Development of a device for postural change while sitting for the prevention of neck or low back pain in office workers

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การพัฒนาอุปกรณ์เปลี่ยนท่าทางในขณะนั่งเพื่อป้องกันอาการปวดคอหรือหลังในผู้ที่ทำงานใน
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งานวิจัยนี้มีวัตถุประสงค์เพื่อพัฒนาอุปกรณ์เปลี่ยนท่าทางในขณะนั่งเพื่อป้องกันอาการปวดคอหรือหลังในผู้ที่ทำงานในสำนักงาน โดยงานวิจัยนี้มีขั้นตอนการศึกษา 4 ขั้นตอน ประกอบด้วย 1) การศึกษาผลของความถี่ในการเปลี่ยนท่าทางในขณะนั่งต่อการรับรู้ความรู้สึกไม่สบายของระบบกระดูกและกล้ามเนื้อระหว่างนั่งทำงาน 1 ชั่วโมงในพนักงานสำนักงาน 2) การศึกษาผลของอุปกรณ์เปลี่ยนท่าทางในขณะนั่งต่อการป้องกันโรคปวดคอและหลังส่วนล่างในพนักงานสำนักงานโดยติดตามผลเป็นระยะเวลา 12 เดือน 3) การศึกษาผลของอุปกรณ์เปลี่ยนท่าทางในขณะนั่งต่อการฟื้นตัวและการกลับมาเป็นซ้ำของโรคปวดคอและหลังส่วนล่างในพนักงานสำนักงานโดยติดตามผลเป็นระยะเวลา 12 เดือน และ 4) การศึกษาลักษณะของพนักงานสำนักงานที่ได้รับประโยชน์สูงสุดจากอุปกรณ์ป้องกันโรคปวดคอและหลังส่วนล่าง ผลการศึกษาที่ 1 พบว่า ในการนั่งทำงาน 1 ชั่วโมงของพนักงานสำนักงาน การเปลี่ยนท่าทางในขณะนั่งด้วยความถี่ 20-30 ครั้ง/ชม. ช่วยลดความรู้สึกไม่สบายที่คอ ไหล่ หลังส่วนบน และหลังส่วนล่างได้อย่างมีนัยสำคัญทางสถิติ เมื่อเทียบกับการเปลี่ยนท่าทางในขณะนั่งด้วยความถี่ 10 ครั้ง/ชม. ผลการศึกษานี้ถูกนำไปใช้ในการพัฒนาอุปกรณ์เปลี่ยนท่าทางในขณะนั่งโดยผู้เขียนและทีมวิศวกรรม อุปกรณ์ดังกล่าวประกอบด้วยสามองค์ประกอบได้แก่ เบาะรองนั่ง กล่องควบคุม และแอปพลิเคชันบนสมาร์ทโฟน อุปกรณ์นี้มีหน้าที่รวบรวมข้อมูลพฤติกรรมการนั่งและแนะนำการขยับตัว โดยการปั๊มลมเข้าและดูดลมออกไปในส่วนต่างๆ ของเบาะรองนั่ง โดยอุปกรณ์นี้ค่าความเที่ยงตรงและความสอดคล้องอยู่ในระดับดีถึงดีมาก ผลการศึกษาที่ 2 และ 3 พบว่า พนักงานสำนักงานที่ได้รับอุปกรณ์เปลี่ยนท่าทางในขณะนั่งมีอุบัติการณ์เกิดโรคปวดคอและหลังส่วนล่างในรอบ 12 เดือนน้อยกว่า มีระยะเวลาในการฟื้นตัวสั้นกว่า และมีอุบัติการณ์เกิดโรคปวดคอและหลังส่วนล่างซ้ำในรอบ 12 เดือนต่ำกว่ากลุ่มควบคุมอย่างมีนัยสำคัญทางสถิติ สุดท้าย ผลการศึกษาที่ 4 พบว่าพนักงานสำนักงานที่มีชั่วโมงการทำงานในหนึ่งวันที่มากกว่า และผู้ที่มีระดับความเครียดในที่ทำงานที่สูงกว่า จะได้รับประโยชน์จากการใช้อุปกรณ์เปลี่ยนท่าทางในขณะนั่งเพื่อป้องกันโรคคอมากกว่าเมื่อเปรียบเทียบกับกลุ่มควมคุม นอกจากนี้ พนักงานสำนักงานที่ไม่ได้ใช้อุปกรณ์รองหลังส่วนล่างขณะนั่งทำงาน จะได้รับประโยชน์จากการใช้อุปกรณ์เปลี่ยนท่าทางในขณะนั่งเพื่อป้องกันโรคปวดหลังส่วนล่างมากกว่าเมื่อเปรียบเทียบกับกลุ่มควมคุม

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Nipaporn Akkarakittichoke : Development of a device for postural change while sitting for the prevention of neck or low back pain in office workers. Advisor: Prof. PRAWIT JANWANTANAKUL, Ph.D. Co-advisor: Prof. Mark P. Jensen, Ph.D.

