and breakout spaces, and the floor space was 35% larger than before relocation. During our study, the organization needed to expand and hire more employees, which resulted in the offices becoming crowded a few months after the relocation. The total free floor space for the flex office group remained essentially the same before and after relocation (data not shown). The increased accumulation of steps and walking time could depend on the use of the entire office space to find a suitable work station or locating colleagues, instead of mainly spending time in the own corridor.

In our study, the flex office group increased in weight and BMI at the third follow up despite an increased PA, while the cell office group showed a decreased waist circumference at second and third follow-up, even though their increase in PA was more modest. These results are difficult to interpret, but could be due to factors unknown to us, such as menopause, stress, energy expenditure, and food intake among the participants.

Strengths and limitations of the study

Our study had a prospective controlled design, with a long-term follow-up of 18 months that gave opportunities to study changes and stability of SB and PA in office settings. To our knowledge, no earlier studies within this field have had such long-term follow-up. The usage of both ActivPAL and ActiGraph made it possible to collect accurate data of sedentary time accumulation patterns and PA of different intensity levels. Sedentary time was reported with data from the ActivPAL, which has good-to-excellent validity for detecting sitting, standing, and breaks from sitting (27, 28, 44, 45). The outcomes from ActivPAL and ActiGraph are reported separately. For ActiGraph we used 200 cpm as the cut-off point for LPA to lower the risk that standing was categorized as SB and SB was categorized as LPA. From the ActiGraph, we reported only variables for LPA and MVPA. Walking time (reported from ActivPAL) can be categorized as either LPA or MVPA (from the ActiGraph), depending on the intensity level. The filtered data on both work time, leisure time on work and non-work-days, and total week time made it possible to study compensatory effects.

The development of the PA-promoting program was performed in cooperation with the organization and had a participatory approach, which is recommended to achieve a contextually costumed, anchored, and sustainable intervention (46). Another strength is that the PA-promoting program used in this study presumably could easily and at a low cost be used in a wide range of office settings (see supplementary information).

The study also has some limitations. It was not possible to perform a randomization, either on an individual or group level, although the recruited sample in both groups seems to be representative for the total office population, based on baseline questionnaire data. The two groups were unbalanced regarding distribution of sex and managers, but this did not seem to influence the interaction effect, which strengthens the possibility to generalize the results. Already at baseline, the studied organization had sit–stand tables as standard and a systematic approach to health promotion and ergonomics, which might limit the generalizability of the results to other settings. On the other hand, it shows that the workplace is an important arena for interventions to further increase PA among office workers. The utilization of health and wellness hour was not monitored in the questionnaires. This information would have been of value for interpretation of putative driving factors underlying the changes of PA. There is also a risk that the participants were more physically active during measurements due to social pressure.

A recent Swedish study showed that persons with high SB reported sitting as a habit, standing as uncomfortable, no motivation to stand, and had perceptions that standing reduced work performance (3). Another study, performed in Canada, showed variations for changes in sitting and standing time, where the office staff reduced their sitting time and increased their standing time significantly more than the faculty staff after moving to an activity-permissive office (47). Hadgraft et al (48) identified BMI and organizational tenure as correlates of both total and prolonged sitting time and Pesola et al (39) found their intervention to be more effective among women than men regarding increasing breaks from sedentary time and LPA at work. As our study participants were mainly women, it is difficult for us to draw conclusions on possible differences between genders, although it would be of interest to study if the same differences would appear in a study with comparable large groups of men and women. We have reported the estimated means for groups, but our data also show a wide individual variability. Future studies should identify and investigate factors that affects the behavior patterns for sitting and PA at the workplace, ie, sex, age, work tasks, work environment, and personal characteristics.

Concluding remarks

This study shows that employees in the flex office increased walking time, the number of steps, and MVPA during work hours, and to a larger extent than the employees in the cell office group. Importantly, instead of compensatory effects, further additive effects were seen during leisure time. Sitting time was low and standing time high already at baseline compared to previous studies, and no changes were seen during the study time for sitting or standing in any of the groups, suggesting a possible ceiling effect. More long-term controlled studies with information on site-specific determinants are needed to confirm these results.

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References

1. Church TS, Thomas DM, Tudor-Locke C, Katzmarzyk PT, Earnest CP, Rodarte RQ et al. Trends over 5 decades in U.S. occupation-related physical activity and their associations with obesity. PLoS One 2011;6(5):e19657. https://doi.org/10.1371/journal.pone.0019657.

