# A "Sit Less, Walk More" Workplace Intervention for Office Workers

## Long-Term Efficacy of a Quasi-Experimental Study

Yun-Ping Lin, PhD, OiSaeng Hong, PhD, Chiu-Chu Lin, PhD, Shu-Hua Lu, PhD, Meei-Maan Chen, PhD, and Kwo-Chen Lee, PhD

**Objective:** This study tested the maintenance outcomes of a 3-month Sit Less, Walk More (SLWM) workplace intervention for office workers compared with usual care at 12 months from the baseline. **Method:** A quasi-experimental study was conducted in two workplaces. The intervention group ($n = 51$) received multi-component intervention and the comparison group ($n = 50$) received newsletters only. The outcomes of the study (self-reported psychosocial, physical activity, sitting, and lost productivity; objectively measured cardiometabolic biomarkers) were compared at baseline, 3, and 12 months. **Results:** Generalized estimating equations analyses found that the intervention group had significant improvements in self-regulation for sitting less and moving more ($P = 0.017$), walking ($P = 0.003$), weight ($P = 0.013$), waist circumference ($P = 0.002$), and insulin ($P = 0.000$) at 12 months compared with the comparison group. **Conclusion:** The SLWM intervention was effective in improving self-regulation, walking, and some cardiometabolic biomarkers in office workers.

**Keywords:** cardiometabolic biomarkers, office workers, physical activity, sitting, work productivity

In the modern economy, most people work at sedentary- and light-intensity jobs, representing spending excessive sitting at work. Specifically, people who employ in sedentary occupations, such as desk-based workers, have a combined total of occupational and nonoccupational sedentary behaviors for approximately 11 hours per day.[1,2] This indicates leaving little time to engage in regular physical activity for health benefits[3] and an excessive amount of sedentary behaviors associated with increased health risks.[4–9] Sedentary behaviors usually refer to time spend sitting in the workplace, in an automobile, and during leisure time that involve very low (1.0 to 1.5 METs) energy expenditure.[10,11]

Given the growing public health concern about increasingly sedentary lifestyles, much of the evidence has been demonstrated the links between sedentary time and adverse health outcomes. Prolonged sitting is adversely associated with cardiometabolic biomarkers, premature mortality, all-cause mortality, cardiovascular disease, type 2 diabetes, and metabolic syndrome, after accounting for time spent in moderate to vigorous physical activity.[4–9] A 1-year prospective study conducted with sedentary professional workers in low physical activity occupations also found that changes in sedentary behavior predicted changes in cardiometabolic risk score. Sedentary behavior at work is an occupational health risk that predisposed workers to an elevated risk of developing cardiometabolic disorders.[12]

However, reducing and regularly breaking up prolonged sitting time and replacing it with standing and light-intensity physical activity throughout the day is likely to have a positive effect on glycemia,[13–15] triglycerides,[4] and metabolic outcomes.[16,17] Yet, to effectively combat the harmful effects of prolonged sitting, the type, intensity, and frequency of physical activity may vary in terms of the individuals' habitual physical activity level.[16] An expert statement[18] has provided guidance for employers to promote the reduction of prolonged periods of seated office work toward improved health and productivity, both for individual workers and for the corporate. It has recommended to accumulate at least 2 hours/day of standing and light walking during working hours and eventually progress to a total accumulation of 4 hours/day.

Accordingly, workplace health promotion should address sedentary behavior and physical activity to reduce the detrimental health risks of sitting too much at work. According to two reviews,[19,20] several intervention strategies have been used to reduce workplace sedentary behavior and increase physical activity, including (a) the use of activity-permissive workstations by installing sit-stand workstations, treadmill desks, or pedal machines; (b) promoting employees to take stairs through email communication about the benefits of using stair, using point-of-decision prompts with the display of motivational signs or posters, and/or making the stairwell safer and more attractive; (c) educational/behavioral strategies such as motivating workers to change behavior by using pedometers in combination with goal setting and activity logbooks, by providing individualized feedback on behavior through a website, and/or by individual coaching sessions, motivational interviewing or counselling, advice through emails or brochures; and (d) multi-component strategies that combined the installation of sit-stand workstations with educational/behavioral strategies such as goal setting, self-monitoring, computer software prompts, and problem solving.

There was evidence for the effect of workplace interventions in reducing sedentary behavior and/or increasing physical activity, particularly for multi-component strategies,[19] followed by the use of activity-permissive workstations,[19,20] stair-promoting,[20] and educational/behavioral strategies.[19,20] However, evidence was found for activity-permissive workstations that did not have an impact on hemodynamics and cardiorespiratory fitness, and educational/behavioral strategies that did not have an impact on anthropometric measures.[20] Moreover, there was insufficient or conflicting evidence regarding the impact on work performance,[20,21] as well as lipid and metabolic profiles[20] or cardiometabolic biomarkers.[21]

From the School of Nursing, China Medical University and Department of Nursing, China Medical University Hospital, Taichung, Taiwan (Drs Lin, Lu, Lee); School of Nursing, University of California San Francisco, San Francisco, California (Dr Hong); College of Nursing, Kaohsiung Medical University, Kaohsiung, Taiwan (Dr Lin); College of Nursing, National Taipei University of Nursing and Health Sciences, Taipei, Taiwan (Dr Chen).

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Address correspondence to: Kwo-Chen Lee, PhD, 91 Hsueh-Shih Road, Taichung 40402, Taiwan (rubylee@mail.cmu.edu.tw)



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In addition, a 19-week workplace ''sit less, move more'' web-based program that introduced incidental movement and short walks into the work routine has demonstrated significant improvements in occupational sitting, step counts, waist circumference,[22] and several markers of lost workday productivity.[23]

In brief, both too little exercise and too much sitting are independent health risks and need to be addressed separately. The simple message of ''sit less, move more'' seems more understandable to contemporary people. To fill the existing gaps in the literature, the present study sought to develop and evaluate a theory-informed Sit Less, Walk More (SLWM) workplace intervention. Because sit-stand workstations are generally expensive and not feasible, broader environmental approaches[24] were used to encourage employees to be physically active at work by increasing access to places for physical activity (ie, creating walking routes), providing cues and opportunities for physical activity (ie, motivational posters on the wall and office computers), and creating a supportive corporate culture (ie, senior management support). A personal/team goal-setting approach and a support network[25] incorporated into a team-based 10,000 steps challenge were also used to increase employees' self-efficacy[26] and self-regulation[27] for sitting less and moving more.

## PURPOSE AND HYPOTHESIS

The current study is a continuation of our previous work,[28] which examined the short-term efficacy of a 3-month SLWM workplace intervention on improving cardiometabolic health and work productivity in office workers. The present work aimed to test the long-term effects of a SLWM workplace intervention compared with usual care in increasing supportive workplace environments, self-regulation, self-efficacy and physical activity, and reducing sitting, thus further decreasing cardiometabolic risks and lost productivity over a 9-month follow-up in middle-aged office workers. We hypothesized that the SLWM intervention group would display significantly better workplace environments, self-regulation and self-efficacy, increased physical activity, reduced sitting and cardiometabolic risks, and lost productivity compared with the comparison group.

## METHODS

### Design

The study employed a two-group quasi-experimental design with repeated measures to evaluate a multi-component SLWM workplace intervention. The intervention group received a 3-month SLWM workplace intervention in addition to usual care, whereas the comparison group received usual care only. The usual care consisted of three monthly newsletters about physical activity and sitting. This study was conducted between January 2015 and December 2016 in the two aerospace industrial workplaces in Taichung, Taiwan.

