Process Evaluation of the Physical Activity at Work (PAW) Cluster-Randomised Trial in Thailand

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Table of Contents

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Abstract

Background: An increasing number of multi-component workplace interventions are being developed to reduce sedentary time and promote physical activity among office workers. The Physical Activity at Work trial was one of these interventions, but it yielded an inconclusive effect on sedentary time after six months with a low uptake on the movement breaks, the main intervention component. The present study investigates the factors contributing to the trial's outcome.

Objective: The study evaluates the recruitment and context, implementation, and impact mechanisms of the Physical Activity at Work study.

Methods: Following the Medical Research Council guideline for process evaluation of complex interventions, this mixed-methods study aims to evaluate the PAW study's recruitment and context (how job nature and recruitment of each cluster affected the movement break participation), implementation (dose and fidelity), and mechanisms of impact (how intervention components affected movement break participations, and the facilitators and barriers of the movement breaks). Data from accelerometers, pedometers, questionnaires, on-site monitoring, and focus group discussions were used for the evaluation. Linear mixed models were employed to analyse the effects of different intervention components on the movement breaks. Subsequently, qualitative analysis of the focus group discussion provided additional insights into the relationship between intervention components.

Results: The trial implementation was satisfactory regarding dose delivery and fidelity. However, the limited uptake of the movement breaks could be attributed to 1) context-related challenges, including jobs requiring high cognitive engagement or frequent out-of-office work and meetings; 2) the absence of goal-setting aspects in the detailed design of individual and social components; 3) the lack of effective and sustainable supporting components at the environmental and organisational levels; and 4) elevated workloads in specific clusters, exacerbated during peak periods of the COVID-19 pandemic, serving as a significant barrier. On the other hand, automatic motivation, such as feeling active and relaxed, was ranked as the top facilitator to join movement breaks, followed by reflective motivation of perceived health benefits.

Conclusions: All intervention components significantly contribute to the trial outcome. Our process evaluation encompasses multiple aspects to explain the trial's findings. However, to validate all trial assumptions in future studies, the intervention's logic model must be thoroughly reconstructed and finalised. Clinical Trial: The PAW study was registered at the Thai Clinical Trials Registry (ID TCTR20200604007) on 02 June 2020.

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Abstract

Background: An increasing number of multi-component workplace interventions are being developed to reduce sedentary time and promote physical activity among office workers. The Physical Activity at Work trial was one of these interventions, but it yielded an inconclusive effect on sedentary time after six months with a low uptake on the movement breaks, the main intervention component. The present study investigates the factors contributing to the trial's outcome.

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Results: The trial implementation was satisfactory regarding dose delivery and fidelity. However, the limited uptake of the movement breaks could be attributed to 1) context-related challenges, including jobs requiring high cognitive engagement or frequent out-of-office work and meetings; 2) the absence of goal-setting aspects in the detailed design of individual and social components; 3) the lack of effective and sustainable supporting components at the environmental and organisational levels; and 4) elevated workloads in specific clusters, exacerbated during peak periods of the COVID-19 pandemic, serving as a significant barrier. On the other hand, automatic motivation, such as feeling active and relaxed, was ranked as the top facilitator to join movement breaks, followed by reflective motivation of perceived health benefits.

Conclusion: All intervention components significantly contribute to the trial outcome. Our process evaluation encompasses multiple aspects to explain the trial's findings. However, the intervention's Logic Model must be thoroughly reconstructed and finalised to validate all trial assumptions in future studies.

Funding: Thai Health Promotion Foundation
Trial registration: The PAW study was registered at the Thai Clinical Trials Registry (ID TCTR20200604007) on 02 June 2020.
Keywords: process evaluation, sedentary behaviour, physical activity, workplace

Introduction

Extensive research has examined workplace interventions to reduce sedentary behaviour and promote physical activity globally [1, 2]. Numerous interventions have yielded noteworthy results, showcasing their effectiveness, whereas some have encountered challenges in achieving desired outcomes [2-5]. A meta-analysis from 1998 concluded that workplace interventions had minimal or no impact on improving physical activity [6]. In contrast, a review published in 2003 supported workplace physical activity interventions [7]. A more recent review identified both effective and ineffective interventions, summarising that more successful interventions tended to employ pedometers, utilise Internet-based approaches, and include activities at social and environmental levels [5]. Lastly, complex or multi-component interventions emerge as the most effective workplace strategy for reducing sitting time [4], highlighting the intricate process leading to successful behavioural changes [8].

However, multi-component intervention trial reports often fail to elucidate the rationale and mechanisms behind their results, leaving readers questioning the efficacy of the interventions. Many scholars have criticised these trials as being akin to a “black box”, as the underlying reasons for their success or failure remain unknown [9]. As a result, process evaluations, which assess how interventions were implemented in practice, are essential for deciphering the implications of the results from multi-component intervention trials. These evaluations highlight aspects of the intervention that may require improvement to increase the probability of success [10, 11].

Several frameworks advocate for process evaluations to explore the context, implementation, and impact mechanisms of programs, encompassing aspects such as recruitment, reach, dose, fidelity, and challenges [9-12]. Process evaluations have become particularly relevant as they can help determine whether success or failure lies in implementation, the intervention itself, or a combination of both factors. Additionally, there is increasing acknowledgment that incorporating both qualitative and quantitative data, as well as utilising theoretical frameworks within process evaluations, plays a crucial role in promoting evidence-based practice [13]. For example, the Older People’s Exercise intervention and nursing Accommodation (OPERA) trial uses a mixed-method process evaluation to assess if the multi-component intervention changes residents’ home culture to increase physical activity and if residents engage in exercise activities. The study found no notable cultural shifts or sufficient engagement, thus explaining the trial's null results [14, 15]. Another process evaluation explored the implementation and impact mechanisms of a Park Prescription Intervention trial, revealing key mediators of intervention effects such as park physical activity levels, as well as barriers that may have weakened intervention effectiveness [16].

In Thailand, it has been reported that the majority of adults who engage in sufficient physical activity reside in rural areas, typically due to their work in the agricultural sector, whereas physical activity levels tend to be lower among office workers [17]. Numerous non-research initiatives have been launched to promote physical activity and reduce sedentary behaviour among office workers in Thai companies and organisations. The Physical Activity at Work (PAW) trial [18] marked the first comprehensive cluster-randomised trial aimed at promoting physical activity and reducing sedentary behaviour among Thai office workers. This trial

incorporated a multi-component intervention and utilised accelerometer-measured data, laying a solid foundation for physical activity research in Thailand [19]. However, the trial produced inconclusive findings, leaving critical questions unanswered regarding its underlying causes. We observed suboptimal uptake of movement breaks, the primary intervention component, and inferred that this, coupled with a low recruitment rate, may explain the absence of statistically significant outcomes [19]. Understanding these underlying reasons is essential for making necessary improvements in both research and policy. To address this, we conducted a process evaluation to investigate the factors contributing to the trial's outcome.
Following the Medical Research Council guidance for process evaluation of complex interventions [10], this mixed-methods study aims to evaluate the recruitment and context, implementation, and impact mechanisms of the PAW study. Specifically, we examine how the nature of jobs and recruitment processes within each cluster influenced participation in movement breaks (context), the overall dose and fidelity of the intervention (implementation), the effects of intervention components on participation in movement breaks, and the facilitators and barriers associated with movement breaks (mechanisms of impact).