The objective of this thesis was to develop a device for postural change while sitting for the prevention of neck or low back pain in office workers. This thesis was divided into four stages: 1) to evaluate the effects of postural shifting frequency on perceived musculoskeletal discomfort during 1 hour of sitting in healthy office workers; 2) to evaluate the effects of the postural shift intervention on the 12-month incidence of the onset of neck and low back pain in high-risk office workers; 3) to investigate the efficacy of postural shift interventions on recovery duration and recurrence of neck and low back pain among high-risk office workers, and 4) to identify variables that moderate the effects of postural shifts interventions on the development of neck and low back pain in office workers. The finding of the first study showed that a postural shift frequency of 20-30 times/h significantly led to lower perceived discomfort in the neck, shoulder, upper back, and low back compared to a postural shift frequency of 10 times/h during 1 hour of sitting. These findings were used to develop a custom-designed device for postural change while sitting by the author and engineering team. The device consisted of three components: a seat pad, processor, and smartphone application. The device collected sitting behavior data and provided recommended postural shifting by gradually pumping air into various parts of the seat pad. The device had good to excellent validity and consistency. The results of the study two and three revealed that office workers who received the postural shift intervention significantly reduced the 12-month incidence rate, shortened recovery time, and reduced recurrence of neck and low back pain. Finally, the finding of the fourth study showed that workers who worked more hours/day and who endorsed higher levels of psychological work demand gained more benefits from the postural shift intervention regarding the prevention of neck pain development than those in the control group. In addition, the workers who had no lumbar support gained more benefits from the postural shift intervention regarding the prevention of low back pain development than those in the control group.

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Nipaporn Akkarakittichoke

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CHAPTER 1
General introduction

1.1 Outline of this thesis

The thesis consists of seven chapters. The first chapter provides an overview of the study consisting of background and rationale, objectives, scopes, and benefits of the study. The second chapter is a review of relevant literatures. The third chapter describes the effects of postural shifting frequency on perceived musculoskeletal discomfort during 1-hour sitting in office workers. The fourth chapter presents the effects of the postural shift interventions on the 12-month incidence of neck and low back pain in high-risk office workers. The fifth chapter presents the effects of the promotion of postural shift on the 12-month recovery from and recurrence of neck and low back pain in office workers. The sixth chapter describes the characteristics of office workers who benefit most from interventions for preventing neck and low back pain. Given the above considerations, the last chapter provides an overall conclusion, which consists of a summary of the results, limitations of the study and suggestions for further study as well as the clinical implication.

1.2 Background and rationale

Musculoskeletal disorders (MSDs) are regarded as a major health problem among office workers. The annual prevalence rate for neck and low back pain among office workers have been shown to range from 42% to 69% (Ehsani et al., 2017; Areerak et al., 2018) and 31% to 51% (Ayanniyi et al., 2010; Sitthipornvorakul et al., 2015), respectively. Between 34% to 49% (Korhonen et al., 2003; Hush et al., 2009) and 14% to 23% (Juul-Kristensen et al., 2004; Sitthipornvorakul et al., 2015) of office workers reported a new onset of neck pain and low back pain during the 1-year follow-up. In Thailand, musculoskeletal disorders among office workers was 63%, and head/neck and low back were the most frequent musculoskeletal disorders in office workers (Janwantanakul et al., 2008). Musculoskeletal disorders are considered as a major public health problem, both in terms of health and overall well-being of the person and the society (i.e., work performance and social responsibilities). It has imposed relatively high direct and indirect costs, and may affect the quality of life and working condition of patients (Cote et al., 2009; Ranasinghe et al., 2011).

Musculoskeletal pain is assumed to be of multifactorial origin and predominantly related to lifestyle similar to other health conditions. Different occupations are exposed to different working conditions, and the nature of work influences the health of workers (Cote et al., 2009). The main work tasks of office workers are computer-related tasks, attending meetings, making phone calls, giving presentations, with relatively little time spent walking, standing, or lifting (Huysmans et al., 2012). Office workers, thus, spend about one half to two thirds of their workday seated within an office environment (Jans et al., 2007). The pathomechanism of work-related musculoskeletal disorders relates to several risk factors, including individual, physical, and psychosocial factors (Wahlström, 2005).

Work-related physical demands, such as sitting for long periods of time or sustaining awkward postures during work, increase physical load on body parts, which leads to increased muscle activity and fatigue. If there is insufficient time to allow regeneration of body tissue capacity, then a series of responses (muscle fatigue) may further reduce available capacity. This may continue until some types of structural tissue deformation occur, leading to musculoskeletal disorders. A previous study showed a positive association between prolonged sitting at work and neck pain, implying that the risk of neck pain was elevated for those working almost all day in a sitting position (Ariens et al., 2001).

Although prolonged sitting by itself was not associated with the risk of developing LBP (Kwon et al., 2011), occupational groups exposed to poor postures while sitting for longer than half a day have a considerably increased risk of experiencing low back pain (Lis et al., 2007). Prolonged sitting has also been found to induce discomfort in the neck and low back (Nakphet et al., 2014; Waongenngarm et al., 2015), which is a strong predictor of neck and low back pain (Hamberg-van Reenen et al., 2008; Huysmans et al., 2012). Prolonged sustained postures while sitting impair the ability of the postural muscles to support the body and associate with muscular inactivity that could induce muscular weakening (van Niekerk et al., 2012). In addition, the flow of fluid from the discs may be reduced or reversed with an eventual impact on lumbar proprioceptive and consequently more risk of injuries (Hodges and Moseley, 2003).

There has been considerable emphasis on the potential role of dynamic sitting approaches to facilitate spinal micro-movement as a means of reducing MSDs while sitting. “Dynamic sitting” refers to increased trunk motion in sitting which is facilitated by the use of specific chairs or equipment (O'Sullivan et al., 2012). Postural changing while sitting or postural shift or dynamic sitting has been found to increase subcutaneous oxygen saturation, which positively influences tissue viability (Reenalda et al., 2009). Also, dynamic sitting may minimize neck and low back discomfort during prolonged sitting through alternating activity between different parts of the trunk muscles (van Dieen et al., 2001). A specific device which can promote dynamic sitting can thus be beneficial in the prevention of MSDs in the neck and low back.

