PSYCHOPHYSIOLOGICAL MECHANISM OF TRADITIONAL CHINESE MEDICINE (TCM)-BASED INTERVENTION TO REDUCE DAILY SEDENTARY BEHAVIOURS AND IMPROVE WELLNESS AMONG OFFICE WORKERS

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The Hong Kong Polytechnic University

2026

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Psychophysiological Mechanism of Traditional Chinese Medicine (TCM)-based Intervention to Reduce Daily Sedentary Behaviours and Improve Wellness among Office Workers

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A thesis submitted in partial fulfillment of the requirements

for

the degree of Doctor of Philosophy

August 2025

CERTIFICATE OF ORIGINALITY

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ABSTRACT

Sedentary behaviors (SBs) and their associated health risks have attracted increasing attention in clinical and research settings, particularly among office workers. Evidence has revealed that higher levels of SBs in the workplace are associated with higher perceived stress and cortisol levels. However, few studies have focused on the role of stress management in reducing SBs. Traditional Chinese Medicine (TCM)-based body works (e.g., Baduanjin, dantian breathing, acupressure) are low-cost techniques with promising possibilities for addressing stress and SBs in the workplace. The present research tested the effects of a TCM-based sedentariness-reduction intervention on sedentary time, physical outcomes, and psychological outcomes for office workers. We also investigated whether such an sedentariness-reduction effect would operate through stress management. To address these knowledge gaps, this project comprised one systematic review and meta-analysis, a feasibility randomized controlled trial (RCT), and an RCT.

Study 1 (Chapter 3) reports on a systematic review and meta-analysis conducted to examine the pooled effect of SB-reduction interventions on office workers' sitting time, relative to various control conditions. The findings indicated that SB-reduction interventions were generally effective in decreasing workplace sitting time.

Multicomponent interventions combining environmental support with motivational strategies emerged as the most effective approach. However, the quality of the evidence was moderate due to methodological constraints. Future research therefore should not only focus on reducing SBs but also aim to demonstrate the broader physical and psychological benefits of SB-reduction interventions.

Study 2 (Chapter 4) outlines a feasibility RCT conducted with Chinese office workers, comparing a TCM-based intervention for reducing sedentariness with a waitlist control. Thirty-eight participants were randomly assigned to either the intervention or the control group. The intervention comprised three workshops over two weeks, emphasizing mindfulness-based practices and strategies to address environmental factors contributing to SBs, followed by two weeks of guided self-practice. The intervention was deemed both feasible and acceptable, with preliminary results indicating reductions in sitting time and improvements in perceived stress. However, the small sample size limited the ability to detect significant differences in secondary outcomes.

Study 3 (Chapter 5) presents an RCT conducted to assess the effectiveness of a TCM-based intervention in decreasing SBs among 63 middle-aged Chinese office workers, compared with a waitlist control group. The study also investigated changes in the participants' physical activity, health indicators, and the psychophysiological mechanisms underlying the intervention's effects. The four-week intervention led to significant reductions in SBs and improvements in hypothalamic-pituitary-adrenal (HPA) axis regulation, grip strength, emotional well-being, and self-efficacy. In addition, mediation analysis indicated that the decrease in sedentary time was associated with modulation of the HPA axis during the workday.

In summary, this project advances understanding of the role of TCM-based interventions in reducing SBs and managing stress among office workers. The evidence suggested that TCM-based bodywork is practical and effective in decreasing sitting time, reducing stress, and improving health outcomes. These findings underscore the value of incorporating stress management into SB interventions and support the need for a full-scale RCT to confirm these findings and further elucidate other salient biopsychosocial mechanisms.

LIST OF RESEARCH OUTPUT DURING THIS CANDIDATURE

A: Journal publications during the PhD study period (arising from this thesis):

Wang, C., Lu, E. Y., Li, Y., Sun, W., & Tsang, H. W. H. (2025). Effects and psychophysiological mechanism of Traditional Chinese Medicine (TCM)-based intervention to reduce daily sedentary behaviors and improve wellness among office workers: A randomized controlled trial. (In preparation)

Wang, C., Lu, E. Y., Li, Y., Sun, W., Chang, J. R., & Tsang, H. W. H. (2025). Traditional Chinese Medicine (TCM)-based intervention for reducing sedentariness and improving psychological well-being in office workers: A feasibility randomized controlled trial. *Frontiers in Public Health.* (Accepted)

Wang, C., Lu, E. Y., Sun, W., Chang, J. R., & Tsang, H. W. H. (2024). Effectiveness of interventions on sedentary behaviors in office workers: A systematic review and meta-analysis. *Public Health*, 230, 45–51. https://doi.org/10.1016/j.puhe.2024.02.013

B. Conference paper during the PhD study period (arising from this thesis):

Wang, C., Lu, E. Y., Li, Y., & Tsang, H. W. (2025). Multicomponent intervention for reducing sedentariness and improving psychological well-being in office workers: A randomized controlled trial. *American Journal of Occupational Therapy,79. https://doi.org/10.5014/ajot.2025.79S2-PO390*

C. Conference presentations during the PhD study period (arising from this thesis):

Wang, C., Lu, E. Y., Sun, W., Chang, J. R., & Tsang, H. W. (2023, May 10). The effectiveness of interventions in reducing sedentary behaviors in office workers: A systematic review and meta-analysis [Poster presentation]. *PolyU Academy for Interdisciplinary Research Congress*, Hong Kong, China.

Wang, C., Lu, E. Y., Sun, W., & Tsang, H. W. (2023, November 23-24). TCM-based intervention for reducing sedentariness and improving psychological well-being in office workers: Efficacy and psychophysiological mechanism [Oral presentation]. *The 13th Pan-Pacific Conference on Rehabilitation*, Chiang Mai, Thailand.

Wang, C., Lu, E. Y., Li, Y., & Tsang, H. W. (2025, April 3-5). Multicomponent intervention for reducing sedentariness and improving psychological well-being in office workers: A randomized controlled trial [Poster presentation]. *American Occupational Therapy Association INSPIRE 2025 Conference*, Philadelphia, PA, United States.

D: Awards to the student during the PhD study period (arising from this thesis):

Best Oral Presentation Award, The 13th Pan-Pacific Conference on Rehabilitation, Chiang Mai, Thailand, 23^{th}-24^{th} November 2023.

ACKNOWLEDGMENTS

I extend my deepest gratitude to my chief supervisor, Professor Hector Tsang, for his unwavering guidance, insightful advice, and steadfast support throughout my PhD journey. His mentorship has provided invaluable opportunities for my scholarly development, and his timely suggestions have been instrumental in my professional growth.

I am profoundly grateful to my co-supervisor, Dr. Erin Lu, for her exceptional dedication and expertise over the past four years. Her continuous guidance and encouragement were indispensable to the completion of this research and thesis.

Special thanks also go to the staff of the Department of Rehabilitation Sciences, particularly Dr. Raymond Chung, for his patient guidance on statistical analysis, and Mr. Dennis Mok for his prompt logistical assistance.

I warmly acknowledge my teammates: Yutong Li, Wen Sun, and Yiting Weng, along with my friends in the RS and AMA department, for their steadfast support and encouragement during challenging times. I also thank the research personnel from Professor Tsang's team—Gail Li, Sammy Wong, Monica Zhang, and Yoyo Fung—for their essential contributions to data collection and analysis.

My sincere appreciation goes to all of the study participants, without whom this research would not have been possible.

Finally, I reserve my utmost gratitude to my family: my parents, sister, husband, and daughter, whose unconditional love, patience, and encouragement have sustained me throughout this journey.

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LIST OF ABBREVIATIONS

AUC	Area under the curve
BMI	Body mass index
CAR	Cortisol awakening response
CI	Confidence interval
CVD	Cardiovascular disease
DASS	Depression, anxiety and stress
DBP	Diastolic blood pressure
ELISA	Enzyme-linked immunosorbent assay
ES	Environmental support
GRADE	Grading of Recommendations, Assessment, Development, and Evaluation
GPAQ	Global Physical Activity Questionnaire
HDL	High-density lipoprotein cholesterol
HPA	Hypothalamic-Pituitary-Adrenal
IPAQ	International Physical Activity Questionnaire
IR	Insulin receptor
ITT	Intention-to-treat
MCCIs	Monte Carlo confidence intervals
MD	Mean difference
METs	Metabolic equivalents
MOST	Measure of Older Adult's Sedentary Time
MS	Motivational strategies
Multi	Multicomponent
MVPA	Moderate-to-vigorous physical activity
OD	Optical density
OSPAQ	Occupational Sitting and Physical Activity Questionnaire

PA	Physical activity
PICOS	Participants, Intervention, Comparison, Outcome, Study design
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PSQI	The Pittsburgh Sleep Quality Index
PSS	Perceived stress scale
RCT	Randomized controlled trial
SBP	Systolic blood pressure
SBs	Sedentary behaviors
SD	Standard deviations
SE	Standard error
SF-36	The 36-Item Short Form Survey
TCM	Traditional Chinese Medicine
WSQ	Workforce Sitting Questionnaire

Chapter 1 Introduction

This chapter is an overview of the global health burden posed by sedentary behaviors (SBs), the association between SBs and stress, and an introduction of a Traditional Chinese Medicine (TCM)-based intervention as a novel solution to addressing SBs and improving physical and mental health. The chapter sets out the background of the study and states the research gaps, and it ends by providing the schematic structure of this thesis.

1.1 Background

1.1.1 Sedentary behaviors (SBs)

Sedentary behaviors are a well-recognized public health concern, with increasing empirical evidence linking them to a range of health risks in adults[1-3]. Reports have indicated that 31% of adults globally do not engage in sufficient physical activity and are involved in excessive SBs. Increased SBs have been found to be associated with higher costs related to various noncommunicable diseases and annual out-of-pocket healthcare expenditures[4, 5]. With high levels of SBs and physical inactivity, approximately 500 million new cases of preventable noncommunicable diseases could emerge by 2030, imposing a substantial financial burden on healthcare systems[6].The detrimental health effects of SBs have been well-documented and can occur independently of moderate to vigorous physical activity[7, 8]. Extended periods of sedentary behaviors have been linked to a higher risk of death from cardiovascular diseases, as well as an increased likelihood of developing cancer, a range of metabolic and musculoskeletal conditions, cognitive decline, and depression[9, 10]. Systematic reviews of prospective studies have demonstrated that prolonged SBs increase the risk of cardiac disease, cancer, and all-cause mortality by nearly 1.2-fold[11]. In addition, a meta-analysis found a 5% increase in the risk of all-cause mortality for each additional hour of sitting beyond seven hours per day[12].Furthermore, daily sedentary time exceeding 9.5 hours represents a critical threshold, linked to a statistically significant increase in mortality risk[13].Therefore, reducing SBs is crucial for promoting public health and alleviating economic burdens.

1.1.2 Sedentary work environments

Sedentary work environments significantly contribute to SBs, with office workers typically spending more than 70% of their working hours in a sedentary state[14, 15]. A recent study highlighted that individuals who predominantly sat at work had a 16% higher risk of all-cause mortality and a 34% increased risk of mortality from cardiovascular disease (CVD) compared with those who were mostly non sedentary at work[16]. Furthermore, high volumes of sedentary time have been associated with a heightened susceptibility to adverse mental health outcomes. This is particularly evident in the worsening of depressive symptoms, anxiety, and general psychological strain[17, 18]. These findings underscore the urgent need to design and implement interventions aimed at reducing sedentary behavior while enhancing both physical and mental well-being among office workers.

Currently, various strategies have been integrated into workplace interventions that target SBs, including health education, environmental modifications (such as sit-to-stand workstations)[19, 20], and motivational strategies (such as prompts, positive feedback, and social competitions)[21, 22], as well as combinations of environmental and motivational elements[23, 24]. However, it remains unclear which type of intervention is the most effective in reducing SBs and how these interventions impact health- and work-related outcomes, such as cardiovascular function, psychological well-being, and work engagement.

1.1.3 Stress contributes to sedentary behaviors

Research has demonstrated that stress is an important contributor to sedentary behaviors[25, 26]. Office workers sitting for more than three hours daily have reported higher stress levels compared with those sitting for less than three hours[27]. A systematic review of 168 studies consistently found higher stress levels associated with increased workplace sedentary behaviors[28]. Experimental studies also have revealed that reduced physical activity and increased sedentary time can lead to negative affect, due to higher stress after exercise deprivation and extended screen time[29-31]. This cycle may exacerbate depression and anxiety, further diminishing participation in activities [32, 33]. Therefore, stress management may be an effective strategy for reducing sedentary behaviors among office workers.

1.1.4 The role of Traditional Chinese Medicine-based body works

Traditional Chinese Medicine (TCM)-based body works, including qigong, dantian breathing, and acupressure, offer culturally relevant and easily practiced interventions to address stress among office workers[34]. Qigong, a TCM-based mind-body exercise, has demonstrated benefits for both physical and psychological outcomes[35, 36], with preliminary evidence suggesting that it has benefits for young sedentary groups[37]. Multicomponent interventions incorporating qigong, dantian breathing, mindfulness, and acupressure have shown significant effects on stress management and physical health in office workers[38]. These practices are feasible alternatives to sedentary behaviors, as they require short amounts of time and small spaces for self-practice. Implementation of a TCM-based intervention to reduce sedentary behavior among Chinese office workers holds promise, yet such interventions have not been developed and studied rigorously, thus highlighting the need to test their feasibility and effectiveness in this population. In addition, an understanding of the psychophysiological mechanisms underlying these interventions is essential for providing scientific evidence for future applications. Previous research has shown that TCM-based interventions, such as Baduanjin, effectively reduced perceived stress levels and lowered salivary cortisol concentrations, thereby alleviating depressive symptoms in adults[34, 35]. However, the role of changes in stress levels as a potential psychophysiological mechanism in the context of reducing sedentary behavior requires exploration.

1.2 Thesis objectives

Against the above backgrounds, this project sought to address critical gaps in understanding the effectiveness of a TCM-based intervention to reduce sedentariness and sedentary behaviors, and to determine the underlying psychophysiological mechanisms of such an intervention. The study's specific objectives were:

(1) To examine the pooled effect of previous SB reduction interventions on office workers' sitting time and identify the essential components of these interventions, to inform the design of the present study.

(2) To explore the effects of previous SB reduction interventions on health- and work-related outcomes.

(3) To test the feasibility of implementing a TCM-based sedentariness reduction intervention for Chinese office workers and to study its health benefits using a randomized controlled trial (RCT) with Chinese office workers.

(4) To test the efficacy of the TCM-based sedentariness reduction intervention in reducing SBs in Chinese office workers, compared with a waitlist control.

(5) To explore the benefits of the TCM-based sedentariness reduction intervention on physical activity and other physical and psychological outcomes, compared with a waitlist control.

(6) To explore the psychophysiological mechanism that is related to stress and that underlies the effects that the TCM-based sedentariness reduction intervention has on sedentary behavior.

(7) To explore the association between daily changes in stress levels (both perceived stress and cortisol level) and overall changes in sedentary behavior within and between the Chinese office workers who participated in the TCM-based sedentariness reduction intervention.

A systematic review and meta-analysis was conducted to address Objectives (1) and (2), a feasibility study was carried out for Objective (3), and an RCT was implemented to address the remaining objectives.

1.3 Overview of chapters

To present the studies that addressed all of the above objectives, this thesis has been organized into five chapters, encompassing a systematic review and meta-analysis, a feasibility randomized controlled trial (RCT), and an RCT. Notably, the findings discussed in Chapter 3 have been published in a peer-reviewed journal (i.e., *Public*

Health).

To begin, Chapter 2 presents a comprehensive literature review detailing the operational definitions and measurements of sedentary behavior, workplace sedentary behaviors, and their association with stress. The chapter also examines the emerging application of TCM modalities in sedentary populations. In addition, the chapter outlines the theoretical foundations and hypotheses of the specific studies that constitute this thesis.

Chapter 3 is a systematic review and meta-analysis to summarize the extant evidence regarding workplace interventions aimed at reducing prolonged sitting, while assessing their health benefits. The synthesized findings provide a theoretical framework for selection of the intervention component in the present study.

Chapter 4 details a feasibility study designed to assess the implementation potential of a TCM-based intervention for reducing sedentary behavior—including a brief introduction, statement of the specific problem, and the objectives related to the intervention. This study simultaneously investigated the preliminary impacts on occupational sitting and health outcomes, thereby establishing essential empirical groundwork for a subsequent definitive RCT. The protocol's operational feasibility and acceptability parameters are rigorously documented to inform future scalability.

Expanding upon these foundational insights, Chapter 5 employs quantitative analysis to delineate the psychophysiological pathways that mediate the intervention outcomes. Special emphasis is placed on elucidating the stress modulation pathways through biomarker analysis (e.g., saliva cortisol levels) and psychometric evaluation, revealing how TCM interventions may confer benefits via neuroendocrine regulation and enhanced stress management in sedentary office workers.

The final chapter (Chapter 6) presents a general summary of the findings of the above studies, and it highlights the study's implications and puts forward specific recommendations. The chapter also presents the conclusions that can be drawn from the findings of the overall study, as well as the principal take-home messages from the study.

Chapter 2 Literature Review

This chapter reviews the definitions, epidemiology, and measurements of SBs among office workers, as well as the literature on the pathways between SBs and workplace stress. It also reviews the evidence of TCM-based interventions in sedentary groups. The chapter ends with the rationale of the study, the research objectives, the hypotheses, and the significance of the research.

2.1 The definition of sedentary behavior

The concept of sedentariness was introduced in 1953 when Morris and his colleagues observed that London bus drivers, who were largely inactive during work, experienced higher rates of cardiovascular events compared to the more active bus conductors[39]. However, for a long time sedentary behaviors were blurred with the concept of physical inactivity. "Sedentary" was often used to denote no exercise or the failure to meet the levels of physical activity (PA) recommended by the World Health Organization. Eventually that changed, however, and since the 1990s scholars in public health have differentiated physical inactivity from sedentary behaviors. The standardization of definitions and terminologies around sedentary behaviors occurred in the 2010s, and sedentariness was recognized as a distinct behavior and risk factor for chronic disease that was independent of PA[40]. From 2012, Trembley *et al.* defined physical inactivity as "an insufficient PA level to meet current recommendations, specifically failing to accumulate at least 150 minutes of moderate PA or 75 minutes of vigorous PA, or a combination of both intensities per week," whereas sedentary behavior is "any waking behavior characterized by an energy expenditure ≤1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture, such as computer use, reading, talking on the telephone, video game playing, etc."[41, 42]. Hence, SBs comprise those behaviors that involve sitting and expending a low amount of energy. Over the past decade, this definition has been extensively utilized both in literature reviews and in experimental research[20, 43, 44]. The same definition has also been applied throughout this study.

2.2 Epidemiology and health risks of sedentary behavior

The global epidemiological shift toward sedentary lifestyles has intensified scholarly interest in the associated health risks of those lifestyles. A comprehensive analysis of 39 large-scale, population-based studies indicated that globally, adults reported a median sedentary time of 5.5 hours per day. However, objective measurements suggested 8.2 hours of daily sedentariness on average, which was 1.5 times the self-reported sedentary time[45]. Cross-cultural comparisons have demonstrated geographical consistency, with Americans engaging in sedentary activities during 55% of waking hours (7.7 hours/day), while Australians spending 7.5 to 9 hours per day in total sedentary time[11, 46]. Similar patterns of long sedentary times have been observed in Hong Kong—according to a recent territory-wide survey in Hong Kong, approximately 20% of the population aged 15 or older spent at least 10 hours being sedentary per day[47]. Research examining factors associated with SBs in adults has found that sedentary time tends to rise with increasing age, full-time employment, and higher levels of education[45]. This trend was especially pronounced in workplace settings, where office employees spent about 75% of their workday sitting, often in continuous periods lasting 30 to 60 minutes[48, 49]. The Stormont study, a comprehensive cross-sectional analysis involving 4,436 employees from the Northern Ireland Civil Service, revealed that office workers' self-reported sitting for an average of 625±168 minutes during a typical workday[50]. Australian desk-based office workers reported a median sitting time of 300 minutes during the workday[51].

Numerous studies have demonstrated that prolonged sedentary behaviors negatively affect various aspects of health[2, 7, 8]. Put simply, inactivity harms human health, including detrimental effects on cardiovascular function, insulin sensitivity, carbohydrate metabolism, visceral fat deposits, inflammation, and so on[52]. A recent systematic review and meta-analysis of observational studies found a significant dose-response relationship between sedentary time and CVD risk. Participants in the highest sedentary category (median duration: 10.5 hours per day) had a 24% increased risk of developing CVD compared with those in the lowest sedentary group (median duration: 2.75 hours per day). In terms of CVD mortality, the highest sedentary group (median duration: 10.2 hours per day) exhibited a 29% higher risk of CVD-related death compared with the lowest category (median duration: 2.98 hours per day)[53]. Another study highlighted a tenfold reduction in insulin sensitivity for both antilipolytic and lipogenic regulation in sedentary individuals compared with their physically active counterparts. This metabolic impairment was linked to decreased mRNA expression of insulin receptors (IRs) and their primary signaling substrates 1 and 2 in the adipose tissue of sedentary subjects[54].

Beyond the well-documented health risks linked to prolonged sitting among adults, research has also identified significant workplace health impacts from high amounts of sedentary time. Several studies have found a strong association between sedentary behavior and presenteeism, which refers to reduced work productivity[55, 56]. Although

Rosenkranz et al. did not find a direct link between sedentary behavior and presenteeism, their results showed that participants who spent the most time sitting (over 91% of the time) experienced lower job satisfaction and higher levels of fatigue compared to those who sat the least (less than 75% of the time)[57]. Furthermore, high volumes of sedentary time have been linked to an increased risk of poor mental health, including more severe depression, anxiety, and psychological distress[58]. **Based on the above evidence, therefore, reducing and interrupting sedentary behavior among office workers could be a crucial strategy for improving their overall health.**

2.3 Measurements of sedentary behavior

In the previous section, we reviewed studies that have highlighted the detrimental effects of sedentary behavior on health. Consequently, it is essential to mitigate sedentary habits through evidence-based and effective interventions. Equally important is the creation of a reliable assessment tool for sedentary behaviors—a crucial tool for advancing research in this field. With the definition of sedentary behavior becoming increasingly precise, scholars have significantly advanced the methods for its measurement. The evolution from direct observation by a trained observer to the creation of self-report questionnaires, and ultimately to the assessment using wearable devices, has equipped us with refined tools to comprehensively understand sedentary behavior patterns. This section reviews both questionnaire-based methods and device-based methods for measuring sedentary behavior in population- and intervention-based studies.

Utilizing questionnaires to assess sitting time is a practical and cost-effective method for collecting data from large populations. This approach not only enables efficiency data gathering but also provides valuable insights into the context and specific domains of sedentary behaviors[59]. The International Physical Activity Questionnaire (IPAQ) and the Global Physical Activity Questionnaire (GPAQ) have been the most commonly used questionnaires with items on SBs[60,61]. There have also been other questionnaires designed for particular populations, such as the Occupational Sitting and Physical Activity Questionnaire (OSPAQ), the Workforce Sitting Questionnaire (WSQ), and the Measure of Older Adults' Sedentary Time (MOST). Researchers can select these tools on the basis of their research questions. The IPAQ has been a reliable self-report tool with intraclass correlation coefficients from 0.62 to 0.88[62, 63]. It is available in both long and short versions, with items on PA and sedentary behaviors, respectively. The long, self-administered IPAQ covers four domains of PA: job-related activity, transportation, housework/gardening, and leisure-time activity. The level of PA within each domain is evaluated by assessing the frequency with which participants engage in vigorous- or moderate-intensity activities, cycling, and/or walking, with each activity lasting at least 10 minutes per session over the previous seven days. For instance, in the domain of job-related PA, participants are asked: "During the last 7 days, on how many days did you perform vigorous and/or moderate physical activities as part of your work?" and "On a typical day when you engaged in such activities, how much time did you usually spend performing vigorous and/or moderate physical activities at work?" The questionnaire also includes questions about sedentary behaviors, estimated by the usual daily sitting time on weekdays and weekends during the previous seven days, excluding the time spent in motor vehicles[62]. The short version of the IPAQ consists of four general items assessing overall PA levels during the previous seven days, along with a single item evaluating sedentary time on a typical weekday. The questionnaire was designed for ease of self-administration and can be completed in a short amount of time. The GPAQ is also a valid and reliable tool for measuring PA and includes one question that assesses sedentary behavior on a typical day. However, while the GPAQ is a valid measure for moderate-to-vigorous physical activity (MVPA) and changes in MVPA, it has been found to be less accurate than objective measures are in assessing current levels and changes in SBs[59]. This highlights the need for using complementary methods to capture the nuances of SBs. Meanwhile, self-report methods can often result in underestimations of sitting time, due to social desirability bias or difficulties in accurately recalling such behavior[64]. Consequently, objective assessment methods are necessary to achieve more precise measurements of SBs.

Accelerometers, widely used for measuring free-living physical activity, have been recognized as suitable choices for studies on sedentary behaviors. The devices mostly used in sedentary behavior research are the ActiGraph and activPAL, both of which have demonstrated high reliability and validity in previous studies[65-67] but differ in functionality and application. The ActiGraph is typically worn on the wrist, waist, or ankle and uses accelerometry to assess sedentary time, energy expenditure, sleep patterns and physical activity (intensity, frequency, and duration) by applying specialized algorithms to raw accelerometry data[68]. It is generally recommended to wear the device on the waist for three to five consecutive days to ensure a more accurate assessment of sedentary behavior among adults[69, 70].

The activPAL, a compact activity monitor, is affixed to the anterior thigh to facilitate continuous tracking, typically over a seven-day period. This device provides a scientifically robust assessment of sedentary behavior, standing, and ambulation, while accurately capturing transitions between seated and upright postures[71]. However, its adoption involves higher costs compared with the ActiGraph, and it is typically designed for continuous 24-hour wear, whereas the ActiGraph is optimized for use during waking hours[71].

While device-based measures have been the gold standard for assessing total sedentary time, they are not able to capture contextual information or determine specific behaviors. Domain-specific diary logs are therefore essential for supplementing and clarifying the duration and locations of daily sedentary activities. **Thus, combining device-based and questionnaire-based measures enables a more comprehensive assessment of sedentary behaviors, capturing not only total time of a behavior but also the context in which it occurs.**

2.4 Association between stress and sedentary behaviors among office workers

The workplace is a significant setting in which adults accumulate high levels of sedentary behaviors, and office workers have become a particularly high-risk group due to their long periods of sitting while working[26]. Prolonged sitting has been associated with adverse effects such as perceived stress and poor executive function, memory, and attention[72]. A systematic review found that higher stress levels were consistently associated with more sedentary behaviors in the workplace[28]. The positive associations between sedentary behaviors and stress were also demonstrated in a survey of more than 34,000 adults from six countries[73]. Although some recent studies have reported null associations between stress and sedentary behaviors, those findings predominantly derived from investigations involving non-working or retired adults with diabetes—a demographic whose stress profiles may differ from those of actively employed individuals[74]. Conversely, emerging evidence has indicated that among working populations, sedentary behavior is significantly associated with stress[75]. Experimental studies also have found that reducing PA and increasing sedentary time can lead to negative affect [29]. Moreover, occupational stress has also been identified as a driver of SBs, because individuals often manage stress by adopting passive coping mechanisms—such as prolonged TV viewing or extended sitting[25]. A recent cross-sectional study highlighted that occupational stress significantly predicted sedentary durations exceeding seven hours per workday[25]. Logistic regression analyses quantified that risk, showing that stressed office workers faced a 5.06-fold increase in prolonged sitting and a 5.15-fold lower likelihood of low-to-moderate PA levels compared with their nonstressed counterparts[25]. This vicious cycle may lead to adverse outcomes such as depression and anxiety, which subsequently diminish PA engagement and promote greater sedentary habits[76]. Notably, factors such as job demands and social support have shown no significant association with sitting time or activity levels, underscoring stress as an important predictor[25].

Collectively, these findings highlight stress as a key predictor of increased sedentary behaviors in office-based populations, thus highlighting the need for targeted workplace interventions to break this harmful pathway. However, despite the evidence linking stress to prolonged sitting, **stress-management strategies explicitly aimed at reducing sedentary behaviors among office workers have yet to receive sufficient empirical attention.**

2.5 Reduction of workplace sedentary behaviors through Traditional Chinese Medicine (TCM)-based body works

Body works based on TCM, including qigong, dantian breathing (i.e., diaphragmatic breathing with mindfulness), and acupressure, may be promising practices to address the sedentariness in Chinese office workers, given their cultural relevance and ease of practice[34]. The harmful effects of prolonged sitting (*Jiu Zuo*) have been recognized in TCM for millennia. As early as the *Huang Di Nei Jing* (*The Yellow Emperor's Inner Classic*), physicians documented *Jiu Zuo Shang Rou* (muscle damage from prolonged sitting) and its pathological consequences. From a TCM perspective, sitting for extended periods stagnates spleen qi[1], impairing its functions in digestion, nutrient distribution, and fluid metabolism. This can lead to spleen qi deficiency, disrupting the balance of qi, blood[2], and bodily fluids[3]—a state that may contribute to chronic diseases[77]. Therefore, avoiding prolonged sitting has become a principle of disease prevention and health promotion among the Chinese. Traditional Chinese Medicine-based therapeutic practices, such as dantian breathing, qigong, and acupressure, can restore qi flow and counteract the harms caused by prolonged sitting[77].

Qigong is a TCM-based mind-body exercise with simple movements, and it has

[1] In Traditional Chinese Medicine (TCM), *Qi (气)* is regarded as both the vital energy and fundamental substance that forms the human body and sustains its physiological functions. The spleen plays a central role in transforming food into Qi and blood—a process driven by *Spleen Qi (脾气)*, which governs nutrient metabolism, blood integrity, and tissue maintenance, and is essential for digestion and overall health

[2] In TCM, *blood (血)* is considered to be a dense, material form of Yin essence with both physical and energetic functions, intrinsically linked to Qi and the organ systems.

[3] *Bodily fluids (Jin Ye,津液)* in TCM encompass all fluids other than blood, are derived from food and water, and play key roles in hydration, nourishment, and metabolic balance, while being regulated by various organs.

demonstrated benefits in physical and psychological outcomes[35, 36]. Recent studies have indicated its particular benefits for sedentary office workers, including enhanced physical and mental wellbeing across different age groups[78]. Notably, a multicomponent intervention with qigong, dantian breathing, and acupressure has significantly enhanced office workers' stress management and physical health[38]. Furthermore, an online Baduanjin (a form of qigong) program recently revealed its potential to mitigate sedentary behaviors, with intervention participants showing significantly less increase in sedentary time than controls did[79].

Dantian breathing is a mindfulness-based breathwork practice rooted in TCM, combining diaphragmatic breathing with focused attention to promote mind-body integration[80]. By directing awareness to the lower abdominal region (dantian), this technique has been shown to optimize autonomic nervous system activity and foster a relaxed state of mind[81, 82]. Evidence has supported the role of dantian breathing in stress reduction, with studies reporting significant decreases in salivary cortisol levels among healthy adults following its regular practice[83].

Similarly, acupressure is a therapeutic technique rooted in TCM that involves applying manual pressure—using the fingers, hands, knuckles, or blunt tools—to specific acupoints on the body[84]. This practice aligns with TCM's meridian theory, which suggests that gentle, sustained pressure (rather than needles) can regulate the flow of energy *(Qi)* throughout the body[85]. Research has shown that acupressure modulates the parasympathetic and sympathetic nervous systems, enhances blood circulation, restores physiological balance, and promotes systemic homeostasis[86]. Recent studies have highlighted that acupoints such as Yintang (EX-HN3) and Shenmen (HT7) are effective in promoting emotional regulation and stress relief[86].