Methods

Description of the Cluster-Randomised Trial

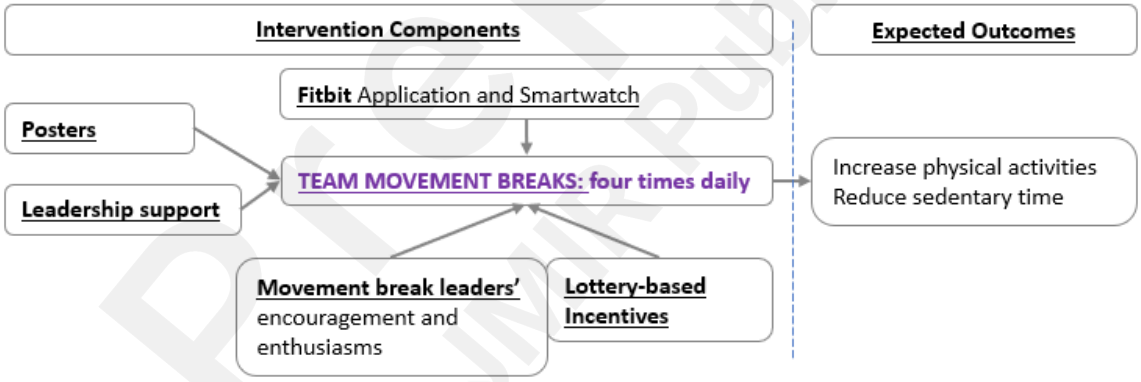
The PAW study received approval from the Ethical Review Committee for Research in Human Subjects, Ministry of Public Health (ECMOPH) (protocol number: 004-2563), in accordance with the Declaration of Helsinki, and was conducted at the Ministry of Public Health, Thailand. Detailed methodological information regarding the cluster-randomised trial was published in the protocol [20] and main results [19] manuscripts. Briefly, between July and September 2021, we recruited 282 office workers (with a mean age of 38.6 years, SD 10.4 years, and 80.9% female) from 18 offices. Following baseline data collection, participants were randomised into nine control offices (142 participants) and nine intervention offices (140 participants). The 6-month intervention took place between September 2021 and March 2022, consisting of six components across four levels, as outlined below:

- *Individual-level components* included: i) provision of a wearable device with real-time feedback (Fitbit® smartwatch, Inspire HR), ii) utilisation of a Fitbit® smartphone application, and iii) offering individual weekly lottery-based financial incentives, where one intervention-group participant who participated in at least 70% of the movement breaks within the previous week was randomly selected to receive a 500THB (US$16) reward.
- *Social-level components* included: i) team movement breaks of light-to-moderate intensity, lasting at least four minutes and occurring four times a day (alarm clocks with speakers were provided to movement break leaders to initiate sessions), serving as the primary intervention component, and ii) team-based incentives of an additional 500THB (US$16) weekly lottery reward given to the winner if at least 70% of the participants in the cluster also attended at least 70% of the movement breaks within the previous week. Alarm reminders were set at four local times: 9.30 am, 10.30 am, 2.30 pm, and 3.30 pm, and trained movement break leaders managed the starting times, songs, and movements. Participants working from home were encouraged to join sessions via web conferencing.

- *Environmental-level* component consisted of three types of posters providing information on: i) health risks associated with high sedentary time, ii) benefits of physical activity, and iii) examples of stretching exercise.
- *Organisational-level* component involved leadership support; office directors sent messages twice a week via Line™ to encourage participants to reduce sedentary time using movement breaks, increase physical activity, and announce reward winners with compliments and photographs of the reward ceremony.

As described above, the multi-component intervention was developed using the Socio-Ecological Model [8, 21]. The intervention components were strategically designed to complement one another, with a particular focus on the primary component: the movement breaks. Additionally, department directors actively encouraged participants to attend more movement break sessions and announced the weekly lottery reward, which was contingent upon the frequency of participation in the movement breaks. Two movement break leaders per office were trained to oversee these sessions. Moreover, posters were displayed to inform participants about the adverse effects of prolonged sedentary behaviour and to provide examples of strategies to break sedentary time in the office. All intervention participants were equipped with a Fitbit® smartwatch, Inspire HR, pre-set to remind them to interrupt prolonged sitting every 30 minutes. Consequently, the intervention operated as illustrated in **Figure 1**.

Figure 1. Mechanism of associations between intervention components and outcomes



We formulated our research questions to encompass the context, implementation, and impact mechanisms, with a specific emphasis on the primary intervention component, the movement breaks. This emphasis stemmed from two key considerations:

i) As previously noted, our intervention design places the movement break as the central intervention component, supported by other components.

ii) We observed a low participation rate in movement break sessions, with a median percentage of 31.5% (IQR = 20.4% - 42.7%). Moreover, 77.8% of the intervention participants attended less than half of the breaks throughout the intervention period. We hypothesised that the absence of a significant intervention effect could be attributed to low attendance in movement break sessions [19]. Hence, our current focus is to investigate the underlying reasons behind this issue.

Table 1. Descriptions of the process evaluation components, specific questions, and the data sources

Process Evaluation Components	Specific Process Evaluation Questions	Quantitative Data	Qualitative Data
Recruitment and Context			
Recruitment	How does recruitment influence participation in movement breaks?	Recruitment rate	Recruitment fashion
Context	What impact do job descriptions and baseline characteristics of each cluster have on movement break participation?	Baseline summary statistics of each cluster	Job description of each cluster
Implementation			
Dose	What was the extent of intervention delivery?	Online monitoring: - Fitbit® wear time - Conducts of movement breaks	On-site monitoring
Fidelity	Was the intervention delivered as intended?	Associations between participation in movement breaks and daily Fitbit® sedentary time, as well as step counts during the intervention period	On-site monitoring
Mechanism of impact			
Testing the assumptions behind the intervention design	How did supporting components influence participation in movement breaks?	Effects of intervention components on the percentage of weekly movement break participation	Focus group discussions
Participants' attitude	What were the facilitators and barriers to participation in movement breaks?	Additional questionnaire regarding facilitators and barriers to participation in movement breaks	Focus group discussions

Data collection

Baseline and Follow-up data collection

Questionnaires
An interviewer-administered questionnaire, based on the Thai National Statistical Office's health survey and capturing sociodemographic data such as age and education [22], was used to collect participant data at both baseline and follow-up. Additionally, intervention participants were asked supplementary questions regarding the implementation of the intervention during the follow-up data collection (see **Additional File 1**).

