Developing a Multi-Component Intervention to Reduce Sedentary Behaviour and Promote Physical Activity for the Physical Activity at Work (PAW) Programme Among Office Workers in Thailand

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Abstract

Sedentary behaviour and physical inactivity increase the risks of non-communicable diseases. Rapid industrialisation and urbanisation have resulted in more sedentary occupations, increasing the number of those suffering from the diseases. This paper describes the two main phases:1) prototype development and 2) feasibility of the process of complex, i.e., multi-component intervention development for the Physical Activity at Work (PAW) – a cluster-randomised trial with 6-month active multi-component intervention to reduce sedentary behaviour and increase physical activity in Thai office workers. The prototypedevelopment phase aimed to review existing theories and frameworks to synthesise the prototype intervention and conducted semi-structured interviews to understand office workers' attitudes towards overall and occupational physical activity as well as sedentary behaviour. The feasibility phase aimed to implement a 2-week prototype intervention and conducted semi-structured interviews to investigate the attitude towards the intervention. The multi-component intervention was developed based on the Socio-Ecological Model framework, including 1) individual-level: a wearable activity tracker and lottery-based incentives, 2) societal-level: team movement break and team-based incentives, 3) environmental-level: posters with education on sedentary behaviours and how to perform movement breaks, and 4) organisational-level: leaders' encouragement messages. Behaviour Change Techniques were used to mediate the effect of each component. Refinements were made throughout the intervention development process, guided by the results from each step. These processes inform other development of similar interventions for a large-scale study aiming at multifaceted behavioural change.

Trial registration: The PAW study was registered at the Thai Clinical Trials Registry (Registration number: ID TCTR20200604007) on 02 June 2020 (02/06/2020).

Introduction

Sedentary behaviour (SB) and physical inactivity have a detrimental impact on health. Previous studies have shown individuals who engage in high SB or minimal physical activity (PA) face an increased risk of mortality and non-communicable diseases such as diabetes and cardiovascular disease [1, 2]. Notably, the most consistent association has been observed with type 2 diabetes [1, 3]. Individuals who engage in more than 5.8 hours of PA per week may not derive additional benefits from further increasing their PA [4]. Despite the growing body of evidence, the precise amount of PA required as a substitute for SB to achieve health benefits remains unknown. To date, only general recommendations have been provided to replace SB with PA [5].

Workplaces are promising settings for reducing sedentary time, particularly among office workers. Occupational sitting time constitutes a significant portion of daily sedentary time among this group [6]. High levels of sedentary time were observed in 64% of white-collar professions in the US [7]. Similarly, in Singapore, office workers exhibit high levels of SB, spending a median of seven hours sitting at work each day, which accounts for 75% of their work hours [8]. SB is also highly prevalent in Thailand, with 78.1% of office workers classified as highly sedentary [9]. In this context, the workplace appears to be a strategic setting for implementing interventions to reduce SB and increase PA.

In Thailand, non-communicable diseases account for more than 70% of all deaths [10]. These diseases share common modifiable risk factors such as physical inactivity, unhealthy diet, tobacco smoking, and unhealthy use of alcohol. Physical inactivity alone is estimated to contribute to 2.4% of all-cause mortality in Thailand [11]. Despite the World Health Organisation recommending that adults aged 18 and above engage in at least 75–150 minutes of vigorous or 150–300 minutes of moderate-intensity PA per week, approximately 30.9% of Thai adults do not meet this guideline [9]. In addition, Thais spend most of their days (approximately 14 hours) being sedentary [9].

In 2016, Thailand hosted the sixth Congress of the International Society for Physical Activity and Public Health and introduced a weekly programme encouraging civil servants to engage in one hour of PA at work [12]. Subsequently, in 2017, The Thai Ministry of Public Health developed a 5-year National Non-Communicable Diseases Prevention and Control Strategic and Action Plan (2017–2021)[13]. As part of this national plan, the Thai Health Promotion Foundation funded the Physical Activity at Work (PAW) project, a cluster-randomised trial to test the effects of a multi-component intervention to reduce SB and promote PA among Thai office workers. The study was conducted at the Department of Medical Services, Ministry of Public Health, Thailand. The PAW study was registered in the Thai Clinical Trials Registry under the study ID TCTR20200604007 [14], and the study protocol as well as the main results have been published elsewhere [15, 16]. This study aimed to describe the design process of the PAW multi-component intervention.

Multi-component intervention design and development process

Our intervention development processes were guided by the Medical Research Council Framework for developing and evaluating complex interventions to improve health and healthcare, 2008 [17]. This framework consists of non-linear stages emphasising the iterative nature

of development, feasibility testing, and product evaluation. In case of the tested intervention is found unfeasible, it is advised to return to the development stage, make refinements, and perform another feasibility assessment. Similarly, if the intervention is deemed ineffective during the evaluation phase, it is recommended to revisit the feasibility and development stages [18].

A team comprising 20 researchers, including behavioural scientists, health economists, public health researchers, statisticians and trial coordinators, was responsible for planning, designing and executing the development process. Regular team meetings and ad-hoc discussions were held to ensure a coherent and effective strategy, along with comprehensive review processes to address any concerns or challenges. The development process followed key phases as depicted in Fig. 1:

1) Phase I Prototype Development; aimed at creating the prototype intervention, which included:

1. Conduct literature reviews to identify relevant theories and frameworks that inform the selection of components of the multi-component intervention
2. Administer semi-structured interviews to assess participants' awareness and understanding of overall and occupational PA and SB. The objective was to develop a prototype of an effective intervention package by identifying relevant factors that influence behaviour change and understanding how participants comprehend the main concepts of PA and SB. The primary aim of the interview was to gain insights into participants' awareness, knowledge, perceptions, and attitude towards PA and SB in general, as well as during working hours in the workplace. The secondary aim was to explore the factors that influence these movement behaviours and the opportunities and strategies they believe could help them to become more active and less sedentary while at work.