### Participants

The inclusion criteria were full-time office workers who: (1) sat for at least 6 hours a day at work, (2) were at least 20 years of age, (3) had no difficulty performing physical activity, and (4) were not pregnant. The exclusion criterion was planning to take a leave from work for more than 2 weeks or relocate to another workplace during the 3-month intervention period.

To determine the appropriate sample size, we used nQuery Advisor program.[29] A medium effect size (0.50) was expected. We estimated about 20% attrition rate, based on previous research[25] and our experience working with office workers. With 80% power and 5% significance, we need to recruit at least 50 per group.

### Type of Interventions

The comparison group received an education-only intervention (usual care), which included three monthly newsletters to provide knowledge about (1) benefits of physical activity, negative health effects of physical inactivity, and ways to add more physical activity to workday routine; (2) dangers of prolonged sitting and simple exercises can be done at your desk; and (3) public health recommendations for physical activity, including intensity, frequency, duration, type, and total amount.

The SLWM workplace intervention (experimental intervention) was developed on the basis of the results of our focus group, and three theoretical models: McLeroy et al[30] ecological model; Bandura[26] self-efficacy theory; and Bandura[27] social cognitive theory of self-regulation. The SLWM program, a complex intervention, was designed to create a supportive workplace environment for staying active at work and increase participants' self-efficacy and self-regulation in promoting physical activity and reducing prolonged sitting, in order to improve their cardiometabolic health and work productivity.

The details of the intervention have been reported elsewhere[28] and are briefly described below. The SLWM intervention included the following components: (a) three monthly newsletters (same as usual care), (b) six biweekly motivational tools, (c) a team-based 10,000 steps challenge, (d) environmental prompts, and (e) walking routes and resources.

All participants of the SLWM intervention received a Participant Handbook, 12 copies of weekly Step Log and Sitting Time Log, and a Yamax Digi-Walker SW-200 Pedometer (Yamasa Tokei Keiki Co., Ltd., Tokyo, Japan) immediately after the baseline measures. The pedometer was used as a motivational tool for increasing and self-monitoring walking. The Participant Handbook was used to complement the face-to-face communication regarding (a) the timing and content of intervention; (b) benefits and incentives for participation; (c) responsibilities of participants; and (d) educational information about how to use the pedometer, how to set personal and team goals, how to record daily steps and sitting time, walking maps near neighborhoods and the workplace, tips to sit less and move more, and questions and answers (Q & A). The participants were encouraged to refer to the handbook for information when necessary.

Six biweekly motivational tools adapted from Dishman et al[25] contained educational information regarding ways to increase participants' self-efficacy and self-regulation for sitting less and moving more, including setting goals, overcoming barriers, avoiding sedentary temptations and relapse, staying motivated, and keeping on moving. After reading these tools, participants would become more confident in self-observation, judgment, and reaction regarding their physical activity and sitting behavior, and setting goals for themselves and developing strategies and plans to reach the behavioral goal and desired outcome.

As previously described,[28] the team-based 10,000 steps challenge used a social support approach and rewards to encourage team members' participation, goal setting, and goal achievement. Eight team leaders were selected by their respective team members (4 to 9 individuals per team) to engage and motivate them toward goal achievement. Team leaders as coordinators between the participants and the research liaison also assisted with collecting log data biweekly from their team members. To recognize and celebrate the champion team's success, an awards ceremony was held biweekly by the research team and Department of Industrial Safety and Environmental Protection (ISEP) together in the intervention site. To demonstrate senior management support, the director of the ISEP physically presented at each ceremony. To enhance participants' self-efficacy and thus self-regulation, we encouraged champion team members to share their successful experiences in accomplishing goals. A large poster designed to record and compare team goal achievement was also presented in the ceremony as a background picture. To acknowledge their performance, a group photo was taken in front of the poster and sent to all intervention participants via email biweekly.

To create a supportive workplace environment for sitting less and moving more, environmental prompts were posted throughout the workplace and also loaded onto participants' office computers to remind them of taking a 1-minute break every hour. In addition, a walking route was designed in the workplace to promote walking at work for health walks or lunch time walks.

The SLWM workplace intervention was conducted with the help of a trained research assistant, a research liaison (ie, onsite occupational health nurse), and eight team leaders. Before the intervention, a 60-minute meeting was held by the principal investigator with the research liaison and team leaders to initiate coordination, review the study process, and solicit comments and suggestions for successful implementation. Research Liaison Handbook and Team Leader Handbook were also provided to them as a project implementation manual. The study protocol was reviewed and discussed with the research liaison and the director of the ISEP to ensure the feasibility of implementing the SLWM workplace intervention.

To maintain intervention fidelity, the principal investigator monitored the conduct of the intervention by working closely with the research assistant, while the research assistant worked intensively with the research liaison and observed the intervention site weekly. The participant's questions were answered by project staff (specifically the principal investigator, research assistant, and research liaison) within 24 hours to improve adherence to the intervention.

The maintenance phase lasted for 9 months from the completion of the 3-month intervention, and intervention participants received an electronic version of the 4-page booster booklet via email at 6 months. The booster booklet provided information on "reducing sedentary behaviors: sitting less and moving more," which was created by Len Kravitz.[31]

## Measures

For purposes of this study, the psychosocial measures refer to supportive workplace environment (six items), self-efficacy for physical activity (12 items), self-efficacy for reducing sitting (nine items), and self-regulation for sitting less and moving more (10 items). Each of these measures is described as follows.

*Supportive workplace environment* was assessed using the Chinese version of the Perceived Workplace Environment Scale (PWES-C).[32] This is a six-item scale assessing the six dimensions of perceived workplace environment relative to physical activity, including individual, social, organizational, community, policy, and physical environments.[33] The items are rated on a 5-point Likert scale (1 = none, 5 = a great amount). The rating reflected participants' perceptions of the extent to which their workplace environments support physical activity, with higher scores indicating greater support. In this study, the Cronbach alpha reliability coefficient for the PWES-C was 0.82.

*Self-efficacy for physical activity* was evaluated by the Scale of Exercise Self-Efficacy.[34] To minimize participants' response burden and redundancy in the scale items, we used 12 out of 15 items to measure participants' confidence in engaging in regular physical activity in different situations or the presence of barriers. Regular physical activity refers to engaging in moderate or vigorous physical activity for 30 minutes (at least 10 minutes at a time) on 5 days a week, or walking 10,000 steps per day. Definitions of moderate and vigorous physical activity were added to this scale. The items are rated on a 6-point Likert scale (1 = not at all confident, 6 = completely confident), with higher scores indicating higher self-efficacy. In this study, the Cronbach alpha reliability coefficient for the scale was 0.94.

*Self-efficacy for reducing sitting* was measured by a barrier self-efficacy scale,[35] which was adapted from a survey used in a national campaign – Swap It, Don't Stop It. It consists of nine items designed to assess specific barriers to reducing sitting at work, such as "stand up during meetings at work, even though no one else was." The items are rated on a 5-point Likert scale (1 = not at all confident, 5 = very confident), with higher scores reflecting higher barrier self-efficacy. The reliability (Cronbach alpha = 0.90) of the original English version has been previously pilot tested.[35] In this study, we translated the barrier self-efficacy scale into Chinese. Content validity of the scale was sought from a panel of four experts in the area of occupational health (one physician, one nurse, one industrial hygienist, and one nursing professor), using the content validity index,[36] to ensure relevance of the scale in the Taiwan culture for office workers. The scale was then pretested with 10 office workers to establish semantic and technical equivalence.[37] The Cronbach alpha reliability coefficient was 0.89, and content validity index was 1.0.