Data monitoring

Movement break schedule
A data monitoring team, consisting of the trial implementor and an administrator, conducted weekly random field visits to four offices during their scheduled movement break sessions, adhering to the initial timetable. Monitored data included: i) occurrence of sessions, ii) session quality, iii) participant attendance, and iv) any issues encountered during the session. Movement break leaders were responsible for submitting weekly schedules via Microsoft Excel Online, indicating session timings and dates. Updates were required if a session did not fall within the 30-minute alarm window at 9:30 am, 10:30 am, 2:30 pm, or 3:30 pm, indicating absence or starting times outside the specified windows.

Fitbit® data and Movement break participation

During the 6-month intervention period, we collected Fitbit® data, which included wear time, sedentary time, and step counts. Daily activity data were anonymised and used to compile weekly lists of potential reward recipients and to assess compliance with movement breaks. Participation in each movement break session was determined by: i) analysing a quadratic function of steps, ii) detecting quadratic functions within the 1-hour timeframe of movement breaks, and iii) accumulating at least 100 steps.

Quantitative Data Analysis

Linear mixed models were employed to examine the associations between intervention components and activity outcomes, as well as between the intervention components themselves. These models incorporated random intercepts from both individual and cluster levels, while also accounting for random slope by including intervention weeks. Weekly individual data were derived from daily Fitbit® records, follow-up questionnaire responses, and monitoring data (see **Table 2**).

Table 2. Variables used in the models

Variable name	Explanation	Scale
1. Associations between movement break participation on daily Fitbit® sedentary time and step counts during the intervention period		

Outcome variable		
Sedentary time	Daily sedentary time from Fitbit® data	Cont. (min)
Step	Daily step count from Fitbit® data	Cont. (step count)
Exposure variables		
Movement break participation	Daily movement break participation	Ordinal; 1 - 4
2. Effects of intervention components on weekly movement break participation percentage		
Outcome variable		
Movement break participation percentage	The frequency of an individual's participation in movement break sessions within a specific week relative to the maximum number of sessions available during that week	Cont. (percentage)
Exposure variables		
Individual reward	We designated the weeks following individual reward wins as {1}, while all other weeks were coded as {0}, using the online monitoring data.	1 = Won a reward last week 0 = Others
Cluster reward	We assigned {1} to the weeks following office colleagues' reward wins and {0} to all other weeks, using the online monitoring data.	1 = A colleague in the same office cluster won a reward last week 0 = Others
Fitbit® wear time	We categorised the average weekly wear time of Fitbit® for each individual into a binary variable using the median.	1 = Wore Fitbit® at or above the median wear time 0 = Wore Fitbit® below the median wear time
Fitbit® wear time (alternative)	How often did Fitbit® lead you to engage in physical activity in the office in the last two weeks of the intervention?	1 = At least 4 days per week 0 = Less than 4 days per week
Leadership support	How often did the Directors' support lead you to engage in physical activity in the office in the last two weeks of the intervention?	1 = At least 4 days per week 0 = Less than 4 days per week
Movement break leaders	How did the movement break leaders' (1) encouragement and (2) enthusiasm contribute to participants joining the movement breaks? (We asked the movement break leaders and used the data as cluster-representative data)	3 = Both factors contributed 'somewhat' or 'a lot' 2 = Only the encouragement contributed 'somewhat' or ' a lot' 1 = Only the enthusiasm contributed 'somewhat' or ' a lot' 0 = Both factors contributed 'not at all', 'very little', or 'a little'
Posters	How often did the posters lead you to engage in physical activity in the office in the last two weeks of the intervention?	1 = At least 4 days per week 0 = Less than 4 days per week

Posters (alternative)	Alternative: How many different designs of the posters were in your office?	1 = 3 - 4 designs 0 = 0 - 2 designs

Data were analysed using RStudio Version 4.0.3 and Stata software version 14.2, with a significance level of 5%.

Focus group discussion

The qualitative aspect of the study involved focus group discussions aimed at exploring participants' perspectives on facilitators and barriers to engaging in movement breaks, as well as their attitudes toward intervention components. Intervention clusters were initially ranked by mean percent participation in movement breaks. Subsequently, up to six participants with the highest percent participation from the top two-ranking clusters and up to six participants with the lowest percent participation from the bottom two-ranking clusters were invited for each of the four focus group discussions, employing purposive sampling.

Four focus group discussions took place via 45 to 75-minute online Zoom meetings, with participants joining from their respective offices. Sessions were recorded with participants' consent, capturing both video and audio, while notes were taken during the interviews. Prior to the formal interview, participants were briefed about the interview's purpose, format, and estimated duration, with the option to interrupt as needed.

Verbatim transcriptions were manually conducted by hired research assistants. The transcriptions were then subjected to deductive thematic analysis, with facilitator and barrier serving as overarching themes, and the socio-ecological model employed as subthemes [8]. Two analysts (KA and BS) independently coded each transcript using the pre-established framework. References under themes and subthemes were compared and discussed to ensure consistency and accuracy. Intercoder reliability was not analysed in this study.

An interview guide (**Supp Table S1**) was developed based on the research question: ‘What are the facilitators and barriers of movement breaks participation?’. The Socio-Ecological model informed this guide. Four interviewers (50% female) conducted the interviews. They comprised the PAW trial implementer (first author; Doctor of Medicine), two study administrators (Bachelor of Communication Arts and Master of Political Science), and one research assistant (Bachelor of Clinical Pharmacology) who was not a trial staff member. All interviewers underwent a comprehensive two-day training programme tailored to the qualitative data collection and analysis requirements of the study. This training was led by a Thai senior researcher (PhD, Anthropology). The interview guide served as a reference tool, ensuring that critical topics were not overlooked. During interviews, the researcher flexibly adjusted the sequence, content, and style based on individual responses. Emotions and non-verbal cues expressed by participants were carefully documented.

Code names were used in place of real names in the recorded data to protect participant privacy. Data collection and analysis proceeded concurrently throughout the study. After coding the transcripts from four focus group discussions, researchers and supervisors deliberated on data saturation. Subsequently, two additional focus group discussions were conducted with clusters ranked in the top and bottom thirds, following the same procedures. No new themes emerged from these final two discussions, indicating that data saturation had been achieved.