Several studies have developed different chairs, equipment, or devices to provide dynamic sitting, however controversy still exists about the effectiveness in their ability to individually change sitting posture and on the prevention of neck and low back pain. To date, no study has investigated the long-term effect of a specific device for preventing musculoskeletal disorders in the neck or low back in office workers. Thus, this study has two major aims; 1) to develop a device that can induce postural change while sitting 2) to investigate the effectiveness of such device in reducing discomfort in the neck or low back and the 12-month incidence of non-specific neck or low back pain in high-risk office workers.

1.3 Objectives of the study

- To evaluate the effects of postural shifting frequency on perceived musculoskeletal discomfort during 1 hour of sitting in healthy office workers.
- To evaluate the effects of postural shifts on the 12-month incidence of neck and low back pain in high-risk office workers.
- To investigate the efficacy of postural shift interventions aimed to reduce sitting discomfort on recovery duration and recurrence of neck and low back pain among high-risk office workers.
- To identify variables that moderate the effects of postural shift interventions on the development of neck and low back pain in office workers.

1.4 Scope of the study

There were two major phases of this project aimed to invent a reliable and valid device for postural change while sitting to prevent neck or low back pain in sedentary workers. The first phase was the development of a device for postural change while sitting, and the second phase was the effectiveness of device testing. The device has consisted of two programs, DynaRest® and DynaSit® program.

DynaRest® was developed to promote active breaks while DynaSit® was developed to promote postural change or postural shift while sitting for the prevention of musculoskeletal disorders in the neck and low back among high-risk office workers. The DynaRest® was developed and published by the author's colleague. This thesis, therefore, was mainly focused on the information involved with DynaSit®.

In the first phase, this study was conducted to develop a device to trigger postural change while sitting. The device will automatically and continuously detect sitting time and sitting posture. The device consists of three parts including 1) a seat pad with pressure sensors, 2) a controller with DynaSit® algorithm, and 3) a smartphone application (HealthySit® application). When three parts of the device were completed, it was tested for validity, consistency, test run, and durability test. All information regarding technically developing a device and clinical test were provided in Appendix A. During the development process, there was a lack of empirical evidence on the effect of frequency of postural shift on the development of perceived discomfort in neck and low back in office workers. Thus, the literature review and the experimental study were conducted to gain inside knowledge to create the DynaSit® algorithm. Thus, the aim of the first study (Chapter 3) was to examine the effects of postural shifting frequency on perceived musculoskeletal discomfort during 1 hour of sitting in healthy office workers.

In the second phase, several studies were conducted to prove the effectiveness of a device. The purpose of the second study was to evaluate the effectiveness of a device for postural change while sitting to prevent a 12-month incidence of neck and low back pain in office workers (Chapter 4). Next, the third study was conducted to investigate the effectiveness of this device in the ability to shorten recovery time and reduced the recurrence of neck and low back pain in office workers were also investigated (Chapter 5). Last, the characteristic of office workers who benefit most from interventions for preventing neck and low back pain were identified by a moderation analysis study. This information could be used to inform better individual-treatment matching resulting in improving the effectiveness and efficiency of a device.

1.5 Benefits of the study

The finding of the present study provided information about the effect of a device for postural change while sitting on the prevention of new onset, the shortened duration of recovery time, and the prevention of recurrence of neck and low back pain in high-risk office workers. Besides, the characteristic of office workers who benefit most from the device were indicate in this study which would be essential for improving the efficacy of current device for preventing neck and low back pain. The device for postural change while sitting would be useful for sedentary worker whose work required to sit for long periods of time.

CHAPTER 2

Review of literature

2.1 Definitions

2.1.1 Definition of office workers

Office workers are defined as the people who spend most of their times in workplace and their work usually involve with computer, participation in meeting, giving presentation, reading, phoning and few walking, standing, or lifting (IJmker et al., 2006). Office workers usually work with computers and spend their time mainly in sitting position.

2.1.2 Definition of non-specific neck pain

Non-specific neck pain is defined as neck symptoms without specific spinal disease (such as cancer, spinal infection, spinal fracture, or inflammatory arthritis), spinal cord compromise (determined by the presence of any of the following signs; diffuse sensory abnormality, diffuse weakness, and hyper-reflexia or presence of clonus); or radiculopathy (determined by the presence of myotomal weakness or dermatomal sensory abnormality) (Leaver et al., 2007). In this study, neck pain patients are defined as subjects who reported pain intensity greater than 30 millimeters (mm) on a 100-mm visual analog scale (Tsauo et al., 2007) and having a period of pain lasting more than 1 day (Hush et al., 2009). A modified Nordic Questionnaire is used to define the area of neck (Kuorinka et al., 1987).

2.1.3 Definition of non-specific low back pain

Non-specific LBP is defined as LBP without recognizable pathology that can be identified as the cause of pain (such as cancer, spinal infection, spinal fracture, or inflammatory arthritis), spinal cord compromise (determined by the presence of any of the following signs; diffuse sensory abnormality, diffuse weakness, and hyper-reflexia or presence of clonus) or radiculopathy (determined by the presence of myotomal weakness or dermatomal sensory abnormality) (Airaksinen et al., 2004; Krismervan Tulder, 2007; Leaver et al., 2007). In this study, non-specific LBP patient is defined as subjects who reported pain intensity greater than 30 millimeters (mm) on a 100-mm visual analog scale (Tsauo et al., 2007) and having a period of pain lasting more than 1 day (Hush et al., 2009). A modified Nordic Questionnaire is used to define the area of lower back (Kuorinka et al., 1987).