2) Phase II Feasibility study; involved conducting a study to assess the feasibility of implementing the prototype intervention and refine its components. This phase included:

1. Implement the prototype intervention for a period of two weeks
2. Administer semi-structured in-depth interviews to collect participants' attitudes and perspectives on the prototype intervention. These interviews explored participants' perceptions of the intervention components, providing valuable insights to refine and improve the intervention.

Comprehensive details of the semi-structured in-depth interviews conducted in both Phase I and Phase II are provided in the supplementary material, following the Consolidated Criteria for Reporting Qualitative Research (COREQ) checklist.

Participants

The participants in this study were full-time office workers from the Health Intervention and Technology Assessment Program (HITAP), Ministry of Public Health. This sample was selected based on similarities in the type of organisation, profession, task and personal characteristics with the offices where the main trial was implemented. HITAP is a non-profit private organisation that focuses on health technology assessment research. The office workers in both organisations primarily engage in desk-based tasks, indicating a potential alignment in values and attitudes towards health and well-being. HITAP consists of three offices with a total of 49 Thai office workers. For this study, two offices located furthest from each other were chosen, comprising 22 and 24 workers, respectively. The office in the middle, consisting of only three office workers and featuring an isolated work area, was not included. Eligibility criteria for participation were as follows: 1) absence of planned travel within the 3-week study period, 2) absence of health-related issues preventing moderate physical activities, and 3) age between 18 and 60. Of the 49 workers, 11 were deemed ineligible due to their travel plans. Recruitment was closed after reaching 20 interested participants on a first-come, first-served basis, with 10 participants per office (Fig. 2). This decision was made due to the limited time frame of 2 weeks and available resources. All participants received detailed information about the study during the recruitment process, and written informed consent was obtained between January and February 2020. The study received ethical approval from the Institute for the Development of Human Research Protections (IHRP) Ethics Committee, in accordance with the Declaration of Helsinki (protocol number: 004-2563).

Phase I Prototype Development

1. Literature Reviews to identify frameworks, theories, and intervention components

Socio-Ecological Model

The PAW multi-component intervention was developed based on the Socio-Ecological Model framework, which posits that behaviour is influenced by individual, social, organisational and environmental factors [19–21]. This model has been previously adapted to the PA and

SB domains. Sallis et al. formulated the Socio-Ecological Model of Change for the four domains of active living: recreation, transport, occupation, and household, allowing for the identification of barriers and facilitators for PA [20]. Owen et al. expanded the model to address SB, emphasising the importance of behaviour settings and social frames in changing SB [21]. Interventions informed by the Socio-Ecological model demonstrated greater effectiveness in promoting PA and reducing SB [19, 20, 22]. For our intervention, we adapted factors influencing behavioural change into the intervention components at individual, social, organisational, and environmental levels (Fig. 3). The design of the intervention component at the organisational level also drew influence from the social cognitive theory [23] and social learning theory [24].

Complex intervention and its components

A complex intervention is commonly defined as an intervention containing several interacting components with varying degrees of complexity [25]. Our approach was informed by systematic reviews highlighting the effectiveness of complex interventions targeting PA or SB in the occupational domain compared to single interventions [26–28]. Notably, a systematic review by Chu et al. [26] showed that multi-component interventions achieved the greatest reduction in workplace sitting time (-88.8 min/8-h workday), outperforming environmental interventions (-72.8 min/8-h workday) and educational/behavioural strategies (-15.1 min/8-h workday). By introducing multiple components that target and mediate different levels of the behavioural change mechanism, we aimed to enhance the intervention effect, which would have been challenging to achieve if individual components were introduced separately.

The PAW intervention is divided into four dimensions and comprises six components (Fig. 3). The dimensions and corresponding components are as follows:

1) individual-level: Fitbit (a wearable activity tracker) and lottery-based incentives

2) societal-level: team movement break and team-based incentives

3) environmental-level: poster

4) organisational-level: leaders' messages.

Behaviour Change Techniques [29] were used to mediate the effect of each component. Table 1 provides an overview of how the intervention components map onto each dimension of the Socio-Ecological model and indicates which Behaviour Change Techniques were adopted. A detailed description of the theories used is provided in the supplementary material (**Supplementary Table 1**).