Furthermore, systematic reviews have shown that acupressure was superior to sham or treatment-as-usual controls in alleviating depressive symptoms in adult populations[87, 88]. Notably, both dantian breathing and acupressure can be practiced in a standing posture.

In summary, qigong, dantian breathing, and acupressure present feasible alternatives to sedentary behaviors in the workplace. These practices can serve as self-management techniques to address both sedentariness and stress, thereby helping office workers reduce prolonged sitting, decrease screen time, and incorporate more PA during work hours. **However, while TCM-based interventions show promise for addressing sedentary behaviors and health improvement, robust clinical evidence is still lacking. Rigorous experimental studies are required to establish the effectiveness of those interventions in reducing sedentary time and delivering health benefits.**

2.6 Potential psychophysiological mechanisms in workplace interventions

Sedentary behaviors are clearly unhealthy, and it is crucial to understand the psychophysiological mechanisms underlying successful interventions' development[89]. To date, interventions aimed at reducing sedentary behavior in office workers have primarily focused on environmental changes, educational or behavioral approaches, and multicomponent interventions that combine organizational and individual elements [90-93]. However, most of these studies have focused solely on whether the interventions reduced sedentary behavior outcomes, with less attention given to the mechanisms underlying their effectiveness. While some studies have explored psychological elements of social cognitive constructs, such as motivation, self-efficacy, and perceived behavioral control, few have examined stress as a mechanism for reducing sedentary behaviors [79, 94, 95].

Research has shown that stress is closely related to office workers' sedentary behaviors[96]. Perceived stress is a psychological concept that refers to an individual's feelings or thoughts about how stressed they feel at a given time or over a given period[97]. Work-related stress has been found to have negative effects on mood and emotional well-being [98]. When individuals experience stress, their motivation to engage in any form of activity tends to decrease, leading them to rely more on sedentary behaviors as a coping mechanism. For instance, using smart devices for leisure activities can serve as a distraction from stress or provide temporary relief from negative emotions while sitting or lying down [99, 100] . However, it is important to note that maladaptive coping strategies, such as excessive screen time, can contribute to increased sedentary behavior. Consequently, individuals experiencing stress tend to be more likely to exhibit sedentary behaviors.

From a physiological perspective, high levels of sedentary behaviors have been associated with higher levels of cortisol, a hormone that is released by the adrenal glands in response to stress[101]. Previous studies have demonstrated that sedentary behavior was associated with increased cortisol levels and heightened stress responses[102]. Chronic stress can activate the Hypothalamic-Pituitary-Adrenal (HPA) axis response, increasing cortisol concentration[103]. Excessive cortisol secretion can disrupt the HPA axis's negative feedback loop, paradoxically leading to sustained HPA activation and further cortisol overproduction[104]. This overproduction can enhance depressive symptoms and burnout, leading to low PA or an inactive state.

Therefore, high cortisol levels can potentially lead to increased sedentary behavior[101]. **In summary, it is plausible to reduce office workers' sedentariness through alleviating their perceived stress and lowering their cortisol levels.**

Meanwhile, it is noteworthy that the majority of existing studies investigating the association between sedentary behaviors and stress employed cross-sectional designs or pre and post assessments[28]. Currently, no research has longitudinally monitored dynamic changes in both stress and SBs throughout an experimental intervention period. Furthermore, interindividual heterogeneity exists in adherence to TCM-based interventions. Consequently, examining the within- and between-subject linkages between self-practice of TCM-based body works and changes in sedentary behaviors during the intervention, while simultaneously investigating the mediating role of daily fluctuations in stress, represents a methodologically robust approach to detecting systematic differences in intervention responsiveness across individuals.

2.7 Conceptual model of the present study

Based on the existing literature, we proposed a conceptual model (Figure 2-1) in which TCM-based interventions were considered to be able to effectively reduce sedentary behaviors in office workers by promoting stress management.

To test this conceptual model, the present study used an RCT design to evaluate the effectiveness of TCM-based interventions in reducing sedentary behaviors in office workers. Measures of stress, including cortisol levels and perceived stress, were used to test the mediation effectiveness of stress between TCM-based intervention and sedentary behaviors.

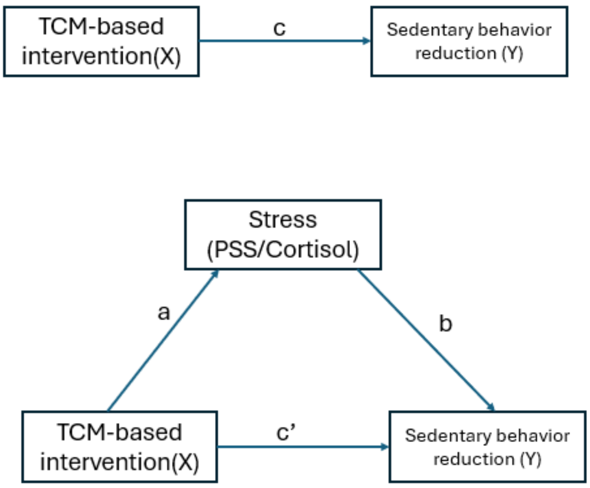


Figure 2-1 Conceptual model: A mediation model to demonstrate how stress mediates the effectiveness between a TCM-based intervention and sedentary behaviors. Note: a,b,c, and c' refer to the paths of the model.

2.8 Research objectives

Following this conceptual model, the study’s overarching aim was to develop a TCM-based intervention for reducing sedentariness, testing its efficacy, and exploring its mechanisms. Therefore, we first conducted a systematic review and meta-analysis to understand the existing interventions and their active ingredients. Then, we developed our own intervention and tested its feasibility using a feasibility study. Last, we carried out an randomized controlled trial to evaluate the intervention’s efficacy and explore its mechanisms.

2.8.1 The objectives of the systematic review and meta-analysis

The specific objectives of this research’s systemic review and meta-analysis were:

(1) to examine the pooled effect of previous interventions to reduce the sedentary behaviors of office workers, particularly their sitting time, and identify the essential components of these interventions, in order to inform the design of the present study;

and

(2) to explore the effects of previous SB reduction interventions on health- and work-related outcomes.

2.8.2 The objectives of the feasibility study

The specific objectives of the feasibility study were:

(1) to test the feasibility of implementing a TCM-based sedentariness reduction intervention with Chinese office workers and study the intervention's health benefits by conducting a randomized controlled trial (RCT) with Chinese office workers.

2.8.3 The objectives of the pilot RCT study

The specific objectives of the pilot study were:

(1) to test the efficacy of the TCM-based sedentariness reduction intervention in reducing SBs in Chinese office workers, compared with a waitlist control,

(2) to explore the benefits of the TCM-based sedentariness reduction intervention on office workers' physical activity and other physical and psychological outcomes, compared with a waitlist control,

(3) to explore the stress-related psychophysiological mechanisms that underlie the effects of the TCM-based sedentariness reduction intervention on the office workers' sedentary behavior (refer to Figure 2-2), and

(4) to explore the association between daily changes in the stress levels (both perceived stress and cortisol levels) and overall changes in the sedentary behavior within and between the Chinese office workers who participated in the TCM-based sedentariness reduction intervention (refer to Figure 2-3).

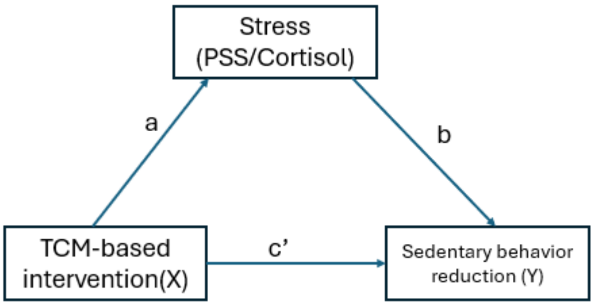


Figure 2-2 Mediation analysis overview. Path a: the path of the effect of the intervention on stress; Path b: the effect of changes in stress on total sitting time; and Path c': the direct effects of the intervention on total sitting time.

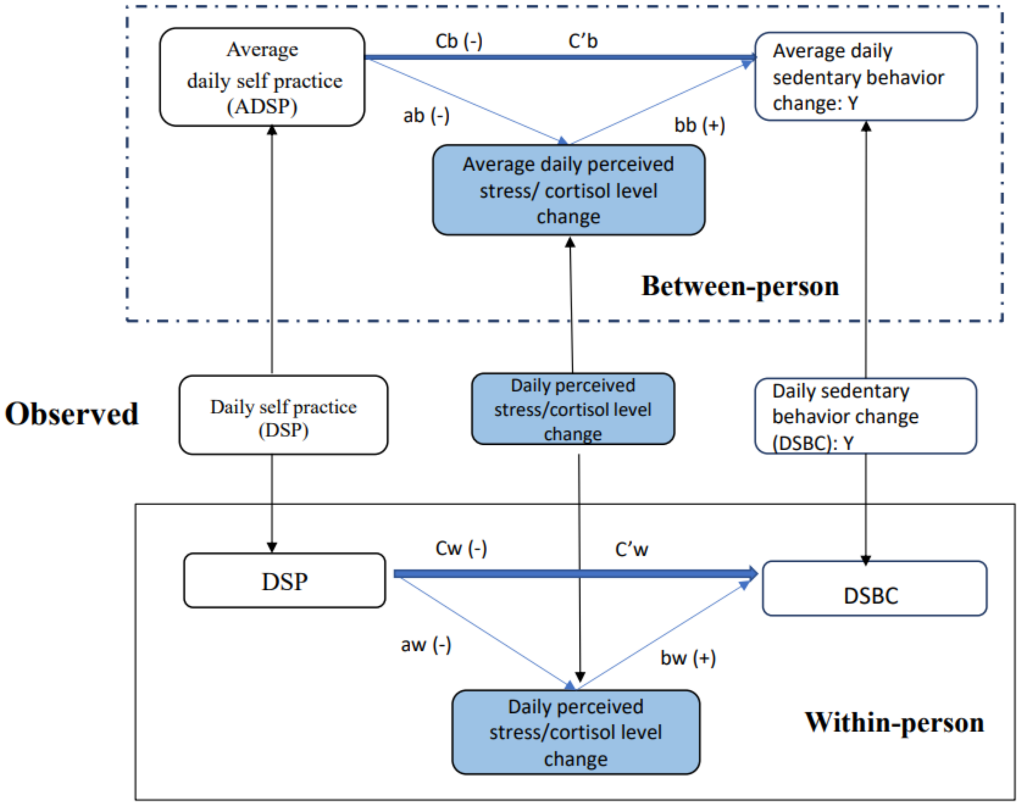


Figure 2-3 Multilevel structural equation model showing a 1-1-1 multilevel mediation model between the duration of daily self-practice, change of perceived stress or cortisol levels, and the change of sedentary behaviors. Note: c'w, c'b=direct effect; cw, cb=total effect; the figure is based on Preacher *et al.*[105].

2.9 Hypotheses of the pilot RCT study

We proposed the following hypotheses for the pilot study.

•**Hypothesis 1 (Referring to Objective 1)**:

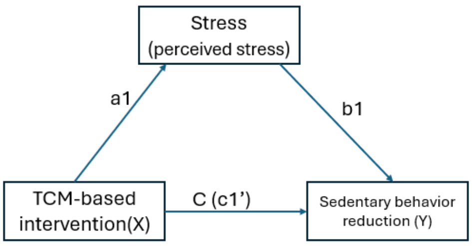
(H1): A TCM-based intervention will significantly reduce the sedentary behaviors of office workers in the intervention group compared with the reduction in SBs in the waist-list control group.

•**Hypothesis 2 (Referring to Objective 3-psychological mechanism)**:

(H2a): In accord with Path c: A TCM-based intervention will significantly reduce the sedentary behavior of office workers.

(H2b): In accord with Path a1: A TCM-based intervention will significantly reduce the perceived stress level of office workers.

(H2c): In accord with Path c1' and Path b1: Office workers' perceived stress levels will mediate the relationship between their TCM-based intervention and their sedentary behavior.

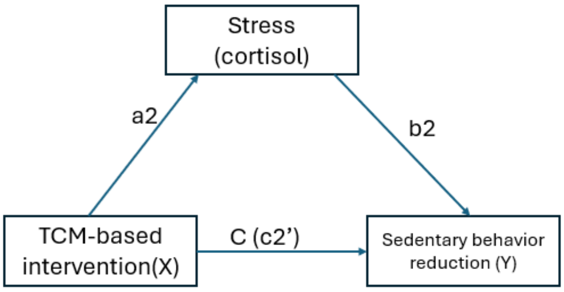


•**Hypothesis 2 (Referring to Objective 3-physiological mechanism)**

(H2d): In accord with Path c2': A TCM-based intervention will significantly reduce the sedentary behavior of office workers.

(H2e): In accord with Path a2: A TCM-based intervention will significantly reduce the cortisol level of office workers.

(H2f) In accord with Path c2' and Path b2: Cortisol levels will mediate the relationship between TCM-based intervention and the sedentary behavior of office workers.



2.9 Significance of the study

This study can be considered a pioneering effort to test the effectiveness of a TCM-based intervention designed to reduce sedentary behaviors among office workers. It also explores the psychophysiological mechanisms underlying this intervention, providing valuable insights into how TCM-based programs can effectively address sedentary lifestyles in the workplace. It offers an evidence-based training program that is both easy to learn and replicate and therefore that can serve as a valuable resource for researchers and clinicians seeking to develop interventions that decrease sedentary behaviors across various populations, including adolescents, adults, and older adults, thereby enhancing their overall health.

Furthermore, by utilizing longitudinal data, the study reveals changes in the proposed psychophysiological constructs both within and between individuals, thus leading to a deeper and more precise understanding of individual differences. This insight could be instrumental in developing tailored interventions for diverse populations.

Chapter 3 Systematic Review and Meta-analysis of Sedentary Behavior Reduction Interventions

3.1 Introduction

Sedentary behaviors are a widely recognized issue of public health, with growing empirical evidence of their association with a variety of health risks in adults[1, 2]. Reports in the literature have indicated that more than 25 percent of adults do not perform enough physical activity and are engaged in excessive SBs[106]. Office-based employees, in particular, have been found to spend approximately 75 percent of their total working time sitting[48, 49]. High levels of SBs are associated with increased risks of multiple chronic health outcomes, including cardiometabolic syndrome, specific cancers, depression, and musculoskeletal discomfort[9, 41, 107]. Previous reviews have suggested that reducing sedentary time can offer health benefits that are independent of physical activity[10, 11].

Over the past 20 years, various studies have specifically addressed SBs in the workplace[91, 108-111]. In light of social cognition theory and the social-ecological model, interventions to reduce SBs generally have included at least one of the following types/components: (1) environmental support that modifies office environment with special furniture (e.g., sit-to-stand workstations) and/or equipment for physical exercise (e.g., treadmill desks); (2) motivational strategies, including individual and social support to initiate, maintain, or increase motivation to reduce workplace sitting (e.g., prompts, offering positive feedback and social competitions); and (3) health education that enhances office workers' understanding of the harm caused by sedentary lifestyles and the benefits of behaviors that counteract sedentariness in the workplace[112].

Some of the previous systematic reviews focused on the synthesis of the effect elicited by specific types of interventions with environmental support[113-116] or motivational strategies[117]. There have also been other systematic reviews that compared the efficacy of different types of interventions[118, 119]. The review conducted by *Chu et al.*[118] demonstrated that the multicomponent intervention approach led to greater reductions in workplace sedentary time than environmental interventions did. However, the opposite conclusion was derived from the systematic review conducted by *Shrestha et al.*[119]. Another recent meta-analysis supported the effectiveness of multicomponent interventions compared with no intervention[120], but it remains unclear whether multicomponent interventions outperform single-component ones to reduce SBs. Moreover, it is worth noting the limitations identified in the previous meta-analyses, including small sample sizes, a lack of longer-term follow-up, and low-quality evidence[118-120]. Indeed, the long-term effects of interventions for SB reduction remain uncertain[119]. In addition, different SB reduction interventions seek to replace SBs with different substituted behaviors, such as standing and physical activities[121-124], and it remains unknown whether intervention-related sedentary time reduction is actually influenced by the adoption of the different substituted behavior.

Because additional empirical studies on SB reduction interventions with various components and different follow-up periods have been published since 2018, another systematic review and meta-analysis was warranted. Therefore, we sought to examine the pooled effect of SB reduction interventions on office workers' sitting time, relative to all types of control conditions. We also explored the intervention effects over different assessment periods (short- and long-term) and the differences among SB reduction intervention elements and different substituted behaviors in reducing SBs. Finally, we attempted to explore those interventions' effects on health- and work-related outcomes.

3.2 Methods

This systematic review and meta-analysis was conducted following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA),[125] and it was preregistered with PROSPERO (CRD42022338053).

3.2.1 Search strategy and study selection

PubMed, EMBASE, Scopus, Web of Science, MEDLINE (via EBSCO), PsycINFO, and the Cochrane Library were comprehensively searched for studies published from their inception to May 2, 2023. The keywords included "office workers," "sedentary behavior," and "interventions," identified from MeSH terms (the detailed search strategy is presented in **Supplementary Table S3-1**). Additional searches were performed by manually screening the reference lists of the articles identified for consideration.

Identified publications were imported into Covidence[126], and duplicate records were removed both automatically and manually. The titles and abstracts of all records were screened by two independent reviewers (CW and JC) to determine their eligibility for full-text screening. Disagreements were discussed until a consensus was reached, or by consulting the third reviewer (WS). **Figure 3-1** is a flow diagram of the literature search process.

The PICOS (Participants, Intervention, Comparison, Outcome, Study design) principle was utilized to assess each study's eligibility (**Supplementary Table S3-1)**. Studies were included if they had: (1) recruited office workers aged 18 or above as participants; (2) tested an intervention aimed at reducing SBs in workplace; (3) compared an SB reduction intervention with either no intervention or an active comparator; (4) evaluated at least one outcome related to SBs as the primary outcome or secondary outcome; (5) employed an RCT, cluster RCT, crossover RCT or pilot and feasibility RCT; and (6) were published in English and available in full text.

Exclusion criteria included having (1) used an intervention that was not delivered in a workplace setting; (2) adopted a research design other than an RCT; (3) included outcomes not related to SBs; (4) not published in a peer-reviewed journal; and/or (5) been research protocol or review articles.

3.2.2 Data extraction

Two reviewers (CW & JC) used a standard template to extract relevant data from the studies identified. Disagreements were resolved through discussion between the two reviewers. The extracted data included (1) bibliometric data; (2) participants' characteristics; and (3) study characteristics. The primary outcome was sitting time per workday, which included either objective measures (e.g., an accelerometer) or subjective measures (e.g., questionnaires). The secondary outcomes included health-related outcomes (e.g., biomarkers of cardiometabolic risk, musculoskeletal outcomes, and psychological well-being) and work-related outcomes (e.g., work engagement).

Studies that reported the means and standard deviations (SDs) of sitting time (minutes per workday) post-intervention or changes in sitting time from baseline to post-intervention were extracted for meta-analysis. If a study did not report data that included SDs, those values were estimated by conversion from other values (e.g., standard error (SE) and confidence interval [CI]) according to the Cochrane Handbook[127]. When more than one type of measure of sitting time per workday was available, objective data were given priority over subjective data for extraction. The corresponding authors of the studies with incomplete objective measures of sitting time were contacted to obtain missing data. Subjective data on sitting time was extracted only when we could not obtain complete objective data[128]. Sedentary behaviors were measured and analyzed as absolute values of sitting time pertaining to working hours (8 hours), waking hours of an entire workday, or both. The sitting time during the 8-hour period was available in 17 studies[66, 91, 93, 108, 121, 123, 124, 128-137] and was extracted in the present review. For the remaining seven studies[90, 92, 110, 111, 122, 138, 139], the sitting time during waking hours of an entire workday was extracted. For crossover RCTs, only data from the first intervention period were included[140]. The data of the same outcome from multiple assessment points were all extracted.

3.2.3 Risk of bias assessment

Two reviewers (CW and JC) independently assessed the risk of bias in the studies, using the Cochrane risk-of-bias tool 2.0 for RCTs, cluster-randomized, and crossover-randomized trials[141]. The third reviewer (WS) was consulted when disagreements occurred. Five risk-of-bias domains were assessed, and the overall risk-of-bias judgment for each study was determined as “low,” “high,” or “of some concern.”

3.2.3 Data synthesis and analysis

The characteristics of participants and studies were tabulated for qualitative synthesis. All meta-analyses were carried out using Comprehensive Meta-analysis Software, Biostat, version 4[142]. Mean difference (MD) was used to summarize the effect size of primary and secondary outcomes. While the effect sizes of SB reduction interventions in the studies were evaluated based on either (1) MDs in raw scores of sitting time between intervention and control groups post-intervention or (2) between-group MD in change scores from baseline to post-intervention, both types of data were included for meta-analysis following the recommendations in the Cochrane Handbook[143]. For studies with more than two intervention arms targeting SB reduction, data from all of the intervention groups were combined for pairwise comparison with control groups, to avoid unit-of-analysis error[144]. A random-effects model was applied to estimate MD (significant pooled effect size with $p<.05$). Heterogeneity was quantified using Cochrane's I^2 statistic.[145] Begg's funnel plot and Egger's regression test were employed to assess publication bias[146].

Sensitivity analyses were conducted to examine the robustness of the primary analysis, by removing studies with a high risk of bias[147]. Subgroup analyses within this review focused on: (1) intervention components (a. environmental support, i.e., modifications of the office environment with special furniture and/or equipment for physical exercise; b. motivational strategies, i.e., individual or social support for initiating, maintaining, and enhancing office workers' engagement in physically active behaviors; c. health education, i.e., educational activities and/or information that was intended to enhance office workers' awareness of the health risks of SBs and the health benefits of SB reduction; and d. multicomponent approaches, i.e., interventions with at least two of the above components); (2) different substituted behaviors (replacing sitting with standing, physical activity, or active breaks); and (3) various assessment periods (≤3 months, 3–6 months, and >6 months). A meta-regression was conducted to assess the effects of any potential predictors of workplace sitting time, including the participants' age, health conditions (healthy vs. clinical), control conditions (no intervention vs. active comparator), outcome measurement tool (objective vs. subjective measure), study design type (RCT vs. cluster RCT vs. cross-over RCT), and risk of bias (low risk vs. high risk. vs. of some concern).

3.2.4 Certainty assessment

The certainty of the evidence for workplace sitting time and health-related outcomes was appraised within the GRADE (Grading of Recommendations, Assessment, Development, and Evaluation) system[148].

3.3 Results

Initially, 1,572 studies were included (**Figure 3-1**). After removing duplicates, 891 studies underwent title and abstract screening. The high duplication rate may have been due to our search across seven databases. Of the 127 full-text articles retained, 23 were included. An additional search through the reference lists of these studies was conducted, and one study was identified for eligibility. Ultimately a total of 24 studies were included for systematic review and meta-analysis. Figure 3-1 is a PRISMA flow diagram of the literature search and study selection.

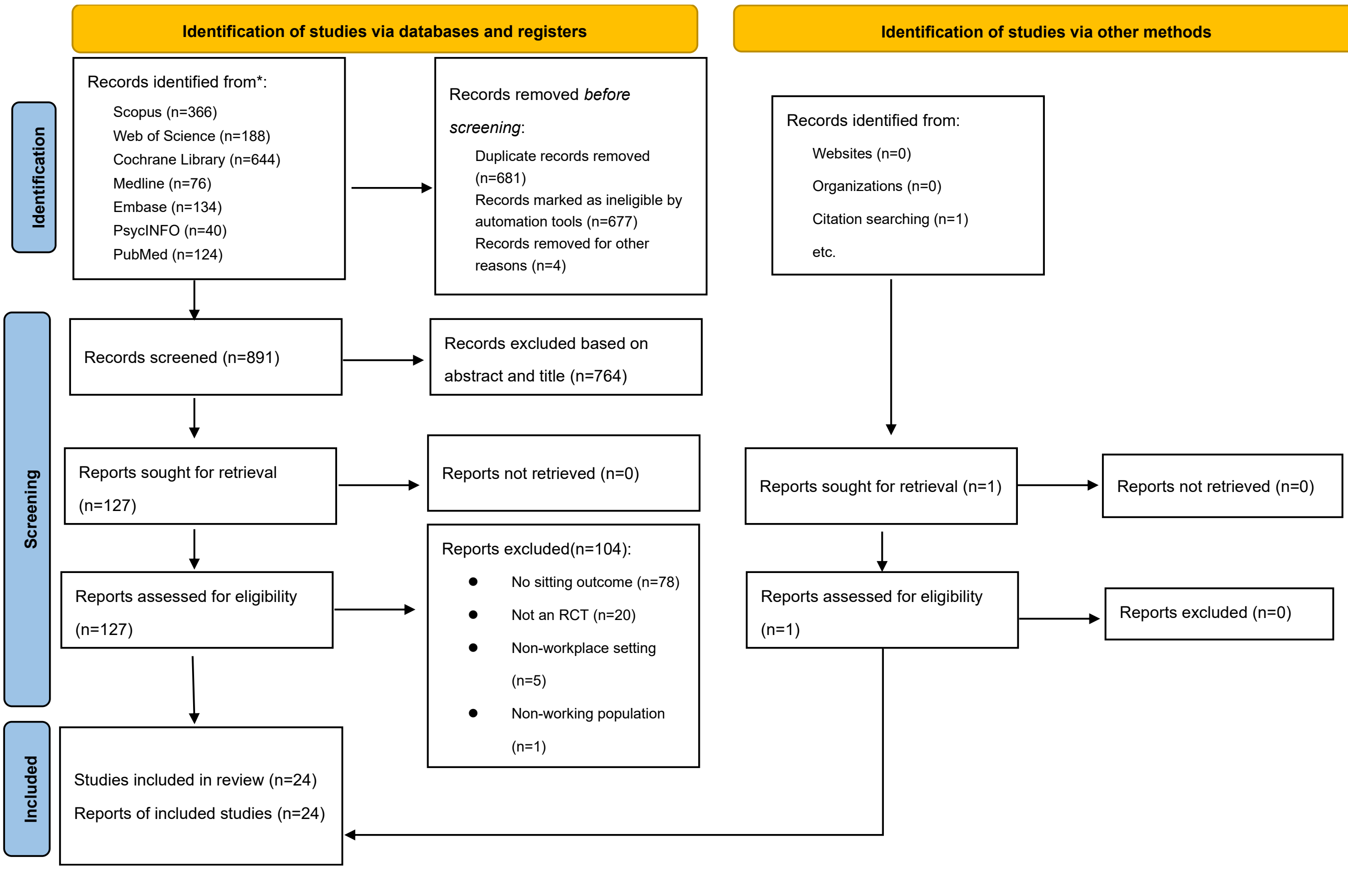


Figure 3-1. PRISMA flow diagram of the literature search and study selection process.

3.3.1 Study characteristics

Of the 24 articles kept for review, 12 were RCTs[91-93, 111, 122, 124, 128, 132, 133, 135, 137, 138], nine were cluster RCTs[66, 90, 110, 121, 130, 131, 134, 136, 139], and three were crossover RCTs[108, 123, 129]. The number of participants ranged from 14 [129] to 630 [136], and 3,169 office workers were included in total. The ages of the participants ranged from 18 to 65 years old. Most of the studies were conducted in a mixed-gender population (n=23), whereas one targeted men only.[123] Most of the studies (n=14) had recruited healthy participants, but eight had instead worked with overweight or obese adults[90, 93, 110, 111, 124, 134, 138, 139], and another used participants at risk of lower back pain[135].

The interventions in all of the studies had adopted educational elements, such as a brief health talk/workshop/consultation and health materials. However, the main proportions of the intervention elements included environmental support (n=4) [91, 108, 132, 137], motivational strategies (n=7)[66, 92, 110, 111, 128, 129, 139], or both of those (n=14)[90, 93, 121-124, 130, 131, 133-136, 138]. The interventions were intended to replace some of the office workers' sitting behavior with various alternative behaviors, including standing[90-92, 108, 121, 122, 128, 130-134, 136, 137], physical activities (e.g., walking, stepping, and treadmill)[66, 90, 93, 110, 111, 123, 124, 135, 138, 139], or active breaks (e.g., tea breaks, walking around and talking to colleagues)[110, 129, 131]. The intervention period ranged from five days [92] to 13 months[93], and thus, the periods to assess the participants' sitting times varied among the studies. Fourteen studies compared SB reduction interventions with no intervention[66, 108, 110, 111, 123, 124, 128-134, 137, 138], whereas active comparators were adopted in the remaining nine studies[90, 92, 93, 121, 122, 135, 136, 139]. Seventeen studies used objective measures for assessing total daily sitting time or sitting time during eight work hours[66, 90-93, 121, 122, 124, 129, 130, 133-139], three used subjective measures[110, 111, 132], and another four used both[108, 123, 128, 131]. Seventeen studies reported secondary outcomes related to health conditions and/or work engagement[66, 90, 91, 110, 121-124, 128-132, 135, 137-139]. **Tables S3-2 through S3-4** detail the overall elements of the interventions.

3.3.2 Risk of bias and publication bias

The individual assessments for risk of bias in each study are shown in **Figures 3-2, 3-3, and 3-4**. The risk of bias was found to be high in three studies, of some concern in 16, and low in five. The most common reasons for the risk of bias were not having blinded the participants, assessor bias, and selection bias. Funnel plot asymmetry and the Egger's test did not indicate significant publication bias in the primary and secondary outcomes (*ps*>0.05, **Supplementary Table S3-5**).

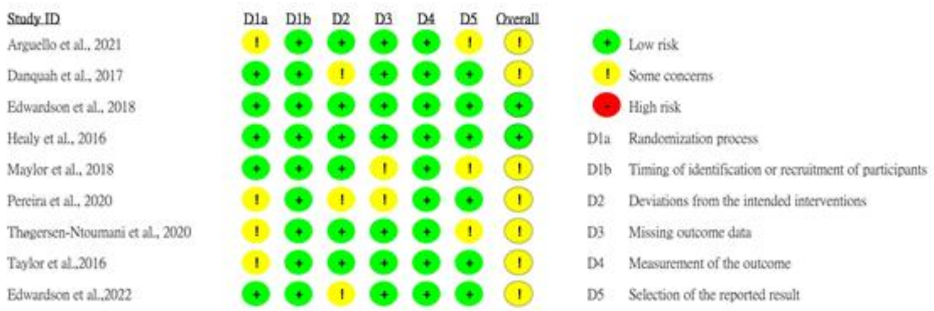


Figure 3-2 Risk of bias in the included cluster RCT studies.

Figure 3-3 Risk of bias in the included RCTs.

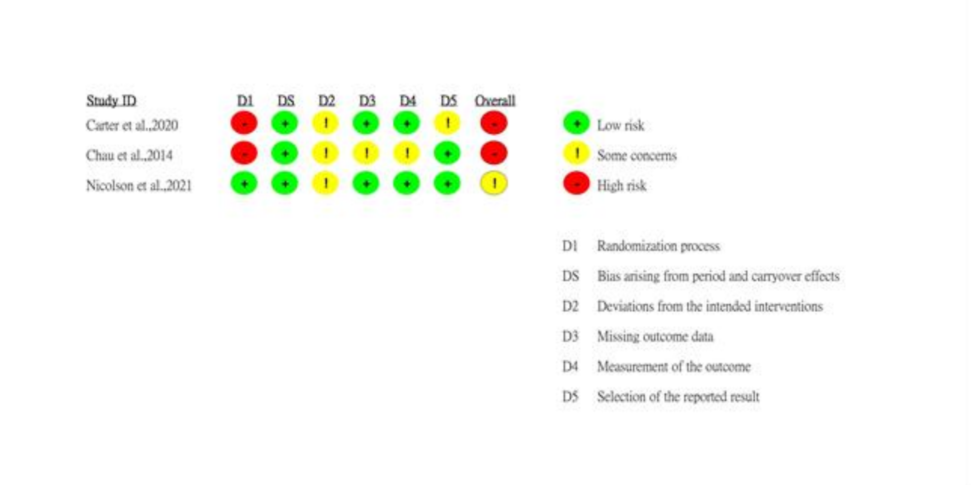


Figure 3-4 Risk of bias in the included crossover RCT studies.