2.2 Pathomechanism of work-related musculoskeletal disorders in office workers

Work-related musculoskeletal disorders in office workers have a multi-factorial origin. Three patho-mechanisms of work-related musculoskeletal disorders in office workers has been proposed as follow:

2.2.1 A model of work-related musculoskeletal disorders

Working with computer (VDU/office technology) has a direct path to physical demands, as defined by the physical coupling between the worker and the tool (i.e.

workstation ergonomics, computer programs) (Fig 1). There is also a direct path from work technology to work organization. The path from work organization to physical demands suggests that the physical demands from work can be influenced by work organization. Increased time pressure leads to an increased number of keystrokes or implementation of new software leads to increased computer mouse use, which in turn may increase the physical load and mental stress. Individual factors are hypothesized to modify the association between physical demands and physical load (i.e. low muscle endurance may result in rapid muscle

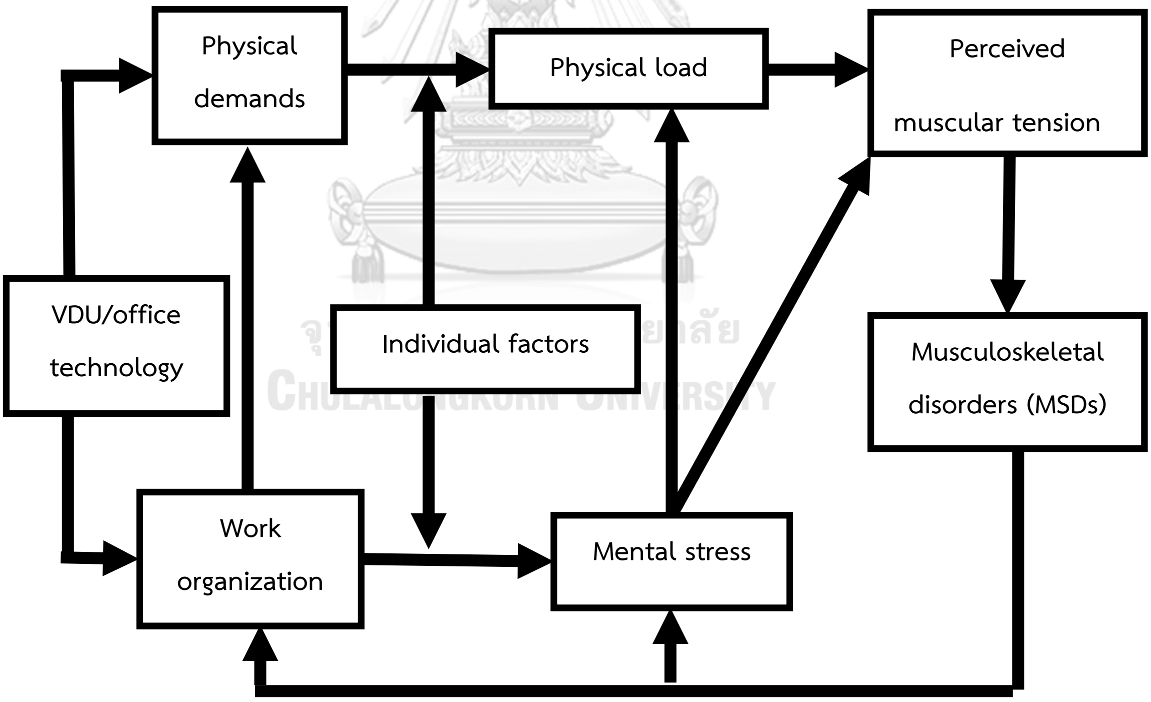

Figure 1 *A model of musculoskeletal disorders in office workers VDU = visual display unit fatigue) (Wahlström, 2005).*

Moreover, individual factors, such as working technique and gender, may affect the physical load. Individual factors are also hypothesized to modify the association between work organization and mental stress. Mental stress may increase muscle activity, which compounds physical load induced by physical demands. Mental stress has been hypothesized to moderate the relationship between physical load and musculoskeletal outcomes (i.e. neck and/or low back pain). The reason for having a direct path from mental stress to musculoskeletal outcomes, not mediated through physical load, is that the mechanisms behind nonspecific musculoskeletal symptoms are not well understood. Muscular tension is hypothesized to be an early sign of musculoskeletal symptoms. Finally, the experience of musculoskeletal symptoms are negative feedback to increase mental stress and causes alteration in work organization (WahlstrÖm, 2005).

2.2.2 A model of neck pain in office workers

The etiology of neck pain is widely accepted to be multifactorial. The result of recent study using path analysis showed that onsets of neck pain was predicted by female gender, having a history of neck pain, monitor position not being level with the eyes, and frequently perceived muscular tension (Fig 2).