Table 1
Summary of intervention components with related Socio-Ecological model and Behaviour Change Wheel

Socio-Ecological Level Targeted	Intervention	Behavioural change technique (taxonomy number) [30]
Individual level	Activity tracker – Fitbit Inspire HR	Feedback on behaviour 2.2
	Lottery-based individual incentive	Material incentive (behaviour) 10.1
		Material reward (behaviour) 10.2
Social level	Team Movement breaks	Behaviour substitution 8.2
		Prompts/cues 7.1
		Action Planning 1.4
		Habit formation 8.3
		Habit reversal 8.4
		Instruction on how to perform a behaviour 4.1
		Demonstration of the behaviour 6.1
		Social comparison 6.2
	Team-based incentive	Social incentive 10.5
		Social reward 10.4
		Social comparison 6.2
Environmental level	Posters	Information about health consequences 5.1
		Instruction on how to perform behaviour 4.1
		Behaviour substitution 8.2
		Material incentive (behaviour) 10.1
Organisational level	Leaders' supports	Information about others' approval 6.3

Individual-level components: Fitbit and Lottery-based incentives

The Fitbit Inspire HR model, an activity tracker, was used as a self-monitoring tool to enhance self-awareness, as SB and insufficient PA often occur subconsciously [31, 32]. The Fitbit device displays step counts and provides prompts when no movement of at least 250 steps per hour is detected. Mobile Health technology, including FitBit, is widely accessible, making it an affordable option to reach a large population while allowing for device personalisation [27]. A comprehensive review of 37 FitBit interventions found that it significantly increased daily step counts and reduced time spent in SB [33]. Nevertheless, Fitbit or self-monitoring is rarely promoted as a single strategy but as part of a multi-component intervention. A systematic review of mobile health interventions at the workplace showed that multi-component interventions were more effective than standalone app-based interventions, as engagement with standalone apps tended to decline over time [27, 28]. Based on these findings, we chose Fitbit as a tool to support participants in promoting PA and reducing SB, while simultaneously recording their adherence to movement breaks.

The individual-based lottery incentives, amounting to 500 THB (14.2 USD), were implemented to increase participants' motivation to actively participate in the movement breaks. According to learning theory, incentives are designed to provide an immediate reward for engaging in behaviours that yield long-term health benefits [34, 35]. Moreover, a literature review indicates that both significant and modest financial incentives can potentially encourage individuals to adopt healthier behaviours [36].

Social-level components: Team movement breaks and Team-based incentives

Team movement breaks served as the main component for reducing SB and increasing PA. A study involving 1107 employed adults in Australia showed that individuals who perceived their work colleagues as physically active were more than two and a half times as likely to report engaging in PA at work. Similarly, those who perceived their employer or manager as active at work were nearly twice as likely to report being physically active [6, 7]. A meta-analysis further demonstrated that interventions incorporating social support structures were more effective in increasing PA than interventions lacking such support [37]. Based on these findings, we hypothesised that group movement breaks would leverage the positive influence of peer pressure among colleagues to elevate PA levels.

Light-intensity PA and moderate-intensity PA were chosen as the target activity levels because of their established positive effects on biomarker outcomes. Additionally, these activity levels were deemed achievable within an office setting. Studies demonstrated that incorporating short, frequent bouts of light-intensity PA throughout the day may reduce the risks of cardiometabolic conditions and mortality [38]. Although higher-intensity PA generally has a more significant positive impact on health [39], integrating it into day-to-day office life may be more difficult [38].

Increasing the time spent in both moderate-to-vigorous-intensity and Light-intensity PA has shown beneficial effects on health [4, 5, 38, 40]. Distributing Light-intensity PA throughout the day, rather than engaging in one continuous bout of PA, has been associated with additional health benefits [41–44]. In addition, increased time spent in Light-intensity PA has been shown to reduce the risk of all-cause mortality (pooled HR 0.71; 95% CI 0.62 to 0.83) [38]. The 2020 guidelines on PA and SB by the World Health Organisation also recommend replacing SB with Light-intensity PA for adults aged 18 to 64 [40]. Mechanistic studies have demonstrated that several short breaks, instead of one long break with the same energy expenditure, lead to better glycaemic control [41–45]. For instance, substituting 6 hours of sitting with 4 hours of walking and 2 hours of standing, compared to an hour of PA with the same energy expenditure, was more effective in controlling insulin levels and plasma lipids in a study involving 18 healthy individuals [43]. An eight-week randomised trial with 49 healthy sedentary employees showed that a 1–2-minute break every 30 minutes resulted in small to moderate declines in total cholesterol, triglycerides, and fasting blood glucose from pre- to post-intervention. In contrast, the group that took longer 15-minute breaks twice daily did not show changes in their health outcomes [41]. Therefore, our intervention aimed to encourage participants to engage in light-intensity PA movement breaks while not discouraging moderate-to-vigorous-intensity PA.

Team-based lottery incentives have been shown to motivate behaviour change [46]. We included team-based rewards contingent on achieving the target behaviour [47–49]. Participants were eligible to receive rewards based on two criteria: their individual targets (see “Individual-based lottery incentives”) and whether the majority of participants in their group met the targets. This system enhanced collaboration and peer support by encouraging participants to work together towards a common goal. Achieving this goal, contingent on individual performance also enhances individual accountability through peer pressure effects [48, 49]. The lottery-based incentives are primarily aimed at enhancing adherence to PA and reducing SB.

This intervention component was selected based on two beneficial factors: timeliness and peer pressure. The weekly distribution of the lottery created a temporal interval between incentive allocations, providing participants with opportunities to reflect and modify their behaviour prior to the subsequent round of incentive distribution. Participants within the same cluster, sharing an office space, had the advantage of witnessing others receiving prices. This factor heightened peer pressure among participants, fostering greater individual and group motivation to earn incentives, ultimately leading to improved group performance. Note that these incentives were given out to intervention clusters only.

