Original Article

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Effects of Breaking Up Prolonged Sitting with an Office-Based Exercise Program on Sitting Time, Physical Activity, Musculoskeletal Discomfort, and Stress in Office Workers: A Randomized Controlled Trial

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Abstract:

Objective: Prolonged sitting in office workplaces increases the risk of non-communicable diseases, work-related musculoskeletal disorders, and psychological health issues. This study evaluated the effectiveness of an office-based exercise program delivered via break reminder software in reducing sitting time, musculoskeletal discomfort, stress, and physical activity in office workers.

Material and Methods: A two-arm, parallel-group randomized controlled trial was conducted over 8 weeks with 58 office workers randomized to an intervention (n=29) or control group (n=29). The intervention group received hourly prompts from break reminder software to perform 5-minute office-based exercises, while the control group continued routine work and received educational brochures on office ergonomics. Primary outcomes were sitting time, standing time, and physical activity (PA) level measured with ActiGraph™ accelerometers; musculoskeletal discomfort was assessed using the Borg CR-10 scale. Stress was a secondary outcome measured by the Suanprung Stress Test-20 (SPST-20). Data were analyzed using mixed-model ANOVA with intention-to-treat and per-protocol approaches.

Results: Of 38 participants completing accelerometer assessments (intervention: n=21; control: n=17), per-protocol analysis showed a significant reduction in sitting time in the intervention group (12.8 min/8-hour workday; p-value<0.001) and increased standing time (12.6 min; p-value=0.005), with significant group-by-time interactions. Neck discomfort

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decreased significantly (p-value=0.001), with improvements in the shoulders and lower back. Stress scores declined in both groups, with a greater reduction in the intervention group (11.1 points; p-value<0.001).

Conclusion: The intervention effectively reduced sitting time, musculoskeletal discomfort, and stress, supporting digital prompts and structured exercises as feasible, low-cost workplace health strategies.

Keywords: break sitting, musculoskeletal discomfort, office workers, physical activity, stress

Introduction

In industrialized countries, computer-based work dominates the modern workplace, with office workers spending the majority of their working hours sitting. Sedentary behavior (SB), defined as any waking activity characterized by energy expenditure <1.5 metabolic equivalent (MET) while in a seated or reclining posture, accounts for over 70% of office workers' working time, averaging more than 8 hours or 579 minutes per day[1]. Accelerometer-based studies have shown that office workers spend 77–82% of their workday in SB, contributing to a sedentary lifestyle and widespread physical inactivity[2]. According to the World Health Organization (WHO), adults aged 18–64 should engage in at least 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity physical activity (MVPA) per week[3]. However, many office workers are unable to meet these recommendations due to prolonged workplace sitting. Physical inactivity and excessive SB have become global public health concerns, contributing significantly to non-communicable diseases (NCDs) such as cardiovascular disease (CVD), cancer, chronic respiratory disease, and diabetes mellitus. In 2018, WHO reported that NCDs accounted for 71% of global deaths, with 85% occurring in low- and middle-income countries. In Thailand, NCDs account for 74% of all-cause mortality, with 25% of risk factors attributable to physical inactivity and SB[4].

Extensive evidence linking prolonged sitting and high sedentary time is strongly associated with work-related musculoskeletal disorders (WMSD), which affect muscles, tendons, nerves, joints, and spinal structures, leading to pain, discomfort, and fatigue, particularly in the neck, shoulders, and lower back[5]. Workplace interventions aimed at reducing sedentary time are increasingly recognized as critical strategies for improving employee health. A recent review classified workplace interventions aimed at reducing SB into three main categories: First, physical environment modifications, such as sit-stand desks; second, individual-level strategies, including walking breaks, stair use, and software reminders; and third, organizational-level approaches, such as policies promoting PA and walking meetings[6]. Evidence shows that interventions like sit-stand desks and walking breaks can reduce workplace sitting by up to 100 minutes per day[7], with additional strong evidence supporting interventions that achieve a clinically meaningful reduction in occupational sitting time of at least 30 minutes per day[8]; however, their health effects, feasibility, and sustainability remain mixed, particularly in real-world office settings. Various break strategies, such as stretching, strengthening, postural exercises, or intermittent standing bouts, have been tested to reduce musculoskeletal (MS) discomfort outcomes[9]. And short, frequent breaks (1–2 minutes every 30 minutes) appear more effective than longer breaks (15 minutes twice daily) in reducing MS discomfort without impairing work productivity. However, microbreaks can also disrupt workflow and may be impractical in busy offices[10].

Emerging evidence suggests that integrating office-based exercises into sitting breaks may provide additional health benefits; however, the findings remain inconsistent[9-11]. Computer-based prompting software, known as point-of-choice (PoC) interventions, offers a promising, low-cost strategy to deliver break reminders and encourage workers to reduce prolonged sitting[12]. Despite their potential, few randomized controlled trials (RCTs) have investigated the combined effects of office-based exercise programs and digital prompts on sitting time, PA, and MS health in real-world office environments. To address these gaps, this study evaluated the effectiveness of an office-based exercise program integrated with break reminder software in reducing workplace sitting time, increasing physical activity levels, and improving musculoskeletal discomfort and stress among office workers over an 8-week intervention period, comparing outcomes between the intervention and control groups.

Material and Methods

Study design and setting

This two-arm, parallel-group randomized controlled trial (RCT) was conducted at a national petroleum company in Bangkok, Thailand, from September 2022 to June 2023. Data were collected at baseline and post-intervention with an 8-week follow-up. The Consolidated Standards of Reporting Trials (CONSORT) guidelines[13] were followed throughout the study (Figure 1).