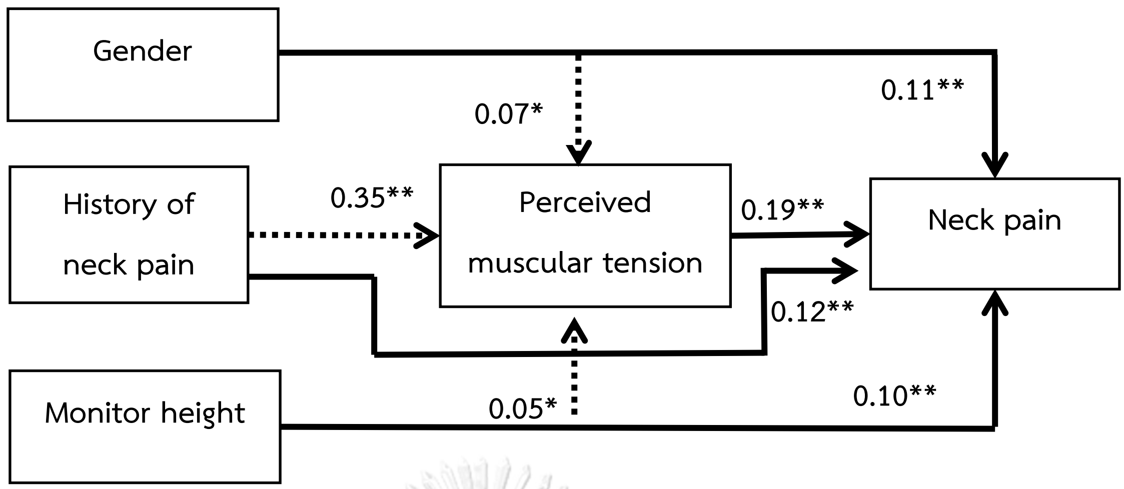

*Figure 2 Path analysis of factors predicting onset of neck pain in office workers with standardized regression coefficients (*p<0.05, **p<0.01) (Paksaichol et al., 2015).*

As proposed by Côté et al. in 2009, each risk factor had direct and indirect effects on the development of nonspecific neck pain in office workers (Cote et al., 2009). The model showed that female gender, having history of neck pain, monitor position not being level with the eyes and frequently perceived muscular tension directly caused neck pain and that perceived muscular tension had the strongest effect on the onset of neck pain. Gender, history of neck pain, and monitor height had indirect effects on neck pain that were mediated through perceived muscular tension. History of neck pain was the most influential effector on perceived muscular tension (Paksaichol et al., 2015).

2.2.3 A model of low back pain in office workers

The result of recent study using path analysis showed that onsets of LBP were predicted by having a history of LBP, frequency of breaks at work, and psychological demand (Fig 3). The model showed that having history of low back pain, frequency of breaks at work, and psychological demand directly caused LBP and that having history of LBP had the strongest effect on the onset of LBP. Apart from having a direct effect on the development of LBP, history of LBP, and frequency of breaks at work had indirect effects on LBP that were mediated through psychological demand (Janwantanakul et al., 2018). History of LBP and frequency of breaks were related to psychological demand. The results also pointed out that frequency of breaks at work had the most influential effect on psychological demand (ประวิตร เจนวรรธนะกุล, 2015). The conceptual model for the onset of nonspecific LBP in office workers proposed in the study is in line with an existing model of musculoskeletal disorders and computer work proposed by Wahlström in 2005, who hypothesized that work technology and organization have a direct path to physical demands. Frequency of breaks at work may be an indicator of amount of repetitive movements or sustained posture for long periods of time. Thus, taking breaks at work frequently may reduce a harmful effect from repetitive movements or sustained posture which may reduce the onset of LBP (Wahlstrom et al., 2003).

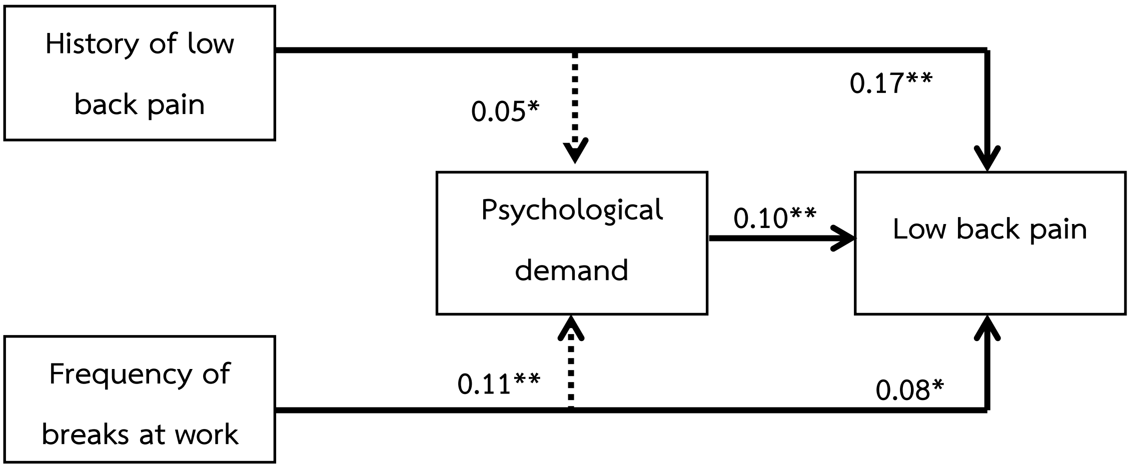

Figure 3 *Path analysis of factors predicting onset of low back pain in office workers with standardized regression coefficients (*p<0.05, **p<0.01) (Janwantanakul et al., 2018).*

2.3 Principle of disease prevention

Prevention means the act or practice of stopping something bad from happening. It means the avoidance of the risk or hazard at work. General principles of prevention are as follow (EU–European Union, 1989):

(a) avoiding risks;

(b) evaluating the risks which cannot be avoided;

(c) combating the risks at source;

(d) adapting the work to the individual, especially as regard to the design of work places, the choice of work equipment, and the choice of working and production methods, with a view, in particular, to alleviating monotonous work and work at a predetermined work rate and to reducing their effect on health;

(e) adapting to technical progress;

(f) replacing the dangerous by the non-dangerous or the less dangerous;

(g) developing a coherent overall prevention policy which covers technology, organization of work, working conditions, social relationships, and the influence of factors related to the working environment;

(h) giving collective protective measures priority over individual protective measures;

(i) giving appropriate instructions to the workers.