Results

Recruitment and Context

The PAW study recruited participants from all clusters within the Department of Medical Services building and the International Health Policy Program, Ministry of Public Health, Thailand, between July and September 2020. The ministry's governance structure is typically bureaucratic, with each department led by a single director general and each office headed by an office director. In total, 18 clusters were successfully recruited, with 15 falling under the Department of Medical Services purview. The remaining three clusters were under the Office of the Permanent Secretary, two of which were part of the International Health Policy Program and located in a distinct building complex (**Figure S1**).

Recruitment procedures at the cluster level proceeded seamlessly. The directors of each office endorsed the active involvement of their respective teams in the trial, resulting in a cluster-level recruitment rate of 100%. For individual-level recruitment, we initiated the process by organising office-specific group meetings to thoroughly explain the trial details. After these meetings, office workers interested in participating could engage with the trial staff to complete the individual informed consent process. To accommodate those unable to attend the scheduled meetings due to prior commitments, additional sessions were arranged.

Despite the bureaucratic governance style, the individual recruitment rate reached 63%, with 282 out of 449 eligible office workers participating. Job descriptions varied and included research-related roles, academic, finance, law, digital, and other administrative positions. At baseline, three clusters exhibited a mean daily sedentary time exceeding nine hours. Moreover, mean daily moderate-to-vigorous physical activity time was generally higher than the current physical activity guideline, reflecting that participants were relatively active. No significant associations were observed among job descriptions, baseline time spent in sedentary or moderate-to-vigorous physical activity, and monitoring data. However, clusters with higher baseline sedentary time demonstrated increased participation in movement breaks (see **Figure S2**). Furthermore, mean age and cluster size appeared to influence participation in movement breaks within the intervention group. Notably, individuals in the cluster with the youngest and smallest number of participants showed minimal participation in movement breaks (see **Table 3**).

Table 3. Context and recruitment of participants and implementation of the intervention

Baseline				Data Monitoring; 6-month intervention period			
Job Description	Cluster size (*n*)	Recruitment percentage	Sedentary time (min/ day)	Lottery-incentive wins	Movement breaks Participation	Maximum Work from Home	Note
Research-related	23	92.0%	541	15	64.6%	50%	
Research-related	8	18.2%	483	0	29.2%	100%	Different building and department
Nursing	13	35.1%	463	4	42.7%	0%	Different department
Finance	10	90.9%	460	0	35.9%	40%	Broadcast from another cluster
Finance	14	82.4%	481	1	31.6%	40%	
Human resource	34	97.1%	473	2	34.2%	50%	
Human resource	18	58.1%	394	1	27.3%	50%	Broadcast from another cluster
Digital	15	60.0%	447	1	21.4%	40%	
Inspection	6	27.3%	350	0	2.42%	40%	3 participants at follow-up

Implementation:

Fidelity: Was the intervention delivered as intended?

On-site monitoring

The on-site monitoring team conducted 65 field visits to participants' offices in the intervention group during their scheduled movement break sessions. During these visits, 35 movement breaks were observed, with 28 sessions (80%) featuring the Department of Medical Services theme song alongside another preferred Thai song. Importantly, there were no instances of cheating, such as merely shaking the Fitbit® without engaging in actual physical activity. However, one participant from cluster 13 chose to take a ten-minute walk outside the office instead of participating in the team movement breaks, even when the sessions were not prompted. This participant managed to secure the weekly rewards three times during the 24-week intervention period. Lastly, no participants from the control group attended the sessions.

All the alarm clocks were operational; nevertheless, leaders opted to broadcast the movement break songs using alternative devices, including the built-in broadcast system and office speakers. Notably, two clusters did not independently initiate their movement break sessions; instead, they waited for another cluster to start because they shared the same broadcast systems.

Weekly rewards were distributed to winners by department directors. On only two out of 24 occasions did winners receive the team-based incentive. A photograph capturing the reward ceremony, featuring face-to-face reward distribution, was shared with all intervention participants through Line™ Openchat.

We received notifications regarding Fitbit® issues, including syncing, freezing, and charging problems, both during and outside our field visits. Fortunately, some participants with technological expertise were able to provide assistance, alleviating the need for the implementation team to respond to every notification. During our observations, we noticed that some participants occasionally left their Fitbits® at home when attending the movement break sessions. Despite understanding that their participation wouldn't be recorded without the Fitbit®, they still chose to engage in the sessions. Additionally, one participant was observed wearing the Fitbit® exclusively during the movement breaks.

All posters remained undamaged and visible, without any changes to their placement.

Due to the COVID-19 pandemic, a work-from-home policy was implemented. However, less than half of the participants worked from home, with only one specific cluster having a 100% work-from-home arrangement. This cluster utilised Zoom for online meetings to conduct their movement breaks. Upon visiting the Zoom link twice, we found only one participant in the virtual meeting, with no movement breaks initiated. In contrast, another cluster coordinated their participation through a Line™ group chat when working from home, ensuring simultaneous session participation without requiring an online meeting.

Online monitoring

We examined the correlation between engaging in movement breaks and daily Fitbit® sedentary time and step counts. Each additional movement break was associated with a reduction of 6.20 min (95% CI: 6.99 – 5.41 min) in sedentary time and an increase of 245 steps (95% CI: 222 – 267 steps) (see **Table 4**). This analysis, based on pedometer-measured outcomes, supported the fidelity of the movement breaks implementation, as our prescribed minimum requirement for a single session was at least four minutes. Furthermore, the cumulative steps surpassed the eligibility criterion of 100 steps. The analysis also suggests successful data synthesis regarding

movement break participation.

Table 4. Associations between movement break participation on daily Fitbit® sedentary time and step counts during the intervention period

	Model A (Beta) [a]	Model B (Beta) [b]
Sedentary time (min)	-6.32** (-7.06 – -5.57)	-6.20** (-6.99 – -5.41)
Steps (count)	263** (242 – 283)	245** (222 – 267)

[a] linear mixed-effect model adjusted for Fitbit® Weartime, with cluster and ID as random intercepts and intervention week number as the random slope
[b] further adjusted for the number of public holidays in that week, age, gender, and education of the participants
**$p < 0.05$

Dose: What was the extent of intervention delivery?

Online monitoring
According to the movement break leaders' weekly reports, a significant number of movement break sessions were never initiated by the leaders in each cluster. By the third week of the intervention, approximately 40% of the scheduled movement break sessions had not been initiated (**Figure S3**). Similarly, the overall average participation in movement breaks declined after the third week of the intervention, reducing to an average of eight sessions per week per participant. Subsequently, the participation rate continued to decrease (**Figure S4**).
We plotted the average daily Fitbit® wear time to assess adherence during the intervention period (**Figure S5**). We found that participants typically wore the devices for ten to fifteen hours per day at the start, with a slight decrease to eight to fourteen hours occurring approximately two to three months into the intervention.