Environmental-level component: Posters

This intervention component addressed psychological factors such as motivation and social norms in the office. It also served as a reminder to participants, emphasising the importance of taking breaks and moving after prolonged periods of sitting. It has been shown that highlighting the benefits individuals can gain from adopting a certain behaviour (i.e., gain-framed) is more effective in promoting behaviour change than focusing on the negative consequences of not adopting the behaviour (i.e., loss-framed). This approach has been proven to be more engaging, comprehensible, and motivational for behaviour change [50, 51].

Importantly, behaviour change is more likely to occur when multiple factors are addressed simultaneously. With this in mind, the posters convey multiple messages that complement each other, encouraging participants to take breaks while also suggesting various activities they can engage in during those breaks. The design of the posters was based on the principles of the Behavioural Change Wheel and Behaviour Change Techniques [30, 52]. By identifying the underlying issues contributing to SB and targeting intervention functions through the Behavioural Change Wheel, several relevant Behaviour Change Techniques were incorporated. These included ‘instruction on how to perform a behaviour’, ‘information about health consequences’, ‘behaviour substitution’, and ‘material incentive (behaviour)’ (**Supplementary Table 1**).

Organisational-level components: Leader’s messages

Several theories have contributed to understanding the impact of leaders on employees, leading to the inclusion of the leader’s messages as a supporting component. The formal leaders within an organisation play a crucial role in influencing their employee’s SB by shaping the work culture and promoting the importance of taking sedentary breaks. Previous studies have shown that an organisation’s culture can positively or negatively impact employees’ SB [53, 54]. According to social learning theory, individuals who are perceived as trustworthy and likeable can serve as persuasive agents for change by informally influencing others, known as opinion leaders [53].

Similarly, social cognitive theory emphasises that people learn by observing and imitating others' behaviours, particularly in social contexts. It highlights the significance of modelling or demonstrating behaviour, providing instructions on how to perform a behaviour, providing encouragement, and providing information on the consequences of actions [55].

To enhance and maintain employees' engagement with the PAW intervention throughout the intervention period, the intervention incorporates encouraging messages from organizational leaders. These messages were designed to serve as positive communication, motivating and supporting participants to actively participate in the intervention. The content and frequency of the messages were carefully designed based on their appropriateness and practicality. They employed encouraging language and tone, fostering a sense of connection among participants and creating peer pressure to engage with the intervention (**Supplementary Table 1**). Moreover, the scheduling of these messages was carefully balanced to ensure their promotional effect without causing any disturbances.

2. Participant's awareness and understanding of SB and PA

Study Design

We used a deductive approach to explore the pre-specified question. Semi-structured in-depth interviews were conducted. Thematic analysis was then used to deduce and categorise the information into main and sub-themes, using the Socio-Ecological model and the Health Belief Model as frameworks [56, 57]. Table 2 presents the interview results as well as the identified potential facilitators and barriers.

Interview Results

At the individual level, five level-2 subthemes were identified (Table 2). Participants expressed a general misconception of PA, perceiving it solely as exercise, and viewed SB as lacking movement. They believed that SB negatively affects physical and mental health while holding positive overall attitudes towards the health benefits of PA. Concerns were raised about the potential negative impact of PA on concentration in the workplace, leading to suggestions that PA might be better suited for leisure time. Despite these concerns, the participants shared various ideas for incorporating sedentary breaks into their work routines. For example, they suggested activities such as taking short walks to get water, engaging in teatime, and conversing with co-workers in different offices. Moreover, they expressed a sense of self-efficacy by highlighting that they did not perceive any physical limitations. For instance, they mentioned that individuals who are overweight can still engage in physical activity, or even those with underlying health conditions can exercise.

At the social level, three sub-themes emerged: peer support, interaction, and work culture (Table 2). The responses regarding the role of peer support in motivating PA varied among participants. Some expressed concerns about the potential impact of workplace PA on colleagues' productivity and concentration, potentially hindering motivation to participate. However, participants also reported that engaging in PA with their colleagues positively influenced their participation, as it fostered encouragement and increased motivation. Moreover, the number of staff members participating impacted the participation rate. Increased participant interactions resulted in higher engagement and a greater likelihood of participation. In addition, it was reported that the organisational culture posed challenges to PA engagement. The prevalence of frequent meetings, lunches, and snacks provided within the office space created an environment that was not conducive to PA. Furthermore, a strict and highly work-focused workplace environment was identified as a factor that encouraged SB.

At the environmental level, three subthemes were identified: built environment, ergonomics and setting, and building design. It was noted that an active workplace environment can facilitate promoting PA within the workplace. In contrast, a rigid workplace environment with assigned desks, chairs, and limited free space might hinder PA promotion. Participants expressed concerns regarding uncomfortable office furniture, which might be a barrier to PA. To address this, the use of standing desks was suggested as a way to reduce SB. Limited office space was also reported as an issue, posing a challenge to engaging in PA due to the difficulty of finding suitable areas.

At the organisational level, two subthemes were identified: the responsibilities and duties of employees and organisational policy. In general, the workload for participants was reported to be high and predominantly desk-based. The type and nature of work, reported as being largely inactive, were commonly identified as barriers preventing PA engagement while facilitating SB. However, it was noted that existing policies could potentially facilitate participants' involvement in the programme. The participants' behaviour was influenced by weighing the barriers they faced, such as time constraints, inconvenience, discomfort, and unpleasant feelings, against the perceived benefits of PA, which included a reduced risk of diseases, improved mental health, and weight loss.