Participants

Office workers aged 20–59 years, employed full-time for ≥2 years, who worked with a computer ≥4 hours/day, were physically inactive (<150 min/week MVPA), and reported MS symptoms in the past three months were recruited. Exclusion criteria included acute illness, chronic MS injury, severe chronic diseases, pregnancy, disabilities, and contraindications per the Physical Activity Readiness Questionnaire (PAR-Q)[14]. Interested employees were screened using the Online Self-report Questionnaire on Computer Work-related Exposure (OSCWE)[15]. Eligible participants underwent interviews on work-related characteristics and a physical examination assessing MS discomfort by licensed physical therapists. Those meeting the criteria provided written informed consent and completed baseline assessments before randomization.

Randomization and blinding

Participants were randomly assigned to intervention or control groups using computer-generated randomization (www.randomizer.org) with a simple random sampling method. Due to the intervention's nature, participants and assessors were not blinded. However, outcome assessors and data analysts were blinded to group allocation to minimize bias.

Procedure

At baseline, demographic and health data (weight, height, body mass index [BMI]), MS discomfort, and stress) were collected. Participants wore an ActiGraph™ wGT3X-BT accelerometer (ActiGraph™, Pensacola, FL, USA) for seven consecutive days to measure PA and sitting time. Devices were worn at the waist level for 8–10 hours per day, with non-wear periods recorded in logbooks. During the 8-week intervention, participants continued their regular work routine. The intervention group's computers were equipped with break reminder software prompting a 5-minute break after every 60 minutes of sitting. At week 8, participants wore accelerometers again using the same protocol. All outcomes were reassessed in weeks 9–10 by the same assessors.

Intervention

Participants in the intervention group had the break reminder software installed in their personal computers, and it was activated to prompt a 5-minute break after every 60 minutes of continuous sitting. The software displayed