Mechanisms of Impact

Following **Figure 1**, we present the effects of each component derived from a mixed-method analysis aimed at exploring the associations between each intervention components and movement break participation. We combine results from both quantitative and qualitative analyses to comprehensively address the question.

a. Quantitative analysis: 3200 participant-week data points were extracted by combining participants' demographics, Fitbit® wear time, sedentary time, steps data, answers from the attitude-toward-intervention-components questionnaire, and online monitoring of rewards (**Table 2**).

b. Qualitative analysis: Each focus group discussion involved three to six participants, resulting in a total of 28 participants across six focus group discussions. The primary data analysts for the main results included four interviewers: the head of the data collection team (male), a program administrator (female), a researcher (male), and a staff member from the Health Intervention and Technology Assessment Programme (female).

Demographic details of all participants from the clusters (coded by ID1 to ID6) involved in the focus group discussions are presented in **Table 4**. Generally, the mean age of participants from the three top-ranked clusters was higher compared to those from three bottom-ranked clusters. The majority of participants were female (≥80%). Notably, the cluster with the lowest participation rate of 2% comprised only three participants at the 6-month follow-up (**Supp Table S2**).

Table 5. Effects of intervention components on weekly movement break participation percentage

	Beta [a]	Standardised Beta
Individual reward	8.64** (0.985 – 16.3)	0.0257** (0.00293 – 0.0484)
Cluster reward	-0.325 (-2.64 – 1.99)	-0.00400 (-0.0325 – 0.0245)
Fitbit® wear time	3.96** (2.28 – 5.65)	0.0696** (0.0400 – 0.0993)
Leadership support	1.82 (-2.25 – 5.90)	0.0309 (-0.0381 – 0.100)
Movement break leaders		
- Enthusiastic	2.00 (-17.2 – 21.2)	0.0770 (-0.663 – 0.817)
- Encouraging	1.49 (-18.8 – 21.8)	0.0576 (-0.724 – 0.840)
- both Enthusiastic and Encouraging	24.1** (8.96 – 39.2)	0.929** (0.346 – 1.51)
Posters	4.49* (-0.493 – 9.47)	0.0695* (-0.00764 – 0.147)

[a] linear mixed-effect model adjusted for the previous-week movement break participation percentage, number of public holidays in that week, age, gender, and education of the participants, with cluster and ID as random intercepts and intervention week number as the random slope
*p < 0.10, **p < 0.05

How did supporting components influence participation in movement breaks?

Lottery-based incentives

Individuals who won the weekly lottery rewards the previous week demonstrated an 8.64 percent (95%CI: 0.985 – 16.3 percent) increase in movement break participation compared to other data points (**Table 5**). However, it is crucial to note the possibility of an overestimation when comparing data from winners against non-winners. To address this, we conducted another subgroup analysis exclusively including winners, revealing a 5.10 percent (95%CI: -3.44 – 13.6 percent) increase in movement break participation. However, this increase lacked statistical significance due to the small sample size included (**Supp Table S3**)

From the focus group discussions, some participants suggested that rather than a single winner receiving a substantial cash prize, there should be multiple winners receiving more affordable rewards:

"Rather than cash, it should be acknowledgements, such as showing who reach this many steps so we can compete with each other..." (C13)

"…could be something cheaper, don't have to be cash. Cheap shirts will do!" (C10)

"…it was indeed a motivating factor, but the conditions for obtaining it should be somewhat more lenient. That is, to make it accessible to a broader audience, but the current conditions seem to be quite high. If it were reduced a bit, say to 100, I believe that providing rewards would be motivating enough." (C8)

- While the worst-performing cluster did not remember the details of the financial incentive:

"Sorry but how much was the reward?" (C17)"

Team-based incentives

We observed no difference in movement break participation percentage (-0.325%, 95%CI: -2.64% – 1.99%) in the weeks following a colleague from the same office winning lottery rewards compared to other weeks. Contrary to our assumptions during the intervention development phase, peer pressure appears to have no discernible effects on motivating movement break participation, as indicated by the quantitative analysis model (**Table 5**).

Different ideas emerged during the focus group discussions, including:

- Peer support was mentioned among members in the best-performing cluster as an important motivator:

"Because it helped the team. If we dance, someone gets 1000THB, if we don't, it's 500THB only." (C12)

- However, others expressed discouragement:

"When I see others got it and I never won for weeks, I was disheartened..." (C12)

- Some participants viewed reward as not motivating:

"...I joined the sessions because I want to be healthier. Rewards are meaningless for me..." (C13)

Fitbit®

There was a 3.96 percent (95%CI: 2.28 – 5.65 percent) increase in movement break participation among individuals who wore their Fitbit® more compared to those wearing them less, using the median weekly wear time as the cut-off point (**Table 5**). However, this increase may be attributed to motivation triggered by Fitbit notifications (e.g., reminders to break prolonged sitting) or potentially to an information bias, wherein participants who wore their Fitbits more were detected more frequently in movement break participation.

To address potential bias, we compared the result with another model where Fitbit exposure was based on self-report, utilising the question: 'How often did you look at the Fitbit tracker during the last 2 weeks of the intervention period?' The analysis revealed that looking at the tracker more frequently (four or more times per week) was associated with a 1.97 higher movement break participation percentage (95% CI: -1.42 to 5.36 percent), without statistical significance (**Supp Table S4**).

Qualitative analysis indicated that participants perceived Fitbit® as beneficial not necessarily for encouraging additional movement breaks but rather for motivating increased exercise and providing real-time feedback:

"I joined short breaks a lot at first, but after a while, I forgot… However, I always wear the watch; look at the daily data" (C13)

"I set my goal to walk 10,000 steps a day after I got the watch, and I succeeded!" (C16)

"…saying Fitbit encourages more movement breaks is wrong for me, but I feel the urge to exercise more from wearing the watch, like running after work" (C17)

Leadership support

Participants perceived the encouragement from directors as ineffective in motivating them to participate in more movement breaks.

Although office directors joined very few movement breaks, participants believed their presence helped motivate everyone in the cluster:

"He joined, I saw. But mostly he's busy" (C16)

"It made us stand up and dance…if we didn't it'd be awkward" (C5)

"We all danced every time our director was present (laugh)" (C8)

Movement break leaders' encouragement and enthusiasms: Clusters with leaders who self-evaluated as more encouraging and enthusiastic had a significant increase of 24.1 percent (95%CI: 8.88 – 39.4 percent) in movement break participation compared to clusters with less encouraging and enthusiastic leaders. However, since these exposure variables are self-reported by cluster leaders, the detected difference may be influenced by other cluster-specific factors.