2.3.1 Level of prevention

Prevention of MSDs can be divided into the primary, secondary, and tertiary prevention (Lintonvan Tulder, 2001; Krismervan Tulder, 2007; Green, 2008)

Primary prevention

Primary prevention is defined as health promotion and specific protection to a community (Lintonvan Tulder, 2001; Krismervan Tulder, 2007; Green, 2008). Primary prevention is provided to healthy people or directed toward susceptible people before they develop a disorder. The aim of primary prevention is preventing the onset or reduction the occurrence or incidence of disease (Lintonvan Tulder, 2001; Krismervan Tulder, 2007; Green, 2008).

Secondary prevention

Secondary prevention is preventive measures for people who have developed a disease, yet remain asymptomatic (Green, 2008). Secondary prevention is restricted to attempts to halt further development of a disease. The aim of secondary prevention is reducing the consequences of the disease or reducing chronicity (Lintonvan Tulder, 2001; Krismervan Tulder, 2007; Green, 2008).

Tertiary prevention

Tertiary prevention is directed at preventing disability in people who have a symptomatic disease in an effort to prevent disease progression or to offer rehabilitation (Green, 2008).

2.3.2 The framework of work-related MSD prevention research

The framework of work-related MSD prevention is composed of 6 steps as follow (Fig 4):

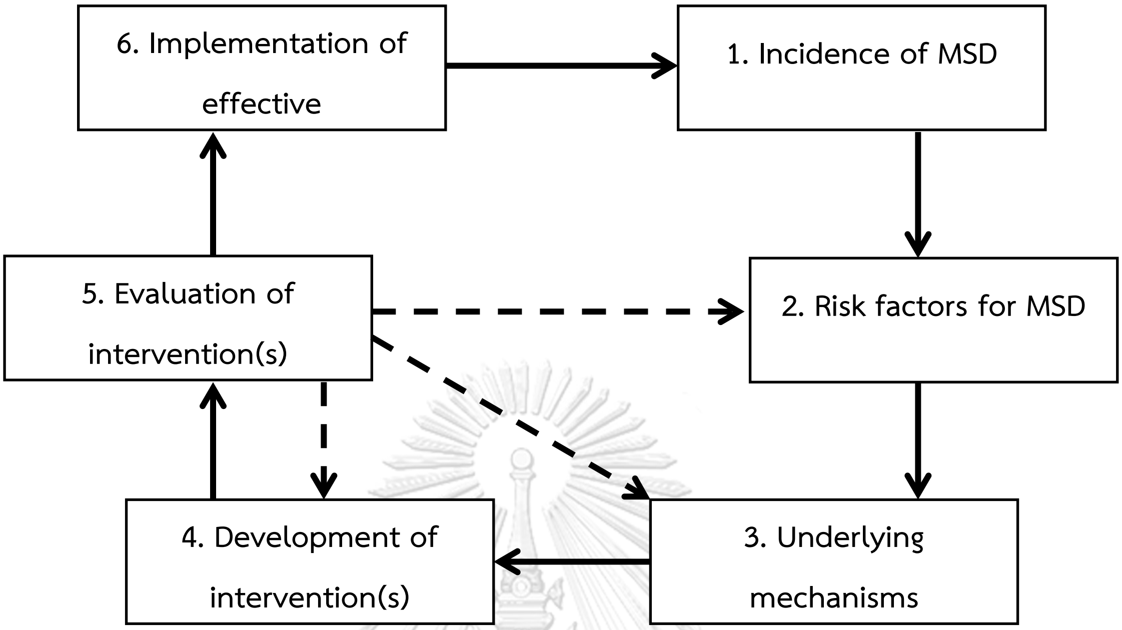

Figure 4 *A framework describing a repeated sequence for prevention of work-related musculoskeletal disorders (MSD) - the six steps in prevention (van der Beek et al., 2017).*

Step 1. Incidence and severity of MSD

The incident and severity of MSD in the working population of interest needs to be identified. In this step, descriptive epidemiological data (such as MSD incidence) can be used, in which severity and the resulting impact (eg, sick leave or work disability or work productivity) of the MSD could also be considered (van der Beek et al., 2017).

Step 2. Risk factors for MSD

This step identifies (work-related) risk factors that may play a role in the incidence of MSD (van der Beek et al., 2017). Epidemiological observational studies are required to gain insight into these risk factors with cross-sectional studies identifying associated factors, and prospective studies being able to make a better distinction between causes and effects (Checkoway et al., 2007).

Step 3. Underlying mechanisms

The underlying mechanisms and pathways, which may cause physiological responses contributing to the development of MSD needs to be identified (Bongers et al., 2002). Formulating the underlying mechanisms for the onset of MSD could help understanding the exact association of a certain risk factor with MSD and should largely determine the content of interventions to prevent MSD (van der Beek et al., 2017).