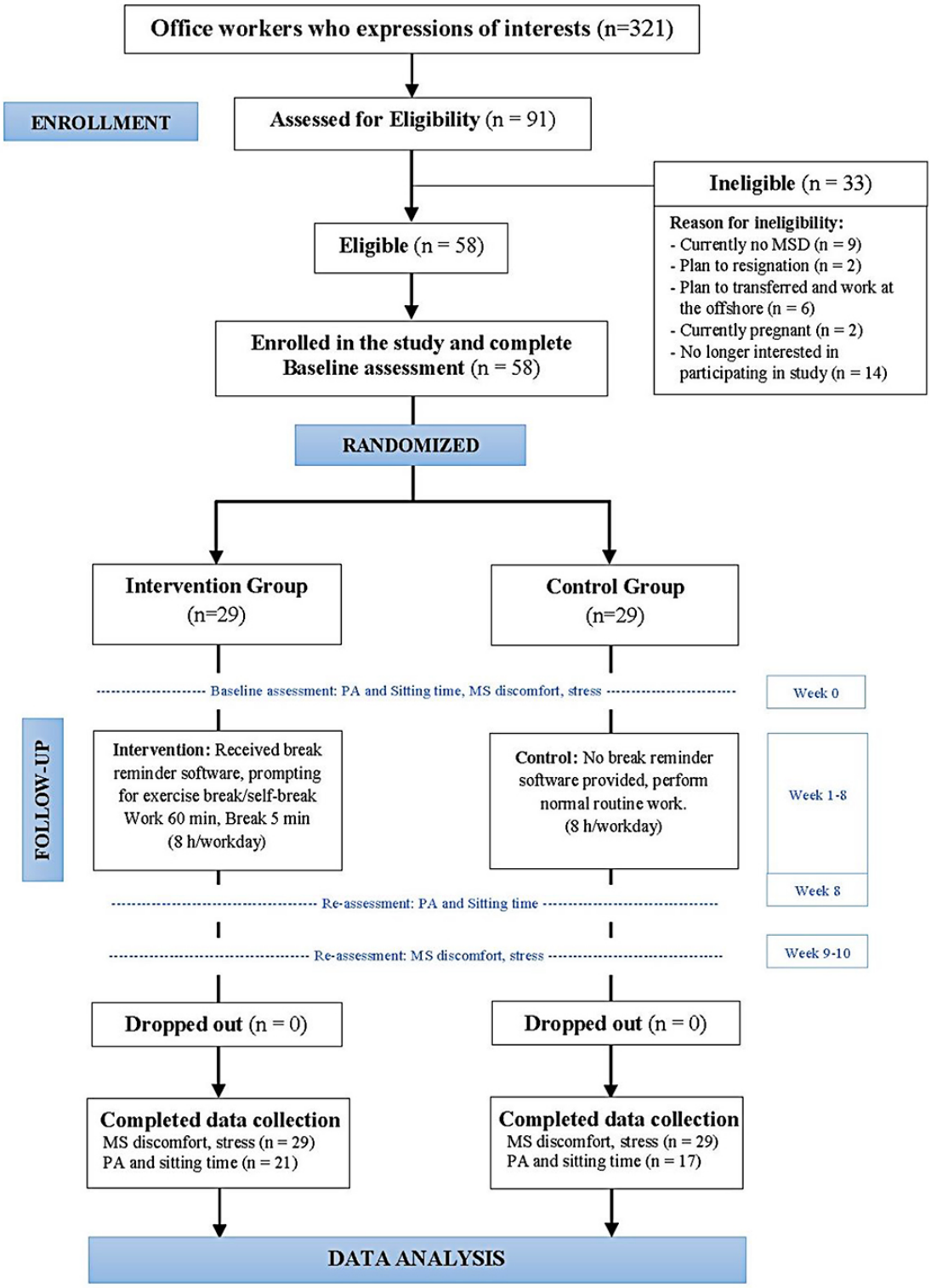


Figure 1 CONSORT flow chart of the study

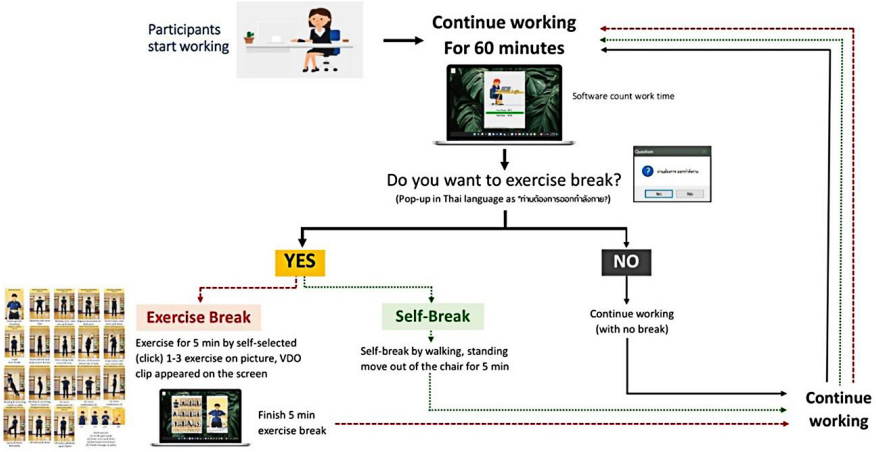
a pop-up every hour, offering three options: "exercise," "self-break," and "no break." Selecting "exercise" led to a menu of 19 office-based exercises (Figure 2, B), with a short video clip, including active stretching, nerve mobilization, breathing, mobility/stability, strengthening, and sensory stimulation exercises. Each session lasted for 5 minutes, with exercises repeated at least 10 times or held for 10–20 seconds. Selecting "self-break" instructed participants to leave their chair and walk or stand, while "no break" allowed for the continuation of work without any break (Figure 2, A). The software reset after each choice and recorded adherence to the intervention.

Control group

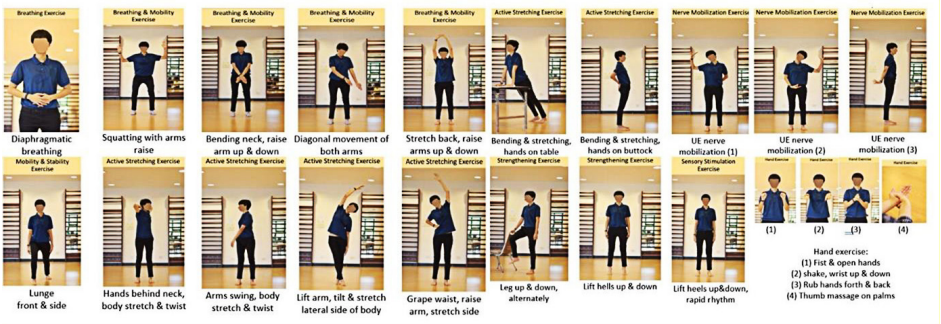
Control participants continued their routine work without software prompts. They received brochures on self-management for office workers, office ergonomics, and general exercises for office workers.

Outcome measures

The primary outcomes were PA level and sitting time, and MS discomfort, with stress as a secondary outcome. Assessments were conducted at baseline and after the 8-week intervention.



(A) Working system of the vreak reminder software with exercise application



(B) 19 office-based exercises in the break reminder software

Figure 2 Break reminder application with office-based exercise program. (A) Working system of the break reminder software with exercise application, (B) 19 office-based exercises in the software

Physical activity and sitting time

PA and sitting time were objectively measured using the ActiGraph, worn on the waist for 8-10 hours for five working days. Device removals were recorded in a logbook to validate wear-time. Data were processed into 60-second epochs using ActiLife software (version 6), and PA intensity was classified using Freedson's cut-points into SB, low physical activity (LPA), moderate physical activity (MPA), moderate-to-vigorous physical activity (MVPA)[16], and no VPA was detected. Sitting and standing time were extracted from the ActiLife software inclinometer function based on self-reported work hours (excluding lunch break). Valid workday (defined as Monday to Friday, excluding public holidays and leave) required a minimum of 3-5 days of accelerometer data covering at least 8 hours per day.

Musculoskeletal discomfort

MS discomfort was evaluated using the OSCWE questionnaire (physical health domain)[15], which included a diagram of nine body regions adapted from the Nordic Musculoskeletal Questionnaire (NMQ)[17]. Participants rated the intensity of discomfort on a Borg CR-10 scale (0=no discomfort, 10=extreme discomfort) for MS symptoms experiences in the past seven days.

Stress

Stress was assessed with the Suanprung Stress Test-20 (SPST-20), a validated 20-item tool using a 5-point Likert scale (1=no stress, 5=severe/high stress) and total score range of 0-100. Scores were categorized as normal stress (≤24), moderate stress (25–42), and high to severe stress (≥43)[18]. Internal consistency of the SPST-20 has been demonstrated with a Cronbach's alpha of 0.7[19].

Adherence

Adherence to the intervention was assessed using the software-based daily activity logs, coded as full adherence (participants performed an exercise break or self-break by clicking the exercise or self-break option with at least one break totalling ≥5 minutes per 8-hour workday) and no adherence (participants clicking "no break" or no data being recorded in the software).

Sample size

Sample size estimation was conducted using G*Power version 3.1.9.7, with the primary outcome being the change in sitting time. Parameters were drawn from a study by Mantzari et al.[20], assuming a mean difference of 63 minutes, S.D. of 104.5, α=0.05, and power=0.80. Allowing for a 10% dropout rate, the required sample size was 34 per group, totalling 68 participants.