3.3.3 Primary outcome: Workplace sitting time

Of the 24 studies included for review, 19[91, 93, 108, 110, 111, 121, 123, 124, 128-138] reported significantly more reduction in workplace sitting time in the intervention groups than in the control groups. However, the remaining five studies[66, 90, 92, 122, 139] did not show such a significant time*group effect, but instead reported trends that favored the intervention group in terms of reducing prolonged sitting time and increasing sitting-to-upright transitions, standing time, and stepping time.

The pooled intervention effects of the 24 studies showed a significant reduction in workplace sitting time (-38.02 mins/workday, 95% *CI*: -47.32 to -28.72; z=-8.011; p<0.001; I^2=49.78%) (**Figure 3-5**). The pooled effect remained significant when the three studies with a high risk of bias[108, 122, 129] were excluded (*MD*=-38.75, 95% *CI*: -48.27 to -29.23; z=-7.98; *Hedges's g*=-0.486; p<0.001; I^2=52.90%, **Figure 3-6**). This finding also held true when eight studies with small sample sizes[92, 122-124, 129, 133, 135, 137] were excluded (*MD*=-41.00, 95% *CI*: -50.12 to -31.89; z=-8.816; *Hedges's g*=-0.516; p<0.001; I^2=46.89%, **Figure 3-7**) and when one study with a five-day intervention was excluded (*MD*=-39.03, 95% *CI*: -48.40 to -29.67; z=-8.71; *Hedges's g*=-0.495 p<0.001; I^2=49.57%, **Figure 3-8**)[92].

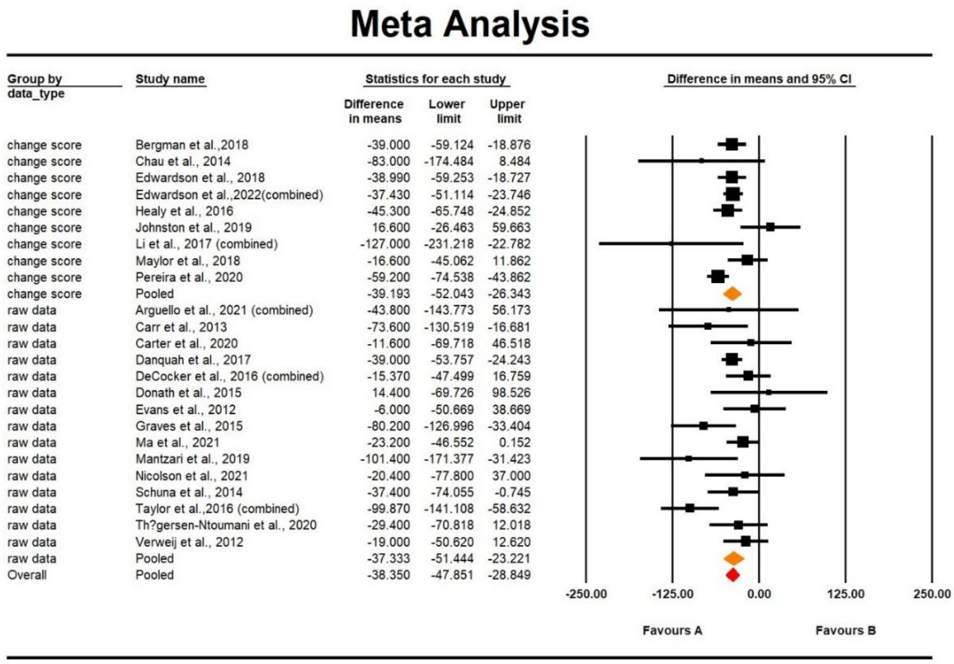


Figure 3-5 Forest plot of the pooled effects of the interventions on the reduction of workplace sitting time.

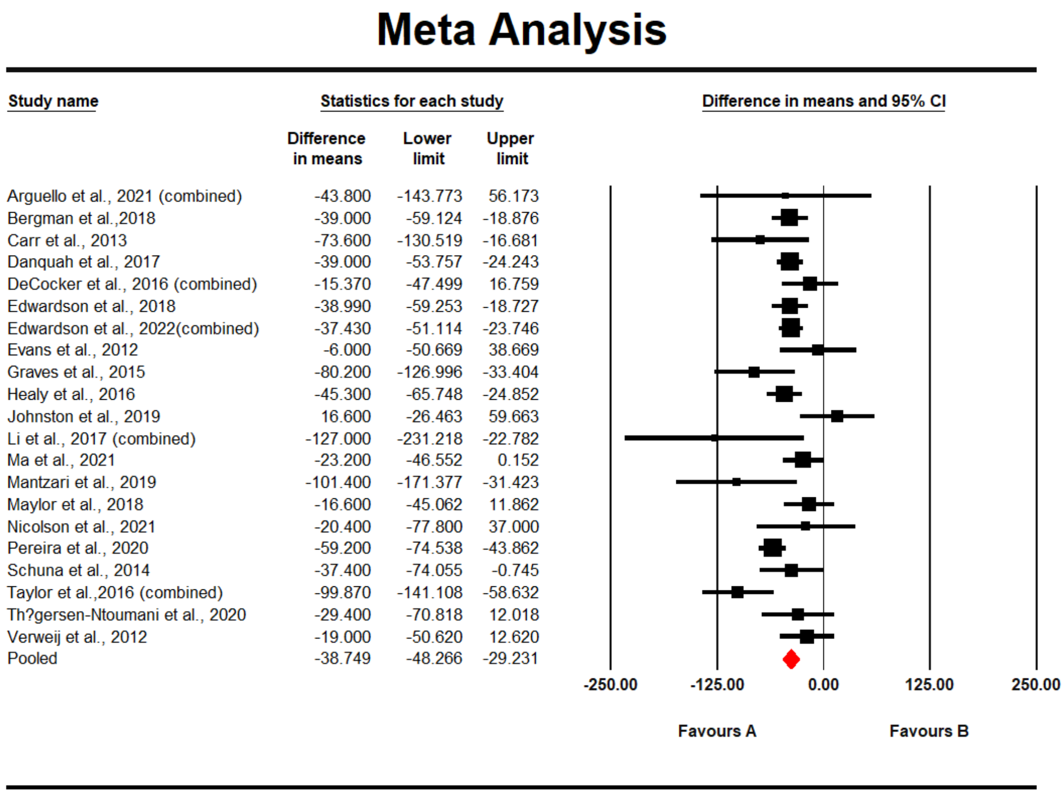


Figure 3-6 Forest plot of the pooled intervention effects on the reduction of workplace sitting time, with three studies with a high risk of bias excluded.

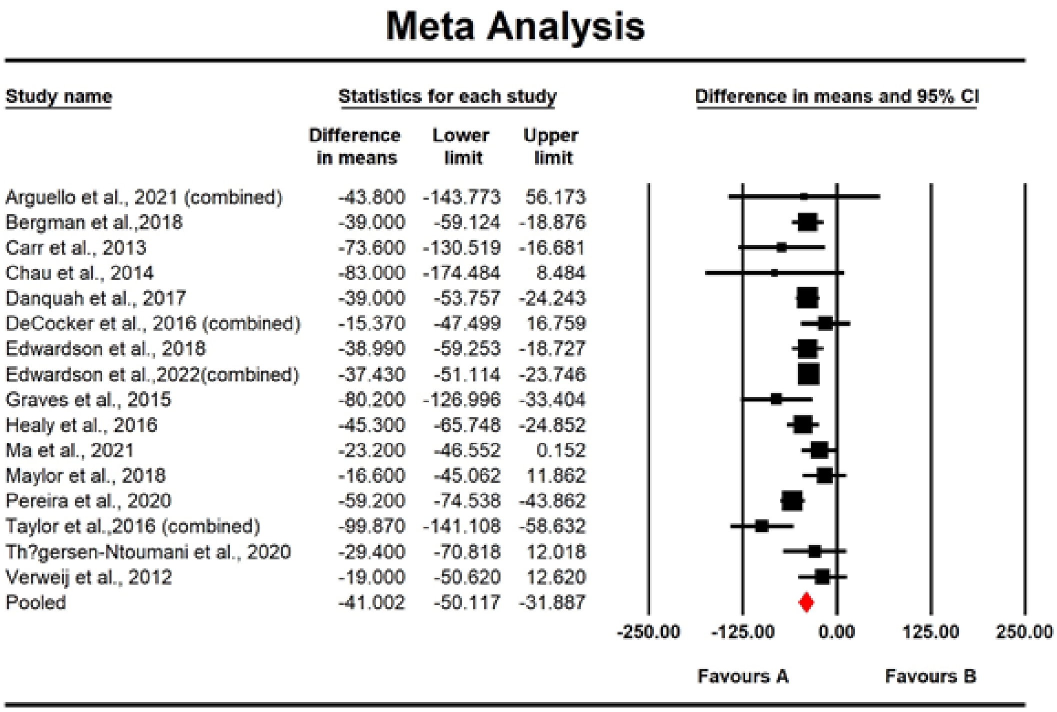


Figure 3-7 Forest plot of the pooled intervention effects on the reduction of workplace sitting time with Carter et al. (2020), Donath et al. (2015), Evans et al. (2012), Johnston et al. (2019), Li et al. (2017), Mantzari et al. (2019), Nicolson et al. (2021), and Schuna et al. (2014) excluded.

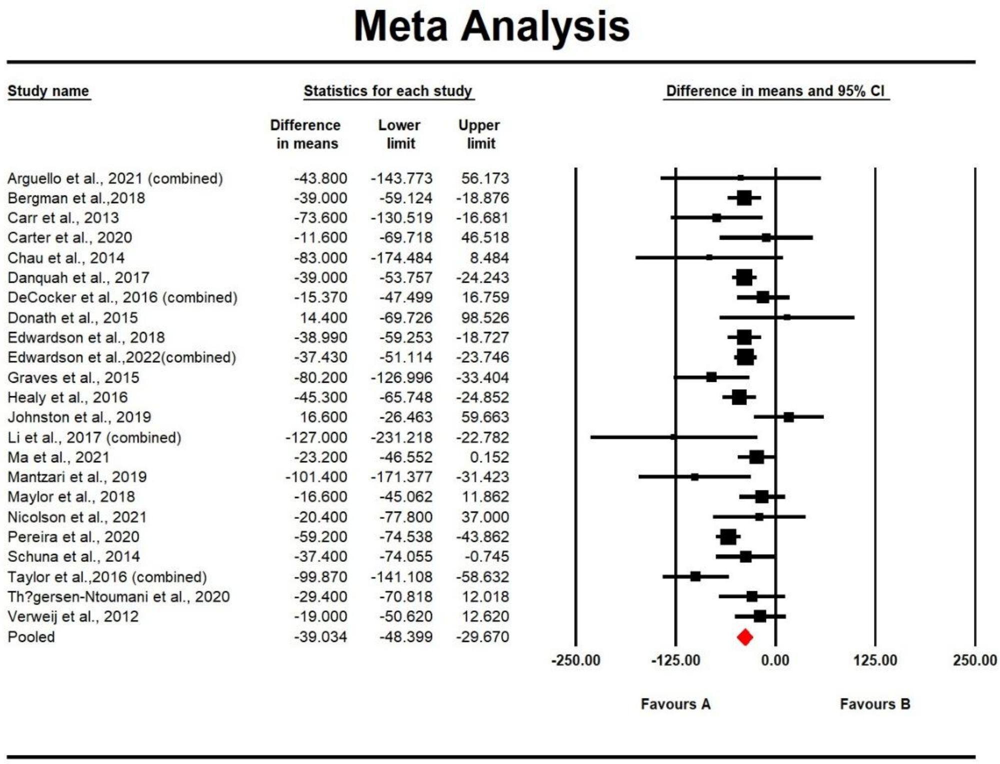


Figure 3-8 Forest plot of the pooled intervention effects on the reduction of workplace sitting time, with Evans et al. (2012) excluded

As was mentioned in the Study Characteristics section above, we categorized the studies on the basis of their intervention elements, and arrived at three subgroups: (1) environmental support (ES)[91, 108, 132, 137], (2) motivational strategies (MS)[66, 92, 110, 111, 128, 129, 139], and (3) multicomponent studies (Multi)[90, 93, 121-124, 130, 131, 133-136, 138]. Because of the common adoption of a health education element as a small part of the interventions of all studies, the effects of this element could not be separated and specified. Another set of subgroups related to different substituted behaviors: (1)

replacing sitting with standing[91, 92, 108, 121, 122, 128, 130, 132-134, 136, 137], (2) replacing sitting with physical activities[66, 93, 111, 123, 124, 135, 138, 139], and (3) replacing sitting with active breaks[129]. The studies could also be divided on the basis of their assessment period: (1) ≤3 months[66, 90-93, 108, 121-124, 128-130, 132-138], (2) 3–6 months[90, 93, 110, 111, 130, 139], and (3) >6 months[90, 93, 130, 134, 136]. In addition, within the different substituted behaviors and assessment period subgroups, the studies could be further divided by their intervention elements. The results of the analyses of all of these subgroups are summarized in **Table 3-1**.

No significant subgroup differences were observed between the intervention elements (q=2.277, df=2, p=0.32). Within the subgroup of studies that assessed workplace sitting time within three months, significant subgroup differences emerged when comparisons were made on the basis of second-level subgroups of intervention elements (q=10.742, df=2, p=0.005): the studies that adopted environmental support or multicomponent elements showed significant reductions in workplace sitting time, but those that adopted motivational strategies did not. In addition, significant differences in pooled effects were found among second-level subgroups of intervention elements in the subgroup of studies that intended to replace sitting with standing (q=6.349, df=2, p=0.042); here too, significant pooled intervention effects were observed in the studies that adopted ES or multicomponent elements, but not those that adopted MS. No significant differences were found in other subgroup analyses.

Table 3-1. Subgroup analyses of the effects of SB reduction interventions on workplace sitting time

Subgroup	No. of studies (participants)	Pooled intervention effect, MD (95%CI)	I^2	z-value	Hedges's g	*p*-value	Subgroup differences Q-value (df)	*p*-value
Intervention element							2.277(2)	0.320
ES[91, 108, 132, 137]	4(208)	-63.68(-107.22, -20.13)	65%	-2.866	-0.653	0.004		
MS[66, 92, 110, 111, 128, 129, 139]	7(896)	-27.99(-50.22, -5.78)	58%	-2.470	-0.309	0.014		
Multi[90, 93, 121-124, 130, 131, 133-136, 138]	13(2065)	-40.74(-50.15, -31.34)	36%	-8.490	-0.558	<0.0001		
Assessment period*								
0–3 months							10.742(2)	***P*=0.005**
ES[91, 108, 132, 137]	4 (208)	-63.68 [-107.22 to -20.13]	65%	-2.866	-0.653	0.004		
MS[66, 92, 128, 129]	4 (228)	-13.94 [-32.20 to 4.32]	0.0%	-1.496	-0.217	0.135		
Multi[90, 93, 121-124, 130, 131, 133-136, 138]	13(2122)	-52.07 [-68.66 to -35.48]	74%	-5.195	-0.641	<0.0001		
>3 to 6 months							0.045(1)	*P*=0.832

MS[110, 111, 139]	3 (668)	-48.41 [-97.20 to 0.381]	80%	-1.945	-0.389	0.052		
Multi[90, 93, 130]	3 (244)	-42.70 [-62.91 to -22.48]	4%	-4.140	-0.586	<0.0001		
Different substituted behaviors, in 21 included studies§							2.995(2)	*P*=0.224
Replacing sitting with standing[91, 92, 108, 121, 122, 128, 130, 132-134, 136, 137]	12 (1626)	-42.11 [-55.21 to -29.01]	52%	-6.299	-0.204	<0.0001		
Replacing sitting with physical activities[66, 93, 111, 123, 124, 135, 138, 139]	8 (776)	-26.95 [-41.04 to -12.86]	22%	-3.749	-0.353	<0.0001		
Replacing sitting with active breaks[129]	1 (14)	-11.60 [-69.72 to 46.52]	0.0%	-0.391	-0.554	0.696		
Different substituted behaviors in different intervention groups #								
Replacing sitting with standing							6.349(2)	***P*=0.042**
ES[91, 108, 132, 137]	4 (208)	-63.68 [-107.21 to -20.15]	65%	-2.868	-0.653	0.004		
MS[92, 128]	2 (146)	-12.18 [-38.26 to 13.91]	0.0%	-0.915	-0.181	0.360		
Multi[121, 122, 130, 133, 134, 136]	6 (1272)	-46.06 [-58.70 to -33.42]	39%	-7.141	-0.592	<0.0001		

Replacing sitting with physical activities								0.437(1)	*P*=0.508
MS[66, 111, 139]	3 (561)	-20.10	[-38.94 to -1.26]	0.0%	-2.091	-0.165	0.037		
Multi[93, 123, 124, 135, 138]	5 (215)	-30.46	[-54.72 to -6.21]	48%	-2.461	-0.494	0.014		

df: degrees of freedom; ES, environmental support; MD, mean difference; MS, motivational strategy; Multi, multicomponent; RCT, randomized controlled trial

$p<0.05$ in bold

*: the only subgroup of multicomponent intervention with >6-month assessment period

§: three studies[90, 110, 131] that had two intervention arms but that targeted different behavioral goals were excluded.

#: the only three articles in the subgroup of multicomponent interventions and motivational strategies replaced sitting time by active breaks

Because there were four studies[108, 123, 128, 131] that mentioned they had adopted both objective and subjective measures of SBs, we conducted a subgroup analysis on the basis of data type. However, two of these studies did not report comprehensive subjective data[123, 128], so the subgroup analysis between subjective and objective data was conducted with the remaining two studies[108, 131] . Notably, the results revealed no significant differences between the various types of data (Objective data: *MD*=-38.43, 95% *CI*: -51.96 to -24.89; z=-5.57; *Hedges's g*=-0.485; $p<0.001$; I^2=0.0%; Subjective data: *MD*=-42.85, 95% *CI*: -75.34 to -10.35; z=-2.58; *Hedges's g*=-0.226; p=0.01; I^2=0.0%). However, the subjective-data reports indicated a slightly greater reduction in sedentary time than the objective-data reports did, with larger confidence intervals (**Figure 3-9**).

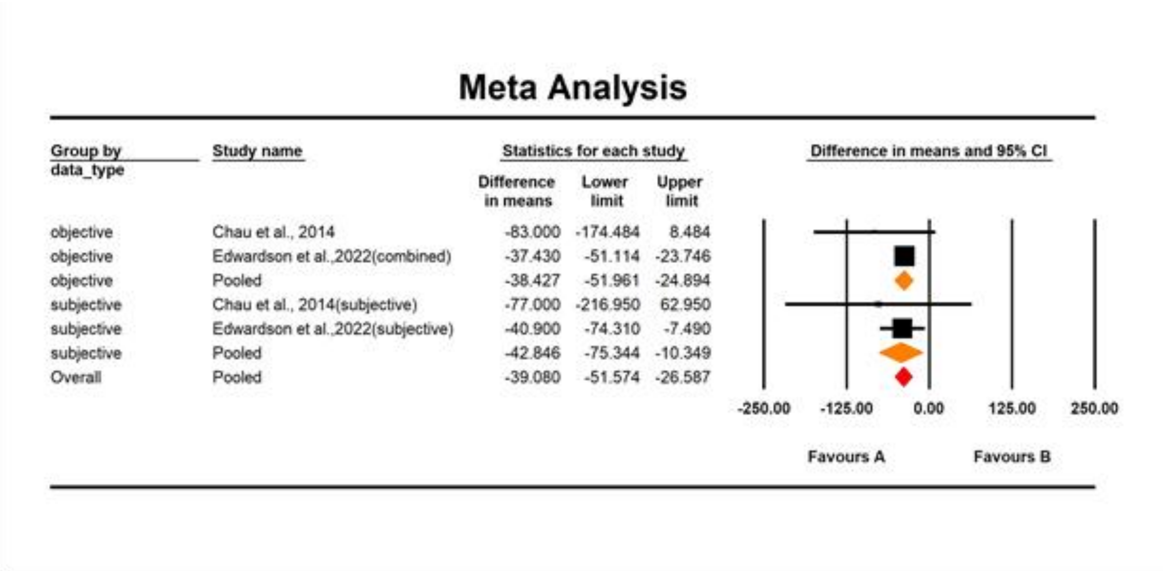


Figure 3-9 Subgroup analysis of the reduction of workplace sitting time, by data type.

To further unpack the pooled effect of the SB reduction interventions in the studies, a meta-regression was conducted of the predictions of the participants' age, health conditions, control conditions, outcome measurement tool, study design type, and risk of bias. None of the predictions was significant (*p*s>0.05). The results of the meta-regression are reported in detail in **Supplementary Table S3-6**.

3.3.4 Secondary outcomes

The overall effect size of the interventions on the secondary outcomes is summarized in **Supplementary Table S3-7**. A significant pooled effect was found for high-density lipoprotein cholesterol [HDL: MD=0.043 mmol/L, 95% CI: 0.01 to 0.08, p=0.01, I^2=0%], but not for other secondary outcomes.

3.3.5 Certainty assessment

The GRADE evidence summary revealed that the certainty of evidence for the reduction of workplace sitting time was rated as moderate certainty. The main factor contributing to the downgrading of certainty was a high risk of bias observed in the studies—specifically because the studies had not blinded the participants, there was evidence of assessor bias, they lacked information about their publishing protocol, or data were missing. The health-related outcomes were rated as very low to low certainty (**Supplementary Tables S3-8 and S3-9**).

3.4 Discussion

3.4.1 General findings

This systematic review and meta-analysis presented moderately confident evidence of the efficacy of all types of interventions for SB reduction to reduce the sitting time of office workers, with a mean reduction of 38 mins/workday, compared with all types of control conditions. That said, it is important to acknowledge that studies with small sample sizes can potentially act as outliers, so after we excluded such studies, the overall reduction in sedentary time increased to a total of 41 minutes per workday.

The evidence was clear and consistent for significant reductions in SBs across different intervention elements. Our results were also consistent with previous reviews that reported multicomponent interventions with environmental elements achieving better results than environmental support alone[118, 149, 150].

Our findings for the subgroups of assessment period lengths revealed that the effects of MS took three months or more to emerge. That was in line with previous findings showing that a relatively long-term change in behavior demands a high frequency of motivational support and coaching[90]. Interventions with ES were generally shorter, perhaps because ES could be novel and curious to office workers initially, causing strong adherence and quick intervention effects for SBs. However, it is possible that such intervention effects might not persist after three months, when the novelty wears off. Multicomponent interventions with both ES and MS elements appeared to be an optimal option for reducing SBs, because they consistently led to reductions of 42–52 minutes of sitting per week across six months. Although the multicomponent interventions' reduction of sitting time within three months appeared to be lower than that for the interventions with just ES, even the higher limit of sitting time reduction after multicomponent interventions (-35 minutes, according to its 95% CI) was within the range of clinically meaningful effects on health[151].

The subgroup results for interventions that used different substituted behaviors suggested that replacing SBs with either standing or physical activities is effective.

Standing appeared to be a more feasible alternative to SBs than physical activities and active breaks were[66, 152]. Interventions with ES generally aimed for more standing, and this may explain why both the ES and multicomponent subgroups showed significant pooled intervention effects within the studies that aimed for standing. For the interventions that intended to replace SBs with physical activities, the pooled effects were also significant within the MS and multicomponent subgroups, despite a smaller mean reduction in sitting time. Because physical activities and active breaks may elicit different health benefits than standing does, further exploration of the comprehensive health outcomes of SB reduction interventions with different goals is warranted.

For the secondary outcomes, we found a significant increase only in high-density cholesterol post-intervention and no significant differences for any of the other indicators—a finding that is inconsistent with those from previous review studies[43, 153]. Differences in our results could be explained by the fact that previous reviews primarily included people who were obese or at risk of disease, and the majority of our articles had healthy participants. Furthermore, most of the interventions in our review used standing to replace sitting, whereas standing could be insufficient to bring beneficial changes in cardiometabolic health[12, 66]. The low certainty of evidence in the secondary outcomes warrants future research to investigate the optimal exercise dosage required for improving health outcomes and to elucidate intervention impacts on diverse populations.

3.4.2 Limitations and future directions

This systematic review had certain limitations. We included only English-language trials, which could result in selection bias. In addition, this study could not compare long-term effects because of the relatively short duration of the interventions in the ES and MS groups. Moreover, it is important to note that the sample size of eight studies included in the analysis was relatively small. Furthermore, the intervention duration in some of the studies was notably short, which potentially could have impacted or interacted with the overall effect sizes as well as the effects specific to certain subgroups. Therefore, longer-term randomized-controlled trials with large sample sizes are needed to understand the sustainability and long-term impacts of reductions in office workers' sedentary time.

3.5 Conclusions and clinical implications

Our systematic review identified health education as an essential component of interventions aimed at reducing SBs among office workers. Combining environmental strategies with motivational approaches could enhance the effectiveness of these interventions. Replacing sedentary behaviors with physical activity and standing has been shown to effectively reduce sedentary time. However, because standing alone may not provide substantial health benefits, substituting SBs with PA appears to be a more promising strategy.

Drawing on all of these findings, we have further hypothesized that interventions based on TCM practices such as Baduanjin and Dantian breathing, integrated with health education and both environmental and motivational strategies, may represent an innovative approach to reducing SBs and enhancing workers' health outcomes. To date, no empirical research has examined the effectiveness of TCM-based interventions in decreasing SBs among office workers. Therefore, it is important to investigate both the feasibility and the health impacts of implementing TCM-based interventions in this population.

Chapter 4 Feasibility Study

4.1 Introduction

According to a recent territory-wide survey in Hong Kong, more than 20% of the population aged 15 years or older spends at least 10 sedentary hours per day[47]. Notably, office-based employees were found to spend approximately 80% of their total working time sitting, with much of that time accumulated in prolonged bouts of sitting for 30–60 minutes[154, 155]. A substantial body of evidence indicated that high levels of sedentary behaviors exert negative effects on numerous physical and psychological outcomes, including increased risks of all-cause mortality, cardiovascular disease, metabolic disorders, musculoskeletal issues, and depression, independently of moderate-to-vigorous physical activity [156, 157]. In addition to these health risks, office workers who remained sedentary for more than three hours per day reported significantly higher levels of perceived stress than those who engaged in less than three hours of sedentary behavior[27]. Notably, a systematic review of 168 studies consistently found positive associations between workplace sedentary behavior and elevated stress levels[28]. The positive associations between sedentary behaviors and stress were also supported by a large-scale survey with more than 34,000 adults from six countries[73]. Therefore, it is imperative to implement interventions that alleviate sedentary office workers' stress and enhance their wellness.

Multiple strategies have been employed to date as interventions to reduce SBs in the workplace, including health education, environmental modifications (e.g., sit-to-stand workstations)[19, 132], motivational strategies (e.g., prompts, positive feedback or social competition)[21, 22], and combinations of both environmental and motivational elements[23, 24]. Our systematic review and meta-analysis indicated that health education, when combined with environmental and motivational strategies, can effectively reduce SBs among office workers, and both replacing sedentary time with PA and with standing have been shown to significantly decrease SBs[158]. However, because standing alone has been found to be insufficient to yield significant improvements in health outcomes among generally healthy people, replacing SBs with PA appears to be a more promising strategy. Moreover, body-based interventions rooted in Traditional Chinese Medicine have rarely been utilized for reducing SBs. Common TCM practices, such as qigong (a mind-body exercise integrating breath control, movement, and mental focus), dantian breathing (diaphragmatic breathing combined with mindfulness), and acupressure (the application of manual pressure to specific acupoints using fingers, hands, knuckles, or blunt tools), can all be performed in a standing position as innovative approaches to reducing SBs. Indeed, those methods have been shown to be culturally relevant and easy-to-learn strategies for health promotion in Chinese populations[38]. The self-practices of qigong, dantian breathing, and acupressure do not require a long period of time or a large space, thus making them feasible alternatives to sedentary behaviors in office workers. Furthermore, previous studies have demonstrated various health benefits of these body works, such as enhanced cardiovascular function, immune function, and sleep quality[159-161]. In addition, psychological distress has been found to be significantly associated with SBs, and qigong, dantian breathing, and acupressure have been found to significantly improve mental health[34]. In that light, the TCM-based approach is likely to broaden the current theories of SB reduction, with qigong, dantian breathing, and acupressure not only being practical alternatives to prolonged sitting, but also bringing health benefits directly. Of course, the TCM practices can easily be applied in combination with existing strategies, including health education, environmental modifications, and motivation strategies.

Therefore, a promising approach to alleviating SBs in office workers in Chinese communities would incorporate a TCM-based intervention with health education, environmental modifications, and motivational strategies. To our knowledge, however, such an intervention has not yet been studied. Consequently, we considered it imperative to test the feasibility of studying the intervention in Chinese office workers with a two-arm RCT. Specifically, recruitment, retention, adherence, assessment completion, adverse events, and participants' acceptance of the TCM-based sedentariness reduction intervention needed to be tested. The effects of the TCM intervention on SBs (operationalized as daily sitting time and sitting time during working hours) and on physical activity needed to be explored. In addition, whereas previous interventions had been successful in reducing SBs or increasing physical activity level, the effects on health outcomes had been inconsistent[158]. Hence, it was also meaningful to explore the physical and psychological benefits of the TCM-based intervention, including sleep quality, blood pressure, hand grip strength, perceived stress, general self-efficacy, and health-related quality of life.

In summary, the present study adopted the design of a feasibility RCT which we developed primarily to test the feasibility of a TCM-based intervention by conducting a two-arm RCT with Chinese office workers, comparing a TCM-based sedentariness reduction intervention with a waitlist control. Secondarily, the study explored the effects of the intervention on SBs, physical activity, and other physical and psychological outcomes.

4.2 Methods

4.2.1 Trial design

The study's design was a two-arm feasibility RCT which adhered to the CONSORT statement for a feasibility trial. Data were collected from December 2023 to April 2024. All eligible participants provided informed consent (Appendix A).

4.2.2 Participants

Potential participants were recruited through posters on the campus of The Hong Kong Polytechnic University (PolyU). To attract additional potential participants, an online briefing session was provided to all of the registered participants to enhance their understanding of the project and confirm their intention to participate. The project team assessed their eligibility within one week of their registration, on the basis of the following criteria.

Inclusion criteria required that each participant: (1) be aged over 18 years; (2) be employed full-time (i.e., >35 working hours per week); (3) self-report sitting time exceeding 5.5 hours per day at work; and (4) able to provide informed consent.

Exclusion criteria required that each participant: **(**1) not have physical or mental conditions that could interfere with their participation in the study; and (2) not have participated in regular TCM-based or mind-body exercise during the month prior to recruitment.

4.2.3 Intervention

The TCM-based intervention to reduce sedentariness in the present study consisted of two stages.

In Stage 1, three workshops were delivered to the intervention group over the course of two weeks, focusing on Baduanjin (a standardized form of qigong comprising eight sequenced body movements), acupressure (using 12 acupoints related to stress management, including Taiyang (Ex-HN5), Yin tang(Ex-HN3), Shenting (GV24), Zan Zhu (BL2), Yuyao, Sibai (ST2), Tianshu (ST25), Qimen (LR 14), Zhangmen (LR13), Neiguan (PC6), Shenmen (HT7), Taixi (KI3)), and mindfulness-based techniques and strategies on office environmental modification. Three workshops, compromising one 60-minute session and two 90-minute sessions, were held face-to-face on the campus of PolyU during lunch hours or after work. The instructors of the workshops were psychologists and occupational therapists with training and expertise in mental health and TCM-based bodywork.