*Self-regulation for sitting less and moving more* was evaluated by a scale of self-regulation strategies,[35] which was adapted from a scale for physical activity intervention. It contains 10 items assessing frequency of use of various strategies to help standing up at work, such as "thought about how much I sit at work." The items are rated on a 5-point Likert scale (1 = never, 5 = very often) with higher scores indicating greater use of self-regulation strategies. The reliability (Cronbach alpha = 0.84) of the English version has been pilot tested.[35] We translated the scale of self-regulation strategies into Chinese, and the reliability and validity of the Chinese version were satisfactory in this study; Cronbach alpha was 0.91, and content validity index was 1.0.

*Physical activity* was evaluated by the Chinese Taiwan version of the International Physical Activity Questionnaire - short form (IPAQ-SF).[38] This is a seven-item, self-report measure assessing frequency and duration of vigorous and moderate intensity physical activity and walking in the past 7 days.[39] Average time spent sitting on a weekday in the past 7 days at work, at home, while doing coursework, and during leisure time was also evaluated. Physical activity scores were calculated by multiplying the duration, frequency, and their corresponding metabolic equivalent (MET) value. A total physical activity score (MET-min/week) was the sum of walking, moderate, and vigorous MET-min/week scores.

*Occupational sitting and physical activity* were measured by the Chinese version of the Occupational Sitting and Physical Activity Questionnaire (OSPAQ).[40] The good reliability and validity of both the original and the Chinese version have been previously demonstrated.[28] The OSPAQ is a six-item, self-report measure assessing the proportion (%) of sitting, standing, walking, and doing physically demanding tasks during a typical work day in the past 7 days. The total numbers of working hours and days at work in the past 7 days were also estimated. Time (minutes/day) spent for sitting, standing, walking, and doing physically demanding tasks were computed by multiplying their respective percentages with the average number of working hours per day.

*Productivity loss* was measured by the Work Limitations Questionnaire - short form (WLQ-SF), with well-established reliability and validity.[41] The Chinese version of the WLQ-SF evaluates the extent to which the health problem interfered with specific aspects of the worker's job performance. The WLQ-SF includes eight items grouped into four domains: time management, physical demands, mental/interpersonal demands, and output demands. The items are rated on a 5-point scale (1 = "difficult none of the time" or "able all of the time"; 5 = "difficult all of the time" or "able none of the time") based on the level of difficulty or ability to perform eight specific job demands in the past 2 weeks. Higher scores indicated greater work limitations due to health problems. To calculate the productivity loss score, the WLQ index was produced by computing a weighted sum from the four WLQ scales. The WLQ index was then converted into the WLQ productivity loss score, representing the percentage of productivity loss due to presenteeism compared with a healthy benchmark sample. In this study, the Cronbach alpha reliability coefficient for the WLQ-SF was 0.79.

*Cardiometabolic biomarkers* were evaluated by weight, waist circumference, blood pressure (BP), blood glucose, insulin, triglycerides, total cholesterol (TC), high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL), cholesterol, and TC/HDL-C ratio. Fasting blood samples were collected in the morning and sent immediately to an accredited medical laboratory for analysis. Weight was recorded to the nearest 0.1 kg using the same scale. Waist circumference was measured twice to the nearest 0.1 cm with a nonexpandable tape at the midpoint between the lowest rib and the iliac crest. A third measurement was made if the difference was at least 1 cm. Participants were asked to sit quietly for 3 to 5 minutes before getting the BP measured twice via an automated sphygmomanometer using the right arm. A third measurement was made if a large difference in systolic BP more than 10 mm Hg or in diastolic BP more than 6 mm Hg. Full details of the measures can be found in our earlier publication.[28]

The *key demographic data* collected included age, gender, marital status, education level, and work hours. The delivery of the SLWM intervention program was monitored by the principal investigator. Questions on use of the program elements were included in the 3-month survey. Overall perceptions of program components were evaluated at 3 months by asking intervention participants to rate the degree (1 = not at all, 5 = very) to which their overall satisfaction with the SLWM program, the program was beneficial to them, and the program was effective at increasing physical activity and decreasing sitting behavior. Furthermore, participants were asked three open-ended questions about what benefits they got from participating in the program, which aspects of the program they found most helpful in increasing physical activity and reducing sitting behavior, and which aspects of the program could be improved for future study implementation. At 12 months, one open-ended question was further asked ‘‘for future study implementation, did you have any suggestions about how to stick with sitting less, standing more and achieving 10,000 steps a day?’’

## Data Collection Procedures

The flow diagram of the data collection procedure is presented in Fig. 1. After obtaining support from senior management and approval from the ethics committees of the Buddhist Dalin Tzu Chi Hospital, two group information sessions about the study were conducted at the intervention and comparison sites, respectively. A research liaison and a trained research assistant screened and recruited eligible participants. Outcomes were measured at 3 months (immediate postintervention) and 12 months (9 months postintervention). Additional information on the recruitment process has been previously published.[28]

## Statistical Analyses

The analyses were based on an intention-to-treat approach to manage missing data from participant dropout. Descriptive statistics were used to describe the participants' profiles. Baseline measures were compared between participants in the intervention and comparison groups, using *t* tests and Chi-square tests, to ensure homogeneity. Generalized estimating equation (GEE) models with exchangeable correlation structure were used to test the effects of the group assignments (intervention vs comparison), the effects of time (pretest vs post-tests), and the group by time interaction for the outcome measures. All analyses were adjusted for potential confounders. A $P$ value of 0.05 or less was used to determine whether results were significant, and a $P$ value less than 0.10 was marginally significant. All analysis was conducted using IBM® SPSS® Statistics 20 (IBM Corp, Armonk, NY).

# RESULTS

## Characteristics of the Participants

Of the 101 participants who met the inclusion criteria and completed baseline measures, 99 participated in 3-month follow-up and 98 completed 12-month follow-up. The mean age of the participants was 49.5 years. There were more female than male participants (52.5% vs 47.5%). The majority were married (85.9%) and had a bachelor's degree or higher education (65.6%). The average weekly hours of work in main job was 41.8. The average body mass index (BMI) was 24.0 kg/m$^2$, with 45.4% of the participants being overweight (24.0 to 26.99) or obese ($\geq$27.0). The BMI cut-offs for Taiwanese adults were determined by Taiwan Health Promotion Administration.[42] There was no significant difference between the intervention and comparison groups in their demographics, except for age (data not shown).

## The Effects of SLWM Intervention on Supportive Workplace Environment, Self-Regulation, and Self-Efficacy

Group-specific mean values for psychosocial outcomes (Table 1) were not significantly different between the intervention and comparison groups at baseline. Significant between-groups differences were observed in self-regulation at 3 and 12 months ($Ps = 0.000$ and 0.017, respectively) and self-efficacy for physical activity at 3 months ($P = 0.007$). Both groups showed significant improvements in self-regulation and self-efficacy for reducing sitting from baseline to 3 and 12 months ($Ps = 0.000$ to 0.008). In addition, the intervention group showed significant improvements in self-efficacy for physical activity from baseline to 3 months ($P = 0.002$) and supportive workplace environment from baseline to 3 and 12 months ($Ps = 0.046$ and 0.011, respectively).

## The Effects of SLWM Intervention on Physical Activity and Sitting

Group-specific mean values for physical activity and sitting outcomes were not significantly different between the intervention and comparison groups at baseline (Table 2). Significant between-groups differences were observed in walking for physical activity at 3 and 12 months ($Ps = 0.000$ and 0.003, respectively) as well as moderate-intensity physical activity ($P = 0.014$) and total physical activity ($Ps = 0.003$) at 3 months. Despite an insignificant between-groups difference in vigorous-intensity physical activity, total physical activity, week-day sitting, occupational sitting, occupational standing, and occupational walking at 12 months, the intervention group showed significant improvements in these variables from baseline to 12 months ($Ps = 0.003$ to 0.041).