Table 2
Interview results

Themes	Sub-themes level 1	Sub-themes level 2	Interview outcomes		Interpretations	Recommendations
			Facilitator	Barrier		
Individual	Psychological	Knowledge		- "PA equals exercise…" - "SB equals no movement."	- A lack of knowledge about PA and SB could be a barrier to participation in intervention.	- Educating and raising awareness could help promote PA.
		Perceived benefits of PA	- "…it improves overall health, relieves office syndrome… less stress". - "good relationships with colleagues."		- Perceived benefits of PA could facilitate intervention adherence - Health risks and concerns were linked to motivation for PA	
		Attitude towards PA		- "… workplace PA might lessen work focus…I prefer PA in leisure time."	- The attitude may lessen the motivation to participate.	- Personal preferences of timing and environment influence attitudes towards PA
		Attitude towards SB	- "I think SB can cause daytime sleepiness, stress, poorer working memory". - "SB can be harmful"	- "…it (SB) was like breaks or relaxation."	- Negative attitude towards SB facilitates intervention adherence. - Thinking SB is a relaxation can hinder participation.	
		Self-efficacy	- "I don't think we have any physical limitation"… "even if I'm fat and have underlying conditions, I can exercise."		- Participants appear to have high self-efficacy, which could facilitate adherence.	
Social	Peer support	N/A	- "when my girlfriend said I look awful…I would want to do more PA."	- "I really don't want to annoy colleagues… like interfere with their focus."	- Positive peer support could help motivate PA. - Concerns about work interruptions could be a barrier.	- The level of influence is likely to be influenced by personal attitudes and beliefs.
	Interaction	N/A	- "what encourages me is when			- Colleagues' encouragement could provide a positive impact.

			colleagues around me talk about running after work…"			- The number of participating staff can affect the participation rate.
	Work culture	N/A		- The work culture was not supportive of PA: "many meetings and high workload, we don't have time."	- Unsupportive culture of the organisation may discourage participants from participating in the intervention.	- The organisation's work culture can have a background impact on participation in the intervention.
Environment	Built environment	N/A	- "active workplace environment can help encourage me to do more PA"	- "actually… the rigid office structure does not really allow us to really…like… exercise"		
	Ergonomics	N/A	- "I've heard that standing desks could help"	- "Office chairs are not comfortable."	- Standing desk could facilitate PA.	
	Setting and building design	N/A		- "the space is limited and might be difficult to move around more"		- Standing desk might not be feasible in the offices
Organisational	Responsibilities and duties	N/A		- "Desk-based work, heavy workload, and sedentary meetings"	- These factors could prevent participants from engaging in PA while facilitating SB.	- Certain job positions may have a higher chance of reducing SB, such as receptionists
	Organisational policy	N/A	- "The organisation implemented programmes to improve PA in the workplace, such as a step count challenge, exercise at 3 pm, and sports days."		- Participants might be aware of the importance of PA from previous programmes	

Phase II Feasibility

Attitude towards intervention: semi-structured in-depth interview

Study design

After providing participants with an information sheet and obtaining their consent, the intervention was implemented for two weeks, from 16 March to 3 April 2020. Participants were invited to share their thoughts regarding the intervention after this period. The interviews lasted up to 120 minutes and were audio-recorded. The verbatim transcriptions were then subjected to analysis. The comments were mapped onto intervention components to refine intervention materials iteratively.

Interview Results

The default setting of the devices was generally reported as sufficient, although participants were given the option to customise it according to their preferences. Some participants experienced technical difficulties when syncing the devices with their phones. Participants generally found the Fitbits to be comfortable to wear. However, one participant experienced an allergic reaction while wearing the device. Additionally, some participants preferred using their smartwatches instead of the provided devices.

Regarding the frequency of movement breaks, some participants thought four times a day was too frequent and suggested reducing it to twice daily. They were concerned about the fixed schedule of movement breaks, as it might hinder their participation if they were occupied at a specific time. Participants preferred not to have movement breaks during meetings, as they did not want to be interrupted from their work tasks. Generally, participants found 3–5 minutes for the movement breaks to be acceptable. Feedback regarding the intensity of the movement breaks was positive, as participants appreciated that it did not cause sweating and was not overly tiring. They enjoyed the standard movement examples, finding them effective, not too rigorous, and enjoyable. In addition, participants suggested that new movement break activities at times would help boost enthusiasm. Some participants working from home reported that the online version of fixed-scheduled movement breaks enhanced their productivity. The presence of two leaders in the movement breaks also received positive feedback, with active and encouraging leaders being seen as crucial for participation. Lastly, participants expressed a desire to have the freedom to choose their preferred music during the movement breaks.

In terms of the frequency of incentive distribution, some participants viewed it as a positive strategy to encourage participation and suggested that it should be distributed more frequently to those who were actively engaged and adhered to the intervention. On the other hand, some participants felt that the value of the incentives was not high enough, while others expressed no interest in incentives and considered the amount offered negligible. None of the participants met the eligibility criteria for incentives in both weeks. This resulted in some participants perceiving the criteria as difficult to achieve. They became discouraged when they were unable to fulfil a few movement breaks and felt demotivated to comply further.

Participants reported that one set of posters was sufficient, but they found the poster size of A3 to be too small. The messages displayed on the posters were seen as informative and encouraging. However, the locations of the posters were deemed unsuitable, as they were not easily visible. Participants suggested placing the posters in more accessible positions, such as at the entrances, to enhance visibility and reach.

In contrast, the leaders' messages were perceived as unnecessary, unencouraging, too frequent, and lacking any significant effect. Nevertheless, participants found notifications via LINE™ helpful in reminding them about the intervention.