Statistical analysis

Data were analyzed using Statistical Package for the Social Science (SPSS) version 23.0 (IBM Corp, Armonk, NY, USA), with significance set at p-value<0.05. Normality was assessed using the Shapiro-Wilk test. Continuous variables were reported as mean± standard deviation (S.D.), and categorical variables as frequencies and percentages. Baseline characteristics were compared using t-tests or chi-square tests as appropriate. A 2×2 mixed-model ANOVA was used to examine the main effects of group (between-subjects), time (within-subjects), and group-by-time interaction, which indicates whether the intervention had a differential effect over time compared to the control group. Mauchly's test of sphericity was used to verify sphericity assumptions, with Greenhouse-Geisser corrections applied when violated. Outcome variables including physical activity, sitting and standing time, MS discomfort, and stress were analyzed for both between-group and within-group comparisons at baseline and after the 8-week intervention. Significant interaction effects were further explored using paired t-tests with Bonferroni correction to explore changes within groups and differences between groups at each time point. Effect sizes were calculated using partial eta-squared (ηp^2), based on Bakeman's guidelines[21]. Missing data were

addressed using expectation-maximization (EM) single imputation when data were missing completely at random; otherwise, multiple imputation was applied. Analyses were conducted using both intention-to-treat (ITT) and per-protocol (PP) approaches.

Results

Demographic and characteristics of participants

Of 321 office workers expressing interest, 91 underwent eligibility screening. Thirty-three were excluded (Figure 1), leaving 58 participants who completed baseline and 8-week assessments for MS discomfort and stress. For accelerometer-based PA outcomes, 21 participants in the intervention group and 17 in the control group completed follow-up.

Baseline characteristics

The baseline characteristics of the participants (Tables 1 and 2), including continuous and categorical variables, were comparable between the intervention and control groups, confirming successful randomization (all p-values>0.05). Table 1 presents the continuous variables. The mean participant age was 38.5 years (S.D.±8.2), with an average BMI of 23.8 kg/m^2. On average, participants reported spending 7.7 hours/day sitting at work and 8.7 hours/day on computer tasks, with an average work experience of 11.8 years. Adherence to the intervention was 55.2%, with hand exercises, active stretching, and diaphragmatic breathing among the most frequently performed activities.

Table 2 presents the categorical variables. Overall, the sample consisted primarily of females (65.5%), and most participants were single (58.6%). A significant portion of participants (53.5%) reported having a high income (>100,001 Thai baht/month), and 67.2% reported frequently changing positions at work. There were no statistically significant differences in any demographic, work-related, or lifestyle factor between the two randomized groups at baseline, ensuring the groups were well-balanced prior to the intervention.

Physical activity and sitting time

Per-protocol analysis (Table 3) showed the intervention group reduced sitting time by 12.8 minutes per 8-hour workday (p-value<0.001) and increased standing time by 12.6 minutes (p-value=0.005), with

Table 1 Baseline characteristics of participants (continuous variables)

Variables	Baseline characteristics			p-value
	Overall (n=58)	Control (n=29)	Intervention (n=29)	
Demographic and work-related characteristics				
Age (years)	38.5 (±8.2)	38.6 (±8.1)	38.4 (±8.4)	0.91
BMI (kg/m^2)	23.8 (±4.4)	24.3 (±4.1)	23.3 (±4.7)	0.39
Work experience (year)	11.8 (±5.7)	12.1 (±5.7)	11.4 (±5.8)	0.65
Sitting time at work (h/day)	7.7 (±1.3)	7.7 (±1.5)	7.6 (±1.2)	0.77
Time use computer at work (h/day)	8.7 (±1.5)	8.7 (±1.5)	8.8 (±1.6)	0.74
Break frequency at work (time)	2.4 (±1.3)	2.4 (±1.4)	2.3 (±1.3)	0.70
Sleep time/day (h/day)	6.2 (±0.9)	6.0 (±0.8)	6.41 (±0.9)	0.34
Time commute to work (h/day)	1.5 (±0.8)	1.6 (±0.8)	1.4 (±0.7)	0.14

Data are presented as mean (±standard deviation), kg=kilogram, cm=centimeter, h=hour, m^2=square meter, BMI=body mass index

Table 2 Baseline characteristics of participants (categorical variables)

Variables	Baseline characteristics			p-value
	Overall (n=58)	Control (n=29)	Intervention (n=29)	
Demographic characteristics				
Gender				
Male	20 (34.5)	13 (44.8)	7 (24.1)	0.08
Female	38 (65.5)	16 (55.2)	22 (75.9)	
Weight gain or loss within 2 years				
Weight gain	30 (51.7)	15 (51.7)	15 (51.7)	0.90
Weight loss	7 (12.1)	3 (10.4)	4 (13.8)	
Weight stable	21 (36.2)	11 (37.9)	10 (34.5)	
Income (Thai baht/month)				
≥50,000	9 (15.5)	4 (13.8)	5 (17.2)	0.93
50,001–100,000	18 (31.0)	9 (31.0)	9 (31.1)	
>100,001	31 (53.5)	16 (55.2)	15 (51.7)	
Marital status				
Single	34 (58.6)	20 (68.9)	14 (48.3)	0.15
Married	22 (37.9)	9 (31.1)	13 (44.8)	
Divorced/Separated	2 (3.5)	0 (0.00)	2 (6.9)	
Unhealthy lifestyle factors				
No unhealthy lifestyle	13 (22.4)	7 (24.1)	6 (20.7)	0.74
Exercise <3 times/week	21 (36.2)	11 (37.9)	10 (34.5)	
Sleep <6 hours/day	7 (12.1)	2 (6.9)	5 (17.2)	
Smoking	2 (3.4)	1 (3.4)	1 (3.4)	
Alcohol consumption	1 (1.7)	0 (0.0)	1 (3.4)	
less exercise and sleep*	14 (24.1)	8 (27.6)	6 (20.7)	
Leisure time using a computer				
Yes	38 (65.5)	18 (62.1)	20 (68.9)	0.39
No	20 (34.5)	11 (37.9)	9 (31.1)	
Break activity in the office workplace				
No break	1 (1.7)	1 (3.5)	0 (0.0)	0.60
Seated–using computer	1 (1.7)	1 (3.5)	0 (0.0)	
Seated–using a smartphone	14 (24.1)	8 (27.6)	6 (20.7)	
Seated–other activity	5 (8.6)	2 (6.9)	3 (10.4)	
Standing and walking	37 (63.8)	17 (58.6)	20 (68.9)	
Break during workhour				
Lunch break only	42 (72.4)	21 (72.4)	21 (72.4)	0.61
Lunch break and self–break	16 (27.6)	8 (27.6)	8 (27.6)	
Frequently change position at work				
Yes	39 (67.2)	18 (62.1)	21 (72.4)	0.56
No	19 (32.8)	11 (37.9)	8 (27.6)	
Commute mode from home to work				
Bicycle/motorcycle	3 (5.2)	0 (0.0)	3 (10.3)	0.17
Personal car and staff shuttle bus	40 (68.9)	22 (75.9)	18 (62.1)	
Public transportation	15 (25.9)	7 (24.1)	8 (27.6)	