## The Effects of SLWM Intervention on Cardiometabolic Biomarkers and Lost Productivity

Group-specific mean values for cardiometabolic biomarkers and productivity loss outcomes (Table 3) were not significantly different between the intervention and comparison groups at baseline, except for TC/HDL-C ratio. Significant between-groups differences were observed in weight and waist circumference at 3 and 12 months ($Ps = 0.002$ to 0.038). Similar results were observed for diastolic BP. Despite a marginally significant between-groups difference in diastolic BP at 12 months ($P = 0.074$), both groups showed a significant improvement in diastolic BP from baseline to 12 months ($Ps = 0.000$ and 0.029, respectively). Systolic BP also decreased significantly from baseline to 12 months in both groups ($Ps = 0.000$ and 0.016, respectively). A significant between-groups difference was observed in insulin at 12 months ($P = 0.000$), in favor of the intervention group.

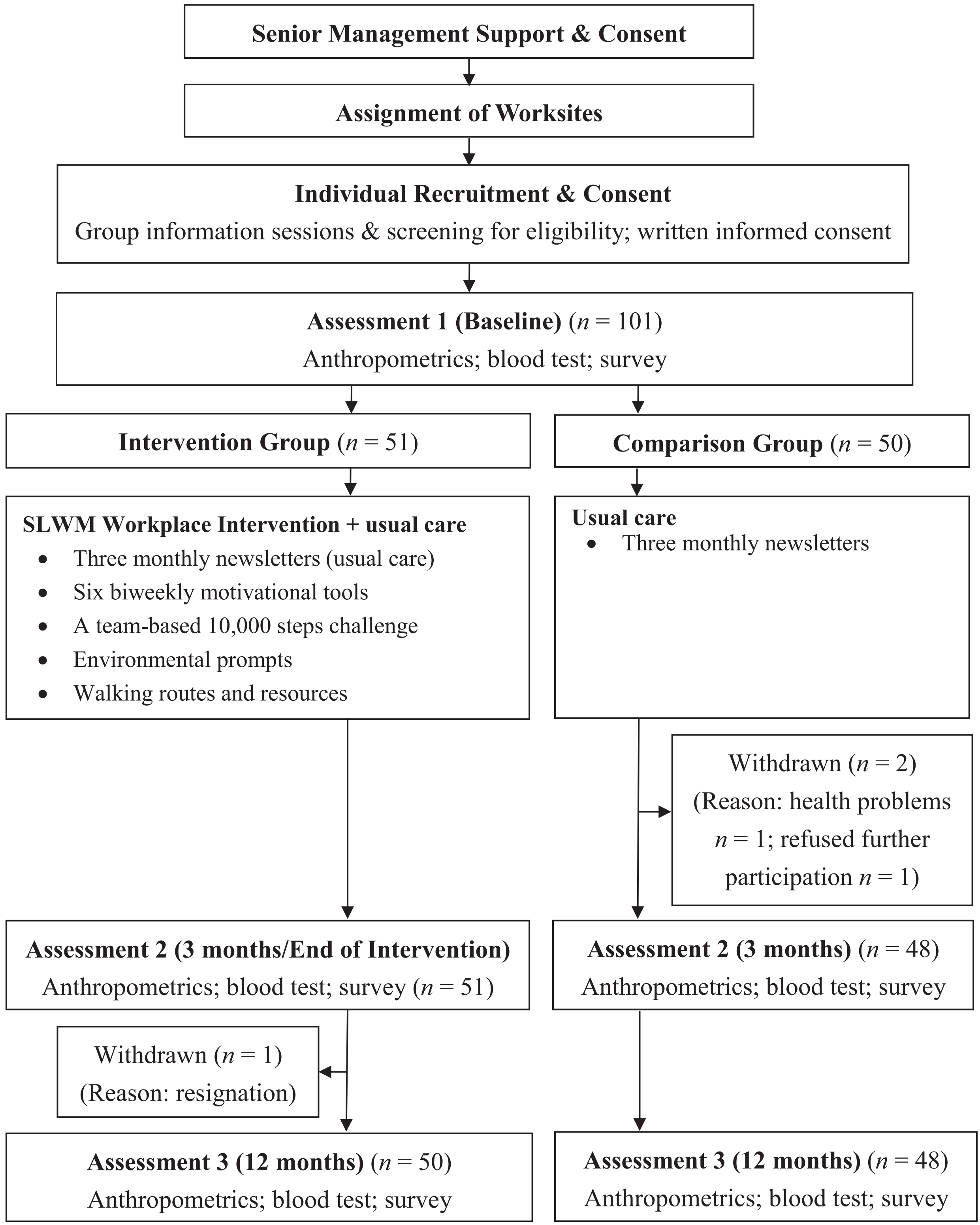


**FIGURE 1.** Flow diagram of the intervention program and measures.

The comparison group showed a significant improvement in cholesterol from baseline to 12 months ($P = 0.001$), which was not significantly lower than the improvement in the intervention group. Glucose worsened significantly from baseline to 12 months in both groups ($Ps = 0.000$ and 0.006, respectively), and the intervention group was significantly worse than the comparison group at 12 months ($P = 0.006$). As for the work productivity loss outcome, there were no significant between-groups differences. However, the

**TABLE 1.** Changes in Psychosocial Outcomes for Intervention and Comparison Participants in a SLWM Workplace Intervention ($N = 101$)

| | Baseline | | 3-month | | 12-month | |
|---|---|---|---|---|---|---|
| **Outcome** | **Mean (SE)** | **$P^*$** | **Mean (SE)** | **$P^{*,\dagger}$** | **Mean (SE)** | **$P^{*,\dagger}$** |
| Supportive workplace environment | | | | | | |
| Between groups | | 0.655 | | 0.782 | | 0.568 |
| Within intervention | 2.49 (4.05) | | 2.68 (4.07) | **0.046** | 2.74 (4.07) | **0.011** |
| Within comparison | 2.56 (4.02) | | 2.71 (4.02) | 0.177 | 2.73 (4.03) | 0.107 |
| Self-regulation for sitting less and moving more | | | | | | |
| Between groups | | 0.370 | | **0.000** | | **0.017** |
| Within intervention | 1.98 (4.43) | | 3.24 (4.43) | **0.000** | 2.56 (4.43) | **0.000** |
| Within comparison | 2.11 (4.43) | | 2.36 (4.42) | **0.002** | 2.37 (4.43) | **0.001** |
| Self-efficacy for physical activity | | | | | | |
| Between groups | | 0.739 | | **0.007** | | 0.841 |
| Within intervention | 3.07 (7.20) | | 3.55 (7.20) | **0.002** | 3.00 (7.21) | 0.653 |
| Within comparison | 3.01 (7.24) | | 2.93 (7.21) | 0.581 | 2.89 (7.24) | 0.396 |
| Self-efficacy for reducing sitting | | | | | | |
| Between groups | | 0.960 | | 0.357 | | 0.784 |
| Within intervention | 2.24 (7.21) | | 2.58 (7.21) | **0.000** | 2.60 (7.21) | **0.000** |
| Within comparison | 2.25 (7.27) | | 2.47 (7.24) | **0.008** | 2.57 (7.24) | **0.001** |

*Normal generalized estimating equation model with identity link, adjusted for baseline age, gender, insulin, and diastolic blood pressure.
†$P$ values for each outcome correspond to between-groups differences and within-groups change from baseline.
Bold values indicate significant at $P < 0.05$.