Stage 2 was another two-week period of facilitated self-practice, and the project team offered regular informational, motivational, and logistical support for participants' use of the skills learned during Stage 1 to reduce their sedentary behaviors. Specifically, the support included one-hour group-based practice sessions held every other workday during lunchtime in a hybrid mode (both face-to-face and online). Moreover, a website with demonstration videos, images, and audio materials related to content of the workshops was available to the participants. They also received health tips, reminders, and prompts at 10:30 AM and 3:30 PM on weekdays, to strengthen their awareness of sedentariness reduction and encourage their ongoing self-practice. Participants were encouraged to practice what they had learned for at least 30 minutes a day. Details about the intervention are reported in **Table 4-1** and **Supplementary Table S4-1**.

Table 4-1 Overview of the TCM-based sedentariness reduction intervention

Stage	Week	Health promotion activities/strategies	Details
1	1	Workshop 1 (face-to-face; 90 min)	• Brief information on sedentary behaviors and their health risks • Mindfulness-based activities: breathing and stretching • Baduanjin (part 1: Form 1 to Form 5)
	2	Workshop 2 (face-to-face; 60 min)	• Acupressure (part 1: Technique 1 to Technique 5) • Strategies to combat environmental factors related to sedentariness

		Workshop 3 (face-to-face; 90 min)	• Baduanjin (part 2: Form 6 to Form 8) • Acupressure (part 2: Technique 6 to Technique 10)
2	3 & 4	Daily reminders and health tips	• Two reminders to reduce sedentary behaviors, and a daily feed of health tips about sedentary behaviors and safety notes on the self-practice of qigong, acupressure, and mindfulness-based activities were sent to the participants throughout WhatsApp • Participants were encouraged to practice what they had learned for at least 30 minutes a day.
		Six group practice sessions	• Participants engaged in group practice sessions every other workday, incorporating qigong, acupressure, and mindfulness-based activities. Each session lasted one hour, totaling six sessions over the course of the program.
		Website support	• Website support was available to address sedentariness at the workplace throughout the entire study.
		Environmental modification	• Small changes in office decoration were made as a reminder of reduced sedentary behaviors • A rearrangement of office supplies was made

4.2.4 Primary outcomes: Feasibility outcomes

To report the intervention's outcomes, feasibility indicators included the participants' recruitment rate, retention, adherence and data measurement completion rate, adverse events, and acceptance of the intervention. The details are listed in Table 4-2.

Table 4-2. Overview of the intervention feasibility outcomes

Outcome	Description	Evaluation method	Evaluation timepoints
Recruitment rate	• The team expected to complete recruitment within nine weeks. • A weekly average of at least five participants enrolled indicated the feasibility of recruitment.	Recruitment logs	Baseline
Retention rate	• Retention rates were monitored by the team during the first week and throughout the 4-week program. • Feasibility was demonstrated with retention rates exceeding 90% in the first week and 80% across the entire 4-week program.	Retention logs	Throughout intervention
Adherence rate	• Adherence was assessed by tracking participant attendance at three workshop sessions and six group practice sessions, as well as compliance with daily reminders. • Participants were expected to attend on average 80% of the group practice sessions.	Attendance record form	4-week intervention
Assessment completion rate	• An overall percentage of missing data at baseline assessment, post-assessment, and follow-up assessment was calculated to understand the feasibility of assessing sedentary behavior and psychophysiological outcomes. • The percentage of missing data was expected to be less than 20% at each assessment time point.	Completion and usable data logs, ActiGraph diary and analysis	Baseline, post, and follow-up

Adverse events	• Adverse events occurring during the implementation of the project were systematically recorded and analyzed. • It was expected that any adverse events could be explained by the deviation from the research protocol.	Self-report	Throughout intervention
Intervention acceptability	• Participants' acceptability and satisfaction were assessed via a post-program questionnaire and a brief phone interview. • The questionnaire featured 16 items, covering aspects including how satisfied the participants were with the program, their self-perceived benefits from the program, their intention to recommend the program to others, the participants' willingness and confidence to incorporate the skills learned into their daily work, the clarity of the instructions, and the perceived usefulness of the content and frequency of the daily reminders. The items are reported in Supplementary Table S2. Responses were measured using a five-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). An average rating of 4 or higher for each item was anticipated. • In addition to the 16 items mentioned above, a comment box was included, inviting participants' written feedback about their experience in the project. Also, during the phone interview, participants were asked about the physical and emotional benefits they had gained from the intervention program, plus any lifestyle changes, any challenges they encountered, and their recommendations for future studies. • Participants' written and verbal comments supplemented the interpretation of feasibility.	Self-designed questionnaire and brief phone interview	Post assessment

4.2.5 Secondary outcomes: Sedentary behaviors, and psychological and physical well-being

To evaluate secondary outcomes as another specific measure of all outcomes, all participants were invited to complete assessments on their sedentary behaviors, physical activity, psychological distress, quality of life, sleep quality, and general self-efficacy at baseline, post-intervention (four weeks after baseline), and at a four-week follow-up (eight weeks after baseline).

4.2.5.1 Sedentary behaviors

Participants were advised to wear an accelerometer, the ActiGraph Wgt3X-BT (ActiGraph, Pensacola, Florida, USA), on the right side of their waist (at the intersection of a vertical line between the armpit and the knee), secured with an elastic belt, during their waking hours, excluding time spent in water-based activities, for a period of 5 workdays at baseline, post-intervention, and later at follow-up. The ActiGraph has demonstrated accuracy and responsiveness in measuring sitting time in previous studies[65, 69, 162]. The participants were asked to wear the Actigraph during working days of the weeks for the assessment schedules (1) one week before the intervention program, (2) the week right after the completion of the program, and (3) the fifth week after the completion of the program, for the monitoring of sedentary behaviors.

An activity log was used to record the participants' wearing of the ActiGraph and their daily sedentary time estimations. Participants were also instructed to document their daily sleep and wake times, as well as periods when the accelerometer was not worn, such as during water-based activities. This activity log, combined with daily records, was utilized to evaluate compliance with wearing the ActiGraph accelerometers. The protocol required that the ActiGraph be worn for at least 10 hours each day, encompassing the full duration of the workday.

Data were downloaded from the monitor using ActiLife software (version 6.16.3) and saved in 60-second epochs across awake periods. The device sampling frequency was set to 30 Hz. Two SB outcomes could be generated: one was the average daily total sitting time during the participant's waking period and the other was the person's average daily sitting time during working hours (from 9am-6pm), because all participants reported working within this timeframe. Sedentary time was typically defined as periods when the accelerometer counts per minute was less than 100. Data for a day were treated as invalid if the monitor was worn less than 10 hours, recorded fewer than 500 steps, or if any single activity, such as light activity or sedentary behavior, accounted for 95% or more of the individual's waking wear time[163]. The activity log was used to verify and correct errors in the ActiGraph's automatic wear detection. For example, if the ActiGraph failed to detect that a participant was wearing the device, but the activity log indicated otherwise, the ActiGraph record was manually corrected. Data from the ActiGraph were excluded if there was less than one day of valid data.

4.2.5.2 Physical activity

Participants' physical activity was measured with the International Physical Activity Questionnaire, Taiwanese short form, a reliable self-reported tool for evaluating physical activity among adults, with correlation coefficients from 0.65 to 0.88[62]. Participants were asked to estimate the number of days they engaged in vigorous activities (e.g., swimming laps, hiking). They were also asked about moderate activities (e.g., brisk walking, gardening), as well as their walking activities. Additionally, participants provided information on how much time they had devoted to these activities during the past seven days. Each participant's total physical activity was determined by adding together the time spent walking and engaging in moderate and vigorous activities, with the results expressed as metabolic equivalent minutes per week (MET-minutes·wk−1). A higher total score reflected a greater level of physical activity[62].

4.2.5.3 Perceived stress

The 10-item version of the perceived stress scale (PSS-10) was utilized to assess the participants' stress levels, and it demonstrated good reliability and validity with Cronbach's α's of 0.78–0.91 and test-retest reliability coefficients of 0.55–0.8[164]. Participants responded to items (e.g., 'In the last month, how often have you felt that you were unable to control the important things in your life?') on a 5-point Likert scale ranging from 0 (never) to 4 (very often). Scoring involved reversing the scores for the four positive items (Items 4, 5, 7, and 8) and summing all item scores. Total scores range from 0 to 40, with higher scores indicating a higher level of perceived stress.

4.2.5.4 Health-related quality of life

The 36-Item Short Form Survey (SF-36) was used to assess the participants' quality of life and showed good reliability and validity. Test-retest reliability for the SF-36 ranged from 0.70 to 0.93, and internal consistency with Cronbach's alpha coefficients ranged from 0.70 to 0.95[165]. The scale evaluates multiple domains of health, including physical functioning, role limitations, and mental health. Items were scored and aggregated into two primary summary scores: the Physical Component Summary (PCS) and the Mental Component Summary (MCS), using standardized scoring algorithms. The scores were transformed to a scale of 0 to 100, where higher scores signify better perceived physical and mental health status.

4.2.5.5 Sleep quality

The Pittsburgh Sleep Quality Index (PSQI) was developed in 1989 by Buysee and colleagues. The PSQI consists of 10 self-assessed sleep questions covering seven factors: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, use of sleeping medication, and daytime dysfunction. The total score of each scale ranges from 0 to 21, and the higher the score, the worse the sleep quality. The Cronbach's α of the original PSQI scale was 0.83, indicating good internal consistency[166].

4.2.5.6 General self-efficacy

Individual self-efficacy was assessed employing the General Self-Efficacy Scale, which yields a cumulative score between 10 and 40. Within this framework, a higher numerical outcome reflects a more robust sense of personal competence. Internal consistency ranged from .76 to .90[167].

4.2.5.7 Blood pressure and hand grip strength

Blood pressure was measured using an electronic device (OMRON, HEM-7156T).

Participants were instructed to remain seated and rest for at least 5 to 10 minutes before the initial measurement. Blood pressure was assessed once on the left upper arm, with the cuff positioned over the brachial artery. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were recorded in millimeters of mercury (mmHg). Hand grip strength was measured using an electronic hand dynamometer (CAMRY EH101, Sensun Weighing Apparatus Group Ltd., Guangdong, China). Participants were seated with feet flat, back supported, and elbow flexed at 90 degrees, with the forearm and wrist in a neutral position. Each hand underwent three trials, with 30 to 60 seconds of rest between trials to prevent fatigue. The average value (in kilograms) from the three trials for each hand was recorded.

4.2.5.8 Demographic information

At baseline, participants provided demographic information about their age, gender, height, weight, educational level, health condition, smoking status, income range, work nature, work years, and office size. Height and weight were self-reported by the participants. Body mass index (BMI) was calculated using the formula weight(kg)/height(m)^2 .

4.2.6 Sample size

As a feasibility study, sample size could not be estimated on the basis of the expected effect size of the TCM-based sedentariness reduction intervention. Instead, a practical sample of 40 participants (20 per arm) was adopted in accord with the recommendations by Billingham and colleagues[168].

4.2.7 Randomization

All of the eligible participants were randomly assigned to one of the two study groups:

① Intervention group: a TCM-based sedentariness reduction intervention group

② Control group: a waitlist control group.

The project team members who were blind to the objectives of the study conducted a randomization sequence using a random number sequence generated by Excel. The allocation ratio was 1:1. Participants were assigned to the control group if their number was odd and to the intervention group if their number was even. Group assignment information was concealed by sealed opaque envelope.

4.2.8 Implementation

The project was implemented by the project team, as indicated in the author list. Recruitment and interventions were carried out by CW and EL, whereas randomization and assessment were performed by ZL and WS. All of these research activities were overseen by HT. Recruitment was started after ethical approval (Appendix B) by the PolyU IRB was obtained (Ref: HSEARS20230629005). Figure 4-1 illustrates the flow of the activities in which the participants were engaged. Upon the completion of all assessments, each participant received HKD 150 in cash as a gesture of appreciation of their engagement.

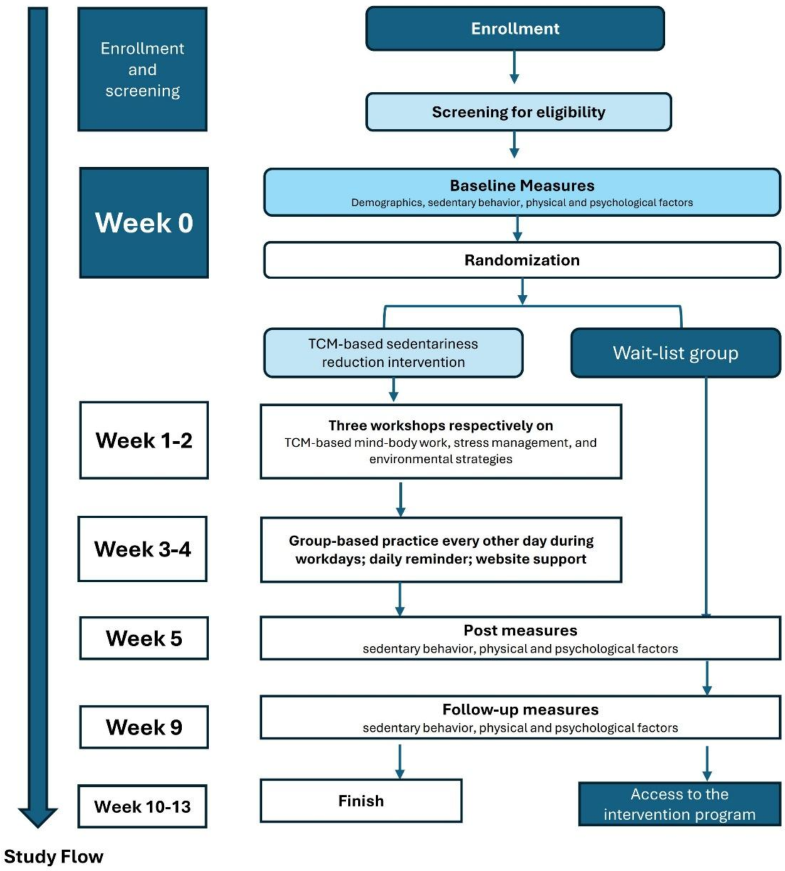


Figure 4-1. Study flow of the 4-week TCM-based sedentariness reduction intervention.

4.2.9 Blinding

Given the design of the present study, it was very difficult to mask the group assignment and research objectives for participants. However, all of the outcomes were assessed by research personnel who were blind to the participants' group assignments.

4.2.10 Statistical methods

Descriptive analysis was conducted to evaluate the feasibility of this study (recruitment and retention rates), the acceptability of the intervention, and participants' overall experiences with the study. The means and standard deviations were calculated for continuous variables, while frequencies and percentages were used for categorical variables. The reliability of the self-designed questionnaire was assessed using the Cronbach's alpha coefficient. A coefficient of 0.7 or higher was considered indicative of acceptable reliability[169].

The health benefits of the TCM-based intervention for reducing daily sitting and changing secondary outcomes was explored using descriptive statistics (mean ± SD, frequency, counts, and percentages). Preliminary trends in the data were explored by calculating effect sizes (Hedge's *g*) of the between-group differences, which was achieved by dividing the difference in the group means by the standard deviation of the pooled data. Hedge's g values of < 0.2, $0.2 \leq 0.5$, $0.5 – 0.8$, and > 0.8 were considered to represent very small, small, medium, and large effects, respectively[170].

Data were analyzed using SPSS v29.0 (IBM Corp., Armonk, NY, USA). The intention-to-treat (ITT) principle was applied in the analysis process[171].

4.3 Results

4.3.1 Recruitment, retention, adherence, assessment completion, and adverse events

Over a nine-week recruitment period, 99 individuals indicated their interest in the study, and 45 (45.45%) were eligible to participate. Seven individuals declined to participate due to scheduling conflicts. The overall recruitment rate of individuals who were eligible was 84.44% (38/45). Thirty-eight participants were randomly assigned to either the intervention group or the control group. The retention rate after the first week was 94.74% (exceeding the expected 90%, with one participant withdrawn from the study), and 84.21% (above the anticipated 80%, with another two participants withdrawn from the study) at the end of the four-week program in the intervention group. Reasons for withdrawal included challenges with adhering to the use of the ActiGraph (n=2) and participants' busy schedules (n=1). A total of 16 participants completed the four-week intervention, which included three workshops and six group practice sessions, with an overall attendance rate of 87.5%. After the four-week intervention, 86.84% of the participants were retained (84.21% in the intervention group and 89.47% in the control group) with one participant's withdrawal at the four-week follow-up in the control group. No adverse event was reported during the study. In summary, the participants' recruitment rate, retention rate, adherence rate, and assessment completion rate were all in line with the expected criteria of feasibility. The CONSORT diagram of the study is shown in Figure 4-2.

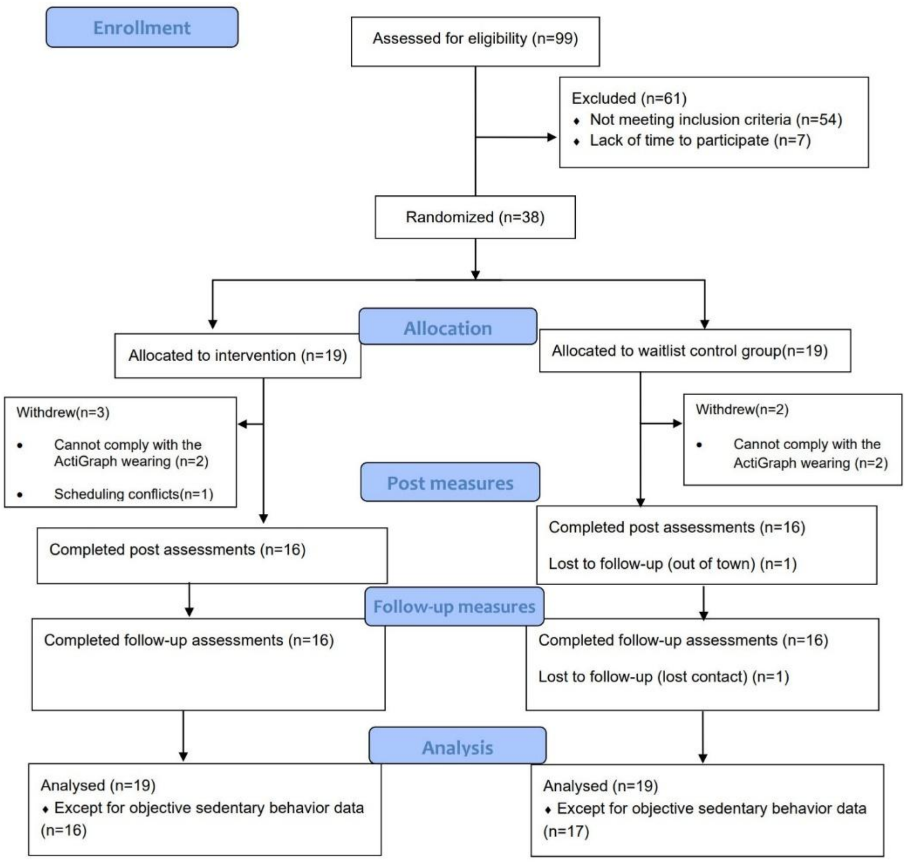


Figure 4-2. CONSORT flow diagram of the study implementation.

Data collection was from December 2023 to August 2024. Completion rates for the intended primary outcome (objective measured daily sitting) were 84.21% for the intervention group and 89.47% for the control group at baseline. At post-intervention and the four-week follow-up, completion rates were 100% and 94.12% for the intervention and control groups, respectively. Table 4-3 shows the demographic information for the participants. No significant differences were found between the two groups in any demographic variable.

Table 4-3 Demographic information for the participants

	Mean (SD)/ N (%)	Mean (SD)/ N (%)	χ^2/t	*p*-value
	Intervention group (n=19)	Control group (n=19)		
Demographics				
Age (years)	34.84(11.19)	34.11(11.32)	0.202	0.841
Sex			0.000	1
Male	6(31.6%)	6(31.6%)		
Female	13(68.4%)	13(68.4%)		
BMI (kg/m^2)	21.89(2.43)	22.07(2.49)	-0.22	0.827
Smoking status			0.000	1
Current smoker	0	0		
Nonsmoker	19(100%)	19(100%)		
Educational level			2.606	0.272
Primary School	0	0		
Secondary School	2(10.53%)	1(5.26%)		
Tertiary Education	2(10.53%)	0		
Undergraduate and above	15(78.95%)	18(94.74%)		
Work nature			3.034	0.219
Clerical	4(21.05%)	9(47.37%)		
Professional (research, teaching, health care)	10 (52.63%)	6(31.58%)		
Administrative	5(26.32%)	4(21.05%)		

Office size (n, %)			1.781	0.619
Cell office (1 person)	2(10.5%)	1(5.3%)		
Shared office (2-3 people)	3(15.8%)	1(5.3%)		
Small landscape office (4-9 people)	4(21.05%)	6(31.58%)		
Medium-size office (10-24	10(52.63%)	1157.89%)		
Monthly income			0.000	1
10k-20k	6(31.58%)	6(31.58%)		
20k-40k	1157.89%)	1157.89%)		
40k-60k	2(10.5%)	2(10.5%)		
>60k	0	0		
Work duration			2.323	0.313
< 5 years	13(68.4%)	14(73.68%)		
5 to 10 years	1(5.3%)	3(15.8%)		
> 10 years	5(26.3%)	2(10.5%)		

4.3.2 Intervention acceptability

Sixteen participants who completed the intervention expressed satisfaction with the research project, yielding a mean satisfaction score of 4.12 out of 5. The questionnaire demonstrated high reliability, with a Cronbach's alpha of 0.928. **Supplementary Table S4-2** lists details of the participants' responses concerning their experiences with the study and its procedures.

After the intervention, 87.5% of the participants expressed that the intervention effectively reduced their sedentary behaviors, while 6.25% had neutral or dissenting views on its impact. More than 75% of the participants reported being able to perform the dantian breathing, Baduanjin exercises, and mindful stretching independently by following the demonstration videos. In contrast, proficiency in performing acupressure was lower, with 56.25% of participants expressing confidence in this practice. Nearly all participants expressed an intention to continue practicing dantian breathing, Baduanjin exercises, and mindful stretching after the intervention concluded. The majority (81.25%) also found the intervention materials easy to understand and considered the frequency and content of the daily reminders twice per weekday to be appropriate. However, adherence to the reminders was limited to 56.25% of the participants consistently or frequently following them.

The interview results showed that 93.75% of the participants reported improvements in both their physical health and emotional well-being, while 81.25% indicated that the program had positively impacted their lifestyle following the intervention. Several participants mentioned that the program heightened their awareness of their health, encouraging them to reduce prolonged sitting. When experiencing work-related fatigue, they engaged in breathing exercises, acupressure, or specific movements from the Baduanjin exercise. One participant commented, “The training served as a helpful reminder to exercise more and regulate my emotions.” Another participant noted, “Long periods of sitting and lack of physical activity previously led to tightness in my lower back muscles, but this has improved. The Baduanjin exercises are simple to learn and can be practiced regularly.” However, some participants reported having faced difficulties, such as, “It was challenging to participate in the group exercises during lunch, as it took time away from eating.” Detailed comments from the phone interviews are summarized in **Supplementary Table S4-3**. In general, the intervention was accepted by the participants.

4.3.3 Participants’ baseline characteristics

The participants’ baseline characteristics are presented in Table 4-4. Their total sitting time throughout the entire workday was 537.37 minutes for the intervention group and 547.31 minutes for the control group. The intervention group and the control group spent an average of 344.68 minutes and 351.47 minutes, respectively, sitting during the nine-hour workday. No statistically significant differences were observed between the groups in terms of their sitting time and health-related measures.

Table 4-4 Baseline characteristics of the participants

		Mean (SD)	*t*	*p*	*Hedges's g*
Total sitting time (min/workday)	Intervention	537.37(86.27)	-0.292	0.772	-0.099
	Control	547.31(109.22)			
Sitting time (min/ 9h workday)	Intervention	344.68(54.78)	-0.349	0.729	-0.119
	Control	351.47(56.72)			
IPAQ	Intervention	1529.65(763.34)	-1.616	0.116	-0.541

	Control	2240.21(1644.92)			
Perceived stress	Intervention	16.32(6.53)	-1.62	0.114	-0.514
	Control	19.79(6.69)			
Hand grip(L/kg)	Intervention	24.06(9.85)	0.472	0.639	0.15
	Control	22.78(6.41)			
Hand grip(R/kg)	Intervention	27.05(10.69)	0.649	0.521	0.211
	Control	25.31(7.47)			
SBP (mmHg)	Intervention	112.58(17.37)	0.011	0.992	0.003
	Control	112.53(12.99)			
DBP (mmHg)	Intervention	71.95(10.34)	0.579	0.566	0.184
	Control	70.26(7.33)			
General self-efficacy	Intervention	26.74(4.28)	1.075	0.29	0.346
	Control	25.06(5.21)			
PQSI	Intervention	5.89(3.25)	-1.137	0.263	-0.361
	Control	7.05(3.03)			
Quality of life_SF-36					
Physical Component Summary (PCS)_T score	Intervention	51.29(6.98)	1.737	0.091	-0.087
	Control	47.17(7.64)			
Mental Component Summary (MCS)_T score	Intervention	45.52(11.42)	1.790	0.082	0.569
	Control	38.19(13.72)			

DBP=Diastolic blood pressure; IPAQ= International Physical Activity Questionnaire; PQSI=Pittsburgh Sleep Quality Index Scale; SBP=Systolic blood pressure.

Note: The sitting time data included 16 observations in the intervention group and 17 in the control group. For other outcomes, there were 19 samples in each group.

4.3.4 Potential of the intervention to reduce daily sitting and improve secondary outcomes

Table 4-5 summarizes the participants' intervention-related changes in sedentary behaviors and psychophysiological measures following the four-week intervention, while **Supplementary Table S4-4** presents details of the four-week follow-up results and changes from the baseline. Upon the completion of the intervention, the intervention group reduced their total daily sitting time by 21.61 minutes (*SD* = 60.45) and their sitting time during their nine-hour working time by 16.24 minutes (*SD* = 45.69). Conversely, the control group increased their sedentary time based on the same two indicators. As a result, the intervention group demonstrated a trend of greater reduction in sedentary behavior than the control group did, with medium effect sizes (*Hedges's g* = 0.648 for total daily sitting time and *Hedges's g* = 0.588 for sitting time during working hours). However, the differences in the change scores between the two groups for both total sitting time and sitting time during working hours did not reach statistical significance (p = 0.075; p = 0.057, respectively). The intervention group also showed significantly more increases in physical activity relative to the control group, with a medium effect size (*Hedges's g* = 0.705, p = 0.043). Furthermore, after the four-week intervention, the intervention group experienced a significant reduction in perceived stress (p = 0.003), while the control group did not have significant changes in their perceived stress (*Hedges's g* = 0.333). The intervention group also showed a trend of outperforming the control group in enhancing their right-hand grip strength, with a small effect size (*Hedges's g* = 0.423). However, these between-group differences were not statistically significant (p = 0.302 and p = 0.192, respectively). Although the control group showed trends of greater improvements in their sleep quality and the physical fitness component of the SF-36 compared with the intervention group (*Hedges's g* = 0.546 for sleep quality and 0.402

for the physical fitness component), again the differences between-group were not statistically significant ($p = 0.213$ and $p = 0.094$, respectively).

Table 4-5 Intervention-related changes in sedentary behavior, physical activity, psychological and physical well-being outcomes from baseline to post-intervention

		Baseline (T1)	Post-intervention (T2)	Within-subject Difference			Change from Baseline to Post-intervention	Between-group Differences in Change from Baseline to Post-intervention		
		Mean (SD)	*Mean (SD)*	*t*	*p*	*Hedges's g*	*Mean (SD)*	*t*	*p*	*Hedges's g*
Total sitting time (min/workday)	Intervention	537.37(86.27)	515.66(90.93)	1.43	0.173	0.339	-21.61(60.45)	-1.844	0.075	-0.627
	Control	547.31(109.22)	569.59(70.99)	-1.226	0.238	-0.283	22.28(74.96)			
Sitting time (min/ 9h workday)	Intervention	344.68(54.78)	328.44(74.28)	1.422	0.176	0.337	-16.24(45.69)	-1.976	0.057	-0.588
	Control	351.47(56.72)	367.47(54.56)	-1.377	0.187	-0.318	16.00(47.91)			
IPAQ	Intervention	1529.65(763.34)	3023.09(1951.9)	-3.042	0.008	-0.702	1493.44(2024.44)	2.107	0.043	0.705
	Control	2240.21(1644.92)	2441.82(1966.18)	-0.549	0.591	-0.127	201.62(1514.88)			
Perceived stress	Intervention	16.32(6.53)	13.26(7.21)	3.392	0.003	0.745	-3.05(3.92)	-1.048	0.302	-0.333
	Control	19.79(6.69)	18.37(7.91)	1.118	0.278	0.246	-1.42(5.54)			
Hand grip (Left/kg)	Intervention	24.06(9.85)	24.59(9.81)	-1.404	0.177	-0.308	0.54(1.67)	-0.025	0.98	-0.008
	Control	22.78(6.41)	23.34(5.85)	-0.753	0.461	-0.166	0.56(3.23)			
Hand grip (Right/kg)	Intervention	27.05(10.69)	27.57(10.81)	-0.887	0.387	-0.195	0.42(2.06)	1.331	0.192	0.423
	Control	25.31(7.47)	23.79(10.81)	1.093	0.289	0.240	-1.42(5.64)			
SBP (mmHg)	Intervention	112.58(17.37)	112.00(17.40)	0.388	0.702	0.085	-0.58(6.50)	0.197	0.845	0.062
	Control	112.53(12.99)	111.37(13.84)	0.456	0.654	0.1	-1.16(11.06)			
DBP (mmHg)	Intervention	71.95(10.34)	71.84(11.62)	0.086	0.933	0.019	-0.11(5.34)	-0.343	0.734	-0.109
	Control	70.26(7.33)	70.79(8.66)	-0.383	0.706	-0.084	0.53(5.99)			

General self-efficacy	Intervention	26.74(4.28)	26.95(25.55)	-0.233	0.818	-0.051	0.21(3.94)	-0.191	0.849	-0.063
	Control	25.06(5.21)	25.94(5.94)	-0.609	0.552	-0.144	0.44(2.87)			
PQSI_total score	Intervention	5.89(3.25)	5.58(2.69)	1.242	0.23	0.273	-0.32(1.11)	1.720	0.094	0.546
	Control	7.05(3.03)	6.05(2.70)	3.269	0.004	0.718	-1.00(1.33)			
Quality of life_SF-36										
Physical Component Summary (PCS)_T score	Intervention	51.29(6.98)	51.92(6.85)	-0.643	0.528	-0.141	0.63(4.25)	-1.267	0.213	-0.402
	Control	47.17(7.64)	49.75(8.10)	-2.167	0.044	-0.476	2.58(5.18)			
Mental Component Summary (MCS)_T score	Intervention	45.52(11.42)	48.07(11.77)	-2.476	0.023	-0.544	2.54(4.48)	0.288	0.775	0.091
	Control	38.19(13.72)	40.06(13.57)	-0.887	0.387	-0.195	1.87(9.19)			

DBP=Diastolic blood pressure; IPAQ= International Physical Activity Questionnaire; PQSI=Pittsburgh Sleep Quality Index Scale; SBP=Systolic blood pressure.

4.4 Discussion

4.4.1 General findings

With the design of our feasibility RCT, the present study demonstrated the feasibility of implementing and evaluating a TCM-based intervention aimed at reducing sitting time among office workers. Recruitment was successfully completed within a reasonable timeframe, with high rates of participant retention and data completion. Overall, the intervention was deemed both acceptable and feasible, with regular group practice sessions, daily prompts, and website support from the research team identified as particularly valuable components.