The Final Intervention

Based on the findings from the literature review conducted in Phase I, the semi-structured in-depth interviews focusing on participants' awareness and understanding of SB and PA models, the implementation of the prototype intervention during the 2-week pilot study, and the subsequent semi-structured in-depth interview assessing participants' attitudes towards the intervention in Phase II, the final intervention for the PAW project was developed. Table 3 presents a detailed overview of the processes involved and the components of the final intervention.

To address the challenges encountered by participants with the technology, we made adjustments to the Fitbit sync reminders, reducing them to twice a week. Additionally, we ensured timely support for any technical issue that participants faced. It is important to note that even participants with smartwatches still needed to wear Fitbit to record their participation data accurately. Regarding the frequency of movement breaks, while some participants felt too frequent, we decided to proceed with the four times daily frequency to assess the potential benefits of multiple short breaks, as suggested in previous research [41]. To prevent monotony, we provided more examples of enjoyable movements and allowed participants to propose new hit songs to keep the breaks engaging.

In order to increase attainability and provide greater encouragement, we lowered the eligibility criteria for both individual and team-based rewards to 70%. Participants were also allowed to modify the start time within a 1-hour time window for higher flexibility. Moreover, we recommended online meetings for group movement breaks during work-from-home.

Regarding the posters, we increased the size to A1 for better clarity and visibility of the messages. The positioning of the posters was determined collaboratively by both researchers and participants, as the workers have a better understanding of their office layout and visibility. Lastly, to strike a balance between providing encouragement and avoiding message overload, we reduced the frequency of

leader encouragement messages to twice a week. One of the weekly messages featured a photograph capturing the moment the directors presented the reward to the winner, aiming to inspire greater participation (Table 3).

Discussion

This paper describes an evidence-informed process for the methodological development of a multi-component intervention tailored for the target population. Qualitative methods were employed in two phases: Phase I involved literature reviews, and Phase II employed semi-structured in-depth interviews. These methods yielded insights into theories, frameworks, and participants' attitudes on PA and SB, informing the intervention's context for the target population. Combining the results from both phases, a comprehensive understanding of the intervention's suitability and feasibility within the workplace was achieved.

The World Health Organisation guideline on *Population-Based Approaches to Increasing Levels of Physical Activity* [40] recommends using a model when developing a complex intervention. In Phase I, the Socio-Ecological model was selected as the primary guide for the prototype development processes. Related theories were used in a similar study by Estabrooks et al. 2011, which integrated the Protection Motivation Theory and The Ecological Model of Physical Activity to develop a multiple modality theory-based PA-promotion intervention [58]. While these theories are relevant, the Socio-Ecological Model comprehensively covers behaviour change at all levels and allows for the integration of various Behaviour Change Techniques. Additionally, Social Cognitive Theory and Social Learning Theory were adopted to design the intervention at the organisational level, leveraging the influential role of leaders in the workplace.

Important refinements were made throughout the intervention development process, guided by the results obtained at each step. In light of the pilot study, where no participants qualified for incentives, adjustments were made to increase attainability while maintaining the effectiveness of the incentives. The eligibility criteria for lottery-based and team-based incentives were lowered from 80–70% to strike a balance between achievability and motivational impact. Furthermore, participants were given the flexibility to modify the start time of movement breaks, with the requirement of leaders documenting the movement breaks logs and the modification being made at least one hour in advance. A broader range of standard movements was provided through videos and online resources to enhance participants' engagement, allowing them to choose movements that suit their preferences. Additionally, participants were given the opportunity to create their own moves, which underwent eligibility assessments before implementation.

The trial implementation faced certain limitations that impacted its practicality. Due to restricted timelines, resource availability, and staffing constraints, not all findings from the semi-structured interviews on participants' awareness of PA and SB could be fully integrated into the intervention development process. An important example was the exclusion of standing desks from the final intervention, despite evidence of their effectiveness [26] and insights from the initial interview (Table 2). Two factors influenced this decision. First, there were challenges in modifying government-provided materials, such as desks, due to limitations imposed by the parcel department at the main trial site and constraints regarding available office space. Second, the constrained timeline and resources posed additional limitations on the implementation possibilities.

The insights gained from the semi-structured interviews on participants' attitudes towards the intervention were not entirely integrated into the intervention development. Despite participants raising specific concerns about using Fitbit, such as syncing issues with smartphones, Fitbit remained the most suitable device for data collection due to its overall high satisfaction among participants. Regarding leaders' messages, while participants did not enthusiastically receive them, we recognised their importance as a component that targets the organisational level. Therefore, we retained their inclusion in the intervention but reduced their frequency to twice weekly.

Additionally, it is crucial to acknowledge further limitations of this study. Firstly, the sample for the pilot study and both interviews was limited to one unit. Despite efforts to ensure similarity in the type of organisation, profession, tasks, and personal characteristics, the participants in the cluster-randomised trial were drawn from 13 units within the entire department. Furthermore, the sample size was relatively small, with only 20 participants in the pilot study and the semi-structured interview assessing participants' awareness and understanding of SB and PA models and 10 participants in the semi-structured interview assessing attitudes towards the intervention. Another limitation is the short duration of the pilot study, which lasted only two weeks. This limited timeframe did not provide sufficient opportunity for participants to become accustomed to the intervention and provide more detailed feedback.