**TABLE 2.** Changes in Physical Activity and Sitting Outcomes for Intervention and Comparison Participants in a SLWM Workplace Intervention ($N = 101$)

| | Baseline | | 3-month | | 12-month | |
|---|---|---|---|---|---|---|
| **Outcome** | **Mean (SE)** | **$P^*$** | **Mean (SE)** | **$P^{*,\dagger}$** | **Mean (SE)** | **$P^{*,\dagger}$** |
| International Physical Activity Questionnaire (short form) | | | | | | |
| Walking, MET min/week | | | | | | |
| Between groups | | 0.267 | | **0.000** | | **0.003** |
| Within intervention | 421.97 (5,181.94) | | 1,701.87 (5,192.73) | **0.000** | 859.16 (5,184.44) | **0.000** |
| Within comparison | 576.03 (5,206.72) | | 660.51 (5,217.60) | 0.481 | 560.06 (5,219.99) | 0.877 |
| Moderate, MET min/week | | | | | | |
| Between groups | | 0.381 | | **0.014** | | 0.810 |
| Within intervention | 330.54 (3,566.77) | | 803.00 (3,581.48) | **0.002** | 411.77 (3,575.18) | 0.568 |
| Within comparison | 203.65 (3,572.43) | | 286.40 (3,567.54) | 0.121 | 322.47 (3,589.30) | 0.072 |
| Vigorous, MET min/week | | | | | | |
| Between groups | | 0.352 | | 0.423 | | 0.157 |
| Within intervention | 344.74 (8,474.98) | | 1,040.00 (8,489.96) | **0.010** | 669.00 (8,459.92) | **0.005** |
| Within comparison | 244.37 (8,464.24) | | 681.92 (8,456.36) | **0.011** | 368.44 (8,493.17) | 0.115 |
| Total, MET min/week | | | | | | |
| Between groups | | 0.478 | | **0.003** | | 0.108 |
| Within intervention | 1,197.42 (12,612.91) | | 3,640.76 (12,643.65) | **0.000** | 1,924.29 (12,614.34) | **0.003** |
| Within comparison | 994.44 (12,642.84) | | 1,817.18 (12,646.21) | **0.002** | 1,251.99 (12,703.36) | 0.110 |
| Sitting hours on a week day | | | | | | |
| Between groups | | 0.445 | | 0.985 | | 0.762 |
| Within intervention | 10.86 (11.12) | | 10.11 (11.11) | **0.031** | 10.28 (11.11) | **0.027** |
| Within comparison | 10.62 (11.16) | | 9.88 (11.18) | **0.009** | 10.16 (11.28) | 0.126 |
| Occupational Sitting and Physical Activity Questionnaire | | | | | | |
| Sitting at work, hours/day | | | | | | |
| Between groups | | 0.726 | | 0.475 | | 0.284 |
| Within intervention | 7.79 (6.70) | | 7.29 (6.69) | 0.126 | 7.41 (6.70) | **0.041** |
| Within comparison | 7.73 (6.74) | | 7.39 (6.77) | 0.126 | 7.60 (6.78) | 0.339 |
| Standing at work, hours/day | | | | | | |
| Between groups | | 0.559 | | 0.494 | | 0.569 |
| Within intervention | 0.57 (3.82) | | 0.86 (3.82) | **0.000** | 0.78 (3.81) | **0.008** |
| Within comparison | 0.63 (3.84) | | 0.81 (3.82) | 0.110 | 0.76 (3.86) | 0.122 |
| Walking at work, hours/day | | | | | | |
| Between groups | | 0.919 | | 0.054 | | 0.559 |
| Within intervention | 0.70 (3.71) | | 1.10 (3.69) | **0.000** | 0.88 (3.70) | **0.026** |
| Within comparison | 0.71 (3.71) | | 0.87 (3.72) | **0.016** | 0.83 (3.71) | 0.062 |

*Normal generalized estimating equation model with identity link, adjusted for baseline age, gender, insulin, and diastolic blood pressure.
†$P$ values for each outcome correspond to between-groups differences and within-groups change from baseline.
Bold values indicate significant at $P < 0.05$.

**TABLE 3.** Changes in Cardiometabolic Biomarkers and Lost Productivity Outcomes for Intervention and Comparison Participants in a SLWM Workplace Intervention ($N = 101$)

| | Baseline | | 3-month | | 12-month | |
|---|---|---|---|---|---|---|
| **Outcome** | **Mean (SE)** | $P^*$ | **Mean (SE)** | $P^{*,\dagger}$ | **Mean (SE)** | $P^{*,\dagger}$ |
| Weight, kg | | | | | | |
| Between groups | | 0.320 | | **0.029** | | **0.013** |
| Within intervention | 64.26 (82.16) | | 63.81 (82.16) | **0.021** | 63.54 (82.13) | **0.016** |
| Within comparison | 66.18 (82.43) | | 66.26 (82.43) | 0.603 | 66.42 (82.45) | 0.329 |
| Waist circumference, cm | | | | | | |
| Between groups | | 0.491 | | **0.038** | | **0.002** |
| Within intervention | 82.65 (63.08) | | 80.14 (63.13) | **0.000** | 80.99 (63.08) | **0.001** |
| Within comparison | 83.59 (63.19) | | 82.69 (63.10) | 0.132 | 84.20 (63.12) | 0.276 |
| Systolic blood pressure, mm Hg | | | | | | |
| Between groups | | 0.947 | | 0.200 | | 0.148 |
| Within intervention | 118.15 (64.85) | | 117.02 (64.92) | 0.332 | 112.68 (65.08) | **0.000** |
| Within comparison | 118.05 (65.22) | | 118.93 (65.41) | 0.401 | 115.24 (65.28) | **0.016** |
| Diastolic blood pressure, mm Hg | | | | | | |
| Between groups | | 0.634 | | **0.000** | | 0.074 |
| Within intervention | 78.78 (29.07) | | 76.23 (29.15) | **0.001** | 74.56 (29.14) | **0.000** |
| Within comparison | 78.94 (29.24) | | 81.55 (29.37) | **0.002** | 76.89 (29.21) | **0.029** |
| Glucose, mg/dL | | | | | | |
| Between groups | | 0.566 | | 0.192 | | **0.006** |
| Within intervention | 86.70 (64.49) | | 88.07 (64.45) | 0.377 | 94.57 (64.34) | **0.000** |
| Within comparison | 88.01 (65.36) | | 87.09 (65.37) | 0.261 | 90.32 (65.33) | **0.006** |
| Insulin, uIU/mL | | | | | | |
| Between groups | | 0.051 | | 0.087 | | **0.000** |
| Within intervention | 7.45 (15.09) | | 7.63 (15.16) | 0.767 | 6.96 (15.18) | 0.371 |
| Within comparison | 6.92 (15.17) | | 8.57 (15.29) | **0.007** | 9.22 (15.23) | **0.000** |
| Triglycerides, mg/dL | | | | | | |
| Between groups | | 0.502 | | 0.088 | | 0.898 |
| Within intervention | 113.86 (538.97) | | 105.88 (538.54) | 0.094 | 112.30 (539.79) | 0.840 |
| Within comparison | 121.33 (544.82) | | 124.64 (544.89) | 0.469 | 118.59 (544.42) | 0.578 |
| Cholesterol, mg/dL | | | | | | |
| Between groups | | 0.435 | | 0.521 | | 0.332 |
| Within intervention | 191.93 (305.99) | | 187.22 (306.20) | 0.087 | 187.38 (306.11) | 0.225 |
| Within comparison | 197.39 (308.50) | | 195.02 (308.35) | 0.324 | 188.42 (308.53) | **0.001** |
| High-density lipoprotein cholesterol, mg/dL | | | | | | |
| Between groups | | 0.097 | | 0.526 | | 0.826 |
| Within intervention | 60.35 (88.99) | | 60.05 (89.00) | 0.716 | 59.85 (89.04) | 0.643 |
| Within comparison | 56.22 (89.42) | | 55.13 (89.43) | 0.254 | 55.42 (89.55) | 0.332 |
| Low-density lipoprotein cholesterol, mg/dL | | | | | | |
| Between groups | | 0.442 | | 0.926 | | 1.000 |
| Within intervention | 106.60 (225.22) | | 105.09 (225.39) | 0.451 | 104.97 (225.21) | 0.581 |
| Within comparison | 110.80 (226.99) | | 109.29 (226.98) | 0.357 | 108.85 (227.05) | 0.286 |
| Total cholesterol to HDL cholesterol ratio | | | | | | |
| Between groups | | **0.023** | | 0.096 | | 0.523 |
| Within intervention | 3.29 (7.61) | | 3.23 (7.60) | 0.249 | 3.24 (7.61) | 0.614 |
| Within comparison | 3.68 (7.69) | | 3.74 (7.68) | 0.227 | 3.57 (7.68) | 0.060 |
| Lost productivity, % | | | | | | |
| Between groups | | 0.887 | | 0.913 | | 0.113 |
| Within intervention | 4.17 (23.36) | | 2.98 (23.28) | **0.008** | 3.06 (23.30) | **0.010** |
| Within comparison | 4.26 (23.52) | | 3.14 (23.49) | **0.007** | 4.21 (23.54) | 0.926 |