While most of the participants demonstrated strong comprehension of the intervention content, showing confidence and dedication to maintaining their practice of qigong, dantian breathing, and mindfulness stretching exercises, a small subset expressed hesitancy about their ability to perform self-administered acupressure techniques post-intervention. This suggests that, in future studies that focus on self-administered acupressure, it will be important to provide additional support and motivation to encourage participants to increase the frequency and repetition of their practicing, in the hope of enhancing their confidence and competence in these techniques.

Importantly, this study extends the findings from previous studies with office workers by demonstrating that a merged intervention involving Baduanjin, a stress management strategy and prompt tools, and website support has the potential for reducing office workers' daily time spent sitting[79]. Encouragingly, a drop in the participants' daily sitting time was observed during working hours, and that improvement was sustained during the follow-up phase. This discrepancy from other studies might have been attributed to the high adherence rates in our study, contrasting with previous studies that reported declining adherence over time in their intervention groups[79]. In addition, the regular and extended group practice sessions in our study were led by professionals and provided participants with ample time to clarify queries and learn and thus assimilate the skills, which boosted their confidence to continue practicing after the intervention. This too is likely to have contributed to the sustained reduction in sedentary time observed during the follow-up phase. However, it is important to note that the differences in change scores between the two groups were not statistically significant, likely due to the small sample size. In addition, the effect size of total daily sitting time at follow-up had diminished to a small level. This trend aligns with prior research suggesting that exercise and motivational interventions may yield significant short-term effects but struggle to maintain long-term sustainability[158]. Future studies that focus on exercise or motivational strategies may need to extend the duration of their intervention in order to foster habit formation and enhance long-term effectiveness[110, 172].

Furthermore, this study's TCM-based intervention was effective in reducing perceived stress levels and demonstrated a trend in improving handgrip strength within the intervention group. Although no significant differences were found between the groups for either outcome, the intervention still demonstrated potential not only to directly reduce sedentary behaviors, but it also counteracted the negative consequences caused by SBs.[28, 173]. In future RCTs, an evaluation of such health benefits is warranted, as is an examination of the underlying biopsychosocial mechanism. Interestingly, the control group showed greater improvements in quality of life than the intervention group did, likely due to their lower baseline SF-36 scores, which allowed for more potential improvement. Nevertheless, this difference was not statistically significant between the two groups. With larger sample sizes in the future, the intervention group and the control group would likely be statistically equivalent in quality of life at baseline, and that would allow researchers to evaluate the effect more validly. Furthermore, it remains unclear why the control group showed more improvement in sleep quality than the intervention group did. Objective measures of sleep parameters and sleep logs would need to be collected in the future to reveal the full effects of the TCM-based intervention on sleep quality.

4.4.2 Limitations and future directions

This study presented several limitations that require further refinement. First, most of the secondary outcomes relied on self-reported data, which may have been too subjective and might have introduced recall bias. Future research should incorporate physiological measures. For example, stress markers, such as cortisol levels, can be collected to evaluate an intervention's impact on stress. Second, the participants in this study were predominantly healthy office workers, which may have limited the generalizability of our findings from those with pre-existing health conditions and those in different work environments. Future studies should explore the intervention in more diverse cohorts, to validate its broader applicability. Third, the sample size in the present study was relatively small and lacked sufficient power to detect significant differences in the primary and secondary outcomes. Future research should include larger sample sizes and examine the intervention in more diverse populations, in an effort to validate its broader applicability.

4.4.3 Conclusions

This study demonstrated the feasibility and acceptability of delivering a TCM-based sedentariness reduction intervention to reduce time spent sitting by office workers and improve certain health outcomes. It was crucial next to conduct a full-scale RCT to draw a conclusive finding and explore such an intervention's long-term sustainability across diverse populations.

4.4.4 Summary

The feasibility study established a robust foundation for further investigation into the effects and underlying mechanisms of TCM-based interventions designed to reduce sedentary behavior among office workers. However, the feasibility study did not include objective biomarkers to assess stress-related changes, nor did it thoroughly evaluate participants' adherence to the intervention protocol or their dynamic stress responses during the implementation phase. To address these limitations, the subsequent main trial incorporated important methodological enhancements: (1) systematic collection of salivary cortisol samples to quantify physiological stress responses, and (2) longitudinal monitoring of self-reported practice adherence, stress levels, and sedentary behavior throughout the two-week self-practice period. These refinements sought to elucidate the mechanistic pathways of the intervention and enhance the rigor of outcome assessments.

Furthermore, focusing on middle-aged office workers was particularly important, as they are at a critical juncture in which lifestyle changes can significantly impact long-term health outcomes. Healthier middle-aged workers contribute to a more productive workforce, reducing absenteeism and healthcare costs for employers.

Furthermore, by preparing these individuals for a healthier transition into older age, societies can reduce future demands for care services for older individuals and support sustainable social development. Therefore, the main study focused primarily on enrolling middle-aged office workers.

Chapter 5 Main Study

5.1 Introduction

Integrating the findings from the available literature, our earlier chapters have demonstrated significant associations between sedentary behaviors in adults and a range of adverse health outcomes, including elevated risks of cardiovascular mortality, cancer, various metabolic and musculoskeletal disorders, cognitive decline, and depression[2, 7, 8]. Extant studies on the correlates of SBs among adults have shown that time spent being sedentary increases with age, full-time occupation, and higher education [45]. This trend was found to be evident in office settings, with workers maintaining seated positions for 75% of their work hours, typically in uninterrupted 30–60-minute intervals [48, 49]. Previous cross-sectional studies consistently have revealed that office workers self-report an average of 10 hours of occupational sitting per day[50,51]. Notably, the prevalence of SBs has been found to be significantly higher among office workers aged 45 and above than in those aged 18–24[174]. Evidence has indicated that SBs are significantly associated with stress in working populations[75, 96]. Middle-aged individuals have been found to be among the groups experiencing high levels of perceived stress, likely due to the diverse roles, responsibilities, and demands they faced during that stage of life[175]. Perceived stress, defined as an individual's subjective evaluation of stress experienced at a particular time or over a specific period[97], has been found to significantly predict sedentary durations exceeding seven hours per workday[25]. When individuals experience stress, their motivation to engage in any form of physical activity tends to decrease, leading them to rely more on SBs as a means of coping. For instance, using smart devices for leisure activities can serve as a distraction from stress and can provide temporary relief from negative emotions while sitting or lying down[99, 100].

Beyond the association with perceived stress, research has also linked SBs to elevated cortisol levels and heightened stress responses[102]. Chronic stress can activate the Hypothalamic-Pituitary-Adrenal (HPA) axis response, increasing cortisol concentration[103]. Excessive cortisol secretion could in turn disrupt the HPA axis's negative feedback loop, paradoxically leading to sustained HPA activation and further cortisol overproduction[104]. This overproduction can enhance depressive symptoms and burnout, leading to low physical activity or an inactive state. Therefore, high cortisol levels can potentially lead to increased SBs[101]. Collectively, these findings underscore the importance of incorporating stress management strategies for office workers, in order to reduce their sedentary behaviors effectively. However, empirically validated stress-management interventions specifically designed to reduce sitting time in office workers remain scarce. Given the high prevalence of SBs and stress among middle-aged adults, along with the global trend of population aging, it is essential to develop effective health promotion strategies for middle-aged office workers and support successful aging.

Traditional Chinese Medicine-based practices, such as qigong, *dantian* breathing, and acupressure, may be promising to address the sedentariness in Chinese office workers, given their cultural relevance and ease of practice[34]. Our preliminary feasibility study, reported in Chapter 4, suggested that a TCM-based intervention aimed at reducing workers' sitting time holds promise for decreasing occupational SBs and perceived stress. The results reported medium effect sizes for reducing workday sitting time and small effect sizes for lowering perceived stress, after four weeks of intervention. However, the small sample size limited the statistical power to detect significant intervention effects on SBs and to explore underlying psycho-physiological mechanisms. Therefore, larger-scale trials were necessary to confirm the effectiveness of the intervention and to explore its underlying mechanisms.

Moreover, very few previous studies have longitudinally tracked dynamic changes in both stress and SBs throughout an intervention period. In addition, considerable interindividual variability prevails in people's adherence to TCM interventions. Therefore, we considered it essential as a pioneering study to simultaneously explore the within-person and between-person associations between workers' self-practice of TCM-based bodyworks and their sedentary behaviors, as well as the mediating role of daily fluctuations in their levels of stress.

On the basis of existing literature and our feasibility study findings, we proposed a conceptual model (Figure 5-1) in which we postulated that TCM-based interventions would reduce SBs among office workers through stress management pathways. To test this model, an RCT study was conducted as the main study of my PhD thesis to (1) test the efficacy of the TCM-based sedentariness reduction intervention in reducing SBs in Chinese office workers, compared with a waitlist control; (2) explore the benefits of the TCM-based sedentariness reduction intervention on the office workers' physical activity and other physical and psychological outcomes, compared with a waitlist control; (3) explore the psychophysiological mechanism related to stress that underlay the effects of the TCM-based sedentariness reduction intervention on SBs; and (4) explore the association between daily changes in stress levels (both perceived stress and cortisol levels) and overall changes in SBs within and between the Chinese office workers who participated in the TCM-based sedentariness reduction intervention.

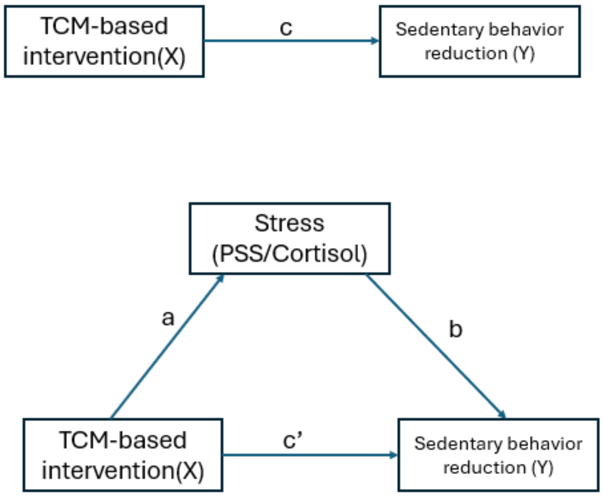


Figure 5-1 Conceptual model: A mediation model to demonstrate how stress mediates the effectiveness between a TCM-based intervention and SBs. Note: a,b,c, and c' refer to the paths of the model.

5.2 Methods

5.2.1 Trial design

The study design was a two-arm randomized controlled trial that adhered to the CONSORT statement for randomized trials[176]. Data were collected from February 2024 to December 2024. Ethical approval for this study was obtained from the Human Subjects Ethics Committee of The Hong Kong Polytechnic University (Ref: HSEARS20230723005, Appendix C). All eligible participants provided informed consent (Appendix D).

5.2.2 Participants

The project targeted middle-aged sedentary office workers in Hong Kong through promotional posters displayed across the campus of the Hong Kong Polytechnic University (PolyU). The recruitment strategies employed were consistent with those used in our feasibility study. The project team assessed their eligibility within one week of registration, using the following criteria.

Inclusion criteria: To participate in the study, the participants were required to (1) be in the age range of 45 to 65 years old; (2) be full-time employees (i.e., over 35 working hours per week); (3) self-report a sitting time longer than 5.5 hours per day at work; and (4) be capable of providing informed consent.

Exclusion criteria: The prospective participants were excluded if they (1) had physical or mental conditions that could interfere with their participation in the study; or (2) had engaged in regular TCM-based or mind-body exercise during the month prior to recruitment.

Because all eligible participants were nonclinical adults, they provided informed consent independently by signing a consent form after attending a briefing session, reviewing the project information sheet, and receiving verbal introduction and explanation from the project team.

5.2.3 Intervention

The TCM-based sedentariness reduction intervention in the main study consisted of two stages.

In Stage 1, three workshops were delivered to the intervention group over a period of two weeks, focusing on Baduanjin, acupressure, mindfulness-based techniques, and strategies for environmental modification of their offices. Three workshops comprised one 60-minute session and two 90-minute sessions. The workshops were held on the campus of PolyU in a face-to-face format.

Stage 2 comprised an additional two weeks, engaging in facilitated self-practice during which the project team offered regular informational, motivational, and logistical support to help participants apply the skills learned during Stage 1 to reduce their sedentary behaviors. Specifically, the support included one-hour group-based practice sessions that were held every other workday during lunchtime in a hybrid mode (both face-to-face and online). In addition, a website with demonstration videos, images, and audio materials related to the content of the workshops was available to the participants. They also received health tips, reminders, and prompts twice per weekday to strengthen their awareness of reducing their sedentariness and encourage ongoing self-practice. Participants were encouraged to practice what they had learned for at least 30 minutes a day. Based on participant feedback from the feasibility study, acupressure demonstration videos were provided in the main trial to facilitate participant learning. **For comprehensive details regarding the interventions, please consult the Methods section in Chapter 4 and Supplementary Table S4-1.**

5.2.4 Outcomes

All participants were invited to complete assessments of their sedentary behaviors, physical activity, psychological distress, saliva cortisol, quality of life, sleep quality, general self-efficacy, blood pressure, and handgrip strength at baseline, post-intervention (Week 5), and at a four-week follow-up (Week 9). Participants in the intervention group underwent a two-week supported self-practice phase. Throughout this phase, participants were asked to wear an ActiGraph, keep a daily log of self-estimated sedentary time and perceived stress levels, and submit salivary samples every other day.

5.2.4.1 Primary outcomes: Sedentary behaviors

Sedentary behaviors were assessed using the same methods as those used in the feasibility study; please refer to the Methods section in Chapter 4 for details.

5.2.4.2 Secondary outcomes: Perceived stress, saliva cortisol, physical activity, health-related outcomes, and diary of perceived stress and saliva cortisol

The 10-item version of the perceived stress scale (PSS-10) was utilized to assess stress levels and demonstrated good reliability and validity, with Cronbach's α's of 0.78–0.91 and test-retest reliability coefficients of 0.55–0.8[164]. Higher scores correlate to more stress.

Saliva cortisol. Saliva samples were collected in a 50 mL centrifuge tube (B.D. Bioscience, CA, USA) at three times in a designated workday (i.e., 7:00–9:00 am, 1:00–3:00 pm, and 7:00–9:00 pm). Participants were instructed to collect saliva at home or at designated labs during the designated period. Morning samples were obtained within 30 minutes of waking, prior to oral hygiene practices or breakfast consumption, and immediately transferred to a 4°C preservation environment. Midday and evening collections were conducted within designated time windows, adhering strictly to either preprandial conditions or a 2-hour postprandial interval. In instances of fluid intake, a 15-minute waiting period was mandated before sample acquisition[177]. Participants were required to contemporaneously document daily tobacco use, alcohol consumption, and tea ingestion through a self-reported questionnaire.

Upon completion of the three samplings, participants promptly notified research personnel to facilitate immediate cryopreservation at –80°C. To mitigate repeated freeze-thaw cycles, samples underwent controlled thawing at 4°C for 24 hours preceding analytical procedures. Post-thaw processing was expeditiously conducted to ensure cortisol quantification within minimized temporal windows, thereby controlling inter-assay variability. To determine the salivary cortisol concentration (measured in ng/mL), the salivary cortisol assays were performed by enzyme-linked immunoassays, according to the manufacturer's instructions (Assay Designs, MI, USA) by using cortisol ELISA kits from Fine Test® according to their standardized manual guidelines[178]. The immunoassay exhibited a validated quantification range of 0.391–25 ng/mL, with a sensitivity threshold of <1.0 ng/mL (Fine Test). The concentration of cortisol in the samples was then determined by comparing the OD of the samples to the standard curve. The concentration of the target substance was inversely proportional to the OD450 value.

Physical activity. Participants' physical activity was measured with the International Physical Activity Questionnaire, Taiwanese short form, which is a reliable self-reported tool for evaluating physical activity among adults, with correlation coefficients from 0.65 to 0.88[62]. Participants were asked to estimate the number of days they engaged in vigorous activities (e.g., swimming laps, hiking). They were also asked about moderate activities (e.g., brisk walking, gardening), as well as walking activities. In addition, the participants reported the duration of time spent on these activities over the previous seven days. The total physical activity for each participant was calculated as the sum of walking, medium and vigorous physical activity, and was expressed in terms of metabolic equivalent minutes per week

(MET-minutes·wk−1). Higher scores indicated higher levels of physical activity.

Diary data collection during the supported self-practice period. During the two-week self-practice period, participants of the intervention group were instructed to wear the ActiGraph monitor continuously, except during sleep or activities involving water exposure (e.g., swimming or showering). They were required to complete a daily online questionnaire on the duration and frequency of their self-practice of qigong, acupressure, breathing, and mindful stretching. They also recorded their perceived stress levels using the PSS-4[179], and indicated the periods during which they wore the ActiGraph monitor. Salivary samples were collected at two designated time slots: 7:00–9:00 am and 4:00–6:00 pm, following the previously described protocol. After each afternoon saliva collection, participants were required to immediately notify the research team to facilitate prompt sample retrieval and storage. Both online questionnaires and saliva samples were collected on the same day, on an alternate-day schedule, throughout the study.

Emotional state. The depression and anxiety subscales of DASS-21 were used to assess the participants' emotional state. The DASS-21 is a reliable and valid 21-item instrument with three subscales (depression, anxiety, and stress), each rated on a four-point Likert scale[180]. Subscale scores are calculated by summing the relevant seven items and multiplying by two, with higher scores indicating greater levels of symptoms in each domain.

Other health-related outcomes were assessed in the same way as that used in the feasibility study. Please refer to Chapter 4, Methods section.

5.2.5 Adverse events

During the study, information on adverse events was collected from the participants. An adverse event was defined as any untoward medical occurrence that did not necessarily have to be causally related to the study or the intervention. Participants were asked to report any adverse events to the project team by email, phone, or in person during the measurement visits.

5.2.6 Demographic information

At baseline, the participants provided demographic information about their age, gender, height, weight, educational level, any health conditions, smoking status, income range, work nature, work years and office size. Height and weight were self-reported by the participants. Body mass index (BMI) was calculated using the formula: weight(kg)/height(m)^2 .

5.2.7 Sample size

The sample size was determined on the basis of the findings from our feasibility study, with the primary objective of detecting a medium effect size ($f = 0.25$) for the intervention's impact on reducing daily sitting time both at the end of the intervention and during the follow-up period. Calculations were performed assuming $\alpha = 0.025$ and power $(1–\beta) = 0.80$, while accounting for a 20% attrition rate. This yielded the required enrolment of 54 participants (27 per group) to ensure adequate statistical sensitivity.

5.2.8 Randomization

All of the eligible participants were randomly assigned to one of the two study groups:

① Intervention group: a TCM-based sedentariness reduction intervention group, and

② Control group: a waitlist control group.

The project team members who were blind to the objectives of the study conducted randomization using random numbers generated by Excel. The allocation ratio was 1:1. Participants were assigned to the control group if the number was odd and to the intervention group if the number was even. A sealed opaque envelope concealed group assignment information.

5.2.9 Implementation

Recruitment and interventions were conducted by CW and EL, while ZL performed randomization and assessment. All of these research activities were overseen by HT. Recruitment commenced after ethical approval had been obtained. Upon completion of all assessments, the participants in the intervention group received HKD 550 in cash as a token of appreciation for their engagement. In contrast, participants in the control group received HKD 350 in cash.

5.2.10 Blinding

Due to the design of the main study, it was challenging to conceal group assignments and research objectives from participants. However, all outcomes were assessed by research personnel who were blinded to the participants' group allocations.

5.2.11 Statistical methods

The means and standard deviations (SDs) were calculated for the continuous variables, while frequencies and percentages were generated for categorical variables. The normality of the continuous data was first checked using the Shapiro-Wilk test. For variables whose distribution was not normal, their baseline scores between the two groups were compared using the Mann-Whitney U test. To minimize missing data, all questionnaires were collected electronically using user-friendly interfaces. As reported in the previous studies, participants' cortisol values were skewed and were therefore log10-transformed for analysis[181]. The cortisol concentration area under the curve (cAUC) was calculated using the trapezoidal method[182]. After employing the boxplot-based outlier detection protocol (threshold: ±1.5 × IQR) to maintain data integrity, extreme values were excluded from subsequent analyses[183]. The intention-to-treat (ITT) principle with last observation carried forward (LOCF) method was applied in the analysis process[171].

Baseline, post, and follow-up assessments. A two-way repeated measures ANOVA was utilized to assess potential interaction effects between time and group. For variables that did not satisfy the sphericity assumption, the Greenhouse-Geisser correction was applied when the epsilon (ε) value was below 0.75, while the Huynh-Feldt correction was used for ε values between 0.75 and 1. If sphericity was confirmed (ε = 1), the standard sphericity assumed test was used. When appropriate, Games-Howell post hoc tests were conducted for pairwise comparisons to identify differences across time points and between groups[184]. If the interaction effect was not significant, changes in scores from T0 to T1 and from T0 to T2 were compared between the two groups using independent *t*-tests. To control for type I error due to multiple primary outcomes, a Bonferroni-adjusted significance level of 0.025 was used for primary outcomes. For secondary outcomes, statistical significance was defined as $p < 0.05$, without adjustment for multiple comparisons, and results should be interpreted as exploratory. All analyses were performed using IBM SPSS Statistics version 29.0.

Mediation analysis. A mediation analysis using PROCESS Model 4 investigated the intervention's indirect effect on SBs through perceived stress and cortisol levels, with bias-corrected 95% confidence intervals derived from 5,000 bootstrap resamples. Data were transformed to a standardized score for analysis. The analysis followed two sequential phases: first, assessment of whether group assignment significantly predicted perceived stress/cortisol (X→M path), and second, evaluations of both the direct effect of the group on changes in the sitting time (the X→Y path) and the indirect effect via perceived stress/cortisol. Mediation was considered significant if the bootstrap confidence interval for the indirect effect did not include zero.

Daily diary data analyses. Multilevel Structural Equation Modeling (MSEM) was performed in R to investigate the associations between daily changes in perceived stress, cortisol levels, and overall sedentary behaviors among individuals in the intervention group, considering both within-person and between-person differences.

Utilizing a 1-1-1 design, the MSEM separated the variance of day-level (Level 1) variables into within-person and between-person components, allowing for the examination of potentially distinct relationships at each level. Through daily self-practice (DSP) analyses, the study assessed: (a) how day-to-day fluctuations in an individual's self-practice influenced their sedentary behaviors (within-person effects); (b) how an individual's average self-practice level affected their sedentary behaviors (between-person effects); and (c) whether these associations were mediated by changes in perceived stress or salivary cortisol at both the within- and between-person levels. Given the possible non-normal distribution of indirect effects, such as cortisol concentrations, 95% Monte Carlo confidence intervals (MCCIs) were employed to determine statistical significance[185]. The indirect effect was considered significant if the MCCI did not contain a zero value.

5.3 Results

During an eight-month recruitment phase, 199 potential participants expressed interest in the study, of whom 63 middle-aged office workers met the eligibility criteria. Those 63 participants were randomly allocated to either the intervention group (n = 31) or the control group (n = 32) using a randomization procedure. At baseline, all of the participants in the intervention group provided complete data. In contrast, one participant in the control group refused to wear the ActiGraph, and two participants did not submit their salivary cortisol samples. At the postintervention assessment, two participants (6.45%) in the intervention group were unable to attend due to scheduling conflicts. In the control group, five participants (15.63%) withdrew from the study: two could not be contacted, and three withdrew due to scheduling conflicts. Among the 27 participants in the control group who completed the assessment, ActiGraph data from two individuals were found to be invalid. At follow-up, two participants in the intervention group were unable to participate in the assessment because they were out of town. The remaining 27 participants (87.10%) in the intervention group completed all assessments. Similarly, 27 participants (84.38%) in the control group completed all follow-up assessments; however, ActiGraph data from four of these participants were invalid. Data analysis was performed using the intention-to-treat approach, maintaining a consistent sample size of 31 for the intervention group across all assessment time points. In the control group, the sample size across all assessment time points was 31 for ActiGraph data, 30 for salivary cortisol data, and 32 for all other measures. The CONSORT diagram of the study is shown in Figure 5-2.

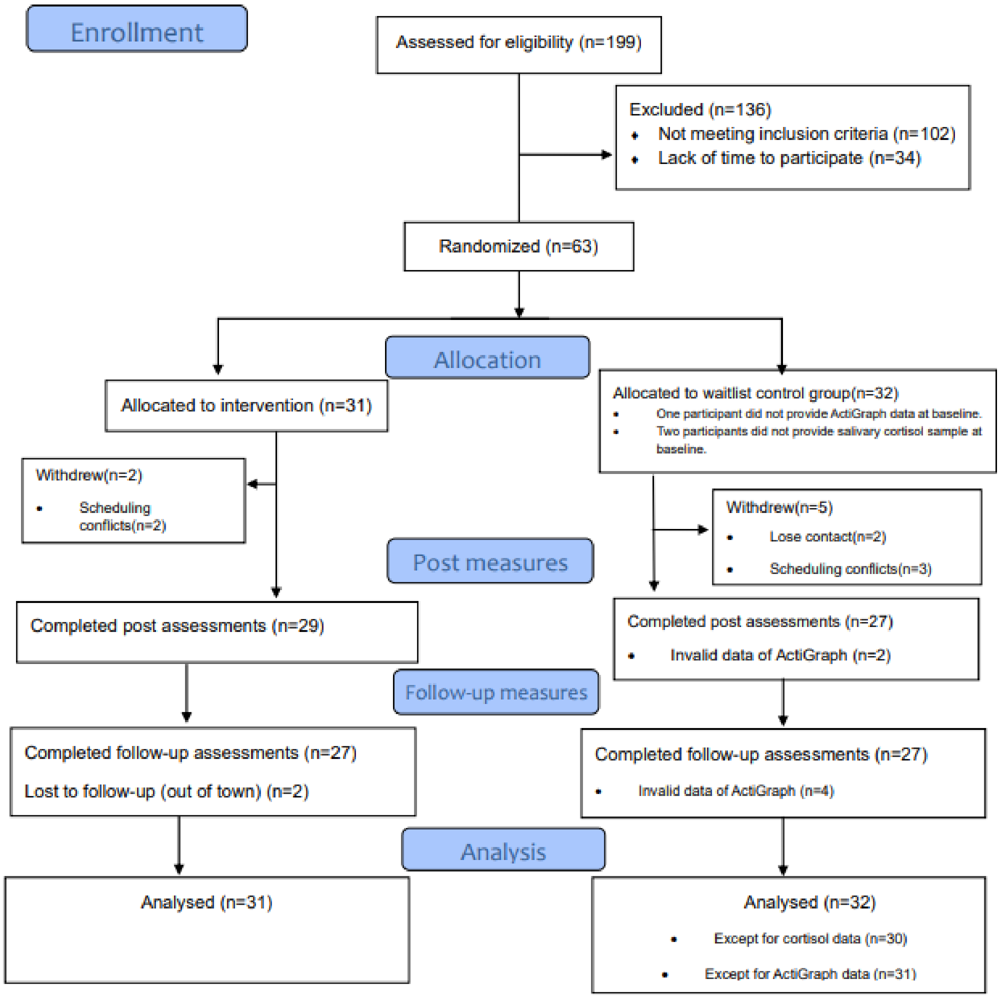


Figure 5-2 The CONSORT diagram of the main study.

Data collection was from February 2024 to December 2024. Table 5-1 shows the demographic information of the participants. The mean age of the participants was 53.29 years (*SD* = 6.67) in the intervention group and 53.00 years (*SD* = 5.47) in the control group. Male participants comprised 29.03% (*n* = 9) of the intervention group and 21.88% (*n* = 7) of the control group. The mean BMI was 24.48 (*SD* = 2.99) for the intervention group and 23.55 (*SD* = 3.52) for the control group. Most participants were generally healthy. In the intervention group, 38.71% had one or two distinct comorbid conditions, while in the control group, 18.75% reported one to three comorbidities. These conditions included hyperlipidemia, diabetes, hypertension, heart disease, and obesity. All participants with hyperlipidemia, diabetes, hypertension, or heart disease were receiving regular pharmacological management for these diagnoses. In addition, self-reported neck and/or back discomfort was noted in nine participants in the intervention group and 10 participants in the control group. None of these musculoskeletal complaints had been formally diagnosed by a clinician. All participants were full-time employees and nonsmokers, with the majority holding a bachelor’s degree or higher. No significant differences were found between the two groups in any demographic variable.

Table 5-1 Demographic information of the participants of the main study

	Mean (SD)/ N (%)	Mean (SD)/ N (%)	χ^2/t	*p* value
	Intervention group (n=31)	Control group (n=32)		
Demographics				
Age (years)	53.29(6.67)	53(5.47)	0.189	0.851
Sex			0.426	0.572
Male	9(29.03%)	7(21.88%)		
Female	22(70.97%)	25(71.12%)		
BMI (kg/m^2)	24.48(2.99)	23.50(3.49)	1.197	0.236
No. of diseases			5.274	0.153
0	19(61.29%)	26(81.25%)		
1	9(29.03%)	3(9.38%)		
2	3(9.68%)	2(6.25%)		
3	0	1(3.12%)		

Smoking status			0.000	1
Current smoker	0	0		
Nonsmoker	31(100%)	32(100%)		
Educational level			0.127	0.938
Primary School	0	0		
Secondary School	3(9.68%)	4(12.5%)		
Tertiary Education	7(22.28%)	7(21.88%)		
Undergraduate and above	21(67.74%)	21(65.63%)		
Work nature			4.512	0.341
Professional (research, teaching, health care)	13(41.94%)	6(18.75%)		
Manager	1(3.23%)	2(6.25%)		
Accountant	2(6.45%)	4(12.5%)		
Administrative	7(22.58%)	11(34.38%)		
Clerical	8(25.81%)	9(28.13%)		
Office size (n, %)			1.803	0.614
Cell office (1 person)	4(12.9%)	7(21.88%)		
Shared office (2-3 people)	3(9.68%)	1(3.13%)		
Small landscape office (4-9 people)	8(25.81%)	8(25%)		
Medium size Office (10-24)	16(51.61%)	16(51.61%)		
Monthly income			8.919	0.112
10k-20k	5(16.13%)	4(12.5%)		
20k-40k	13(41.94%)	13(40.63%)		
40k-60k	9(29.03%)	7(21.88%)		
60k-80k	3(9.68%)	0		
80k-100k	1(3.23%)	6(18.75%)		
>100k	0	2(6.25%)		
Work duration			3.135	0.209
< 5 years	12(38.71%)	6(18.75%)		

5 to 10 years	5(1.61%)	6(18.75%)
> 10 years	14(45.16%)	20(62.5%)

BMI=Body mass index

5.3.1 Participants' baseline characteristics

Table 5-2 summarizes the baseline characteristics of the participants. The total sitting time across the entire workday averaged 644.28 minutes for the intervention group and 614.44 minutes for the control group. During the 9-hour work period, participants in the intervention group spent an average of 400.99 minutes seated, compared with 396.98 minutes in the control group. The perceived stress scores were 18.81 for the intervention group and 16.34 for the control group. In the intervention group, mean salivary cortisol concentrations were 16.95 ng/ml in the morning, 13.83 ng/ml at midday, and 9.81 ng/ml in the evening, with a 12-hour cumulative secretion of 161.41 ng/ml. For the control group, corresponding values were 20.52 ng/ml in the morning, 13.90 ng/ml at midday, and 12.69 ng/ml in the evening, with a 12-hour cumulative secretion of 183.00 ng/ml. No statistically significant differences were found between the groups for any variables.