Conclusion

This comprehensive description of a complex intervention development process provides valuable insights into the intricate and challenging nature of creating, refining, and implementing an effective complex intervention that aligns with its relevant context and target population. The findings highlight the integration of behavioural change theories with practical considerations when addressing SB and

PA in the workplace. There remains a need for a more rigorous approach to developing and piloting new interventions before conducting randomised-controlled trials. This requires careful planning, adequate time frames, and sufficient resources. The description of the PAW development process can guide informing and supporting the development of other complex behaviour change interventions for feasible large-scale studies aimed at promoting PA and reducing SB.

Abbreviations

PA
physical activity
SB
sedentary behaviour
PAW
Physical Activity at Work

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, Thailand (IRB00001629). Any modification to the approved protocol will be submitted for review by the ethics committee. All participants provided written informed consent prior to the participation.

Consent for publication: NOT APPLICABLE

Availability of Data and Materials: The data and materials used in this study are available upon request from the corresponding author. Please contact Katika Akksilp at gochi.akk@gmail.com for access to these resources.

Competing interests: The authors do not have conflicts of interest to report.

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Author's Contributions: All authors contributed to the study design and/or delivery of the intervention. KA was Principal Investigator (PI) of the trial. NB, KA, and AD drafted the manuscript together. RN and TR provided expertise on behavioural economics, such as the design of the lottery-based and team-based incentives. FMR and AMM provided expertise on frameworks and theories behind the intervention development. AMM trained the research team regarding the qualitative interviews and analyses. TA, WI, YT, and CC closely monitored the conduct of the entire study with essential supports. 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).

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Tables

Table3 is available in the Supplementary Files section.

Figures

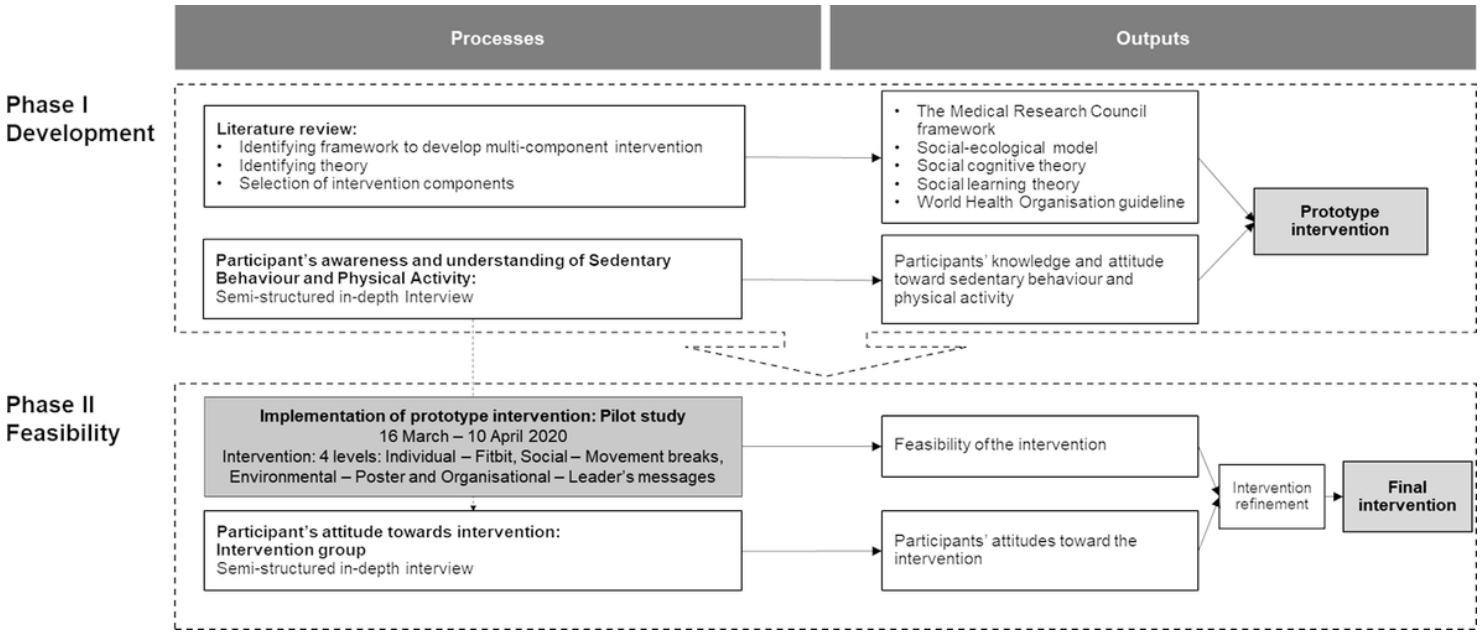

Figure 1

A schematic diagram summarising phases of the PAW multi-component intervention development (October 2019 to June 2020)