HDL, high-density lipoprotein.
*Normal generalized estimating equation model with identity link, adjusted for baseline age, gender, insulin, and diastolic blood pressure.
†$P$ values for each outcome correspond to between-groups differences and within-groups change from baseline.
Bold values indicate significant at $P < 0.05$.

intervention group had a significant improvement in productivity loss from baseline to 3 and 12 months ($Ps = 0.008$ and 0.010, respectively).

## DISCUSSION

We developed a 3-month SLWM workplace intervention for office workers and tested its effectiveness. We found that self-regulation for sitting less and moving more, walking for physical activity, weight, waist circumference, diastolic BP, and insulin in the intervention group were significantly or marginally significantly improved both at 3 and 12 months when compared with the comparison group. This finding suggests that a SLWM workplace intervention could effectively improve participants' self-regulation, walking for physical activity, weight, waist circumference, diastolic BP, and insulin, and that such an improvement could be sustained for 9 months after the intervention.

The observed improvements could be related specifically to the application of a team-based 10,000 steps challenge that includes elements of pedometer and Step Log, Sitting Log, goal setting, and group competition. This study design did not test the effectiveness of specific intervention components, but our process evaluation data suggested that pedometer and Step Log, Sitting Log, goal setting, and group competition (also including elements of support group approach, rewards and public recognition) were the most helpful components reported by participants (manuscript in preparation).

In the current study, we used the pedometer as a motivational tool to record and give feedback on the number of steps taken on a daily basis in combination with goal setting and Step Log already demonstrated as successful in increasing employees' moderate and vigorous physical activity and walking.[25] This accords to a review[43] that indicated physical activity interventions that included an activity monitor increased daily walking or moderate to vigorous physical activity over a period of 12 weeks or less. Also, this review suggested physical activity consultations about goal setting and self-efficacy to overcome barriers to physical activity to enhance program effectiveness. In the present study, to increase participants' self-efficacy and self-regulation for sitting less and moving more, we sequentially guided participants via biweekly motivational tools and monthly newsletters, as well as provided ongoing support and encouragement through the process of group competition for 10,000 steps challenge.

However, the behavioral change patterns were not maintained through the 12-month period, although we still observed several significant differences between the two groups and within the intervention group at 12 months. The likely explanation for this is that after the 3-month intervention, participants received limited dose of an electronic version of the booster booklet for sitting less and moving more[31] only once at 6 months. This indicates the importance of the routinization and institutionalization of the SLWM workplace intervention to continually encourage and support employees to stick with sitting less and moving more. Yet, this can only be achieved through organizational-level support, which is known to be essential in helping employees take positive steps toward an active, healthy lifestyle.[24,44]

In addition, it is speculated to highlight the possibility of investigating strategies to foster and maintain intrinsic motivation, such as rewards, feedback, and other external events.[45] We did provide challenges, positive performance feedback, and rewards to satisfy participants' psychological needs of competence and a relational support to facilitate their intrinsic motivation, but a sense of autonomy (self-determined) might not be well received by intervention participants. This is likely because, at least to some degree, team members might be urged into action, simply with the intention to achieve goals and win prizes for their team (feeling of pride). That is, the extrinsic motivation for the behavior was more of a passive compliance, rather than an active personal commitment. Consequently, the purpose of setting goals to give participants' direction and to enhance their self-regulation and persistence of effort[46] might work as expected during the 3-month intervention period, but not as effectively through the 12-month period.

This study documented changes in psychosocial and physical activity outcomes that occurred as a result of participating in the SLWM intervention. In accordance with our hypotheses, intervention participants' self-regulation for sitting less and moving more and walking for physical activity significantly improved from baseline to 3 and 12 months compared with comparison participants, although these gains appeared to have attenuated by 12 months. This may have been because changes in the self-regulation skills were associated with changes in physical activity. It is also recommended that future studies further examine the potential mediation effect of self-regulation skills on the relationship between physical activity and cardiometabolic risks and lost productivity. In addition, both comparison and intervention participants had increased their self-efficacy for reducing sitting at 3 and 12 months, but there was no group by time interaction, in that the comparison group improved their self-efficacy for reducing sitting to a large extent at 12 months.

We also attempted to identify potential mechanisms through which physical activity and sitting time may change cardiometabolic risks and lost productivity. Our findings partially support the hypothesis that office workers who received SLWM intervention had reduced cardiometabolic risks and productivity loss. The results of this study concur with the notion that the improvements of physical activity and sitting time are associated with reduced body weight,[3] waist circumference,[9,22,47] BP,[3] and fasting insulin[4,8] at 3 months. These positive findings of the current study even remained at 12 months. Surprisingly, few workplace interventions have focused on dual behaviors (physical activity and sitting behavior),[22,23] and even fewer have examined the effects of such programs on cardiometabolic risks.[22] Therefore, few data were available for this comparison.

The study found no significant difference between the two groups in the participants' productivity loss at 3 and 12 months. However, there were significant differences within the intervention group at 3 and 12 months. This suggests that the SLWM program might also be a benefit to office workers, especially in terms of sitting different people argue that standing instead of sitting is disturbing your focus and concentration. Previous research[23] also found positive results of the percentage of losses in health-related productivity in desk-based employees who participated in a 19-week ''sit less, move more'' workplace web-based intervention ($n = 264$). Better work performance was associated with employees being more physically active. Nonetheless, a 4-week randomized cross-over trial ($n = 28$) using sit-stand desks to reduce sitting time at work in office workers has been found to have no impact on work productivity.[48]

We did not find significant improvements in triglycerides, cholesterol, HDL-C, TC/HDL-C ratio, and LDL-C. Nevertheless, it may have clinical importance because these cardiometabolic risks did not tend to get worse with age and as participants were potentially exposed to unhealthy food temptations in obesogenic environments in modern societies in general. It is also important to understand that our intervention may be effective in either enabling healthy people to stay healthy or just keeping people from not getting worse. As evidenced by Edington,[49] ''just don't get worse'' is the first step toward improving health, and its healthcare costs (medical and pharmacy) remain the same or drop lower, just like those people change in a positive direction. Having said that, though, a large 4-year workplace-based physical activity intervention ($n = 2929$)[50] found a beneficial change in HDL-C levels among middle-aged factory employees. This study used three strategies similar to ours, including raising awareness about the benefits of physical activity, using environmental approaches and physical activity campaigns (especially walking) with the pedometer provided. Another study[51] focused on reducing sitting time using sit-stand workstations among office workers was able to show a decrease in TC, but not in triglycerides, glucose, systolic, and diastolic BP at 8 weeks.