Step 4. Development of intervention(s)

The fourth step is to develop and introduce an intervention, which is likely to reduce the incidence of MSD. Key issues in developing the intervention are whether the risk factor is amendable to change, the relative contribution of the risk factor to the MSD and the success of interventions in reducing this risk factor These interventions are preferably based on an understanding of underlying etiological mechanisms of MSD, as identified in step 2 and 3, and often focus on reducing a possible risk factor, also taking other (non-physical and/or work-related) factors into consideration (van der Beek et al., 2017).

Step 5. Evaluation of intervention(s)

This step is to evaluate the effectiveness of preventive interventions. This can start with efficacy studies under well-controlled circumstances and can move on to effectiveness studies in a real working-life situation. Changes in the risk factors along the hypothesized pathway of the intervention and changes in proximal outcomes should be evaluated (van der Beek et al., 2017).

Step 6. Implementation of effective intervention(s)

The last step is implementation and scale up of the study results in the working society, with an amenable trade-off between effectiveness and required (economic or productivity) resources. Implementation research can evaluate the implementation process and its effects, while a better insight into fidelity of an intervention can help to design good implementation strategies at organizational and community levels. Implementation would result in a positive effect on the occurrence, severity and/or impact of MSD as monitored in a repetition of the first step. Hence, the circle is closed towards the first step. (van der Beek et al., 2017).

2.4 Risk factors for non-specific neck and low back pain

2.4.1 Risk factor for non-specific neck pain

Risk factors for non-specific neck pain were divided into three groups: individual, work-related physical, and work-related psychosocial risk factors. A recent systematic review summarized the results of five high-quality and two low-quality prospective cohort studies investigating the predictive value of 47 individual, work-related physical, and psychosocial factors for the onset of non-specific neck pain in office workers (Paksaichol et al., 2012). The results showed that strong evidence was found for female gender and previous history of neck complaints to be predictors of the onset of neck pain. Limited evidence for pain started after an accident, irregular head and body posture, duration of employment in same job <1 year, poor computer skills, distance of the keyboard from the edge of the table <15 cm, high task difficulty, low influence at work, and high muscular tension as predictors for new-onset neck pain in office workers. Conflicting evidence was found for factors, such as older age, daily computer use, high mouse usage time, screen height above eye level, high job strain, and high demand.

2.4.2 Risk factor for non-specific low back pain

Risk factors for non-specific low back pain were divided into three groups: individual, work-related physical, and psychosocial risk factors. According to a recent systematic review, there were only three high-quality prospective cohort studies on risk factors for the onset of non-specific low back pain in office workers. Of 22 investigated factors, the results indicated strong evidence for history of LBP and limited evidence for the combination of postural risk factors and job strain (for females only) as predictors for new-onset LBP in office workers.

2.5 Primary preventive intervention for non-specific neck and low back pain in office workers

2.5.1 Primary preventive interventions for non-specific neck pain

A few studies aiming for primary prevention of non-specific neck pain among office workers have been reported (Sihawong et al., 2014; Sitthipornvorakul et al., 2015). A 12-month prospective cluster-randomized controlled trial found that healthy office workers with lower-than-normal neck flexion movement or neck flexor endurance who received exercise program that included daily stretching exercise and twice-a-week muscle endurance training have lower incidence of neck pain (12.1%) compared with office workers who received no intervention (26.7%) (Sihawong et al., 2014). Moreover, a 1-year prospective study found that increasing physical activity (daily walking steps) by 1,000 reduced the risk of neck pain by 14% (Sitthipornvorakul et al., 2015). According to systematic review by Hoe et al. in 2012, they found moderate-quality evidence to suggest that the use of arm support with alternative mouse may reduce the incidence of neck/shoulder MSDs (Hoe et al., 2012).

2.5.2 Primary preventive intervention for non-specific low back pain

There are few studies on primary prevention of non-specific LBP among office workers (Sihawong et al., 2014; Sitthipornvorakul et al., 2015). A 12-month prospective cluster-randomized controlled trial found that healthy office workers with lower-than-normal trunk extension flexibility or trunk muscle endurance have lower incidence of low back pain (8.8%) compared with office workers who received no intervention (19.7%) (Sihawong et al., 2014). According to a 1-year prospective study, no significant association between physical activity (daily walking steps) and the onset of low back pain was found (Sitthipornvorakul et al., 2015). However, further analysis showed that office workers with lower-than-normal trunk muscle endurance who have lower 10,000 daily walking steps have higher incidence of low back pain compared with office workers who have higher 10,000 daily walking (OR=3.66) (ประวิตร เจนวรรธนะกุล, 2015).

2.6 Biomechanics of sitting

2.6.1 General classification of sitting posture

Sitting position for the standard tests is the position that subject feels most comfortable every time when he or she sits (Hostens et al., 2001). Seated posture is affected by seat-back angle, seat-bottom angle and foam density, height above floor, and presence of armrests. Sitting causes the pelvis to rotate backward, leading to changes in lumbar lordosis, trunk-thigh angle, knee angle, muscle effort, and intervertebral disc pressure (Harrison et al., 1999).

To determine human sitting posture, it is convenient to categorize seated posture by location of the center of gravity (CG). Harrison et al (1999) classified sitting postures into three types: anterior, middle, and posterior sitting postures. The authors noted that these three postures differed with respect to the location of the center of gravity of the body, the proportion of body weight transmitted to the floor by the feet, and the shape of the lumbar spine. Harrison et al (1999) showed radiographically that during transition of standing to sitting subjects posteriorly averagely rotated their pelvises 40 degrees.

In the middle position (Fig 5, C), the center of gravity is above the ischial tuberosities, and the feet transmit about 25% of the body weight to the floor. In sitting in a relaxed middle position, the lumbar spine is either straight or in slight kyphosis.