Table 5-2 Baseline characteristics of the main study's participants

	Mean (SD)	Mean (SD)	*t*	p value	Hedges's g
	Intervention group (n=31)	Control group (n=32)			
Total sitting time	644.28(90.48)	614.44(72.80)	1.431	0.158	0.359

(min/workday) #					
Sitting time (min/ 9h workday) #	400.99(53.61)	396.98(42.13)	0.327	0.745	0.082
IPAQ	1840.00 (1022.15)	2067.72(1218.97)	-0.802	0.426	-0.200
PSS	18.81(6.24)	16.34(5.79)	1.625	0.109	-0.404
Saliva cortisol #					
Morning(ng/ml)	16.95(13.21)	20.52(17.94)	-0.887	0.379	-0.224
Afternoon(ng/ml)	13.83(14.63)	13.90(13.37)	-0.020	0.984	-0.005
Evening(ng/ml)	9.81(6.54)	12.69(10.80)	-1.262	0.217	-0.319
cAUC (hour*ng/ml)	161.41(108.93)	183.00(126.71)	-0.714	0.478	-0.181
Hand grip strength(L/kg)	22.64(7.23)	21.18(6.50)	0.844	0.402	0.210
Hand grip strength(R/kg)	24.31(7.72)	22.21(7.00)	1.130	0.263	0.281
SBP (mm/hg)	120.13(18.67)	114.32(11.00)	1.492	0.071	0.374
DBP (mm/hg)	75.84(10.58)	74.17(8.22)	0.764	0.448	0.192
PSQI	7.29(2.91)	7.91(3.28)	-0.788	0.434	0.196
DASS_depression	3.97(4.28)	2.91(2.68)	1.184	0.241	0.295
DASS_anxiety	4.32(2.93)	3.44(2.87)	1.211	0.230	0.302
PCS_T score	44.36(7.21)	45.36(8.37)	-0.503	0.617	-0.126
Mental Component Summary (MCS)_T score	39.59(12.99)	43.01(10.70)	-1.131	0.263	-0.284
GSE	24.06(4.77)	26.22(4.01)	-1.944	0.056	-0.484

cAUC=Cortisol area under curve; DASS=Depression Anxiety Stress Scales; DBP=Diastolic blood pressure; GSE=General self-efficacy scale; IPAQ=International Physical Activity Questionnaire;

MCS=Mental component summary; PCS=Physical component summary; PSQI=Pittsburgh Sleep Quality Index Scale; PSS=Perceived stress scale; SBP=Systolic blood pressure.

#: The ActiGraph data for the control group included 31 participants, while the cortisol data included 30 participants.

5.3.1 Effects of the intervention on the primary outcome

Table 5-3 summarizes intervention effectiveness and changes in daily total sitting time following the four-week intervention and four-week follow-up period.

A significant time-by-group interaction effect was observed for total sitting time (F = 4.964, partial $\eta^2 = 0.076$, $p = 0.008$). Pairwise comparisons revealed significant reductions in sitting time from T0 to T1 and from T0 to T2 in the intervention group (all $ps < 0.025$), whereas no significant changes were found in the control group.

Table 5-3 Intervention-related effects in daily total sitting time

Outcomes					Time*Group			*Pairwise comparison*
		Mean (SD) T0	Mean (SD) T1	Mean (SD) T2	F	P	Partial η^2	
Total sitting time (min/workday)	Intervention	644.28(90.48)	587.87(90.94)	599.82(113.41)	4.964	0.008	0.076	*T0-T1*; T0-T2**
	Control	614.44(72.80)	614.97(105.83)	585.90(97.59)				*None*

*: p<0.025

5.3.2 Effects of the intervention on secondary outcomes

Table 5-4 and Supplementary Table S5-1 summarize the intervention effectiveness and changes in physical activity and stress level following the four-week intervention and four-week follow-up period.

For physical activity level, no significant time-by-group interaction was detected (F = 1.24, partial η^2 = 0.04, p = 0.297). However, post-intervention changes (T2–T0) showed a greater increase in the intervention group (mean change = 571.71) compared with the control group (mean change = 239.84; see Supplementary Table S5-1), although this difference was not statistically significant (p = 0.419).

A marginally nonsignificant time-by-group interaction was observed for perceived stress scores (F = 2.988, partial η^2 = 0.047, p = 0.057). Postintervention changes (T2–T0) indicated a greater reduction in stress scores in the intervention group (mean change = –2.97) compared with the control group (mean change = -0.91; see Supplementary Table S5-1), but this difference was marginally nonsignificant (p = 0.053).

For 12-hour salivary cortisol secretions, a significant time-by-group interaction effect was detected (F = 4.428, partial η^2 = 0.07, p = 0.016). The control group exhibited a significant increase in cortisol secretion relative to baseline at both T0–T1 and T0–T2 (all *ps* < 0.05). No significant time-by-group interactions were found for salivary cortisol concentrations at morning, midday, or evening timepoints. However, postintervention analysis showed a significantly greater reduction in morning cortisol concentrations in the intervention group than in the control group (t = -2.299, *Hedges's* g = -0.581, p = 0.025; see Supplementary Table S5-1). While midday and evening concentrations increased more in the control group than in the intervention group, these differences were not statistically significant (all *ps* > 0.05; see Supplementary Table S5-1).

Table 5-4 Intervention-related effects on physical activity and stress levels

Outcomes					Time*Group			*Pairwise comparison*
		Mean (SD) T0	Mean (SD) T1	Mean (SD) T2	F	P	Partial η^2	
IPAQ	Intervention	1840.00(1022.15)	2282.81(1253.91)	2411.71(1900.56)	1.24	0.297	0.04	*NA*
	Control	2067.72(1218.97)	2034.97(1509.01)	2307.56(1865.15)				*NA*
PSS	Intervention	18.81(6.24)	15.48(6.49)	15.84(5.98)	2.988	0.057	0.047	*NA*
	Control	16.34(5.79)	15.03(5.69)	15.44(5.44)				*NA*
Morning cortisol ¶	Intervention	1.11(0.36)	1.11(0.32)	0.99(0.53)	3.054	0.055	0.049	*NA*
	Control	1.15(0.39)	1.26(0.46)	1.34(0.57)				*NA*
Afternoon	Intervention	0.89(0.53)	1.08(0.63)	1.21(0.43)	1.899	0.154	0.032	*NA*

cortisol ¶								
	Control	0.93(0.47)	1.38(0.39)	1.27(0.41)				*NA*
Evening cortisol ¶	Intervention	0.85(0.40)	1.01(0.43)	1.10(0.44)	2.538	0.083	0.041	*NA*
	Control	0.87(0.54)	1.32(0.40)	1.23(0.38)				*NA*
Cortisol_AUC¶	Intervention	2.12(0.28)	2.18(0.28)	2.27(0.38)	4.428	0.016	0.07	*None*
	Control	2.16(0.32)	2.48(0.34)	2.46(0.37)				*T0-T1*; T0-T2**

AUC=Area under curve; IPAQ=International Physical Activity Questionnaire; NA=Not applicable; PSS=Perceived stress scale.

¶: The data for cortisol levels were converted into log10 for analysis

*: $p<0.05$

Supplementary Tables S5-2 and S5-3 summarize the intervention-related effects, as well as changes in other physical outcomes (including hand grip strength, blood pressure, and the physical component of quality of life) and psychological outcomes (such as sleep quality, emotional well-being, the mental component of quality of life, and general self-efficacy) over the eight-week study period. A significant time-by-group interaction was found for left-hand grip strength (F = 3.128, partial η^2 = 0.049, p = 0.047); however, follow-up pairwise comparisons showed no statistically significant differences between time points within either group.

For the DASS subscale scores, a significant time-by-group interaction was only observed for the DASS-Anxiety subscale (F = 3.710, partial η^2 = 0.058, p = 0.03). For the intervention group, DASS-Anxiety scores significantly decreased during the period from T0 to T2 ($p < 0.05$). A significant time-by-group interaction was also detected for general self-efficacy ($F = 5.359$, partial $\eta^2 = 0.081$, $p = 0.007$), but pairwise comparisons did not reveal any statistically significant differences between time points within either group.

No significant time-by-group interaction effects were found for the remaining outcome measures (see Supplementary Tables S5-2 and S5-3 for the details).

5.3.3 Exploratory analysis of mediation with perceived stress as mediator

The secondary outcome of perceived stress was used in a mediation model to determine the mediating role played by perceived stress on the effect that a TCM-based intervention had on reducing sedentary time, as is shown in Figure 5-3.

In Stage 1 (X→M), the regression model assessing reductions in perceived stress accounted for 5.77% of the variance ($R^2 = 0.057$, $F(3,58) = 3.675$, $p = 0.06$). The intervention group showed a marginally nonsignificant reduction in perceived stress ($\beta = -0.479$, $p = 0.06$, 95% CI [-0.979, 0.208]). In Stage 2 (X→Y), the model predicting reductions in sedentary time explained 14.1% of the variance ($R^2 = 0.141$, $F(2,59) = 4.85$, $p = 0.011$). The intervention group showed a significant direct reduction in sitting time (β = -0.660, p = 0.010), whereas changes in perceived stress did not significantly predict changes in sitting time (β = 0.112, p = 0.368). These results indicated that the intervention's effect on reducing sedentary time was primarily direct, with no significant indirect mediation effect via changes in perceived stress.

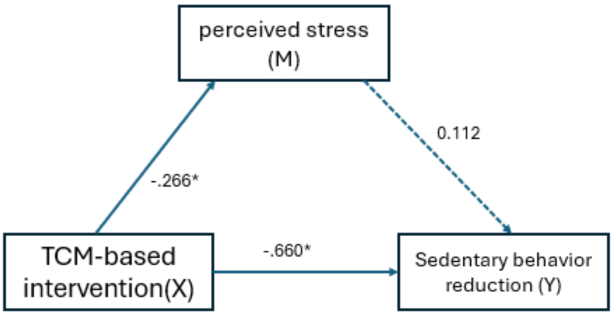


Figure 5-3 A mediation model to determine the mediating role of perceived stress on the effect of a TCM-based intervention on reducing sedentary time. *p<0.05

5.3.4 Exploratory analysis of mediation (cortisol as mediator)

As is depicted in Figure 5-4, the secondary outcome of cortisol levels was used in a mediation model to evaluate the mediating role of salivary cortisol levels on the impact of a TCM-based intervention on sedentary time reduction.

In Stage 1 (X→M), the regression model for changes in cortisol explained 18.91% of the variance (R^2 = 0.189, F (3,57) = 13.76, p = 0.0005). The intervention group was associated with a significant decrease in cortisol (β = -0.863, p = 0.0005, 95% CI

[-1.328, -0.397]).

In Stage 2 (X→Y), the model for reduction in sedentary time accounted for 24.23% of the variance (R^2 = 0.242, F (2,58) = 9.27, p = 0.0003). Reductions in cortisol were significantly associated with decreases in sitting time (β = 0.379, p = 0.004, 95% CI [0.1231, 0.6349]), while the direct effect of group on sitting time was not statistically significant (β = -0.3866, p = 0.133).

Overall, the findings supported a mediation model, thus suggesting that the intervention reduced sedentary time primarily by regulating the cortisol levels.

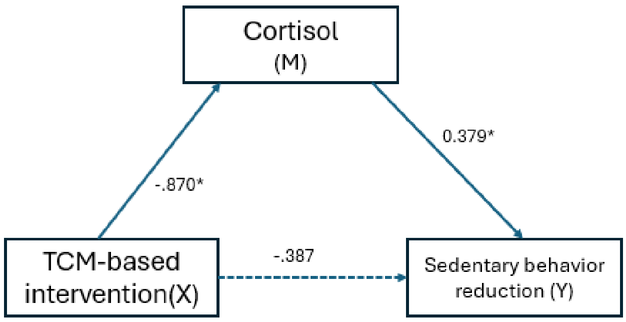


Figure 5-4 A mediation model to determine the mediating role of salivary cortisol in the effect of a TCM-based intervention on reducing sedentary time. * p<0.05

5.3.5 Exploratory analysis of multilevel mediation (cortisol as mediator)

Because three participants in the intervention group showed no variation in perceived stress during the self-practice period, this variable lacked variability and could not be included in the structural equation modeling. Therefore, multilevel mediation analysis was performed with cortisol as the sole mediator.

Figure 5-5 shows a 1-1-1 multilevel mediation model between duration of daily self-practice, changes in cortisol levels, and changes in SBs. Changes in cortisol levels did not mediate the association between practice duration and sedentary time. Specifically, practice duration was not significantly associated with cortisol changes at either the within-person level (b = -0.28, p = 0.646) or the between-person level (b = -0.001, p = 1.000). Similarly, cortisol-level changes did not significantly predict sedentary time (within-person: b = 0.034, p = 0.274; between-person: b = 0.034, p = 0.899). Consequently, the indirect effects of practice duration on sedentary time through cortisol were nonsignificant at both levels (within-person: ab = 0.197, p = 0.548; between-person: ab = -0.000, p = 1.000). Notably, significant within-person variability was observed in both cortisol changes (σ^2 = 22,078.368, p < 0.001) and sedentary time changes (σ^2 = 6,352.047, p < 0.001), thus indicating physiological and behavioral fluctuations within individuals.

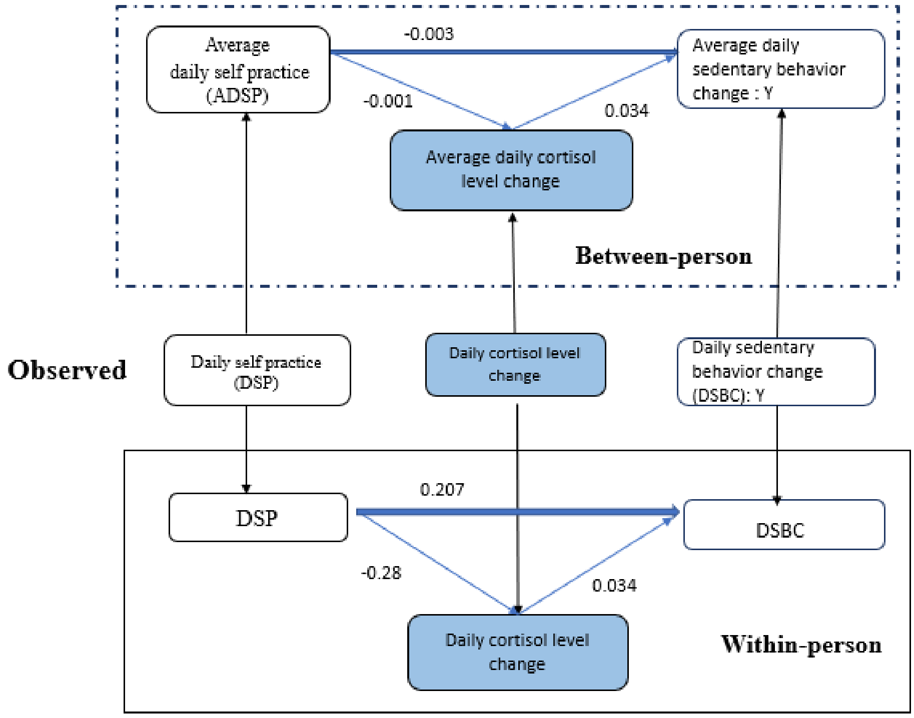


Figure 5-5 Multilevel structural equation model showing a 1-1-1 multilevel mediation model between daily self-practice duration, changes in cortisol level, and changes in SBs.

5.4 Discussion

This pilot RCT demonstrated that a TCM-based intervention to promote reduced time spent sitting significantly reduced sedentary time in middle-aged office workers during their workdays, with medium effects sustained at a four-week follow-up. The intervention group achieved a 44-minute reduction in total daily sitting time, thereby exceeding the 30-minute threshold associated with clinically meaningful health benefits and demonstrating practical significance[186]. Although previous multicomponent interventions have reported substantial reductions in workplace sedentary time (ranging from 50 to 125 minutes per day)[20, 67, 155], those approaches typically required significant financial investment due to the provision of height-adjustable workstations or portable pedal machines. In contrast, our intervention not only effectively reduced sedentary time, but it also offered a easily implemented, and widely scalable solution. Moreover, compared with interventions such as providing sit-stand desks in the workplace, this approach offered the added advantage of extending SB reduction into nonwork periods, thereby promoting a promising overall decrease in sedentary time. However, given the short follow-up period in the present study, the long-term effects of this intervention have yet to be determined.

5.4.1 Psychological and secondary outcomes

A variety of workplace stressors are commonly encountered by employees during the workweek, such as heavy workloads, time pressures, and interpersonal conflicts, all of which may significantly elevate the workers' cortisol secretion[187]. The study's intervention group exhibited a significantly smaller increase in salivary cortisol secretion than the control group did, both immediately after the intervention and at follow-up. This suggested that participants in the intervention group experienced better stress regulation, as reflected by their lower cortisol secretion levels compared with those of the control group. Although the time-by-group interaction for perceived stress did not reach statistical significance, the intervention group experienced a greater reduction in perceived stress than the control group did. The lack of statistical significance may be attributable to the fact that some participants initially reported only mild to moderate stress levels, limiting the potential for marked improvement.

Overall, therefore, the TCM-based intervention is promising not only in reducing SBs but also in supporting stress management and modulating hypothalamic-pituitary-adrenal (HPA) axis activity. These findings address a gap in literature, because previous interventions focusing primarily on environmental or motivational strategies have generally yielded limited improvements in health outcomes, particularly in stress management, even when they were successful in reducing sedentary time[24, 172, 188].

With the present study's larger sample size, we were able to show improvements in health-related outcomes that were not evident in our earlier feasibility study. Post-intervention, the intervention group demonstrated significantly greater gains in left-hand grip strength and quality of life compared with the control group, as well as more pronounced improvements in their emotional regulation and general self-efficacy. These results were consistent with previous research which had indicated that TCM-based bodywork can enhance physical function, alleviate negative emotions, and improve self-efficacy[189, 190].

5.4.2 Stress pathways

Importantly, our findings indicated that changes in the workers' cortisol levels mediated the effect of the TCM-based intervention on reducing their SBs, thus suggesting that the intervention may decrease sedentary time in part by modulating levels of cortisol secretion. These results provided preliminary insights into the potential mechanisms that underlie SB reduction among office workers and suggested that effective stress management strategies may facilitate SB reduction in individuals with sedentary lifestyles. However, changes in perceived stress did not mediate the relationship between the TCM-based intervention and reductions in SBs. One possible explanation for that unexpected result, as noted above, was that some participants in the study had low to moderate levels of perceived stress at baseline and that fact may have limited the potential for the intervention to produce substantial changes in perceived stress scores. Furthermore, interventions based on TCM may require a longer duration (e.g., 12 weeks) to achieve significant reductions in perceived stress[191]. Therefore, future research should consider implementing longer intervention periods in an effort to more thoroughly evaluate both the intervention's effects on perceived stress and the underlying mediating mechanisms.

In addition, our multilevel mediation analysis did not reveal a significant mediating effect of cortisol-level changes on the changes in SBs during the final two weeks of the intervention period. Because this was only tested within the intervention group, the nonsignificant findings were likely due to the small sample size. A sample of 50 was recommended for multilevel studies using diary methods[192], whereas the multilevel data in the present study were collected from only 29 participants. Furthermore, in addition to the duration of self-practice in TCM-based bodywork, the regularity of the self-practice could also make a difference in outcomes. The duration and regularity of the self-practice might have interacted with each other to affect the changes in cortisol levels and SBs. Future studies are warranted that will test more comprehensive multilevel models and larger sample sizes.

5.4.3 Limitations and future directions

This pilot RCT had several limitations that warrant further consideration. First, most of the middle-aged participants included in this study exhibited mild to moderate perceived stress levels; therefore, the findings may not be generalizable to populations experiencing severe stress conditions. Second, the participants' cortisol awakening response (CAR) was not assessed in the present study, owing to the limited resources. Although the participants were relatively healthy, evaluating their CAR could have strengthened the robustness of our results. Third, because the cohort consisted of relatively healthy individuals, the study was unable to assess intervention responses or elucidate underlying mechanisms in populations with different diseases. Fourth, the follow-up period in the present study was relatively short, which precluded the assessment of the long-term effects of the intervention. Fifth, due to the limited sample size, caution should be exercised when interpreting the results of the mediation analysis and multilevel mediation models. Sixth, SBs were measured only on workdays, which limits the generalizability of the findings to non-working days. Additionally, while the ActiGraph was worn on the waist, this placement typically provides less precise data on sedentary postures compared to thigh-worn devices. Future studies should employ more precise measurement protocols—such as thigh-mounted sensors—and assess sedentary patterns across both workdays and non-workdays. Finally, missing data were handled using the LOCF method, which may have underestimated data variability and consequently have affected confidence intervals and *p*-values, potentially introducing bias. Future studies should employ larger sample sizes, longer follow-up periods, and more precise measures of cortisol (e.g., morning cortisol response, diurnal patterns, and blood tests) to comprehensively evaluate the efficacy and long-term impacts of the intervention. To improve the reliability and validity of the findings, advanced statistical techniques for handling missing data should also be considered. Moreover, including participants with diverse health statuses will allow for evaluations of the intervention's effectiveness across different populations and will facilitate exploration of other potential physiological and psychological mechanisms.

5.4.4 Conclusions

The present study has provided preliminary evidence that a four-week TCM-based intervention can successfully reduce office workers' sedentary behaviors through modulating the HPA axis. A full-scale RCT is now needed to confirm the current findings and to explore additional potential mechanisms.

Chapter 6 General Discussion and Conclusions

Sedentary behaviors are a well-recognized public health concern, with a growing body of empirical evidence linking them to a range of health risks in adults[1-3]. The aforementioned studies in this thesis have satisfactorily addressed the following seven objectives: (1) to examine the pooled effect of previous SB reduction interventions on office workers' sitting time and identify the essential components of these interventions in order to inform the design of the present study; (2) to explore the effects on health- and work-related outcomes of previous SB-reduction interventions; (3) to test the feasibility of implementing a TCM-based sedentariness reduction intervention with Chinese office workers and study its health benefits using a randomized controlled trial; (4) to test the efficacy of the TCM-based intervention to reduce sedentariness for reducing SBs in Chinese office workers, in comparison with a waitlist control; (5) to explore the benefits of the TCM-based sedentariness reduction intervention on workers' physical activity and other physical and psychological outcomes, in comparison with a waitlist control; (6) to explore the psychophysiological mechanism related to stress underlying the effects of the TCM-based sedentariness reduction intervention on sedentary behaviors; and (7) to explore the meditating effects of daily changes in stress (both perceived stress and cortisol level) on the linkage between the duration of self-practice of TCM-based bodyworks and changes in daily sedentary behavior within and between the Chinese office workers who participated in the TCM-based intervention to reduce office worker sedentariness. This chapter presents a synthesis of the primary findings from these studies and discusses how the findings have addressed each of the objectives and at the same time whether each of the hypotheses was supported. Last, but not least, the findings' clinical and research implications are illustrated.

6.1 Summary of research findings

6.1.1 The effectiveness of interventions on sedentary behaviors in office workers: A systematic review and meta-analysis (Study 1)

The systematic review and meta-analysis of Study 1 addressed the first two objectives. By comprehensively evaluating the effectiveness of existing interventions designed to reduce sedentary behaviors among office workers and analyzing data from 24 studies involving 3,169 participants, the results provided moderate evidence that such interventions could decrease occupational sitting time by an average of 38 minutes per workday compared with control conditions. Multicomponent interventions that incorporated ES demonstrated greater efficacy than either ES or MS alone did

(Objective 1), in line with previous research [118, 149, 150].

In the exploration of the previous SB reduction interventions' effects on health- and work-related outcomes **(Objective 2)**, the findings revealed only a significant increase in high-density lipoprotein cholesterol following the interventions; no significant differences were observed in other health indicators or work-related outcomes. This result contrasts interestingly with previous review studies, likely because earlier reviews included primarily individuals who were obese or at risk of some clinical condition, whereas most of the studies in our analysis involved healthy participants[43, 153]. Furthermore, most of the interventions in our review replaced sitting with standing, which may not be sufficient to yield substantial improvements in cardiometabolic health[12, 66]. Given the low certainty of evidence for these health and work-related outcomes, therefore, future research should focus on determining the optimal exercise dosage required to improve health outcomes, and it should explore the effects of such interventions across more diverse populations.

6.1.2 Traditional Chinese Medicine (TCM)-based intervention for reducing sedentariness and improving psychological well-being in office workers: A feasibility randomized controlled trial (Study 2)

A feasibility RCT design was implemented to address **Objective 3**. In that study, 38 participants were enrolled to evaluate the practicality of implementing and assessing a

TCM-based intervention aimed at reducing sitting time among office workers. Recruitment was highly successful, with an average of 11 participants enrolling per week during the planned nine-week period—more than double our initial estimate of five per week. Retention was also robust: 94.74% of the participants remained after the first week of intervention, surpassing our anticipated rate of 90%. Throughout the four-week intervention, the retention rate was sustained at 84.21%, exceeding the projected 80%. The intervention adherence rate reached 87.5%, meeting our target for participants to attend at least 80% of the group practice sessions. In addition, data completion rates at each assessment stage in both groups consistently exceeded 80%, again in line with our expectations. Even more importantly, no adverse events were reported by the participants. The intervention was found to be safe, acceptable, and feasible. The majority of participants displayed a thorough comprehension of the intervention and demonstrated confidence and adherence in sustaining the intervention's TCM practices, such as Baduanjin, dantian breathing, and mindfulness stretching. However, a minority of the participants reported uncertainty regarding the independent application of acupressure techniques after the intervention. These findings underscored the need for future research on self-administered acupressure to integrate enhanced support and motivational strategies, thereby fostering greater participant confidence, consistency, and skill acquisition.

In addition to its encouraging feasibility results, this study advanced previous research by demonstrating that a comprehensive intervention which involved Baduanjin, a stress management strategy, and prompt tools and website support, has noteworthy potential for reducing office workers' daily time spent sitting[79]. Importantly, reductions in sitting time were evident during working hours and were maintained during the follow-up phase, a result likely linked to strong participant adherence and the availability of regular, expert-led group sessions that supported skill development and increased confidence[79]. Nevertheless, the magnitude of the effect lessened over time, in line with previous findings, together underscoring the difficulty of sustaining long-term behavioral changes after exercise and motivational programs[158]. These results indicate that future studies should explore lengthening the intervention period to encourage habit formation and improve long-term outcomes[110, 172].

Furthermore, the TCM-based intervention showed promise in alleviating participants' perceived stress and enhancing their hand grip strength, thus suggesting its potential not to only decrease sedentary behavior but also to address its negative health impacts[28, 173]. Continued research is needed to further evaluate these health benefits and clarify the mechanisms involved.

6.1.3 The effects and psychophysiological mechanism of a Traditional Chinese Medicine (TCM)-based intervention to reduce daily sedentary behavior and improve wellness among office workers: A randomized controlled trial (Study 3)

Objectives 4 through 7 were investigated in our third segment of this research—an RCT study. This pilot RCT, which included 63 middle-aged office workers, found that a TCM-based intervention led to a significant 44-minute reduction in total daily sedentary time—thus exceeding the benchmark for clinically meaningful health benefits[186] **(Objective 4)**. This outcome **supports Hypothesis 1**, indicating that the TCM-based intervention to reduce sedentariness could significantly decrease SBs among office workers compared with the waitlist control group. The intervention demonstrated significant effectiveness, as well as apparent cost-efficiency and scalability. While earlier research had indicated that multicomponent interventions (integrating environmental and motivational strategies) or ES alone can produce larger decreases in sedentary time, those typically necessitate considerable financial resources for equipment, such as sit-stand desks[67, 155]. Furthermore, the health gains from merely substituting sitting with standing are relatively limited[188]. In that light, our intervention offers distinct advantages in terms of both its affordability and its positive impact on physical and psychological health outcomes.

Regarding **Objective 5**, which explored the benefits of the TCM-based sedentariness reduction intervention on physical activity as well as other physical and psychological outcomes, in comparison with the control group, the office workers in the intervention group exhibited better stress regulation, as indicated by a smaller increase in salivary cortisol levels and a greater, albeit non-statistically significant, reduction in perceived stress—an insignificance potentially due to their lower initial levels of perceived stress. The intervention also resulted in marked improvements in hand grip strength, quality of life, emotional regulation, and self-efficacy, thus corroborating previous evidence on the broad benefits of TCM-based approaches[189, 190], and further supporting the value of SB reduction strategies for generally healthy individuals.

For **Objective 6**, which sought to explore the underlying psychophysiological mechanisms, results showed that changes in perceived stress did not mediate the relationship between the intervention and reductions in sitting time—results that ***do not support Hypothesis 2 regarding a psychological mechanism***. This may have been attributable to the participants' low to moderate baseline levels of perceived stress, which might have limited the intervention's observable impact on their perceived stress. In addition, some research has suggested that mind-body interventions may require a longer duration to produce significant changes in perceived stress[191]. As a result, perceived stress was not identified as a significant mediator in this study. However, reductions in SBs were partially explained by changes in cortisol levels, indicating that the intervention's effectiveness may be linked to modulation of the HPA axis, thereby **supporting Hypothesis 2, with its proposed physiological mechanism.** These results highlight the importance of stress management in SB interventions and point to the necessity for longer intervention periods and additional research to clarify the underlying mechanisms and improve long-term outcomes.

For **Objective 7**, which sought to explore whether daily fluctuations in stress levels mediated the relationship between the duration of self-practice of TCM-based bodywork and changes in daily sedentary behaviors among office workers in the intervention group, several challenges were encountered. Notably, three participants showed no variation in perceived stress during the self-practice period, resulting in insufficient variability for inclusion in the structural equation modeling. Furthermore, a multilevel mediation analysis did not reveal a significant mediating effect from cortisol changes on SBs during the final two weeks of the intervention. The limited sample size within the intervention group may have contributed to the nonsignificance of these findings. In addition, both the duration and the consistency of TCM-based body-work self-practice may have an influence on outcomes, and their interaction could impact changes in cortisol levels and SBs. Future research with larger sample sizes and more comprehensive multilevel models is recommended, to further investigate these relationships.

6.2 Significance and implications of the project

6.2.1 Clinical significance and implications

This body of research provides robust evidence for the clinical value of interventions targeting sedentary behaviors among office workers. The study's systematic review and meta-analysis demonstrated that health education is an essential component in efforts to reduce SBs. Multicomponent interventions, particularly those integrating environmental and motivational strategies, could significantly reduce occupational sitting time. Substituting SBs with physical activity and standing has been found to be effective in decreasing sedentary time. However, because standing as a single activity may be insufficient to confer substantial health benefits, replacing SBs with physical activity is a more promising approach and warrants further promotion and investigation.

Furthermore, the TCM-based sedentariness reduction interventions (investigated in the feasibility RCT and pilot RCT) yielded clinically meaningful reductions in sedentary time (up to 44 minutes per day), as well as improvements in stress regulation, hand grip strength, quality of life, and self-efficacy. These findings underscore the potential of

TCM-based approaches to deliver holistic health benefits that address both physical and psychological domains, without requiring expensive equipment or specialized infrastructure. Such characteristics clearly can enhance the accessibility and scalability of these interventions in diverse workplace settings.

Collectively, a TCM-based sedentariness reduction intervention is not only effective, but also safe, feasible, and acceptable, offering practical solutions for clinicians, particularly occupational therapists, to incorporate in addressing the health risks associated with prolonged sitting in office-based populations. Because TCM-based interventions for reducing SBs are easy to learn and implement, they represent an excellent approach to health management. Occupational therapists and other health professionals, as experts in promoting healthy lifestyles and as evidence-based practitioners, are especially well-equipped to employ self-management strategies, and they could use the self-management approach from this study to guide their clients in adopting and maintaining healthy behaviors at home, in the workplace, and in community settings.

6.2.2 Research significance and implications

This research is a pioneering effort toward systematically evaluating the effectiveness of TCM-based interventions for reducing sedentary behaviors among office workers and exploring the mechanisms that underlie those interventions. Through a comprehensive research program, the study critically assessed the effectiveness, feasibility, and psychophysiological mechanisms of interventions that targeted sedentary behaviors in office settings, thereby significantly advancing the knowledge in this field.