Participants believed that movement break leaders' enthusiasm and encouragement helped them join more break sessions:

"He was very active and always encourages everyone to stand up and dance" (C8)

"We were aware of the scheduled time, but if we were occupied, the leader would notify us" (C13)

Nevertheless, some participants mentioned that they did not rely on leaders:

"No matter how many people in the office, we danced. no leaders, no problem at all" (C12)

"I'm not sure...leaders always initiated the activity, but we did not always join" (C16)

"No one was available." (C17)

Posters

Participants who reported that posters motivated them to engage in more movement breaks during the last two weeks of the intervention exhibited approximately a five percent higher participation rate, although this increase lacked statistical significance (**Table 5**). Notably, this increase may indicate participants' attitudes toward the intervention component rather than the direct effects of the posters themselves. Therefore, we compared the result by converting the variable to whether participants accurately identified the number of different styles of posters in their offices. The analysis revealed no significant difference in movement break adherence between those who answered correctly and others (1.97, 95% CI: -1.34 – 5.23) (**Supp Table S5**). Qualitative analysis showed that while posters initially captured interest, over time, they failed to sustain attention:

"At first I read them. I thought it was helpful and tried to follow some moves. After a while I just ignored them" (C2)

"I didn't really read it that much…just walk pass" (C3)

The standardised beta coefficients of all exposures indicate that the self-evaluated enthusiasm and encouragement of movement break leaders were the most important variables among those included, followed by Fitbit® wear time and the individual reward (**Table 5**).

Facilitators and barriers to movement break participation

Figure 2. Facilitators and barriers to movement break participation

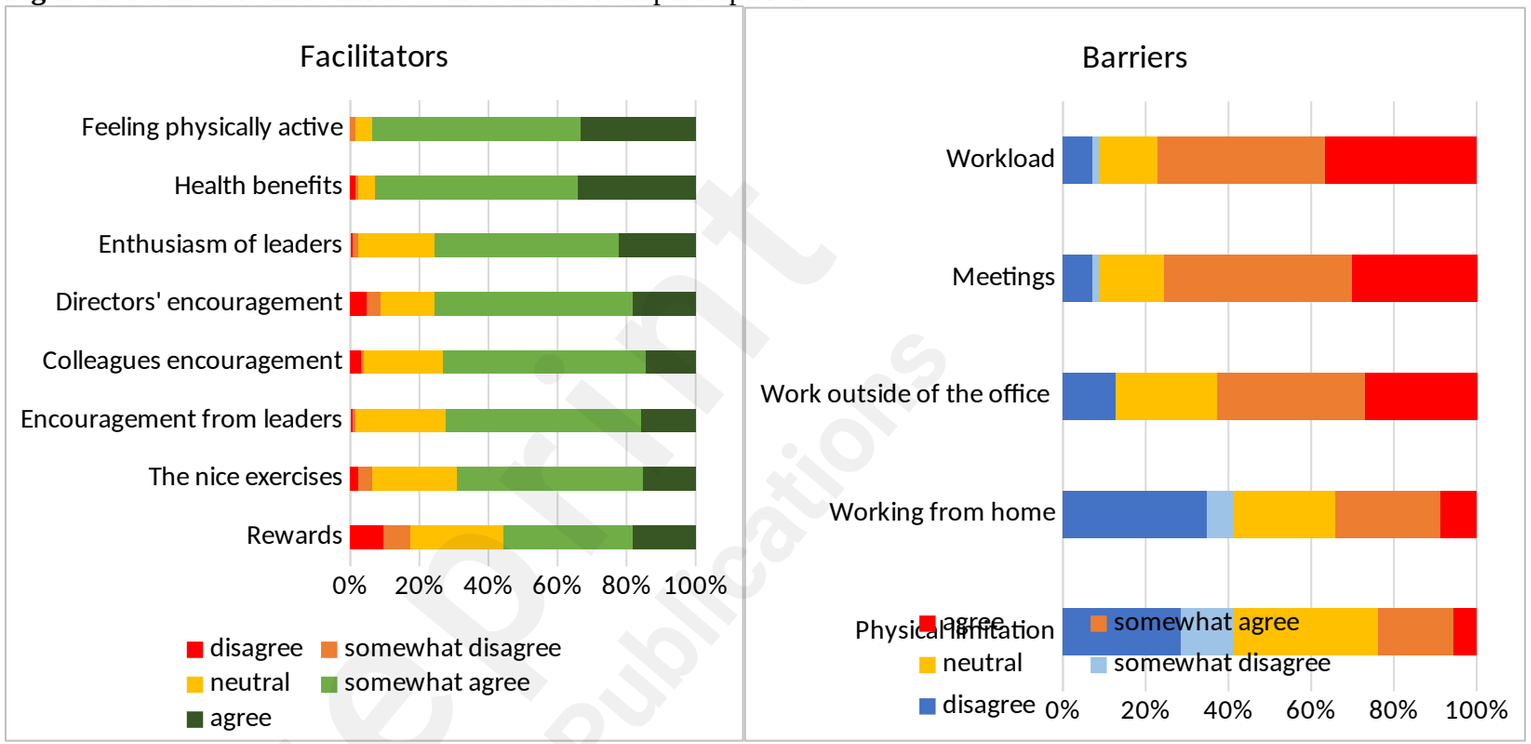


Figure 2 illustrates participants' attitudes regarding the facilitators and barriers to movement break participation. The top two facilitators of their involvement were the positive feelings associated with being physically active and the perceived health benefits. Additionally, encouragement from leaders, directors, and colleagues constituted the second category of facilitators. The appeal of engaging in enjoyable exercises also motivated their participation. Interestingly, weekly rewards ranked lowest among the facilitators for the intervention participants.

Conversely, the primary barrier perceived by participants was their workload, followed by meetings and working outside of the office. Surprisingly, many participants did not view working from home as a barrier to their participation.