Data are presented as frequency (percentage; %).
*Participants who reported both <3 times/week and sleep <6 hours/day

Table 3 Per-protocol analysis compares the intervention group (n=21) and control group (n=17). Descriptive data of PA and sitting time with statistical significance and effect size of the group-by-time interaction and within-group change score at the follow-up period.

Physical activity	Baseline	Week 8	Within group		Between group		Group by time interaction	
			Mean diff (post-pre)	p-value	p-value	Effect size (ηp^2)	p-value	Effect size (ηp^2)
SB (min)								
Control	392.9 (±49.8)	378.1 (±64.5)	-14.8	0.281	0.094	0.076	0.926	0.000
Intervention	436.6 (±38.4)	420.1 (±61.2)	-16.5	0.183				
LPA (min)								
Control	100.5 (±41.3)	86.4 (±42.1)	-14.1	0.153	0.789	0.002	0.065	0.091
Intervention	91.3 (±29.2)	101.9 (±46.8)	10.6	0.230				
MVPA (min)								
Control	10.4 (±5.2)	11.5 (±7.5)	1.1	0.469	0.274	0.033	0.983	0.000
Intervention	7.1 (±6.2)	8.3 (±5.5)	1.2	0.403				
Walking Step count								
Control	5193 (±2223)	3974 (±1650)	-1219	**0.003***	**0.005***	0.197	0.079	0.083
Intervention	4715 (±1664)	4418 (±1330)	-297	0.390				
Daily position								
Sitting time (min)								
Control	348.2 (±13.8)	351.5 (±21.9)	3.3	0.372	0.064	0.092	**0.002***	0.228
Intervention	350.3 (±18.2)	337.5 (±15.0)	-12.8	**<0.001***				
Standing time (min)								
Control	128.5 (±26.2)	117.2 (±21.4)	-11.3	**0.022***	0.826	0.001	**0.001***	0.284
Intervention	122.5 (±18.7)	135.1 (±16.4)	12.6	**0.005***				
Lying (min)								
Control	8.2 (±6.1)	8.8 (±4.7)	0.6	0.806	0.427	0.018	0.665	0.005
Intervention	6.9 (±4.4)	9.0 (±10.8)	2.0	0.360				

Data are provided as means (±standard deviation). Effect size was used Partial Eta Squared (ηp^2). SB=sedentary behavior, LPA=low-physical activity, MVPA=moderate-to-vigorous physical activity, min=minute per 8 hour/day

significant group-by-time interactions (p-value=0.002). No significant changes were observed in SB, LPA, or MVPA. Walking step counts significantly declined between groups (p-value=0.005).

Musculoskeletal discomfort

Intention-to-Treat (ITT) analysis (Table 4) illustrates reductions in MS discomfort. Neck discomfort significantly decreased in the intervention group (p-value=0.001) but remained unchanged in controls, with significant between-group (p-value=0.020) and group-by-time effects. Shoulder discomfort also showed significant between-group differences (p-value=0.046), though interaction effects were not significant. Lower back discomfort declined in both groups but more markedly in the intervention group (2.41 to 1.62), with a significant between-group effect (p-value=0.005). No significant changes were observed in other body regions. No adverse events were reported during the study.

Stress

Stress scores (SPST-20) (Table 4) decreased

significantly in the intervention group by 11.1 points (43.5 to 32.3, p-value<0.001), compared to a smaller reduction in the control group. However, no significant group-by-time interaction was found. In the ITT analysis, stress scores decreased in both groups over 8 weeks. The intervention group showed a greater reduction (43.5 to 32.4) than controls (50.1 to 43.4), with a significant between-group effect but no significant interaction.

Table 4 Intention-to-treat analysis compares the intervention group (n=29) and control group (n=29). Descriptive data of musculoskeletal discomfort and stress with statistical significance and effect size of the group-by-time interaction and within-group change score at the follow-up period