2. Aittasalo M, Livson M, Lusa S, Romo A, Vähä-Ypyä H, Tokola K et al. Moving to business - changes in physical activity and sedentary behavior after multilevel intervention in small and medium-size workplaces. BMC Public Health 2017 Apr;17(1):319. https://doi.org/10.1186/s12889-017-4229-4.

3. Nooijen CF, Kallings LV, Blom V, Ekblom Ö, Forsell Y, Ekblom MM. Common perceived barriers and facilitators for reducing sedentary behaviour among office workers. Int J Environ Res Public Health 2018 Apr;15(4). https://doi.org/10.3390/ijerph15040792.

4. Smith L, Sawyer A, Gardner B, Seppala K, Ucci M, Marmot A et al. Occupational physical activity habits of UK office workers: cross-sectional data from the active buildings study. Int J Environ Res Public Health 2018 Jun;15(6):E1214. https://doi.org/10.3390/ijerph15061214.

5. Parry S, Straker L, Gilson ND, Smith AJ. Participatory workplace interventions can reduce sedentary time for office workers--a randomised controlled trial. PLoS One 2013 Nov;8(11):e78957. https://doi.org/10.1371/journal.pone.0078957.

6. Tremblay MS, Aubert S, Barnes JD, Saunders TJ, Carson V, Latimer-Cheung AE et al.; SBRN Terminology Consensus Project Participants. Sedentary Behavior Research Network (SBRN) - Terminology Consensus Project process and outcome. Int J Behav Nutr Phys Act 2017 Jun;14(1):75. https://doi.org/10.1186/s12966-017-0525-8.

7. Dunstan DW, Howard B, Healy GN, Owen N. Too much sitting--a health hazard. Diabetes Res Clin Pract 2012 Sep;97(3):368–76. https://doi.org/10.1016/j.diabres.2012.05.020.

8. Katzmarzyk PT, Church TS, Craig CL, Bouchard C. Sitting time and mortality from all causes, cardiovascular disease, and cancer. Med Sci Sports Exerc 2009 May;41(5):998–1005. https://doi.org/10.1249/MSS.0b013e3181930355.

9. Biswas A, Oh PI, Faulkner GE, Bajaj RR, Silver MA, Mitchell MS et al. Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis. Ann Intern Med 2015 Jan;162(2):123–32. https://doi.org/10.7326/M14-1651.

10. Diaz KM, Howard VJ, Hutto B, Colabianchi N, Vena JE, Safford MM et al. Patterns of sedentary behavior and mortality in U.S. middle-aged and older adults: a national cohort study. Ann Intern Med 2017 Oct;167(7):465–75. https://doi.org/10.7326/M17-0212.

11. Stamatakis E, Ekelund U, Ding D, Hamer M, Bauman

AE, Lee I-M. Is the time right for quantitative public health guidelines on sitting? A narrative review of sedentary behaviour research paradigms and findings. Br J Sport Med. https://doi.org/10.1136/bjsports-2018-099131. [Epub ahead of print].

12. Owen N, Healy GN, Matthews CE, Dunstan DW. Too much sitting: the population health science of sedentary behavior. Exerc Sport Sci Rev 2010 Jul;38(3):105–13. https://doi.org/10.1097/JES.0b013e3181e373a2.

13. Lahtinen M, Ruohomäki V, Haapakangas A, Reijula K. Developmental needs of workplace design practices. Intell Build Int. 2015;7(4):198–214. https://doi.org/10.1080/17508975.2014.1001315.

14. Kim J, de Dear R. Workspace satisfaction: the privacy-communication trade-off inopen-plan offices. J Environ Psychol 2013;36:18–26. https://doi.org/10.1016/j.jenvp.2013.06.007.

15. Hallman DM, Mathiassen SE, Jahncke H. Sitting patterns after relocation to activity-based offices: A controlled study of a natural intervention. Prev Med. 2018 Jun;111:384–90. https://doi.org/10.1016/j.ypmed.2017.11.031.

16. Foley B, Engelen L, Gale J, Bauman A, Mackey M. Sedentary Behavior and Musculoskeletal Discomfort Are Reduced When Office Workers Trial an Activity-Based Work Environment. J Occup Environ Med 2016 Sep;58(9):924–31. https://doi.org/10.1097/JOM.0000000000000828.

17. Carnethon M, Whitsel LP, Franklin BA, Kris-Etherton P, Milani R, Pratt CA et al.; American Heart Association Advocacy Coordinating Committee; Council on Epidemiology and Prevention; Council on the Kidney in Cardiovascular Disease; Council on Nutrition, Physical Activity and Metabolism. Worksite wellness programs for cardiovascular disease prevention: a policy statement from the American Heart Association. Circulation 2009 Oct;120(17):1725–41. https://doi.org/10.1161/CIRCULATIONAHA.109.192653.