Table 6 presents thematic analysis results with references under each theme-subtheme from all six clusters. The positive attitudes toward intervention components were mentioned. For example, "*I think having Fitbit® is a really good motivation to move" (C17)* and "*previously when someone invited me to run, I wanted to but it was hard. This (movement breaks) is easier and fun" (C12).* Participants also noted barriers to the intervention, such as the lottery reward design. For example, *"It (individual reward) somehow motivated me, but I guess I just could not do as good as others" (C16).* Another important barrier was the monotonous design of the movement breaks. For example, *"dancing with the same moves gets boring after a while" (C8)* and *"I think we can change the songs to make it more interesting" (C16).*

Table 6 Thematic analysis of focus group interviews on facilitators and barriers to movement break participation

Themes	Subthemes	Quotes
Facilitators	Psychological Capability	- *Previously when someone invited me to run, I wanted to, but it was hard. This is easier and fun. (C12)*
	Social Opportunity	- *"both songs and moves…it was like mass hysteria; others enjoyed the sessions and I wanted to join" (C12)* - *Our director joined, and we danced happily (C8)* - *When my boss dance and I just sat there working, it felt strange, so I joined (C5)*
	Physical Opportunity	- *"I'm happy that there is a new opportunity for me to exercise…in workplace. Normally I don't have time." (C12)* - *Our office is spacious. There are empty spaces for dancing. (C5)*
	Reflective Motivation	- *"my personal goal was actually health, not rewards" (C13)* - *"I set my goal to get the reward and lose weight and cholesterol level because the programme measured those" (C5)*
	Automatic Motivation	- *"it was relaxing, both mind and body…especially the mind." (C17)* - *"just that we got to dance…when the session started, it relieved the stress quite a lot" (C5)*
Barriers	Psychological Capability	- *"10 min. dancing is too short. 30 min. working out is better for your health for the day." (C13)* - *"My programming work never allows me to lose focus" (C16)*
	Social Opportunity	- *"Meetings definitely prevented us to join movement sessions" (C8)* - *"We were not really motivated by directors and colleagues" (C17)*
	Physical Opportunity	- *"sometimes workspace is not wide enough…also I was afraid I'll annoy others who were not in the project" (C13)* - *"…during high workload, we cannot join" (C5) "The high workload never allows us to do anything else" (C17)* - *"Ever since COVID situation got worse, I've been sitting all the time at my desk. It's the workload, can't do anything else." (C16)*
	Reflective Motivation	- *"rewards could be anything, like shoes, incentives don't need to be money, like shirts…" (C5)*
	Automatic Motivation	- *"Each programme shouldn't last long. I mean, we should always change the stimulant to avoid boredom…" (C13)* - *Dancing with the same moves gets boring after a while (C8)* - *I think we can change the songs to make it more interesting. (C16)*

Discussion

The PAW cluster randomised trial of a multi-component intervention, developed based on the socio-ecological framework [8], showed a decrease in participants' waking sedentary time and an increase in moderate-to-vigorous physical activity, although without statistical significance [19]. We conducted a mixed-method process evaluation, following the Medical Research Council guidance [10], to comprehensively describe 1) the recruitment and context, 2) the implementation, and 3) the impact mechanisms of the PAW trial.

Recruitment and Context:

Our team anticipated a high recruitment rate once the office directors approved the inclusion of their offices in the trial, given the bureaucratic nature of the ministry organisation in Thailand. However, recruitment rates were low in many clusters, weakening the trial's statistical power and risking reduced intervention adherence, particularly in the social-level component.

Cluster 17 serves as a notable example, demonstrating minimal engagement in movement breaks (**Table 2**, **Figure S4**). This could be attributed to the recruitment of too few, relatively young participants alongside a high number of non-participants (**Table 2, 5**). Despite its potential for easy qualification for the team-based incentive with just three participants, the cluster might face challenges due to the negative influence of an environment where breaks are discouraged. This aligns with a previous study reporting reduced break-taking in disapproving work environments compared to more supportive ones. [23]. Cluster 13 also faced challenges with a low recruitment rate, yet their engagement in movement breaks was high. Two reasons might explain this: 1) the participant who chose to walk outside the office and secured three weekly rewards increased the cluster's average participation rate, and 2) recruiting at least 13 participants could create an environment conducive to making movement breaks feel enjoyable and secure to participate in.

Job characteristics might also play a role in movement break participation. Cluster 17, 'the inspection office', frequently required its members to leave the office for inspections, which was reflected in their low sedentary time at baseline (**Table 2**) and echoed in the focus group interview. In addition, Cluster 16 represented a digital office where most participants worked on their laptop all day. While this setting might seem ideal for implementing the intervention, participants encountered challenges with breaks as they needed continual focus to code. This aligns with the suggestion that identifying the optimal fit between the organisational context and the intervention is crucial [24]. However, challenges remain when implementing such interventions across organisations with diverse offices, each characterised by unique job contexts and work styles.

Implementation

We implemented the trial with a comprehensive dose delivery, ensuring intervention fidelity by closely adhering to the original plan for each component. Moreover, the findings in **Table 3** affirm the application of precise criteria for enumerating movement breaks, underscoring their correlation with the expected reductions in sedentary time and increments in step counts.

Nevertheless, we encountered challenges related to the frequency of movement break sessions conducted by participants, which we refer to as "dose received" [12]. This inconsistency may be attributed to the performance of movement break leaders, as illustrated in **Figure S3**, which shows that many sessions were never initiated. However, several clusters relied on automatic timing mechanisms to initiate breaks, ensuring sessions commenced even without leaders present. We discuss this further in the subsequent section.

Mechanisms of Impact

Testing the designed intervention components

Healthy behaviours are maximised when environments and policies support healthful choices, and individuals are motivated and educated to make them [25]. As one of the main principles of the ecological model, the interaction of influences means that variables within the system work together synergistically [26]. Hence, our study examined the impact of the supporting components on the movement break participation using a multivariate linear mixed model (**Table 4**).

Movement break leaders' enthusiasm and encouragement appear to contribute to higher participation percentages. However, the cluster that exhibited the best performance challenged this observation, asserting that they initiated sessions independently, even without leaders. Unlike other cluster-randomised trials where exercise sessions were led by non-participants such as physiotherapists [15], movement break leaders in our study were participants and could be replaced if absent. Hence, without the leaders, other members could initiate sessions automatically. Nevertheless, the influence of leaders' encouragement and enthusiasm likely played a role in motivating the rest of the team. Prior research has also found that workplace team leaders play a significant role in facilitating the implementation of workplace interventions [27, 28]. Moreover, a comprehensive review emphasises that effective team performance underscores the fulfilment of leadership styles, supportive team behaviours, communication, and performance feedback [29].

The impact of the team-based incentive on movement break participation was evidently negligible. Regarding individual lottery-based incentives, their influence remains somewhat unclear. Systematic reviews suggest that financial rewards for physical activity have positive short-term effects, surpassing unconditional incentives [30, 31]. Moreover, another study indicates that increasing reward values may lead to improved results [32]. Nevertheless, insights from online-monitoring data and focus group discussions revealed that only one cluster actively pursued rewards and engaged in friendly competition, while others were indifferent. Awarding only one winner per week might demotivate participants who faithfully adhered to the intervention but never won. This phenomenon can be explained using goal-setting theory, which suggests that setting clear and appropriately challenging goals is crucial [33]. On the other hand, setting unachievable goals may induce stress, anxiety, and perceived pressure [34]. Therefore, overly difficult goals, such as securing the weekly lottery reward, may have discouraged participants.
Fitbit® was perceived as a helpful tool for real-time data monitoring and might help motivate leisure physical activity. However, current evidence indicates unfavourable outcomes regarding the effectiveness of pedometers in increasing physical activity within the workplace or in motivating sedentary breaks [35, 36]. The component might support the movement break only as

a data collection pedometer.
Lastly, posters and leadership support were considered helpful at the start of the intervention but provided no lasting effect over time. These components could be perceived as nudges, which have been widely used for prompting behavioural change among participants by providing alternative options to sedentary habits in the workplace [37]. Posters were aimed at educating participants about sedentary breaks and their health benefits; leadership support was expected to facilitate these behavioural shifts. Management support has also been found to be an essential enabler for workplace intervention participation to reduce sitting time [27, 38, 39]. However, the sustainability of the effects depends on the meticulous design of the intervention components. Future studies evaluating long-term effects must enhance the intervention components to ensure sustainability.