First, the findings from the systematic review and meta-analysis demonstrated that the integration of environmental support with motivational strategies provides a distinctive advantage in reducing SBs among office workers. However, while this approach effectively decreased workers' sedentary time, its impact on their health outcomes was inconsistent. These results underscore the need for future research that not only focuses on reducing SBs but also rigorously evaluates the associated health benefits of such interventions.

Second, the feasibility study established that implementing a TCM-based intervention in real-world office environments to reduce SBs is safe, feasible, and acceptable. Building upon previous research, this study showed that a comprehensive intervention—one that includes Baduanjin exercises, stress management strategies, prompt tools, and website support—holds promise for reducing daily sitting time and improving health outcomes among office workers. Furthermore, the study identified areas for further refinement of our evaluative research, such as the need for more objective measures to assess both physical and psychological outcomes, which will strengthen the evidence for the intervention's health effects.

Last, the pilot RCT has further validated the intervention's effects for decreasing sedentary time in office workers and has revealed notable improvements in several physical and mental health measures. In addition, the study explored possible psychophysiological mechanisms, indicating that the intervention's reduction in sedentary time might be linked to alterations in cortisol levels and regulation of the HPA axis. Nevertheless, because the majority of the participants were relatively healthy, caution is warranted when applying these results to populations with different health profiles.

In summary, the findings of this research fill critical gaps in the existing literature, especially in regard to the effects of Traditional Chinese Medicine-based interventions on sedentary behaviors and health outcomes in office settings. The findings also underscore the importance of conducting future studies to determine the optimal duration of such interventions, conduct long-term follow-ups, and evaluate effectiveness across diverse populations and through additional physiological and psychological pathways. Such research will be essential for developing the most effective and intelligently tailored interventions to enhance health outcomes in various groups.

6.2.3 Public health significance and implications

With the advancement of technology in contemporary office environments, sedentary lifestyles have emerged as a significant health risk for office employees, particularly among middle-aged individuals—a cohort who are experiencing a steady increase in chronic disease rates. From a public health perspective, this area of research carries important implications for enhancing workplace wellness initiatives and preventing disease at the population level. The study topic demonstrates broad social relevance and considerable potential for widespread dissemination.

Therefore, to address the public health challenges, this study implemented a systematic and evidence-based intervention—a TCM-based intervention designed to reduce sedentary behaviors. This approach resulted in a substantial reduction in sitting time among middle-aged office workers and led to notable improvements in their physical and mental health. These findings not only reinforce the evidence base for improving office workers' health but also introduce innovative strategies for promoting healthy and active aging, especially because middle-aged individuals make up the initial cohort transitioning into older adulthood.

The study's TCM-based intervention is distinguished by its cost-effectiveness and its independence from specialized equipment. Unlike environmental support approaches (such as providing sit-stand desks), TCM-based interventions are easier to implement and to scale in resource-limited settings, thus ensuring their availability to a broader population. Their straightforward application and adaptability make them particularly suitable for reducing SBs across various office contexts.

Furthermore, this research shows the critical importance of incorporating stress management into interventions that target sedentary behavior. Modern office workers often experience not only insufficient physical activity but also considerable psychological stress. Integrating stress management with SB reduction strategies can foster a more holistic improvement in overall health, thereby enhancing the sustainability and impact of such interventions. Because TCM-based interventions are easy to learn and implement, they are well-suited not only for workplace environments but also for other settings, such as schools and communities. For example, educational and practical programs aimed at reducing sedentary time can be introduced to students, while TCM-based routines can be promoted among older adults in community settings to help them reduce sitting time and enhance their quality of life.

Moreover, this study offers practical recommendations for employers, policymakers, and public health professionals. The findings provide a scientific rationale for developing effective workplace health promotion programs, and they can serve as a reference for the broader adoption and policy-level implementation of health interventions. By advancing TCM-based strategies, it is possible to achieve more inclusive, sustainable, and far-reaching health promotion—significantly reducing the risks and burdens associated with prolonged sedentary behaviors and ultimately improving public health outcomes.

6.3 Limitations of the studies

Several limitations of the studies included in this thesis should be acknowledged. First, some findings from the systematic review were derived from a limited number of studies with heterogeneous designs, which may have introduced variability or bias; thus, these results should be interpreted with caution. Second, both the feasibility studies and pilot RCTs primarily recruited relatively healthy participants, thus limiting the ability to assess intervention responses or elucidate underlying mechanisms in populations with specific diseases. Third, because the interventions incorporated multiple techniques, it was not possible to isolate the effects of the individual treatment components. Fourth, because salivary cortisol levels can be influenced by numerous factors, more stable biomarkers (such as blood samples) will be needed for a more robust assessment of cortisol concentrations. Fifth, the relatively short follow-up period in this study restricted the evaluation of the intervention's long-term effects. Finally, due to the limited sample size, the results of the mediation analyses and multilevel mediation models should be interpreted with particular caution.

6.4 Conclusions

This research project has significantly enhanced our understanding of sedentary behaviors and the effectiveness of our studies' unique intervention for reducing those behaviors among office workers. Our results indicated that a short-term, TCM-based sedentariness reduction intervention can significantly reduce sedentary time in this population, while also conferring both physiological and psychological health benefits—particularly among middle-aged office workers. Furthermore, the TCM-based intervention was both novel and highly acceptable to the participants as a means of reducing their sedentary behaviors. Importantly, we observed that changes in salivary cortisol levels may be useful as a physiological mechanism for mediating the effects of TCM-based interventions on SBs. This finding provides a new direction for future SB management, specifically highlighting stress management as a potentially indispensable component of interventions that are aimed at reducing workers' sedentary time in office environments. Considering the complex factors involved in modifying behaviors, additional research will be required to investigate other potential mechanisms. In addition, future work should focus on creating intervention strategies that are both affordable and accessible for the wider population (Figure 6-1).

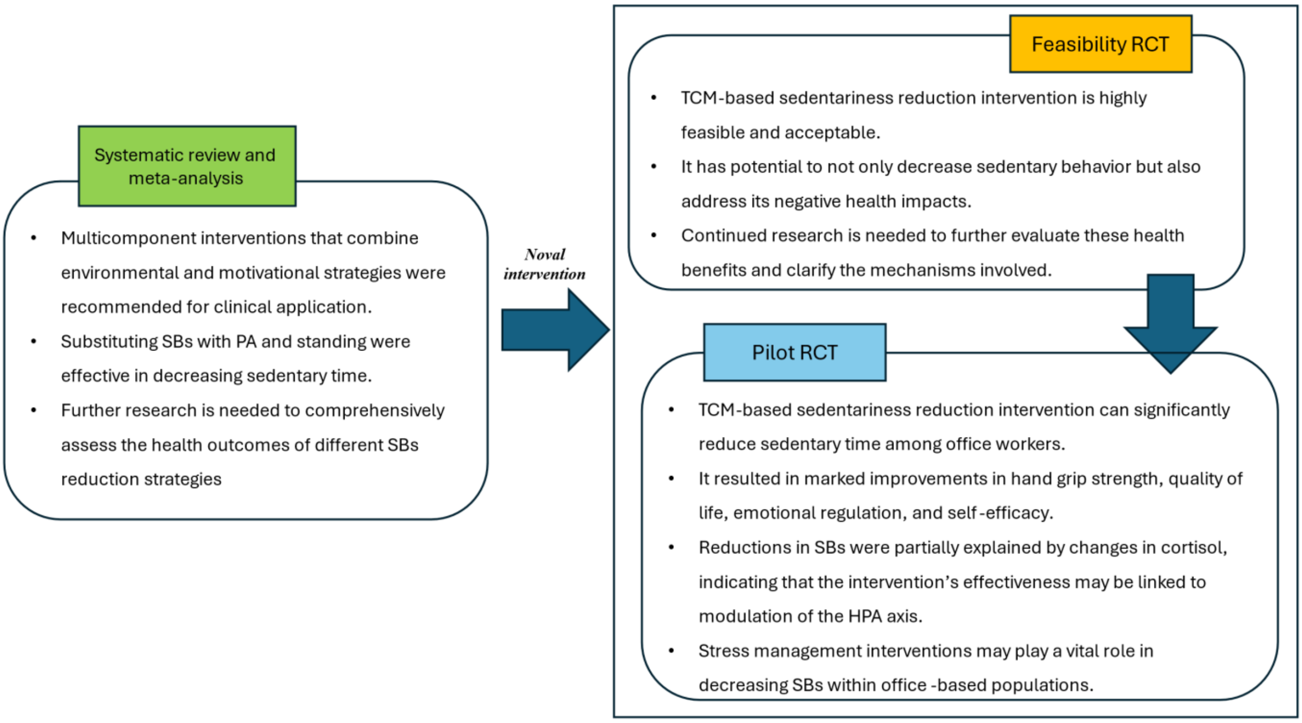


Figure 6-1 Study conclusions of each of the studies in the thesis.

SUPPLEMENTARY TABLES

Supplementary Table S3-1. Searching strategy.

Inclusion and exclusion criteria for study selection

	Inclusion criteria	Exclusion Criteria
Participants	Office workers aged ≥18 years whose occupations involved spending the majority of their working time sitting at a desk, such as administrative workers, help-desk professionals, IT employees, and University staff.	Workers with transportation work like taxi drivers, bus drivers, etc., or workers operating heavy equipment, such as blue-collar workers
Intervention	Any intervention aiming at reducing sedentary behaviors in office workers at the workplace.	Using interventions that were not delivered in a workplace setting.
Comparison	No intervention or other controls.	-
Outcome	Sitting time during work hours or workday as measured by self-report (e.g., questionnaires) or using objective measures (e.g., accelerometer)	No outcome related to sedentary behavior
Study design	Studies with randomized controlled trials (RCT), cluster RCT, crossover RCT or pilot and feasibility RCT were included.	Adopting research designs other than RCTs, reviews. and protocols were excluded.
Language	English	Non-English

Databases

Scopus

Search	Results	Query
1	913,066	TITLE-ABS-KEY (“office workers” OR “office-worker” OR “white-collar worker” OR “office employee” OR

		occupation OR workplace OR “office assistant” OR worksite OR employee OR office)
2		TITLE-ABS-KEY (“sedentary behavior” OR “sedentary lifestyle” OR “prolonged sitting” OR “physical inactivity” OR inactivity OR “sedentary time” OR “sitting time” OR sedentariness OR “time spend sitting”))
3	3,494	1 AND 2
4		TITLE-ABS-KEY (intervention OR program OR “educational intervention” OR “behav* intervention” OR “environment change” OR “environmental change” OR “multicomponent intervention”))
5	1,408	3 AND 4
6		TITLE-ABS-KEY (“randomized controlled trial” OR “randomized clinical trial” OR “randomiz*” OR “randomly” OR “randomis*” OR “cluster rct” OR “crossover rct” OR rct))
7	366	5 AND 6

2) Web of Science

Search	Results	Query
#1	122,376	Topic (“office workers” OR “office-worker” OR “white-collar worker” OR “office employee” OR occupation OR workplace OR “office assistant” OR worksite OR employee)
#2		Topic (“sedentary behavior” OR “sedentary lifestyle” OR “prolonged sitting” OR “physical inactivity” OR inactivity OR “sedentary time” OR “sitting time” OR sedentariness OR “time spend sitting”))

#3	763	#1 AND #2
#4		Topic (intervention OR program OR “educational intervention” OR “behav* intervention” OR “environment change” OR “environmental change” OR “multicomponent intervention”))
#5	484	#3 AND #4
#6		Topic (“randomized controlled trial” OR “randomized clinical trial” OR “randomiz*” OR “randomly” OR “randomis*” OR “cluster rct” OR “crossover rct” OR rct))
#7	274	#5 AND #6
#8		Not (All fields) review
#9	216	#6 AND #7
#10		Not (All fields) protocol
#11	188	#8 AND #9

3) Embase

Search	Results	Query
1	237,509	'office worker”/exp OR “clerical personnel” OR “clerical worker” OR “employee, office” OR “office assistant” OR “office employee” OR “office worker” OR “workplace”/exp OR “workplace” OR “white collar worker”/exp OR “white collar worker” OR “employee”/exp OR “occupation”/exp OR “allied health occupations” OR “occupation” OR “occupations” OR “profession” OR “professional occupation”
2		“health program”/exp OR “health care program” OR “health care programme” OR “health program” OR “health programme” OR “healthcare program” OR “healthcare

		programme" OR "program, health" OR "programme, health" OR "educational intervention"/exp OR "behav* intervention" OR "environmental change"/exp OR "change, environmental" OR "environment change" OR "environmental change" OR "multicomponent intervention"/exp OR "intervention study"/exp OR "intervention studies" OR "intervention study" OR "intervention trial" OR "interventional studies" OR "interventional study" OR "interventional trial" OR treatment
3	98,762	1 AND 2
4		"sitting"/exp OR "activity, sedentary" OR "posture, sitting" OR "seated position" OR "sedentary activity" OR "sedentary work" OR "sitting" OR "sitting position" OR "sitting posture" OR "prolonged sitting"/exp OR "physical inactivity"/exp OR "physical inactivity" OR "sedentary lifestyle"/exp OR "sedentary behavior" OR "sedentary behaviour" OR "sedentary life style" OR "sedentary lifestyle" OR "sedentary time"/exp OR "sedentary time" OR "sitting time" OR "time spent sitting"
5	773	3 AND 4
6		"randomized controlled trial"/exp OR "controlled trial, randomized" OR "randomised controlled study" OR "randomised controlled trial" OR "randomized controlled study" OR "randomized controlled trial" OR "trial, randomized controlled" OR "randomization"/exp OR "random allocation" OR "randomisation" OR "randomization"
7	134	6 AND 5

4) PubMed

Search	Results	Query
*1	110,804	“office workers”[Title/Abstract] OR “office-worker”[Title/Abstract] OR “white-collar worker”[Title/Abstract] OR “office employee”[Title/Abstract] OR occupation [Title/Abstract] OR workplace[Title/Abstract] OR “office assistant”[Title/Abstract] OR worksite[Title/Abstract] OR employee[Title/Abstract]
*2		(“sedentary behavior”[Title/Abstract] OR “sedentary lifestyle”[Title/Abstract] OR “prolonged sitting”[Title/Abstract] OR “physical inactivity”[Title/Abstract] OR inactivity [Title/Abstract] OR “sedentary time”[Title/Abstract] OR “sitting time”[Title/Abstract] OR sedentariness [Title/Abstract] OR “time spend sitting”[Title/Abstract])
*3	1,208	*1 AND *2
4		(intervention [Title/Abstract] OR program [Title/Abstract] OR “educational intervention”[Title/Abstract] OR “behav* intervention”[Title/Abstract] OR “environment change”[Title/Abstract] OR “environmental change”[Title/Abstract] OR “multicomponent intervention”[Title/Abstract])
*5	439	*3 AND *4
*6		TITLE-ABS-KEY (“randomized controlled trial” OR “randomized clinical trial” OR “randomiz*” OR “randomly” OR “randomis*” OR “cluster rct” OR “crossover rct” OR rct))
*7	183	*5 AND *6

*8		NOT (review)
*9	154	*7 AND *8
*10		NOT (protocol)
*11	124	*9 AND *10

5) Medline

Search	Results	Query
1	225,104	AB (“office workers” OR “office-worker” OR “white-collar worker” OR “office employee” OR occupation OR workplace OR “office assistant” OR worksite OR employee OR office)
2		AB (“sedentary behavior” OR “sedentary lifestyle” OR “prolonged sitting” OR “physical inactivity” OR inactivity OR “sedentary time” OR “sitting time” OR sedentariness OR “time spend sitting”)
3	1,489	1 AND 2
4		AB (intervention OR program OR “educational intervention” OR “behav* intervention” OR “environment change” OR “environmental change” OR “multicomponent intervention”)
5	679	3 AND 4
6		AB (“randomized controlled trial” OR “randomized clinical trial” OR “randomiz*” OR “randomly” OR “randomis*” OR “cluster rct” OR “crossover rct” OR rct)
7	102	5 AND 6
8		NOT (protocol)
9	76	7 AND 8

6) PsycINFO

Search	Results	Query
#1	138,392	tiab (“office workers” OR “office-worker” OR “white-collar worker” OR “office employee” OR occupation OR workplace OR “office assistant” OR worksite OR employee OR office)
#2		tiab (“sedentary behavior” OR “sedentary lifestyle” OR “prolonged sitting” OR “physical inactivity” OR inactivity OR “sedentary time” OR “sitting time” OR sedentariness OR “time spend sitting”)
#3	489	#1 AND #2
#4		tiab (intervention OR program OR “educational intervention” OR “behav* intervention” OR “environment change” OR “environmental change” OR “multicomponent intervention”)
#5	237	#3 AND #4
#6		tiab (“randomized controlled trial” OR “randomized clinical trial” OR “randomiz*” OR “cluster rct” OR “crossover rct” OR rct)
#7	43	#5 AND #6
#8		NOT (review)
#9	40	#7 AND #8
#10		NOT (protocol)
#11	40	#9 AND #10

7) Cochrane library

Search	Results	Query

1	60,508	(“office workers” OR “office-worker” OR “white-collar worker” OR “office employee” OR occupation OR workplace OR “office assistant” OR worksite OR employee OR office):ti,ab,kw
2		(“sedentary behavior” OR “sedentary lifestyle” OR “prolonged sitting” OR “physical inactivity” OR inactivity OR “sedentary time” OR “sitting time” OR sedentariness OR “time spend sitting”):ti,ab,kw
3	1412	1 AND 2
4		(intervention OR program OR “educational intervention” OR “behaviour intervention” OR “environment change” OR “environmental change” OR “multicomponent intervention”):ti,ab,kw
5	1136	3 AND 4
6		(“randomized controlled trial” OR “controlled trial”):ti,ab,kw
7	644	5 AND 6

Supplementary Table S3-2. Characteristics of the included studies testing interventions with environmental support

Study	Design; country	No. of participants, age (mean, SD), nos. male/female (if available)	Intervention duration; assessment period	Outcome (unit), measuring tool	Intervention condition description	Intervention goal-target behavior
Chau et al., 2014	Australia crossover-RCT	IG:36; CG: 36; 38 ± 11*(at baseline); 6M/36F* (at baseline)	4-week; baseline–4 weeks	Sitting time, min/8-h workday (Mean, SD); ActivPAL activity monitor; self-report-WSQ & OSPAQ	**IG: -** sit-to-stand workstation - training on workstation usage CG: no intervention	Standing
Graves et al., 2015	UK RCT	IG:26(38.8±9.8), 3M/23F; CG: 21(38.4±9.3),7M/14F	8-week; baseline–4 weeks–8 weeks	Sitting time, min/8-h workday (Mean, SD); self-report- EMA diary	**IG: -** sit-to-stand workstation - training on workstation usage CG: no intervention	Standing
Ma et al., 2021	Japan RCT	IG:36 (AU), 31M/6F (at baseline); CG: 38 (AU), 26M/12F(at baseline)	3-month; baseline–3 months	Sitting time, min/work time (Mean, SD); A tri-axial accelerometer	**IG: -** sit–stand desk - health promotion magazines via monthly email CG: no intervention	Standing

Mantzari et al., 2019	UK RCT	IG:9; CG: 9 ; 43.4±11.2* (at baseline); 7M/11F* (at baseline)	3-month; baseline–3 months	Sitting time, min/8-h workday; (Mean, SD); activPAL3	**IG: -** sit–stand desk -education leaflet on SB, break prolonged sitting and correct ergonomic posture -brief demonstration on desk usage CG: only verbal information	Standing

* Average of groups

AU, age unavailable; CG, control group; EMA, ecological momentary assessment; GU, gender unavailable; IG, intervention group; RCT, randomized controlled trial;

SB, sedentary behavior; SD, standard deviation; SE, standard error; OSPAQ, occupational sitting and physical activity questionnaire; WSQ, workforce sitting questionnaire

Supplementary Table S3-3. Characteristics of the included studies testing interventions with motivational strategies

Study	Design; country	No. of participants, age (mean, SD), nos. male/female (if available)	Intervention duration; assessment period	Outcome (unit), measuring tool	Intervention description	Intervention goal-target behavior
Carter et al., 2020	UK RCT	IG:5; CG: 9 ; 42.5±10.0* (at baseline); 6M/9F* (at baseline)	8-week; baseline–8 week	Sitting time, min/8-h workday (Mean, SD); a tri-axial activPAL monitor	**IG:** - educational e-booklet about the importance of reducing sitting time and instructions on how to initialize the software - computer-based prompts to break every 45 minutes - weekly email feedback and suggestions CG: no intervention	Active breaks
DeCocker et al., 2018	Belgium RCT	IG1:78(40.5±8.6),25M/53F; IG2: 84 (40.7±9.7),27M/57F;	3-month; baseline–1 month–3 months	Sitting time, min/8-h workday (Mean, SD); subsample used	**IG1:** - website-based generic information about SB - personalized computer-based feedback	Standing

		CG: 51(39.3±9.0),15M/36F		activPAL; self-report-WSQ	on SB including tips and suggestions on how to interrupt and reduce sitting time by standing - personalized feedback on psychosocial constructs related to reducing or interrupting sitting -action plan **IG2:** - generic information and tips from websites CG: await-list control condition	Standing
Evans et al., 2012	UK RCT	IG:14(49±8),3M/11F; CG:14(39±10), 3M/11F	5-day; baseline–5 day	Total sitting time, hours/day (Mean.SD); activPAL™	**IG:** - a short educational talk - a short information leaflet - screen-based point of choice prompt to stand every 30 mins for five workdays CG: education only	Standing

Maylor et al., 2018	UK Cluster RCT	IG: 48(43.0±12.6),22M/26F CG: 41(43.7±12.7),16M/25F	8-week; baseline–8 weeks	workplace sitting time, min/work hours (Mean, 95%CI); activPAL micro monitor	**IG:** - education on SB - brainstorm strategies to reduce sitting - individual meetings to provide feedback on health check reports - phone app or computer-prompts to remind to get up and move at regular intervals - goal setting - weekly one-to-one telephone support during intervention, weeks 2–8 - step challenge - office layout changes - poster prompts - pedometer to monitor CG: no intervention	PA

Taylor et al., 2016	USA Cluster RCT	IG1:69; 43±33.3; IG2:59; 44±34.5; CG: 47; 42±29.0; 32M/143F*	6-month; baseline–6 months	Sitting time, min/workday (Mean, SD), self-reported questionnaire-IPAQ long version;	**IG1:** - employees trained and certified as booster break worksite facilitator - peer-led a 15-min physical exercise every workday - cues to each session through a speaker phone announcement - facilitators motivate coworkers and model the sequence of movement - officially incorporate Booster Break sessions as part of the organizational culture - physical space available **IG2:** - computer-based prompts to take 3-minute breaks at 5-hour intervals daily. CG: no intervention	PA Active breaks
Thøgersen-Ntoumani	Australia	IG: 50;	16-week;	Sitting time,	**IG:** - two face-to-face workshops for	PA

et al., 2020	Cluster RCT	CG: 47; 44.40±10.29*; 17M/80F*	baseline–16 week	h/day(Mean, SD); activPAL micro3 device	leaders on supportive communication strategies to motivate participants" engagement - peer leaders provided with a training manual with weekly goals - participants provided with a training manual with specific BCTs to facilitate their implementation - peer-led lunchtime walking - goal setting - app-based motivational support such as offering positive feedback, facilitating choices - Fitbit Zip device to facilitate self-monitoring CG: education and provided with a Fitbit Zip	

Verweij et al., 2012	Australia RCT	IG: 274(46.0 ± 8.0),170M/104F; CG: 249(48.0 ± 9.0),162M/87F	6-month; baseline–6 months	Sitting time, min/workday (Mean, SD), self-reported questionnaire-IPAQ;	**IG:** - five 20- to 30-min counseling sessions on promoting a healthy lifestyle - leaflet on PA and nutrition - short- and long-term goal setting - environmental scan of risk factors - pedometer to monitor CG: no intervention	PA

* Average of groups

CG, control group; CI, confidence interval; GU, gender unavailable; IG, intervention group; IPAQ, international physical activity questionnaire; PA, physical activity; SD, standard deviation; WSQ, workforce sitting questionnaire;

Supplementary Table S3-4. Characteristics of the included studies testing multicomponent interventions with both environmental support and motivational strategies

Study	Design; country	No. of participants, age (mean, SD), nos. of male/female (if available)	Intervention duration	Outcome (unit), measuring tool	Intervention description	Intervention goal-target behavior
Arguello et al., 2021	USA Cluster RCT	IG1:23(43.6±12.2),2M/21F; IG2:22(50.4±12.0),4M/18F; CG:21(41.9±11.5),1M/20F	12-month; baseline–3 months–6 months–12 months	Total daily sedentary time, hours/day (Mean, SD); activPAL™ 3C activity monitor	**IG1:** - sit-to-stand desk. - a 30-min face-to-face counseling session - train to use workstation - periodic face-to-face counseling and feedback at 3, 6, and 10 months - supervisor involvement and supervisor trainings repeated after 3, 6, and 9 months **IG2:** - treadmill desk	Standing

					- training to use treadmill desk - periodic face-to-face counseling and feedback at 3, 6, and 10 months - supervisor involvement and supervisor trainings repeated after 3, 6, and 9 months CG: one counseling session	PA
Bergman et al., 2018	Sweden RCT	IG:40(52.4±6.8),18M/22F; CG:40(50.3±6.7),18M/22F;	13-month; baseline–2 months–6 months–10 months–13 months	Sitting time, min/working hours (MC, 95%CI); activPAL3 or activePAL micro-activity monitor	**IG:** - sit-to-stand desk - treadmill workstation - regular information about the health risk of SB and reminders to use the treadmill via email CG: - sit-to-stand desk - individual health consultation	PA
Carr et al.,	USA	IG: 23(47.6±9.9), 3M/20F;	12-week; baseline–12	Sitting time, min/day	**IG:** - portable pedal machine	PA

2013	RCT	CG: 17(42.6±8.9), 1M/16F	weeks	(Mean, SD); StepWatch	- pedometer for self-monitoring - motivational website - real-time feedback - daily email messages - weekly motivational messages - virtual competition - a forum to share photos and send messages to members CG: no intervention	
Danquah et al., 2017	Denmark Cluster RCT	IG: 173(46 ± 10), 68M/105F; CG: 144(45±11), 39M/105F	3-month; baseline–1 month–3 months	Sitting time, min/8-h workday (Mean,SE); ActiGraph GT3X+	**IG:** - sit-to-stand desk - high meeting tables - lecture (no specific duration) - workshop: once at each workplace - leaflet through website	Standing

					- weekly emails and/or twice-weekly text messages during the intervention period - appointment of ambassadors - managerial support - routes for walking and meeting CG: - sit-to-stand desk	
Donath et al., 2015	Switzerland RCT	IG: 15(45±12),4M/11F; CG: 16(40±10),4M/12F	12-week; baseline–6 weeks–12 weeks	Total sitting time at work, hours/week (Mean, SD); ActiGraph wGT3X-BT	**IG:** - HAWD - three screen-based prompts per workday CG: HAWD	Standing
Edwardson et al., 2018	UK Cluster RCT	IG:77(41.7±11.0), 21M/56F; CG: 69(40.8±11.3),9M/60F	12-month; baseline–3 months–6 months–12 month	Sitting time, min/8-h workday (MC, 95%CI); activPAL micro	**IG:** - a height-adjustable workstation or desk platform - a 30-min educational seminar about the health consequences of sitting and the benefits of	Standing

					reducing and regular breaking up of sitting - a leaflet with educational contents - create an action plan - goal setting - ongoing support: coaching sessions in face-to face or telephone in month 1 and every three months thereafter to discuss process - management group support via regular e-newsletter CG: no intervention	
Edwardson et al., 2022	UK Cluster RCT	IG1:240(45.9±10.1), 74M/166F(at baseline); IG2: 249(43.8±9.93), 64M/185F(at	12-month; baseline–3 months–12 months	Sitting time, min/8-h workday (Mean,SD); activPAL3 micro	**IG1:** - a height-adjustable workstation or desk platform - a brief awareness session	Standing

		baseline); CG: 267(44.5±11.2),71M/196F(at baseline)		accelerometer; self-reported questionnaire-adapted version of OSPAQ	about the benefits of reducing sitting time in and outside of work - small-scale environmental restructuring in the office and at home - set a goal and an action plan - self-monitoring device - ongoing support: 4 coaching sessions - work champions" support via regular emails - social support from colleagues and family members **IG2:** same intervention components as **IG1** without a height-ajustable workstation or	Active breaks

					desk platform CG: no intervention	
Healy et al., 2016	Australia Cluster RCT	IG:136(44.6±9.1),47M/89F; CG:96(47.0±9.7),27M/69F	12-month; baseline–3 months–12 months	Sitting time, min/8-h workday (Mean, SD); activPAL3TM activity monitor	**IG:** - a dual-screen sit-to-stand workstation - 3-hour group consultation workshop with representatives to come up with suitable strategies to specific work contexts with a participatory approach - face-to-face coaching session - phone calls to identify specific goals at every two weeks - personalized email summary after consultation - role model of team champions to promote engagement by sending tailored motivational	Standing

					emails at every two weeks CG: no intervention	
Johnston et al., 2019	Australia RCT	IG:1639.45(39±11),3M/13F; CG:13(40±11),6M/7F	4-week; baseline–2 weeks–4 weeks	Sitting time min/8h workday (AM, 95%CI); activPAL3TM activity monitor	**IG:** - individual consultation - standardized progressive resistance exercise - weekly exercise progress monitoring - information on the safe use of the workstation - sit-to-stand desk CG: - sit-to-stand desk	PA
Li et al., 2017	UK RCT	I1:6(46±4),1M/5F; I2:5(40±13),2M/3F; I3: 6(41±14),0M/6F; CG: 9(41±8),3M/6F	4-week; baseline–4 weeks	Sitting time, min/8-h workday (MC, 95%CI); activPAL PA monitor	**IG1:** - sit-to-stand workstation. - tailored reminders on computer to alert posture adjustment for 40 minutes sitting and 20 minutes standing - bi-weekly emails to encourage	Standing

					adherence **IG2:** - sit-to-stand workstation. - tailored reminders on computer to alert posture adjustment for 30 minutes sitting and 30 minutes standing - bi-weekly emails to encourage adherence **IG3:** - sit-to-stand workstation. - tailored reminders on computer to alert posture adjustment for 20 minutes sitting and 40 minutes standing - bi-weekly emails to encourage adherence CG: no intervention	Standing Standing
Nicolson et	Ireland	IG:8(44.4±11.0),8M;	2-week; baseline–2 weeks	Sitting time, min/work	**IG:** -under-desk pedal device	PA

al., 2021	Cluster RCT	CG: 14(41.5 ±11.0),14M		hours (Mean, SD); ActivPAL3 monitor; self-report- EMA	-one education session on SB and prolonged SB -goal setting -regular digital prompts -weekly email feedback -managerial support -social comparison -friendly competition -Garmin watch to self-monitoring CG: no intervention	
Pereira et al., 2020	USA Cluster RCT	IG:354(45.6±11.4),58M/296F; CG:276(43.3±10.8),103M/173F	12- month; baseline–3months–12 months	Sitting time, min/8-h workday (AMC, 95%CI); activPAL3c micro accelerometer	**IG:** - Ergotron Workfit-TL model sit-stand workstation - Stand & Move at Work "Toolkit" - e-newsletter containing 26	Standing

					topics - receive instructions regarding the desk based ergonomic setup - a 1-on-1 coaching session to identify specific goals and behavior-change strategies relating to the key intervention messages - goal setting - quarterly support emails - managerial support: quarterly meetings and quarterly audits - new policies - worksite sponsored messaging - group cooperation - quarterly support emails	