18. Five Keys to Healthy Workplaces : No Business Wealth without Workers ' Health. World Health Organization. [Internet]. (April 2010). Available from: http://www.who.int/occupational_health/5keys_healthy_workplaces.pdf.

19. National Institute for Occupational Safety and Health. Total Worker Health: Advancing Worker Safety, Health and Well-Being. 2015; Available from: https://www.cdc.gov/niosh/twh/pdfs/faq-for-total-worker-health_2015-03-01-trademark-amended-for-download.pdf.

20. Henning R, Warren N, Robertson M, Faghri P, Cherniack M; CPH-NEW Research Team. Workplace health protection and promotion through participatory ergonomics: an integrated approach. Public Health Rep 2009 Jul-Aug;124 Suppl 1:26–35. https://doi.org/10.1177/00333549091244S104.

21. Pettersson-Strömbäck A, Bodin Danielsson C, Nordin M, Öhrn M, Harder M, Olsson T et al. Slutrapport från Aktikon-projektet i Örnsköldviks kommun. Arbetsmiljö, fysisk aktivitet, hälsa och produktivitet i aktivitetsbaserad kontorsmiljö - en kontrollerad studie i Örnsköldsviks kommun [Internet]. Umeå: Umeå Universitet; 2018;(2). Available from: http://umu.diva-portal.org/smash/get/diva2:1215311/FULLTEXT01.pdf.

22. Healy GN, Eakin EG, Lamontagne AD, Owen N, Winkler EA, Wiesner G et al. Reducing sitting time in office workers: short-term efficacy of a multicomponent intervention. Prev Med 2013 Jul;57(1):43–8. https://doi.org/10.1016/j.ypmed.2013.04.004.

23. Dunstan DW, Wiesner G, Eakin EG, Neuhaus M, Owen N, LaMontagne AD et al. Reducing office workers' sitting time: rationale and study design for the Stand Up Victoria cluster randomized trial. BMC Public Health 2013 Nov;13(1):1057. https://doi.org/10.1186/1471-2458-13-1057.

24. Smith L, Ucci M, Marmot A, Spinney R, Laskowski M, Sawyer A et al. Active buildings: modelling physical activity and movement in office buildings. An observational study protocol. BMJ Open 2013 Nov;3(11):e004103. https://doi.org/10.1136/bmjopen-2013-004103.

25. Zimring C, Joseph A, Nicoll GL, Tsepas S. Influences of building design and site design on physical activity: research and intervention opportunities. Am J Prev Med 2005 Feb;28(2 Suppl 2):186–93. https://doi.org/10.1016/j.amepre.2004.10.025.

26. Bandura A. Health promotion by social cognitive means. Health Educ Behav 2004 Apr;31(2):143–64. https://doi.org/10.1177/1090198104263660.

27. Ryan CG, Grant PM, Tigbe WW, Granat MH. The validity and reliability of a novel activity monitor as a measure of walking. Br J Sports Med 2006 Sep;40(9):779–84. https://doi.org/10.1136/bjsm.2006.027276

28. Lyden K, Kozey Keadle SL, Staudenmayer JW, Freedson PS. Validity of two wearable monitors to estimate breaks from sedentary time. Med Sci Sports Exerc 2012 Nov;44(11):2243–52. https://doi.org/10.1249/MSS.0b013e318260c477.

29. Migueles JH, Cadenas-Sanchez C, Ekelund U, Delisle Nyström C, Mora-Gonzalez J, Löf M et al. Accelerometer Data Collection and Processing Criteria to Assess Physical Activity and Other Outcomes: A Systematic Review and Practical Considerations. Sports Med 2017 Sep;47(9):1821–45. https://doi.org/10.1007/s40279-017-0716-0.

30. Edwardson CL, Winkler EA, Bodicoat DH, Yates T, Davies MJ, Dunstan DW et al. Considerations when using the activPAL monitor in field-based research with adult populations. J Sport Health Sci 2017 Jun;6(2):162–78. https://doi.org/10.1016/j.jshs.2016.02.002.

31. Sasaki JE, John D, Freedson PS. Validation and comparison of ActiGraph activity monitors [Internet]. J Sci Med Sport 2011 Sep;14(5):411–6. https://doi.org/10.1016/j.jsams.2011.04.003.

32. Bergman F, Wahlström V, Stomby A, Otten J, Lanthén E, Renklint R et al. Treadmill workstations in office workers who are overweight or obese: a randomised controlled trial. Lancet Public Health 2018 Nov;3(11):e523–35. https://doi.org/10.1016/S2468-2667(18)30163-4.