Facilitators and Barriers

Automatic motivation of feeling active and relaxed was ranked as the top facilitator to join movement breaks, followed by reflective motivation, including perceived health benefits. The findings are in line with a recent systematic review [39]. Another review also supports the idea that micro-breaks at work can improve wellbeing: boosting vigor and reducing fatigue [40]. In addition, participants generally grasped the health benefits associated with movement breaks. However, some individuals compared movement breaks to aerobic exercise, expressing doubt regarding their health benefits.

Workload and meetings were perceived as the main barriers to movement breaks, which aligns with the previous study's prediction that high workloads, although positively related to the desire to detach from work, would also deter employees from actually taking breaks [23]. In addition, recent findings from a systematic review supported the notion that micro-breaks increase wellbeing but do not necessarily increase work performance, especially in tasks with high cognitive demand. Moreover, the review suggested that breaks longer than ten minutes may be necessary to enhance work performance [40].

On the other hand, meetings presented clear barriers to our intervention design. Future research should be dedicated to advocating feasible and context-specific active meetings within an active workplace. For example, an exploratory study found that standing meetings were feasible, well-received by employees, and may reduce sitting time among the population [41]. However, widespread adoption faces obstacles due to prevailing sedentary work cultures and concerns about self-consciousness in front of senior staff, highlighting the need for broader social behaviour change initiatives [42]

We hypothesised that movement break participation might be low due to the work arrangement during the peaks of the COVID pandemic [19]. However, participants did not consider working from home to be the main barrier to movement break participation. Instead, they thought the COVID pandemic did not significantly hinder their adherence to the intervention due to the working-from-home policy. Instead, they attributed the difficulty to increased workload. Nevertheless, working from home remained one of the barriers to movement break participation. This is in line with another workplace cluster randomised trial, which reported that engaging in physical exercise with colleagues during working hours was more effective than home-based exercise in enhancing vitality and managing pain-related concerns among healthcare workers [43].

Strengths and Limitations:

We conducted a comprehensive mixed-method process evaluation of the PAW multi-component intervention, covering its context and recruitment, implementation, and impact mechanisms. Rigorous analyses were applied to both quantitative and qualitative data. The data are prospective, spanning six months of follow-up. Although the overall results show no significant impact of the intervention, this process evaluation offers insights that could be crucial for the future development and evaluation of intervention packages aimed at reducing sedentary time while improving physical activity levels.

Nevertheless, our study had some limitations. First, we could not test mediators to understand the underlying mechanisms through which one variable influences another due to the trial's lack of efficacy [19]. Second, constructing intervention theories will involve reconstructing a Logic Model [10, 44], a task we plan to undertake in future studies. Third, we could not complete the management and analysis of process evaluation data before the conclusion of the PAW trial. As a result, the process evaluation was conducted post-hoc to elucidate the trial outcomes. Furthermore, our evaluation only incorporated participants' data and perspectives, overlooking input from other stakeholders such as organisational directors and non-participants. Lastly, the team members responsible for process evaluation were also involved in the outcome evaluation. While our team possesses the most comprehensive understanding of the trial details, potential bias in interpretations must be acknowledged [10].

Conclusion

The PAW trial did not significantly reduce sedentary time among Thai office workers. Although the trial implementation was satisfactory regarding dose delivery and fidelity, there was limited uptake of the movement breaks, the key intervention component. This limited uptake could be attributed to 1) context-related challenges, including jobs requiring high cognitive engagement or frequent out-of-office work and meetings; 2) the absence of goal-setting aspects in the detailed design of individual and social components; 3) the lack of effective and sustainable supporting components at the environmental and organisational levels; and 4) elevated workloads in specific clusters, exacerbated during peak periods of the COVID-19 pandemic, serving as a significant barrier. To validate all trial assumptions, the Logic Model of the intervention needs to be comprehensively reconstructed and finalised.

Abbreviations
ECMOPH: Ethical Review Committee for Research in Human Subjects, Ministry of Public Health; HITAP: Health Intervention and Technology Assessment; ICMJE: Committee of Medical Journal Editing; TCTR: Thai Clinical Trials Registry; US: United States;

Declarations
Ethics Approval and Consent to Participate: The study has been approved by the Ethical Review Committee for Research in Human Subjects, Ministry of Public Health (ECMOPH), Thailand (IRB00001629). Any modification to the approved protocol will be submitted for a review by the ethics committee. All participants provided written consent prior to the participation.

Consent for publication: Consent from participants was obtained to publish the results from de-identified data.

Availability of Data and Materials: Participants' data (e.g. case record forms, laboratory test, information sheets, and consents) are stored in a locked cabinet in a researchers' office. All data will be destroyed by researchers within five years after publication. During the study, only de-identified data were used, and the data was only accessible to the research team.

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Author's Contributions: All authors contributed to the study design and/or delivery of the trial. KA was Principal Investigator (PI) of the trial. KA, YT, and CC drafted the manuscript together. FM and CC provided statistical expertise and data management. TR, RN, YT, WI, and FMR provided expertise on conceptualising the process evaluation aspects and the narrative of the manuscript. RN and TR provided expertise on behavioural economics, such as the impact of lottery-based and team-based incentives. TR and FMR provided expertise on physical activity promotion theories and frameworks. All authors have reviewed the manuscript draft, have read, and approved the final version.

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Dissemination Policy: In addition to disseminating our research findings to the funder of this study, the Ministry of Public Health, we will disseminate our findings to other countries, the study participants and the research community. We also followed the authorship guidelines of the International Committee of Medical Journal Editing (ICMJE).

Amendments: If there are any amendments to the study protocol, changes will be reflected in the trial registry.

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Supplementary Files

Multimedia Appendixes

Supplementary material 1.
URL: http://asset.jmir.pub/assets/5a81f727169c230ab3f1c762fde33794.docx

Additional questions for intervention participants.
URL: http://asset.jmir.pub/assets/2be385e4a9a79ef2f995fcf72ad1b32a.docx

Related publication(s) - for reviewers eyes onlies

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