The exception to the ''protection'' finding was in the increase in glucose. Because comparison participants also had an increase in glucose, it is possible that other negative outcomes such as dietary behavior, not measured in this study, might have occurred and could have interfered with the participants' blood biochemistry data or physical activity behavior. Actually, we did not attempt to encourage participants to resist food temptations in the environment during the intervention and maintenance phase. Also, it is likely due to the holiday effects of year-end company dinners (during the 3-month measure) and Father's Day feast (1 to 2 days and 3 to 4 days before the 12-month measure for the intervention and comparison group, respectively). Thus, the results for both groups might reflect normal changes. However, it seems as though the SLWM intervention protected against diet-induced insulin resistance, while the comparison group significantly increased their insulin from baseline to 3 and 12 months.

Participation in the comparison group also produced significant improvements in self-regulation, self-efficacy for reducing sitting, systolic BP, diastolic BP, and cholesterol from baseline to 12 months. A possible explanation, as previously described,[28] three monthly newsletters and three cardiometabolic risk assessments were also provided to the comparison group. Personal assessment reports might provide all participants with an evaluation of their cardiometabolic risks to help them identify their potential health problems that need immediate attention. Therefore, cardiometabolic risk assessments may not only serve as a screening tool but also as a motivational tool to motivate and encourage participants to strive for a more physically active and healthier lifestyle. By only receiving educational information and personal health reports, the comparison group could gain benefits, particularly in enhancing self-regulation skills and self-efficacy for reducing sitting and decreasing systolic BP, diastolic BP, and cholesterol.

### Strengths, Limitations, and Future Research

The study has several strengths. First, low attrition rates; 1.98% at 3 months and 1.01% at 12 months. Second, the study developed and used the intervention protocol for consistent delivery of the intervention. Third, the outcome data were analyzed using an intention-to-treat approach. Finally, the greatest strength of this study is the use of objective measures of cardiometabolic biomarkers.

There are several limitations to the present study. First, many participants enrolled with an interest in promoting their health and/or physical activity (findings from a process evaluation) and thus were potentially already motivated to make health-related behavioral changes. However, a randomized controlled trial may be especially difficult to implement in the workplace. Second, self-reported data were used, and social desirability might have affected reporting. In particular, a major drawback to the use of self-reported measures of movement behaviors might be one reason why we found not stronger effects of the intervention to standing and sitting outcomes. Therefore, future studies should consider using objective measures such as accelerometers to measure physical activity and sedentary behaviors. Third, possible confounding factors (eg, dietary behaviors) that might account for the observed results could not be ruled out with reasonable confidence. Future studies should control for potential dietary confounding variables to better understand the intervention effects. Fourth, this study only monitored the office workers up to 12 months. Future studies should evaluate the effectiveness of the SLWM workplace intervention over a longer period (eg, 24 to 36 months) to specifically examine the longer term effects on physical activity, sitting time, cardiometabolic risks, and lost productivity. Moreover, a longer-duration intervention may be needed to ascertain the intensity and length of support required to sustain the recommended levels of physical activity and breaking up prolonged sitting time. Finally, this study did not consider the cost of the intervention. Future studies could conduct cost-effectiveness analyses of the SLWM intervention.

## CONCLUSION

This study was the first of its kind to examine the main effects of a SLWM workplace intervention on improving physical activity, sitting behavior, cardiometabolic risks, and lost productivity for office workers in an Asian workplace setting. The findings suggest that SLWM workplace intervention is feasible and effective in increasing walking for physical activity and reducing weight, waist circumference, diastolic BP and insulin, and in enhancing self-regulation for sitting less and moving more, relative to the usual care. This study extends our understanding on office workers' perceptions, self-regulation, and maintenance of the targeted behaviors, cardiometabolic health, and work productivity in the SLWM workplace intervention. The findings of this study could be applied to desk-based office workers in other workplaces, and the proposed SLWM workplace intervention could be implemented as organizational routines in occupational health practice. We recommend future studies include more booster interventions and longer follow-up periods to determine the longer-term effects of the SLWM workplace intervention. Future research could also evaluate the cost-effectiveness of such programs.

## REFERENCES


1. Tudor-Locke C, Leonardi C, Johnson WD, Katzmarzyk PT. Time spent in physical activity and sedentary behaviors on the working day: the American time use survey. *J Occup Environ Med*. 2011;53:1382–1387.
2. Wen CP, Wai JP, Tsai MK, et al. Minimum amount of physical activity for reduced mortality and extended life expectancy: a prospective cohort study. *Lancet*. 2011;378:1244–1253.
3. U.S. Department of Health and Human Services. 2008 Physical Activity Guidelines for Americans. 2008. Available at: http://www.health.gov/PAGuidelines/pdf/paguide.pdf. Accessed March 6, 2009.
4. Brocklebank LA, Falconer CL, Page AS, Perry R, Cooper AR. Accelerometer-measured sedentary time and cardiometabolic biomarkers: a systematic review. *Prev Med*. 2015;76:92–102.
5. de Rezende LF, Rodrigues Lopes M, Rey-Lopez JP, Matsudo VK, Luiz Odo C. Sedentary behavior and health outcomes: an overview of systematic reviews. *PLoS One*. 2014;9:e105620.
6. Dunstan DW, Howard B, Healy GN, Owen N. Too much sitting: a health hazard. *Diabetes Res Clin Pract*. 2012;97:368–376.
7. Hamilton MT, Hamilton DG, Zderic TW. Role of low energy expenditure and sitting in obesity, metabolic syndrome, type 2 diabetes, and cardiovascular disease. *Diabetes*. 2007;56:2655–2667.
8. Hamilton MT, Hamilton DG, Zderic TW. Sedentary behavior as a mediator of type 2 diabetes. *Med Sport Sci*. 2014;60:11–26.
9. Wijndaele K, Orrow G, Ekelund U, et al. Increasing objectively measured sedentary time increases clustered cardiometabolic risk: a 6 year analysis of the ProActive study. *Diabetologia*. 2014;57:305–312.
10. Owen N, Healy GN, Matthews CE, Dunstan DW. Too much sitting: the population health science of sedentary behavior. *Exerc Sport Sci Rev*. 2010;38:105–113.
11. Pate RR, O'Neill JR, Lobelo F. The evolving definition of "sedentary". *Exerc Sport Sci Rev*. 2008;36:173–178.
12. Zhou Z, Xi Y, Zhang F, et al. Sedentary behavior predicts changes in cardiometabolic risk in professional workers: a one-year prospective study. *J Occup Environ Med*. 2016;58:e117–e123.
13. Chastin SF, Egerton T, Leask C, Stamatakis E. Meta-analysis of the relationship between breaks in sedentary behavior and cardiometabolic health. *Obesity (Silver Spring Md)*. 2015;23:1800–1810.
14. Dempsey PC, Owen N, Yates TE, Kingwell BA, Dunstan DW. Sitting less and moving more: Improved glycaemic control for type 2 diabetes prevention and management. *Curr Diab Rep*. 2016;16:114.
15. Dempsey PC, Grace MS, Dunstan DW. Adding exercise or subtracting sitting time for glycaemic control: where do we stand? *Diabetologia*. 2017;60: 390–394.
16. Benatti FB, Ried-Larsen M. The effects of breaking up prolonged sitting time: a review of experimental studies. *Med Sci Sports Exerc*. 2015;47: 2053–2061.
17. Healy GN, Dunstan DW, Salmon J, et al. Breaks in sedentary time: beneficial associations with metabolic risk. *Diabetes Care*. 2008;31:661–666.
18. Buckley JP, Hedge A, Yates T, et al. The sedentary office: an expert statement on the growing case for change towards better health and productivity. *Br J Sports Med*. 2015;49:1357–1362.
19. Chu AH, Ng SH, Tan CS, Win AM, Koh D, Muller-Riemenschneider F. A systematic review and meta-analysis of workplace intervention strategies to reduce sedentary time in white-collar workers. *Obes Rev*. 2016;17:467–481.
20. Commissaris DA, Huysmans MA, Mathiassen SE, Srinivasan D, Koppes L, Hendriksen IJ. Interventions to reduce sedentary behavior and increase physical activity during productive work: a systematic review. *Scand J Work Environ Health*. 2016;42:181–191.
21. MacEwen BT, MacDonald DJ, Burr JF. A systematic review of standing and treadmill desks in the workplace. *Prev Med*. 2015;70:50–58.