33. Ulijaszek SJ, Kerr DA. Anthropometric measurement error and the assessment of nutritional status. Br J

Nutr 1999 Sep;82(3):165–77. https://doi.org/10.1017/S0007114599001348.

34. Sullivan M, Karlsson J, Ware JE Jr. The Swedish SF-36 Health Survey--I. Evaluation of data quality, scaling assumptions, reliability and construct validity across general populations in Sweden. Soc Sci Med 1995 Nov;41(10):1349–58. https://doi.org/10.1016/0277-9536(95)00125-Q.

35. Ng N, Söderman K, Norberg M, Öhman A. Increasing physical activity, but persisting social gaps among middle-aged people: trends in Northern Sweden from 1990 to 2007. Glob Health Action 2011;4:6347. https://doi.org/10.3402/gha.v4i0.6347.

36. Danquah IH, Kloster S, Holtermann A, Aadahl M, Bauman A, Ersbøll AK et al. Take a Stand!-a multi-component intervention aimed at reducing sitting time among office workers-a cluster randomized trial. Int J Epidemiol 2017 Feb;46(1):128–40.

37. Healy GN, Eakin EG, Owen N, Lamontagne AD, Moodie M, Winkler EA et al. A Cluster Randomized Controlled Trial to Reduce Office Workers' Sitting Time: Effect on Activity Outcomes. Med Sci Sports Exerc 2016 Sep;48(9):1787–97. https://doi.org/10.1249/MSS.0000000000000972.

38. Swedish Work Environment Authority. The Work Environment 2015. Stockholm; 2016.

39. Pesola AJ, Laukkanen A, Heikkinen R, Sipilä S, Sääkslahti A, Finni T. Accelerometer-assessed sedentary work, leisure time and cardio-metabolic biomarkers during one year: effectiveness of a cluster randomized controlled trial in parents with a sedentary occupation and young children. PLoS One 2017 Aug;12(8):e0183299. https://doi.org/10.1371/journal.pone.0183299.

40. Mansoubi M, Pearson N, Biddle SJ, Clemes SA. Using sit-to-stand workstations in offices: is there a compensation effect? Med Sci Sports Exerc 2016 Apr;48(4):720–5. https://doi.org/10.1249/MSS.0000000000000802.

41. Dohrn IM, Kwak L, Oja P, Sjöström M, Hagströmer M. Replacing sedentary time with physical activity: a 15-year follow-up of mortality in a national cohort. Clin Epidemiol 2018 Jan;10:179–86. https://doi.org/10.2147/CLEP.S151613.

42. Arem H, Moore SC, Patel A, Hartge P, Berrington de Gonzalez A, Visvanathan K et al. Leisure time physical activity and mortality: a detailed pooled analysis of the dose-response relationship. JAMA Intern Med 2015 Jun;175(6):959–67. https://doi.org/10.1001/jamainternmed.2015.0533.

43. Jancey JM, McGann S, Creagh R, Blackford KD, Howat P, Tye M. Workplace building design and office-based workers' activity: a study of a natural experiment. Aust N Z J Public Health 2016 Feb;40(1):78–82. https://doi.org/10.1111/1753-6405.12464.

44. Grant PM, Ryan CG, Tigbe WW, Granat MH. The validation of a novel activity monitor in the measurement of posture and motion during everyday activities. Br J Sports Med 2006 Dec;40(12):992–7. https://doi.org/10.1136/bjsm.2006.030262.

45. Kozey-Keadle S, Libertine A, Lyden K, Staudenmayer J, Freedson PS. Validation of wearable monitors for assessing sedentary behavior. Med Sci Sports Exerc 2011 Aug;43(8):1561–7. https://doi.org/10.1249/MSS.0b013e31820ce174.

46. Mackenzie K, Such E, Norman P, Goyder E. The development, implementation and evaluation of interventions to reduce workplace sitting: a qualitative systematic review and evidence-based operational framework. BMC Public Health 2018 Jul;18(1):833. https://doi.org/10.1186/s12889-018-5768-z.

47. Gorman E, Ashe MC, Dunstan DW, Hanson HM, Madden K, Winkler EA et al. Does an 'activity-permissive' workplace change office workers' sitting and activity time? PLoS One 2013 Oct;8(10):e76723. https://doi.org/10.1371/journal.pone.0076723.

48. Hadgraft NT, Healy GN, Owen N, Winkler EA, Lynch BM, Sethi P et al. Office workers' objectively assessed total and prolonged sitting time: individual-level correlates and worksite variations. Prev Med Rep 2016 Jun;4:184–91. https://doi.org/10.1016/j.pmedr.2016.06.011.

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