MS discomfort and stress	Baseline	Week 8	Within group		Between group		Group by time interaction	
			Mean diff (post-pre)	p-value	p-value	Effect size (ηp^2)	p-value	Effect size (ηp^2)
Musculoskeletal discomfort (Borg CR-10)								
Neck								
Control	3.62 (±2.93)	3.62 (±2.58)	0.00	1.000	**0.020***	0.092	**0.020***	0.092
Intervention	3.66 (±3.01)	2.41 (±2.19)	-1.24	**0.001***				
Shoulder								
Control	2.21 (±2.9)	1.72 (±2.5)	-0.48	0.155	**0.046***	0.069	1.000	0.000
Intervention	2.34 (±2.6)	1.86 (±2.1)	-0.48	0.155				
Upper Back								
Control	1.14 (±2.19)	1.21 (±2.25)	0.06	0.832	0.940	0.000	0.708	0.003
Intervention	1.41 (±2.29)	1.31 (±1.96)	-0.10	0.751				
Lower Back								
Control	3.17 (±2.97)	2.55 (±3.06)	-0.62	0.078	**0.005***	0.130	0.725	0.002
Intervention	2.41 (±2.61)	1.62 (±1.65)	-0.79	**0.025***				
Elbow								
Control	0.10 (±0.55)	0.03(±0.18)	-0.06	0.456	0.293	0.020	1.000	0.000
Intervention	0.07 (±0.37)	0.00 (±0.00)	0.06	0.456				
Wrist								
Control	0.62 (±2.09)	0.45 (±1.72)	-0.17	0.621	0.145	0.037	0.443	0.011
Intervention	0.52 (±1.74)	0.00 (±0.00)	-0.55	0.117				
Hip/Thigh								
Control	0.24 (±0.98)	0.34 (±1.28)	0.10	0.728	0.116	0.099	0.327	0.017
Intervention	0.76 (±1.76)	0.24 (±0.98)	-0.51	0.086				
Knee								
Control	0.62 (±1.69)	0.21 (±0.9)	-0.41	0.163	0.101	0.047	0.740	0.002
Intervention	0.31 (±1.16)	0.03 (±0.2)	-0.27	0.349				
Foot								
Control	0.17 (±0.65)	0.17 (±0.92)	0.00	1.000	0.536	0.007	0.536	0.007
Intervention	0.17 (±0.92)	0.00 (±0.00)	-0.17	0.382				
Stress (SPST-20)								
Control	50.1 (±14.4)	43.4 (±14.1)	-6.58	**0.001***	**<0.001***	0.462	0.174	0.033
Intervention	43.5 (±8.1)	32.4 (±7.3)	-11.10	**<0.001***				

Data are provided as means (±standard deviation), Effect size was used Partial Eta Squared (ηp^2). SPST-20=Stress score of Suanprung Stress test-20 items.
*=p-value<0.05

Discussion

This study provides new evidence that low-cost, scalable break reminder software combined with office-based exercises can reduce workplace sitting time, musculoskeletal discomfort, and stress in real-world office settings. Participants preferred simple, low-intensity exercises such as hand movements, active stretching, breathing, and exercises that could be performed discreetly. In contrast, larger or overhead movements were often ignored because of co-worker visibility concerns. Due to participants being randomly assigned across departments, some performed the exercises alone, which may have increased self-consciousness. These findings are consistent with a recent systematic review[22], which reported that workplace PA programs lacking organizational or peer support often face adherence challenges. Some participants in our study opted for walking breaks rather than performing exercises. These results highlight the need to consider social and environmental factors when designing interventions. Future programs may benefit from integrating team-based exercises, private activity spaces, and managerial support to improve adherence and feasibility. Our findings showed that the intervention effectively reduced sitting time by 12.8 min per 8-hour workday. This aligns with prior studies showing that digital prompts can reduce sedentary time in office workers[23]. For example, multicomponent work-based interventions using digital reminders have reduced sitting time by an average of 71 minutes after one month and 48 minutes after three months per an 8-hr workday[24], while a recent systematic review and meta-analysis reported that multicomponent interventions using digital reminders reduced sitting time by an average of 29.9 minutes per 8-hr workday[25]. Similarly, a recent systematic review by Wang et al. found that workplace interventions using motivational strategies, such as prompts, feedback, and social competition, reduced sitting time by 27.9 minutes per day. Subgroup analyses revealed that interventions promoting standing reduced sitting by 12.2 minutes, and those promoting PA reduced it by 20.1 minutes[11]. Although the reduction in sitting time observed in our study was modest compared to previous findings, it remains meaningful. Even small, sustained reductions in sedentary time may lead to long-term health benefits. Moreover, our findings support previous research showing that even LPA performed during work hours can improve overall movement patterns throughout the workday, interrupting sedentary bouts[12, 26-28]. However, reducing sitting time alone may not be enough to increase overall PA levels, suggesting that additional strategies are needed to promote active behavior in the workplace.

A key strength of this study was the reduction in musculoskeletal discomfort, particularly in the neck, shoulders, and lower back: regions commonly affected by prolonged sitting work. These findings support previous research linking active movement breaks during the workday that can alleviate these symptoms, with strategies to reduce sitting time associated with lower rates of neck and back pain among office workers[29]. Another study found that multicomponent interventions, NEXpro, including neck-specific exercises, significantly reduced neck pain-related work productivity loss. Our study also found a significant reduction in neck discomfort, with more limited improvements in other areas, suggesting that targeted interventions may be more effective for addressing specific regions[30]. Another study of workplace exercise reported broader improvements across multiple body areas following a 6-month workplace exercise program, implying that longer interventions may offer more sustained musculoskeletal health benefits.[31]

The observed reductions in discomfort may be explained by several mechanisms described in prior research[32-34]. Prolonged static postures contribute to sustained muscle contraction and increased mechanical strain on key muscles, such as the upper trapezius, sternocleidomastoid, and erector spinae. Standing and

movement breaks can help relieve lumbar flexion, reduce static spinal load, and decompress intervertebral structures. They also enhance local blood flow and synovial fluid circulation, improving oxygen delivery and removal of metabolic waste. Consistent with these mechanisms, Gram et al. reported that neck-specific exercises reduced discomfort more effectively than general interventions[35], while Pereira et al. found similar benefits using targeted neck exercise strategies[36]. These effects may also align with the cumulative trauma theory proposed by Barr et al., which suggests that behavioral interventions promoting postural variation can disrupt microtrauma cycles and reduce inflammation[37]. In our study, the break reminder software prompted frequent postural changes, likely contributing to reduced discomfort in common affected areas.