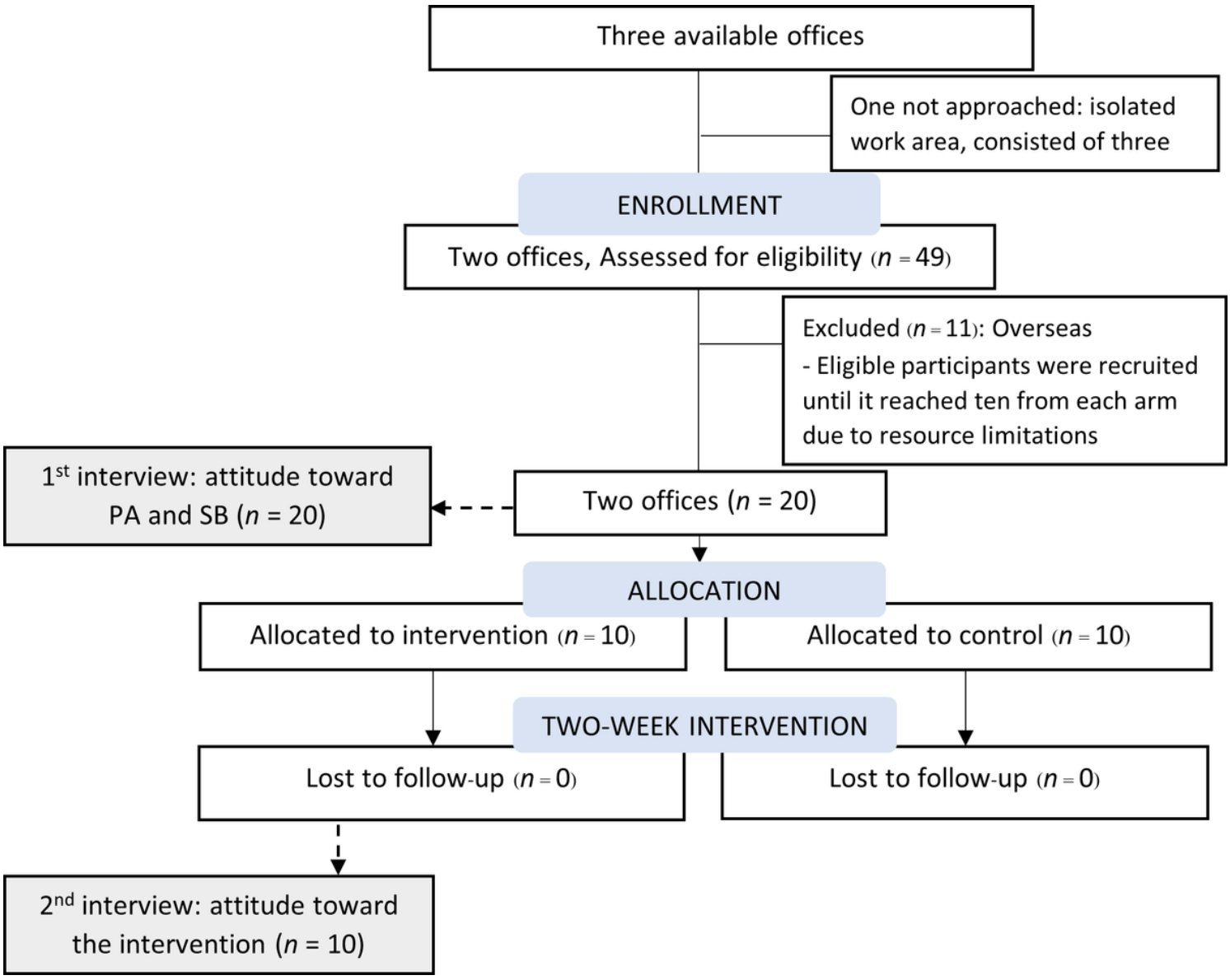

Figure 2

Flow diagram

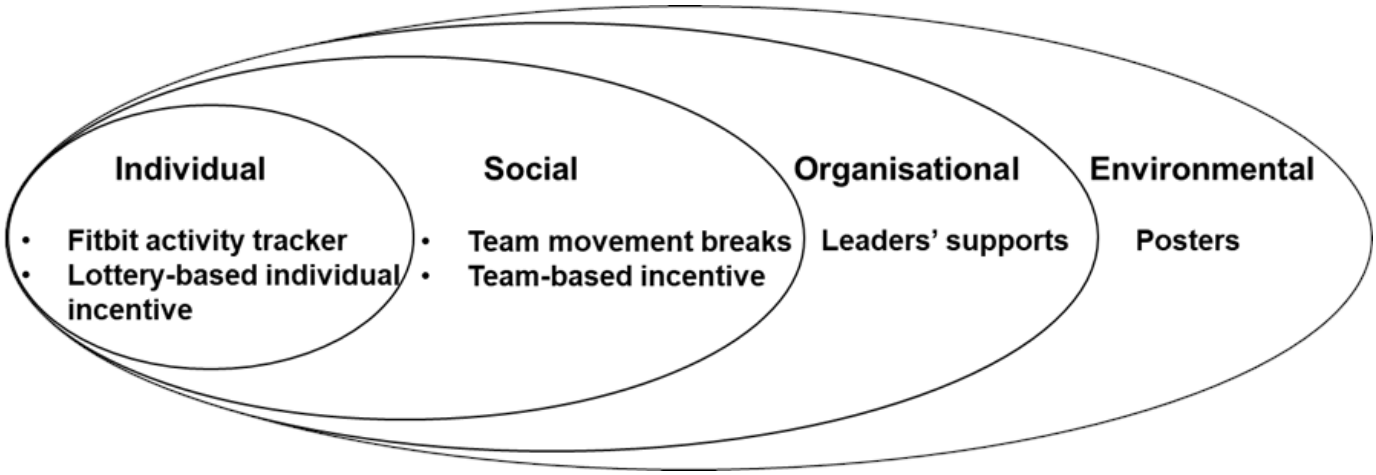

Figure 3

Supplementary Files

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