					- office layout changes - signage - walking routes CG: MOVE+, a multilevel behavioral intervention targeting increases in LPA in the workplace	
Schuna et al., 2014	USA RCT	IG: 15(40.0±9.5); 0M/ 21F(at baseline); CG: 16(40.3±10.9)；1M/19F(at baseline)	3-month; baseline–3 months	Sitting time, min/8.5hworkday (Mean, SE), ActiGraph GT3X	**IG:** - shared treadmill desk - missed session will be reminded - face-to-face visits were made for those participants who had recurring issues with participation CG: no intervention	PA

CG, control group; CI, confidence interval; EMA, ecological momentary assessment; HAWD, height-adjustable working desk; IG, intervention group; OSPAQ, occupational sitting and physical activity questionnaire; PA, physical activity; SD, standard deviation; SE, standard error

Supplementary Table S3-5. Publication bias in the included studies

	Begg's test	Egger's regression test
Outcomes	z-value/p-value(2-tailed)	*t*-value/*p*-value(2-tailed)
workplace sitting time	0.57/ 0.57	0.04/ 0.99
BMI	0.31/ 0.75	0.22/ 0.76
WC	0.37/ 0.71	0.40/ 0.70
SBP	0.30/ 0.76	1.44/ 0.21
DBP	0.00/ 1.00	0.46/ 0.66
Total cholesterol	0.38/ 0.71	1.05/ 0.35
HDL	0.25/ 0.81	0.19/ 0.86
LDL	0.34/ 0.73	1.22/ 0.35
Triglycerides	0.73/ 0.46	1.30/ 0.29
Body fat%	0.25/ 0.81	0.84/ 0.46

Supplementary Table S3-6. Results of the meta-regression with health conditions of participants, control conditions, outcome measurement tool, study design type, and risk of bias predicting the reduction in workplace sitting time

covariate	coefficient	se	95% CI	*p*-value	Q-value(df)	*p*-value
Intercept	-23.1017	20.3322	(-62.9520, 16.7486)	0.2559		
health condition_dummy:2	-3.0974	14.6691	(-31.8482, 25.6453)	0.8328		
control condition_dummy:2	-5.1801	14.3832	(-33.3707, 23.0104)	0.7787		
measurement type_dummy:2	-12.9731	20.3774	(-52.9120, 26.9658)	0.5244		
study design type					0.76(2)	0.6829
study design type_dummy:2	-15.0464	13.1147	(-40.7508, 10.6579)	0.2513		
study design type_dummy:3	-5.7792	33.4091	(-71.2599, 59.7015)	0.8627		
risk of bisa type					0.14(2)	0.9345
risk of bias_dummy:2	-2.4105	17.1977	(-36.1173, 31.2963)	0.8885		
risk of bias_dummy:3	9.3303	37.7842	(-64.7254, 83.3859)	0.8050		
age	-0.2723	1.7332	(-3.6693, 3.1246)	0.8751		
Intervention duration	-1.2010	1.2005	(-3.5569, 1.1489)	0.3159		

SE, standard error; CI, confidence interval

Supplementary Table S3-7. The effects of sedentariness-reduction-behavior interventions on health-related and work-related outcomes

Secondary outcomes	No. of studies (participants)	Pooled intervention effect, MD (95%CI)	Hedges's g	*p*-value	I^2
Health-related outcomes					
WC (cm)	8 (1472)	-0.46 (-1.17 to 0.25)	-0.046	0.20	0.0%
BMI (kg/m2)	9 (1195)	0.024 (-0.16 to 0.21)	0.009	0.79	0.0%
SBP (mmHg)	7 (661)	-0.05 (-1.96 to 1.87)	-0.016	0.96	36%
DBP (mmHg)	7 (661)	0.37 (-1.26 to 1.99)	0.149	0.66	58%
Total cholesterol (mmol/L)	6 (632)	0.017 (-0.07 to 0.11)	-0.024	0.71	0.0%
HDL (mmol/L)	5 (595)	0.043 (0.01 to 0.08)	0.156	0.01	0.0%
LDL (mmol/L)	4 (517)	-0.045 (-0.15 to 0.06)	-0.137	0.38	2%
Triglycerides (mmol/L)	5 (554)	0.138 (-0.08 to 0.36)	0.175	0.22	37%
Body fat%	5 (552)	0.267 (-0.23 to 0.77)	0.095	0.30	0.0%
Neck-shoulder (discomfort)	2 (120)	-0.29 (-0.71 to 0.13)	-0.226	0.18	0.0%
Work-related outcomes					
WE-vigor	2 (114)	0.12 (-0.56 to 0.81)	0.10	0.72	0.0%
WE-dedication	2 (114)	-0.04 (-0.44 to 0.35)	-0.03	0.83	0.0%
WE-absorption	2 (114)	0.01 (-0.32 to 0.34)	0.01	0.93	0.0%

BMI, Body mass index; DBP, diastolic blood pressure; HDL, high-density lipoprotein cholesterol; LDL, low-density lipoprotein cholesterol; MD, mean difference; SBP, systolic blood pressure; WC, waist circumference; WE, work engagement

Supplementary Table S3-8. Summary of findings for sedentariness-reduction-behavior interventions to reduce workplace sitting time among office-based workers

Interventions compared with active control or no intervention on reduction in workplace sitting time

Patient or population: office workers

Setting: workplace

Intervention: Anti -sedentary interventions

Comparison: active control or no intervention

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with active control or no intervention	Risk with Interventions				
Sitting time per workday assessed with: Accelerometer or questionnaire		MD **38.75 lower** (48.27 lower to 29.23 lower)	-	3169 (24 RCTs)	⨁⨁⨁◯ Moderate[a]	

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: confidence interval; **MD:** mean difference

GRADE Working Group grades of evidence

High certainty: we are very confident that the true effect lies close to that of the estimate of the effect.

Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.

Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.

Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

Explanations

a. Downgraded for risk of bias: the risk of bias was found to be high in three studies, of some concern in 16, and low in five. The most common reasons for the risk of bias were not having blinded the participants, assessor bias, and unclear risk of bias due to no information about published protocol or missing data.

Supplementary Table S3-9 Summary of findings for sedentariness-reduction-behavior interventions to affect health-related outcomes of office-based workers

Sedentariness-reduction-behavior intervention compared with active control or no intervention for improving health-related outcomes among office workers

Patient or population: office workers

Setting: workplace

Intervention: Sedentariness-reduction interventions

Comparison: active control or no intervention

Outcomes	Anticipated absolute effects[*] (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with active control or no intervention	Risk with Sedentariness-reduction intervention				
Waist circumference		MD **0.46 lower** (1.17 lower to 0.25 higher)	-	1472 (8 RCTs)	⨁⨁◯◯ Low[a,b]	
Body mass index (BMI)		MD **0.024 higher** (0.16 lower to 0.21 higher)	-	1195 (9 RCTs)	⨁⨁◯◯ Low[a,b]	
Systolic blood pressure (SBP)		MD **0.05 lower** (1.96 lower to 1.87 higher)	-	661 (7 RCTs)	⨁⨁◯◯ Low[a,b]	
Diastolic blood pressure (DBP)		MD **0.37 higher** (1.26 lower to 1.99 higher)	-	661 (7 RCTs)	⨁◯◯◯ Very low[a,b,c]	
Total cholesterol		MD **0.017 higher** (0.07 lower to 0.11 higher)	-	632 (5 RCTs)	⨁⨁◯◯ Low[a,b]	
High-density lipoprotein cholesterol (HDL)		MD **0.043 higher** (0.01 higher to 0.08 higher)	-	595 (5 RCTs)	⨁⨁◯◯ Low[a,b]	

Sedentariness-reduction-behavior intervention compared with active control or no intervention for improving health-related outcomes among office workers

Patient or population: office workers

Setting: workplace

Intervention: Sedentariness-reduction interventions

Comparison: active control or no intervention

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with active control or no intervention	**Risk with Sedentariness-reduction intervention**				
Low-density lipoprotein cholesterol (LDL)		MD **0.045 lower** (0.15 lower to 0.06 higher)	-	517 (4 RCTs)	⊕⊕◯◯ Low[a,b]	
Triglycerides		MD **0.138 higher** (0.08 lower to 0.36 higher)	-	554 (5 RCTs)	⊕⊕◯◯ Low[a,b]	
Body fat%		MD **0.267 higher** (0.23 lower to 0.77 higher)	-	552 (5 RCTs)	⊕⊕◯◯ Low[a,b]	
Neck-shoulder (discomfort)		MD **0.29 lower** (0.71 lower to 0.13 higher)	-	120 (2 RCTs)	⊕◯◯◯ Very low[a,b,d,e]	

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: confidence interval; **MD:** mean difference

GRADE Working Group grades of evidence

High certainty: we are very confident that the true effect lies close to that of the estimate of the effect.

Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.

Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.

Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

Explanations

a. Downgraded for risk of bias: the risk of bias was found to be of some concern in most studies. The most common reasons for the risk of bias were not having blinded the participants and selection bias (issues with allocation concealment).

b. Downgraded for indirectness: this outcome is considered a secondary outcome, and as such, it was not given significant attention in some studies.

c. Downgraded for inconsistency: Heterogeneity $I^2 \geq 50\%$.

d. Downgraded for imprecision: number of participants < 500.

e. Downgraded for publication bias: could not perform publication bias test owing to only 2 studies included.

Supplementary Table S4-1. Description of Baduanjin and important notes of self-acupressure

Qigong-Baduanjin

Form	Name
1	Prop Up the Sky with Both Hands to Regulate the Triple Warmer
2	Draw a Bow on Both sides like Shooting a Vulture
3	Raise Single Arm to Regulate Spleen and Stomach
4	Look Back to Treat Five Strains and Seven Impairments
5	Sway Head and Buttocks to Expel Heart-Fire
6	Pull Toes with Both Hands to Reinforce Kidney and Waist
7	Clench Fists and Look with Eyes Wide Open to Build up Strength and Stamina
8	Rise and Fall on Tiptoes to Dispel All Diseases

Important notes of self-acupressure

Basic principles of self-acupressure	Start with the left side, then proceed to the right. Stimulate each acupoint for one to two minutes. Apply pressure until a mild sensation of soreness, numbness, pain, or distension is experienced.
Acupressure techniques used	Apply pressing and kneading techniques using the thumb. Press downward vertically with the thumb tip, kneading in a clockwise direction for around 20 strokes, followed by 20

	strokes in an anticlockwise direction. Ensure that fingernails are kept short.
Ten techniques	Technique 1: Press and knead the Taiyang Acupoint
	Technique 2: Use both hands to massage in an up-and-down motion from the Yintang to the Shenting repeatedly
	Technique 3: With both hands, massage from Yintang through Zanzhu, Yuyao, and then to Taiyang repeatedly
	Technique 4: Press and knead the Sibai Acupoint
	Technique 5: Tap the head gently with the finger
	Technique 6: Press and knead the Tianshu Acupoint
	Technique 7: Massage along the Liver and Gallbladder Meridians, the area covers Qimen and Zhangmen Acupoint
	Technique 8: Press and knead the Neiguan Acupoint
	Technique 9: Press and knead the Shenting Acupoint
	Technique 10: Press and knead the Taixi Acupoint

Supplementary Table S4-2. Responses regarding the study implementation within the intervention group

Items	Strongly disagree n (%)	Disagree n (%)	Neutral n (%)	Agree n (%)	Strongly agree n (%)
How satisfied are you overall with the study program?	0(0.00)	0(0.00)	0(0.00)	7 (43.75)	9 (56.25)
How logical does the program provided seem to you for reducing sedentary behavior (SB)?	0(0.00)	0(0.00)	0(0.00)	12(75)	4(25)
How confident would you be that this program would be successful in reducing SB?	0(0.00)	1(6.25)	1(6.25)	8(50)	6(37.5)
How confident would you be in recommending this program to a friend or colleague who also has SB?	0(0.00)	0(0.00)	1(6.25)	10(62.5)	5(31.25)
I would feel confident doing the Dantian breathing exercise which was taught during the intervention without assistance.	0(0.00)	0(0.00)	3(18.75)	7(43.75)	6(37.5)
I would feel confident doing the Baduanjin exercise which was taught during the intervention without assistance.	0(0.00)	1(6.25)	3(18.75)	7(43.75)	5(31.25)
I would feel confident doing the acupressure exercise which was taught during the intervention without assistance.	0(0.00)	0(0.00)	7(43.75)	5(31.25)	4(25)
I would feel confident doing the mindful stretching exercise which was taught during the intervention without assistance.	0(0.00)	0(0.00)	1(6.25)	9(56.25)	6(37.5)
I would like to continue doing the Dantian breathing exercise which was taught during the intervention even after the study concludes.	0(0.00)	0(0.00)	1(6.25)	9(56.25)	6(37.5)

I would like to continue doing the Baduanjin exercise which was taught during the intervention even after the study concludes.	0(0.00)	0(0.00)	1(6.25)	9(56.25)	6(37.5)
I would like to continue doing the acupressure exercise which was taught during the intervention even after the study concludes.	0(0.00)	0(0.00)	2(12.5)	10(62.5)	4(25)
I would like to continue doing the mindful stretching exercise which was taught during the intervention even after the study concludes.	0(0.00)	0(0.00)	0(0.00)	12(75)	4(25)
Is it easy for you to understand the information provided by the instructor?	0(0.00)	0(0.00)	3(18.75)	11(68.75)	2(12.5)
Do you think the daily reminders (in WhatsApp) during the experiment are appropriate?	0(0.00)	0(0.00)	2(12.5)	7(43.75)	7(43.75)
Do you think the frequency of daily reminders (in WhatsApp) during the experiment is appropriate?	0(0.00)	0(0.00)	1(6.25)	8(50)	7(43.75)
Do you follow the reminders to break sedentary behavior (WhatsApp reminders) for your workouts?	1(6.25)	4(25)	2(12.5)	4(25)	5(31.25)

Supplementary Table S4-3. Participants' feedback in the phone interview

Themes		
Perceived benefits from the intervention program	Benefits for health and mood	Benefits for lifestyle change
	Enhanced the awareness of	The program has increased

	personal physical and mental health. Minimized sedentary behavior: When tired at work, I practiced breathing techniques, acupressure, or some format of Baduanjin movements. The training helped remind me to stretch and relax more. Baduanjin and acupressure relieved my fatigue and eye strain from screen time. It was a chance to calm the mind and rejuvenate the body. Baduanjin and similar exercises benefit both mind and body, improving circulation and supporting heart and muscle health.	my awareness of my sedentary habits. A timely reminder to exercise more. I made a habit of moving every 30 minutes, even if it was just to walk around or grab something. I tried to find time for mindful stretching or Baduanjin, whether during lunch or before bed, to relax and reduce stress. Incorporating mindfulness into my daily routine.
Challenges faced during the program	The 1:00-2:00 PM group practice conflicts with lunch time. Due to late work hours, some participants may not be able to arrive at the laboratory in time for the 6:30 PM workshop.	
Recommendations for the future study	The overall arrangement was acceptable. Should share more videos on acupressure points. Put the exercises in the mobile app for easy learning.	

Supplementary Table S4-4. Intervention-related changes in sedentary behavior, physical activity, and psychological and physical well-being outcomes from baseline to 4-week follow-up

		Baseline (T1)	Follow-up (T3)	Within-subject Difference			Change from baseline to Follow-up	Between-group Differences in Change from baseline to Follow-up		
		Mean (SD)	Mean (SD)	t	p	Hedges's g	Mean (SD)	t	p	Hedges's g
Total sitting time (min/workday)	Intervention	537.37(86.27)	509.81(110.46)	1.002	0.332	0.238	-27.46(109.60)	0.416	0.681	0.141
	Control	547.31(109.22)	505.39(103.80)	1.924	0.072	0.444	-41.92(89.83)			
Sitting time (min/ 9h workday)	Intervention	344.68(54.78)	311.16(69.60)	2.195	0.044	0.521	-33.52(61.07)	-1.197	0.24	-0.407
	Control	351.47(56.72)	345.28(76.50)	0.367	0.718	0.089	-6.19(69.52)			
IPAQ	Intervention	1529.65(763.34)	2964.15(1880.41)	-3.316	0.004	-0.766	1434.50(1783.62)	1.628	0.113	0.545
	Control	2240.21(1644.92)	2559.85(2415.07)	-0.602	0.555	-0.139	319.65(2189.62)			
Perceived stress	Intervention	16.32(6.53)	13.11(7.87)	2.759	0.013	0.606	-3.21(5.07)	-0.111	0.912	-0.035
	Control	19.79(6.69)	16.79(8.11)	1.999	0.061	0.439	-3.00(6.54)			
Hand grip (Left/kg)	Intervention	24.06(9.85)	24.31(9.27)	-0.781	0.445	-0.172	0.25(1.40)	-0.251	0.804	-0.08
	Control	22.78(6.41)	23.26(5.42)	-0.572	0.574	-0.126	0.47(3.61)			
Hand grip (Right/kg)	Intervention	27.05(10.69)	26.71(9.81)	0.692	0.498	0.152	-0.44(2.80)	0.132	0.896	-0.042
	Control	25.31(7.47)	24.92(6.25)	0.316	0.756	0.069	-0.29(4.07)			

SBP (mmHg)	Intervention	112.58(17.37)	110.36(16.62)	0.757	0.459	0.166	-1.95(11.21)	-0.062	0.951	-0.02
	Control	112.53(12.99)	110.79(12.77)	0.792	0.439	0.174	-1.74(9.56)			
DBP (mmHg)	Intervention	71.95(10.34)	72.21(11.11)	-0.165	0.871	-0.036	0.26(6.94)	-0.371	0.713	-0.118
	Control	70.26(7.33)	71.37(8.95)	-0.682	0.504	-0.15	1.11(7.06)			
General self-efficacy	Intervention	26.74(4.28)	26.26(4.58)	0.46	0.651	0.101	-0.47(4.49)	-0.509	0.614	-0.169
	Control	25.06(5.21)	25.75(6.43)	-0.263	0.796	-0.062	0.25(3.80)			
PSQI_total score	Intervention	5.89(3.25)	5.05(3.08)	1.757	0.096	0.386	-0.84(2.09)	0.397	0.694	0.126
	Control	7.05(3.03)	5.95(2.76)	2.412	0.027	0.53	-1.11(2.00)			
Quality of life_SF-36										
Physical Component Summary (PCS)_T score	Intervention	51.29(6.98)	52.50(5.15)	-1.363	0.190	-0.299	1.20(3.84)	-1.028	0.311	-0.326
	Control	47.17(7.64)	49.91(7.75)	-2.265	0.036	-0.498	2.74(5.27)			
Mental Component Summary (MCS)_T score	Intervention	45.52(11.42)	46.62(11.81)	-0.767	0.453	-0.176	1.10(6.26)	-1.498	0.143	-0.476
	Control	38.19(13.72)	43.09(12.66)	-2.342	0.031	-0.515	4.90(9.11)			

DBP=Diastolic blood pressure; IPAQ= International Physical Activity Questionnaire; PSQI=Pittsburgh Sleep Quality Index Scale; SBP=Systolic blood pressure.

Supplementary Table S5-1. Intervention-related changes in physical activity and stress level.

		T1-T0				T2-T0			
		Mean change (SD)	t	p	Hedges"g	Mean change (SD)	t	p	Hedges'g
IPAQ	Intervention	442.81(1045.66)	1.587	0.118	0.395	571.71(1380.10)	0.814	0.419	0.203
	Control	-32.75(1312.63)				239.84(1818.73)			
PSS	Intervention	-3.32(4.56)	-1.93	0.059	-0.495	-2.97(5.23)	-1.089	0.053	-0.485
	Control	-1.31(3.39)				-0.91(2.86)			
Morning cortisol ¶	Intervention	-0.002(0.40)	-1.089	0.281	-0.275	-1.23(0.61)	-2.299	0.025	-0.581
	Control	0.11(0.41)				0.19(0.44)			
Afternoon cortisol ¶	Intervention	0.19(0.63)	-1.776	0.081	-0.453	0.32(0.62)	-0.147	0.884	-0.037
	Control	0.45(0.51)				0.34(0.58)			
Evening cortisol ¶	Intervention	0.15(0.50)	-2.409	0.019	-0.609	0.24(0.52)	-0.803	0.425	-0.203
	Control	0.45(0.47)				0.36(0.61)			

IPAQ= International Physical Activity Questionnaire; PSS=Perceived stress scale.

¶: The data of cortisol was converted into log10 for analysis

Supplementary Table S5-2. Intervention-related effects in other physical and psychological outcomes.

Outcomes					Time*Group			*Pairwise comparison*
		Mean (SD) T0	Mean (SD) T1	Mean (SD) T2	F	P	Partial η^2	
Hand grip strength(L/kg)	Intervention	22.64(7.23)	23.46(6.51)	21.92(6.06)	3.128	0.047	0.049	*None*
	Control	21.18(6.50)	20.95(7.10)	21.52(6.62)				*None*
Hand grip strength(R/kg)	Intervention	24.31(7.72)	24.30(6.99)	24.31(6.81)	1.300	0.275	0.021	*NA*
	Control	22.21(7.00)	23.02(6.31)	23.58(7.03)				*NA*
SBP (mm/hg)	Intervention	120.13(18.67)	120.26(12.68)	118.58(14.17)	0.182	0.826	0.003	*NA*
	Control	114.84(11.21)	116.47(12.42)	114.16(12.08)				*NA*
DBP (mm/hg)	Intervention	75.84(10.28)	75.68(8.18)	76.45(10.15)	0.821	0.442	0.013	*NA*
	Control	74.16(8.13)	72.59(7.09)	72.66(8.13)				*NA*

PSQI	Intervention	7.29(2.91)	6.19(2.57)	6.42(2.84)	1.550	0.218	0.025	*NA*
	Control	7.91(3.28)	7.19(2.83)	6.37(2.34)				*NA*
DASS_total	Intervention	15.53(10.30)	12.17(8.90)	11.77(9.10)	4.485	0.017	0.07	*T0-T1*; T0-T2**
	Control	11.91(7.61)	12.03(7.85)	12.37(8.24)				*None*
DASS_Depression	Intervention	3.93(4.35)	3.03(3.23)	2.83(3.08)	2.642	0.087	0.042	*NA*
	Control	2.91(2.68)	3.13(2.85)	3.03(2.90)				*NA*
DASS_Anxiety	Intervention	4.37(2.97)	3.40(2.92)	3.17(2.85)	3.710	0.03	0.058	*T0-T2**
	Control	3.44(2.87)	3.53(2.89)	3.69(3.05)				*None*
DASS_Stress	Intervention	7.23(4.12)	5.73(4.05)	5.77(4.01)	3.414	0.036	0.054	*T0-T1*; T0-T2**
	Control	5.56(3.09)	5.37(3.21)	5.66(3.48)				*None*
Physical Component Summary (PCS)_T score	Intervention	44.36(7.21)	47.92(7.27)	48.55(6.96)	2.998	0.057	0.047	*NA*
	Control	45.41(8.24)	45.52(7.91)	47.33(7.80)				*NA*
Mental Component	Intervention	39.59(12.99)	45.79(10.29)	47.29(9.94)	1.921	0.157	0.031	*NA*

Summary (MCS)_T score								
	Control	43.39(10.75)	45.84(9.69)	46.74(8.89)				*NA*
GSE	Intervention	24.06(4.77)	25.71(4.78)	25.45(4.94)	5.359	0.007	0.081	*None*
	Control	26.22(4.01)	24.13(4.26)	25.31(4.20)				*None*

DASS= Depression Anxiety Stress Scales; DBP=Diastolic blood pressure; GSE= General self-efficacy scale; ISI=Insomnia severity index; Questionnaire; NA=Not applicable; PSQI=Pittsburgh Sleep Quality Index Scale; PSS=Perceived stress scale; SBP=Systolic blood pressure.

*: p<0.05

Supplementary Table S5-3. Intervention-related changes in other physical and psychological outcomes

		T1–T0				T2–T0			
		Mean change (SD)	t	p	Hedges's g	Mean change (SD)	t	p	Hedges's g
Hand grip strength(R/kg)	Intervention	0.00(2.38)	-0.826	0.412	-0.206	0.01(2.41)	-1.835	0.072	-0.454
	Control	0.81(4.97)				1.37(3.42)			
SBP (mm/hg)	Intervention	0.13(11.68)	-0.587	0.559	-0.146	-1.55(12.05)	-0.311	0.757	-0.077
	Control	1.63(8.32)				-0.69(9.82)			
DBP (mm/hg)	Intervention	-0.16(6.66)	0.886	0.379	0.221	0.61(8.24)	1.139	0.259	0.283
	Control	-1.56(5.87)				-1.50(6.40)			
PSQI	Intervention	-1.10(2.59)	-0.583	0.562	-0.145	-0.87(2.62)	1.026	0.309	0.255
	Control	-0.72(2.56)				-1.53(2.49)			
Dass_Depression	Intervention	-0.84(3.50)	-1.536	0.132	-0.386	-1.10(3.30)	-1.899	0.065	-0.488
	Control	0.22(1.58)				0.13(1.29)			

PCS_T score	Intervention	3.56(5.78)	2.421	0.018	0.603	4.19(6.04)	1.391	0.167	0.348
	Control	0.11(5.54)				1.92(6.82)			
MCS_T score	Intervention	6.21(12.24)	1.409	0.165	0.353	7.70(12.15)	1.620	0.11	0.403
	Control	2.45(8.52)				3.35(9.01)			

DBP=Diastolic blood pressure; MCS= Mental component summary; PCS= Physical component summary; PSQI=Pittsburgh Sleep Quality Index Scale; SBP=Systolic blood pressure.

APPENDICES

Appendix A1: Informed Consent Form of Feasibility Study (English)

THE HONG KONG
POLYTECHNIC UNIVERSITY
香港理工大學

CONSENT TO PARTICIPATE IN RESEARCH

Exploring the benefits of an anti-sedentary health promotion program for office workers

I ______________________ hereby consent to participate in the captioned research conducted by ________________.

I understand that information obtained from this research may be used in future research and published. However, my right to privacy will be retained, i.e. my personal details will not be revealed.

The procedure as set out in the attached information sheet has been fully explained. I understand the benefit and risks involved. My participation in the project is voluntary.

I acknowledge that I have the right to question any part of the procedure and can withdraw at any time without penalty of any kind.

Name of participant ______________________________

Signature of participant ______________________________

Name of researcher ____Dr Erin Lu____

Signature of researcher ______________________________

Date ______________________________

Hung Hom Kowloon Hong Kong 香港 九龍 紅磡
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Website 網址 www.polyu.edu.hk

Appendix A2: Informed Consent Form of Feasibility Study (Cantonese)

參與研究同意書

研究項目標題: 探索減少久坐的健康教育活動對辦公人群的益處

本人＿＿＿＿＿＿＿＿同意參與由＿＿＿＿＿＿＿＿開展的上述研究。

本人知悉此研究所得的資料可能被用作日後的研究及發表，但本人的私隱權利將得以保留，即本人的個人資料不會被公開。

研究人員已向本人清楚解釋列在所附資料卡上的研究程序，本人明瞭當中涉及的利益及風險；本人自願參與研究項目。

本人知悉本人有權就程序的任何部分提出疑問，並有權隨時退出而不受任何懲處。

參與者姓名＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿
參與者簽署＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿
研究人員姓名＿＿陸依晴博士＿＿＿＿＿＿＿＿＿＿
研究人員簽署＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿
日期＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

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Appendix B: Ethical Approval of Feasibility Study from the Hong Kong Polytechnic University's Research Committee

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

To	Lu Yiqing (Department of Rehabilitation Sciences)		
From	Yee Kay Yan Benjamin, Delegate, Departmental Research Committee		
Email	@	Date	05-Jul-2023

Application for Ethical Review for Teaching/Research Involving Human Subjects

I write to inform you that approval has been given to your application for human subjects ethics review of the following project for a period from 01-Jul-2023 to 30-Jun-2024:

Project Title:	Exploring the benefits of an anti-sedentary health promotion program for office workers
Department:	Department of Rehabilitation Sciences
Principal Investigator:	Lu Yiqing
Project Start Date:	01-Jul-2023
Project type:	Human subjects (non-clinical)
Reference Number:	HSEARS20230629005

You will be held responsible for the ethical approval granted for the project and the ethical conduct of the personnel involved in the project. In case the Co-PI, if any, has also obtained ethical approval for the project, the Co-PI will also assume the responsibility in respect of the ethical approval (in relation to the areas of expertise of respective Co-PI in accordance with the stipulations given by the approving authority).

You are responsible for informing the PolyU Institutional Review Board in advance of any changes in the proposal or procedures which may affect the validity of this ethical approval.

Yee Kay Yan Benjamin

Delegate

Departmental Research Committee (on behalf of PolyU Institutional Review Board)

Page 1 of 1

Appendix C: Ethical Approval of Pilot Study from the Hong Kong Polytechnic University's Research Committee

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

To	Tsang Wing Hong Hector (Department of Rehabilitation Sciences)
From	Pang Marco Yiu Chung, Chair, PolyU Institutional Review Board
Email	@ Date 25-Oct-2023

Application for Ethical Review for Teaching/Research Involving Human Subjects

I write to inform you that approval has been given to your application for human subjects ethics review of the following project for a period from 01-Apr-2022 to 31-Dec-2024:

Project Title:	Reduce sedentariness and enhance physical and psychological health of office workers with TCM-based anti-sedentary intervention: Efficacy and potential psychophysiological mechanisms.
Department:	Department of Rehabilitation Sciences
Principal Investigator:	Tsang Wing Hong Hector
Project Start Date:	01-Apr-2022
Project type:	Human subjects (clinical)
Review type:	Expedited Review
Reference Number:	HSEARS20230723005

You will be held responsible for the ethical approval granted for the project and the ethical conduct of the personnel involved in the project. In case the Co-PI, if any, has also obtained ethical approval for the project, the Co-PI will also assume the responsibility in respect of the ethical approval (in relation to the areas of expertise of respective Co-PI in accordance with the stipulations given by the approving authority).

You are responsible for informing the PolyU Institutional Review Board in advance of any changes in the proposal or procedures which may affect the validity of this ethical approval.

Pang Marco Yiu Chung

Chair

PolyU Institutional Review Board

Appendix D1: Informed Consent Form of Pilot Study (English)

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

CONSENT TO PARTICIPATE IN RESEARCH

Reduce sedentariness and enhance physical and psychological health of office workers with TCM-based anti-sedentary intervention: Efficacy and potential psychophysiological mechanisms

I ______________________ hereby consent to participate in the captioned research conducted by _________________.

I understand that information obtained from this research may be used in future research and published. However, my right to privacy will be retained, i.e. my personal details will not be revealed.

The procedure as set out in the attached information sheet has been fully explained. I understand the benefit and risks involved. My participation in the project is voluntary.

I acknowledge that I have the right to question any part of the procedure and can withdraw at any time without penalty of any kind.

Name of participant ______________________________

Signature of participant ______________________________

Name of researcher ______________________________

Signature of researcher ______________________________

Date ______________________________

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Appendix D2: Informed Consent Form of Pilot Study (Cantonese)

參與研究同意書

研究項目標題:
以中醫為本的減少久坐訓練提升辦公人群的身心健康：療效和潛在作用機制

本人________________同意參與由________________開展的上述研究。

本人知悉此研究所得的資料可能被用作日後的研究及發表，但本人的私隱權利將得以保留，即本人的個人資料不會被公開。

研究人員已向本人清楚解釋列在所附資料卡上的研究程序，本人明瞭當中涉及的利益及風險；本人自願參與研究項目。

本人知悉本人有權就程序的任何部分提出疑問，並有權隨時退出而不受任何懲處。

參與者姓名 ______________________________
參與者簽署 ______________________________
研究人員姓名 ______________________________
研究人員簽署 ______________________________
日期 ______________________________________

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