Regarding stress, although group-by-time interaction was not significant, the intervention group showed a meaningful within-group reduction of 11.1 points, moving from high to moderate stress levels based on SPST-20 criteria[19]. This aligns with the evidence that workplace PA interventions can enhance mental well-being and stress management[38]. The WHO recognises well-being as essential for job satisfaction and productivity, emphasizing the value of stress-reducing strategies. Edwardson et al. reported modest stress improvements from multicomponent interventions combining adjustable desks and movement breaks[39]. Similarly, our findings suggest even small behavioral changes may benefit mental health. However, consistent with a previous systematic review[40] that found only two of eight workplace interventions significantly reduced stress, our results indicate that exercise breaks alone may not be enough. More comprehensive approaches may be necessary to achieve substantial stress reduction.

Limitations

Our study has several limitations. First, the reduced sample size for accelerometer-based PA outcomes and incomplete follow-up data may have limited statistical power to detect smaller effects. Second, adherence to the intervention was moderate, with approximately half of the participants engaging fully with the software prompts. These factors may limit generalizability and underscore the need for improved strategies to enhance engagement and compliance in future trials.

Conclusion

This study demonstrates that an office-based exercise intervention, delivered through break reminder software, effectively reduced workplace sitting time by an average of 12.8 minutes per 8-hour workday and improved standing time, stress, and musculoskeletal discomfort, particularly in the neck, shoulders, and lower back. The intervention was feasible, low-cost, and easy to implement, supporting its potential as a practical workplace health strategy. These findings highlight the value of integrating digital prompts and structured exercise breaks into daily office routines to reduce sedentary behavior and enhance employee well-being. Future research should evaluate long-term outcomes, strategies to sustain adherence, and the integration of ergonomic or organizational support to strengthen impact.

Conflict of interest

All authors declare that they have no conflicts of interest.

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Author contributions

Putsa B and Jalayondeja C: conceptualization, conducted the literature review, designed the study, and project administration. Jalayondeja W, Mekhora K, Bhuanatanondh P, and Jalayondeja C: advised and collected data. Anuraktam K and Kansadub T: supported the break-reminder software for the PA intervention program and software data analysis. Jalayondeja W, Mekhora K, Bhuanatanondh P, Anuraktam K, and Kansadub T: supported data collection. Putsa B and Jalayondeja C: collected and analyzed data. All authors helped to write, review, and prepare the manuscript for publication.

Ethical statement

The study was reviewed and approved by Mahidol University Central Institutional Review Board (COA No. MU-CIRB 2021/109.1805 and Protocol No. MU-CIRB 2021/189.0904) and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants. The trial was registered with the Thai Clinical Trials Registry (TCTR), TCTR ID no. TCTR20240525003.

References

1. McCrady SK, Levine JA. Sedentariness at work: how much do we really sit? Obesity (Silver Spring) 2009;17:2103–5.
2. Thorp AA, Healy GN, Winkler E, Clark BK, Gardiner PA, Owen N, et al. Prolonged sedentary time and physical activity in workplace and non-work contexts: a cross-sectional study. Int J Behav Nutr Phys Act 2012;9:128.
3. Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, et al. World Health Organization 2020 guidelines on physical activity and sedentary behavior. Br J Sports Med 2020;54:1451–62.
4. World Health Organization. Global recommendations on physical activity for health. Geneva: WHO; 2010.
5. Collins RM, Janse Van Rensburg DC, Patricios JS. Common work-related musculoskeletal strains and injuries. S Afr Fam Pract 2011;53:240–6.
6. Parry SP, Coenen P, Shrestha N, O'Sullivan PB, Maher CG, Straker LM. Workplace interventions for increasing standing or walking for decreasing musculoskeletal symptoms in sedentary workers. Cochrane Database Syst Rev 2019.
7. Shrestha N, Kukkonen-Harjula KT, Verbeek JH, Ijaz S, Hermans V, Pedisic Z. Workplace interventions for reducing sitting at work. Cochrane Database Syst Rev 2018;6.
8. Nguyen P, Le LK-D, Nguyen D, Gao L, Dunstan DW, Moodie M. The effectiveness of sedentary behavior interventions on sitting time and screen time in children and adults: an umbrella review of systematic reviews. Int J Behav Nutr Phys Act 2020;17:117.
9. Shariat A, Cleland JA, Danaee M, Kargarfard M, Sangelaji B, Tamrin SBM. Effects of stretching exercise training and ergonomic modifications on musculoskeletal discomforts in office workers: a randomized controlled trial. Braz J Phys Ther 2018;22:144–53.
10. Galinsky T, Swanson N, Sauter S, Dunkin R, Hurrell J, Schleifer L. Supplementary breaks and stretching exercises for data entry operators: a follow-up field study. Am J Ind Med 2007;50:519-27.
11. Wang C, Lu EY, Sun W, Chang JR, Tsang HWH. Effectiveness of interventions on sedentary behaviors in office workers: a systematic review and meta-analysis. Public Health 2024;230:45–51.