 

22. Puig-Ribera A, Bort-Roig J, Gonzalez-Suarez AM, et al. Patterns of impact resulting from a 'sit less, move more' web-based program in sedentary office employees. *PLoS One*. 2015;10:e0122474.
23. Puig-Ribera A, Bort-Roig J, Gine-Garriga M, et al. Impact of a workplace 'sit less, move more' program on efficiency-related outcomes of office employees. *BMC Public Health*. 2017;17:455.
24. Lin YP, McCullagh MC, Kao TS, Larson JL. An integrative review: work environment factors associated with physical activity among white-collar workers. *West J Nurs Res*. 2014;36:262–283.
25. Dishman RK, DeJoy DM, Wilson MG, Vandenberg RJ. Move to improve: a randomized workplace trial to increase physical activity. *Am J Prev Med*. 2009;36:133–141.
26. Bandura A. Self-efficacy: toward a unifying theory of behavioral change. *Psychol Rev*. 1977;84:191–215.
27. Bandura A. Social cognitive theory of self-regulation. *Organ Behav Hum Decis Process*. 1991;50:248–287.
28. Lin YP, Lin CC, Chen MM, Lee KC. Short-term efficacy of a "sit less, walk more" workplace intervention on improving cardiometabolic health and work productivity in office workers. *J Occup Environ Med*. 2017;59:327–334.
29. Elashoff JD. nQuery Advisor® Version 7.0 User's Guide. 2007. Available at: http://www.statsols.com/wp-content/uploads/2013/10/nQ70_version2_manual.pdf. Accessed August 5, 2014.
30. McLeroy KR, Bibeau D, Steckler A, Glanz K. An ecological perspective on health promotion programs. *Health Educ Q*. 1988;15:351–377.
31. American College of Sports Medicine. ACSM Information on...Reducing Sedentary Behaviors: Sitting Less and Moving More. 2011. Available at: https://www.acsm.org/docs/brochures/reducing-sedentary-behaviors-sitting-less-and-moving-more.pdf. Accessed March 3, 2015.
32. Lin YP, Kao TS, McCullagh MC, Edington DW, Larson JL. Translation and psychometric properties of the Chinese version of the perceived workplace environment scale in Taiwanese information technology professionals. *J Occup Health*. 2012;54:223–231.
33. Prodaniuk TR, Plotnikoff RC, Spence JC, Wilson PM. The influence of self-efficacy and outcome expectations on the relationship between perceived environment and physical activity in the workplace. *Int J Behav Nutr Phys Act*. 2004;1:7.
34. Kao YH, Lu CM, Huang YC. Impact of a transtheoretical model on the psychosocial factors affecting exercise among workers. *J Nurs Res*. 2002; 10:303–310.
35. Dunstan DW, Wiesner G, Eakin EG, et al. Reducing office workers' sitting time: rationale and study design for the Stand Up Victoria cluster randomized trial. *BMC Public Health*. 2013;13:1057.
36. Polit DF, Beck CT. The content validity index: are you sure you know what's being reported? Critique and recommendations. *Res Nurs Health*. 2006;29: 489–497.
37. Flaherty JA, Gaviria FM, Pathak D, et al. Developing instruments for cross-cultural psychiatric research. *J Nerv Ment Dis*. 1988;176:257–263.
38. Taiwan Health Promotion Administration. International Physical Activity Questionnaire Taiwan version: short form. 2012. Available at: http://www.hpa.gov.tw/BHPNet/Web/HealthTopic/Topic.aspx?id=201109290003. Accessed August 1, 2014.
39. Craig CL, Marshall AL, Sjostrom M, et al. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc*. 2003;35:1381–1395.
40. Chau JY, Van Der Ploeg HP, Dunn S, Kurko J, Bauman AE. Validity of the occupational sitting and physical activity questionnaire. *Med Sci Sports Exerc*. 2012;44:118–125.
41. Lerner D, Amick 3rd BC, Rogers WH, Malspeis S, Bungay K, Cynn D. The work limitations questionnaire. *Med Care*. 2001;39:72–85.
42. Taiwan Health Promotion Administration. Criteria for Healthy Weight in Adults. 2016. Available at: https://obesity.hpa.gov.tw/TC/weight.aspx. Accessed December 16, 2017.
43. de Vries HJ, Kooiman TJ, van Ittersum MW, van Brussel M, de Groot M. Do activity monitors increase physical activity in adults with overweight or obesity? A systematic review and meta-analysis. *Obesity (Silver Spring)*. 2016;24:2078–2091.
44. Plotnikoff R, Karunamuni N. Reducing sitting time: the new workplace health priority. *Arch Environ Occup Health*. 2012;67:125–127.
45. Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am Psychol*. 2000;55: 68–78.
46. Locke EA, Latham GP. Building a practically useful theory of goal setting and task motivation. A 35-year odyssey. *Am Psychol*. 2002;57:705–717.
47. Carr LJ, Karvinen K, Peavler M, Smith R, Cangelosi K. Multicomponent intervention to reduce daily sedentary time: a randomised controlled trial. *BMJ Open*. 2013;3:e003261.
48. Dutta N, Koepp GA, Stovitz SD, Levine JA, Pereira MA. Using sit-stand workstations to decrease sedentary time in office workers: a randomized crossover trial. *Int J Environ Res Public Health*. 2014;11:6653–6665.
49. Edington DW. *Zero Trends: Health as a Serious Economic Strategy*. Ann Arbor, MI: Health Management Research Center, University of Michigan; 2009.
50. Naito M, Nakayama T, Okamura T, et al. Effect of a 4-year workplace-based physical activity intervention program on the blood lipid profiles of participating employees: the high-risk and population strategy for occupational health promotion (HIPOP-OHP) study. *Atherosclerosis*. 2008;197: 784–790.
51. Graves LEF, Murphy RC, Shepherd SO, Cabot J, Hopkins ND. Evaluation of sit-stand workstations in an office setting: a randomised controlled trial. *BMC Public Health*. 2015;15:1145.

 