12. Evans RE, Fawole HO, Sheriff SA, Dall PM, Grant PM, Ryan CG. Point-of-choice prompts to reduce sitting time at work: a randomized trial. Am J Prev Med 2012;43:293–7.
13. Hopewell S, Chan AW, Collins GS, Hróbjartsson A, Moher D, Schulz KF, et al. CONSORT 2025 statement: updated guideline for reporting randomised trials. PLoS Med 2025;22.
14. Shephard RJ. PAR-Q, Canadian home fitness test and exercise screening alternatives. Sports Med 1988;5:185–95.
15. Mekhora K, Jalayondeja W, Jalayondeja C, Bhuanantanondh P, Dusadiisariyavong A, Upiriyasakul R, et al. Online self-report questionnaire on computer work-related exposure: validity and internal consistency. J Med Assoc Thai 2014;97:S80–3.
16. Freedson PS, Melanson E, Sirard J. Calibration of the computer science and applications, Inc. accelerometer. Med Sci Sports Exerc 1998;30:777–81.
17. Kuorinka I, Jonsson B, Kilbom A, Vinterberg H, Biering-Sørensen F, Andersson G, et al. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. Appl Ergon 1987;18:233–7.
18. Putsa B, Jalayondeja W, Mekhora K, Bhuanantanondh P, Jalayondeja C. Factors associated with reduced risk of musculoskeletal disorders among office workers: a cross-sectional study. BMC Public Health 2022;22:1503.
19. Mahatnirunkul S, Pumpaisanchai W, Tapanya P. Construction of Suan Prung stress test for the Thai population. Bull Suan Prung 1997;13:1–11.
20. Mantzari E, Galloway C, Wijndaele K, Brage S, Griffin SJ, Marteau TM. Impact of sit-stand desks at work on energy expenditure, sitting time and cardio-metabolic risk factors: Multiphase feasibility study with randomised controlled component. Prev Med Rep 2018;13:64-72.
21. Bakeman R. Recommended effect size statistics for repeated measures designs. Behav Res Methods 2005;37:379–84.
22. Grimaud Q, Malloggi L, Moret L, Rowe F, Fleury-Bahi G, Tripodi D. Factors for adherence to a physical activity promotion program in the workplace: a systematic review. BMC Public Health 2025;25:1827.
23. Ojo SO, Chater AM, Hewson DJ, Bailey DP. Workplace productivity, health and wellbeing: findings from a cluster randomised controlled trial of a workplace intervention to reduce sitting in office workers. J Occup Environ Med 2024;66:487-94.
24. Danquah IH, Kloster S, Holtermann A, Aadahl M, Bauman A, Ersbøll A, 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;46:128-40.
25. Parés-Salomón I, Señé-Mir AM, Martín-Bozas F, Loef B, Coffey A, Dowd KP, et al. Effectiveness of workplace interventions with digital elements to reduce sedentary behaviours in office employees: a systematic review and meta-analysis. Int J Behav Nutr Phys Act 2024;21:41.
26. Edwardson CL, Biddle SJH, Clemes SA, Davies MJ, Dunstan DW, Eborall H, et al. Effectiveness of an intervention for reducing sitting time and improving health in office workers: three arm cluster randomised controlled trial. BMJ 2022;378:e069288.
27. De Cocker K, De Bourdeaudhuij I, Cardon G, Vandelanotte C. Effectiveness of a web-based computer-tailored intervention on workplace sitting: a randomized controlled trial. J Med Internet Res 2016;18:e96.
28. Thøgersen-Ntoumani C, Quested E, Smith BS, Nicholas J, McVeigh J, Fenton SAM, et al. Feasibility and preliminary effects of a peer-led motivationally-embellished workplace walking intervention: A pilot cluster randomized trial (the START trial). Contemp Clin Trials 2020;91:105969.
29. Dzakpasu FQS, Carver A, Brakenridge CJ, Cicuttini F, Urquhart DM, Owen N, et al. Musculoskeletal pain and sedentary behaviour in occupational and non-occupational settings: a systematic review with meta-analysis. Int J Behav Nutr Phys Act 2021;18:159.
30. Aegerter AM, Deforth M, Volken T, Johnston V, Luomajoki H, Dressel H, et al. A multi-component intervention (NEXpro) reduces neck pain-related work productivity loss: a randomized controlled trial among swiss office workers. J Occup Rehabil 2023;33:288-300.
31. Karatrantou K, Gerodimos V. A comprehensive workplace exercise intervention to reduce musculoskeletal pain and improve functional capacity in office workers: a randomized controlled study. Healthcare (Basel) 2024;12:915.
32. Johnston V, Chen X, Welch A, Sjøgaard G, Comans TA, McStea M, et al. A cluster-randomized trial of workplace ergonomics and neck-specific exercise versus ergonomics and health promotion for office workers to manage neck pain - a secondary outcome analysis. BMC Musculoskelet Disord 2021;22:68.

33. Luger T, Maher CG, Rieger MA, Steinhilber B. Work-break schedules for preventing musculoskeletal sympto and disorders in healthy workers. Cochrane Database Syst Rev 2019;7:CD012886.
34. Nakphet N, Chaikumarn M, Janwantanakul P. Effect of different types of rest-break interventions on neck and shoulder muscle activity, perceived discomfort and productivity in symptomatic VDU operators: a randomized controlled trial. Int J Occup Saf Ergon 2014;20:339-53.
35. Gram B, Andersen C, Zebis MK, Bredahl T, Pedersen MT, Mortensen OS, et al. Effect of training supervision on effectiveness of strength training for reducing neck/shoulder pain and headache in office workers: cluster randomized controlled trial. Biomed Res Int 2014;2014:693013.
36. Pereira M, Comans T, Sjøgaard G, Straker L, Melloh M, O'Leary S, et al. Workplace ergonomics and neck-specific exercise versus health promotion for office worker productivity: a cluster-randomized trial. Scand J Work Environ Health 2019;45:42–52.
37. Barr AE, Barbe MF. Pathophysiological tissue changes associated with repetitive movement: a review of the evidence. Phys Ther 2002;82:173–87.
38. Abdin S, Welch RK, Byron-Daniel J, Meyrick J. The effectiveness of physical activity interventions in improving well-being across office-based workplace settings: a systematic review. Public Health 2018;160:70-6.
39. Edwardson CL, Maylor BD, Biddle SJ, Clemes SA, Cox E, Davies MJ, et al. A multicomponent intervention to reduce daily sitting time in office workers: the SMART Work & Life three-arm cluster RCT. Public Health Res 2023;11:1-229.
40. Park S, Jang MK. Associations between workplace exercise interventions and job stress reduction: a systematic review. Workplace Health Saf 2019;67:592-601.