The anterior position can be obtained from the middle position either by a forward rotation of the pelvis (Fig 5, B) or by creating a kyphosis of the spine by flexing without much rotation of the pelvis (Fig 5, A). In this anterior position, the center of gravity is in front of the ischial tuberosities, and the feet transmit more than 25% of the body weight to the floor.

In the posterior position (Fig 5, D), the center of gravity is above or behind the ischial tuberosities, and less than 25% of the body weight is transmitted by the feet. This position is obtained by extension rotation of the pelvis and simultaneous kyphosis of the spine (Harrison et al., 1999).

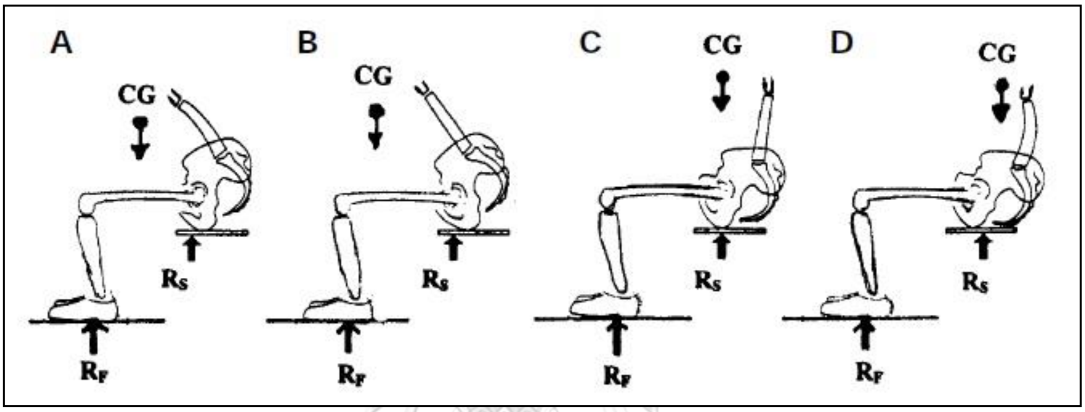

Figure 5 *Three sitting categories on the basis of center of gravity location (Harrison et al., 1999). RS = reaction force through the seat bottom. RF = reaction force from the ground at the feet. CG = center of gravity (Harrison et al., 1999).*

The common seating guideline to apply for all types of chair is as followed (Treaster, 1987):

1) Avoiding compression force under the thighs because it may reduce blood flow to the lower extremities and increase load to nerve, causing pain and numbness.

2) Avoiding flattening the lumbar spine by providing a backrest for lower back supports.

3) Pressure distribution should equally on the weight bearing bony prominence (ischial tuberosities) in the buttock area

4) Allowing adjustments to be made in the dimension of the chair (e.g. height of seat, angle of inclination etc.) in order to accommodate a diversity of user sizes.

2.6.2 The optimal sitting posture

Healthy sitting posture can be thought of as occurring when unnecessary (static) muscle activity, ligamentous tension, intradiscal pressure, and zygapophysial joint forces are minimized, and when body weight is distributed evenly through the ischial tuberosities and thighs to the seat and through the torso via the backrest (Pynt et al., 2001).

In prolonged sitting, there are two components to promote the spinal postural health. First component is postural change during sitting. Movement during sitting has been shown to increase and decrease lumbar discal pressure, there by promoting fluid exchange in the IVD and enhancing its nutrition. Sustained posture without movement causes fluid loss form disc, the capsules of the facet joint and the ligament. The study suggested that sustained sitting in fully kyphosed posture for 20 minutes causes the capsules of the facet joint and ligament elongated, resulting in joint laxity. Prolonged static back muscle activity which occurs in static lordosed posture increases intra-discal pressure and IVD injury. Therefore, it can be conclude that sustained sitting without movement in end-ranged posture; both lordosis or kyphosis, is potentially harmful to the disc, zygapophysial joint, and ligaments (Pynt J, 2002). However, the postural change alone is not sufficient to maintain spinal postural health. Second component for spinal postural health is seat with spine in optimal posture. It has been proposed that an optimal sitting posture for LBP subjects who are sensitized to flexion or extension is a more neutral spine position involving slight lumbar lordosis and a relaxed thorax. This neutral posture avoids potentially painful end-range positions, as well as activating key trunk muscles (O'Sullivan et al., 2010). The goal of neutral sitting position is therefore to promote maximum orthopedic symmetry between left and right sides of the body via a neutral pelvis to avoid obliquity, rotation and posterior tilt of the pelvis. This is to provide equal distribution weight for stability and comfort (Harrison et al., 1999).

2.6.3 Sitting induced low back pain

Prolonged sitting alone was not associated with the risk of developing LBP. The co-exposure factors of awkward postures can induce the risk of LBP increased (Lis et al., 2007; Kwon et al., 2011). In addition, in a systematic review of prospective cohort studies, the combination of postural risk factor and job strain was associated with nonspecific LBP in office workers (Janwantanakul et al., 2012). The extended period of sitting induces many changing to human body. High risk of back problem, numbness and discomfort in the buttocks, legs and feet from surface under pressure is a sequence from prolonged sitting. In a seated posture, the pelvis rotates backward; the lumbar spine may flatten and lose lordotic curve, and the sacral decrease inclination. The weight of the head, torso, arms, hands, and any mass suspended in hands are supported down the spinal column (Fig 6).

The figure indicated a series of individual vertebrae interfaced with compliant discs, able to withstand compressive forces acting axially through the column. The muscles, acting in tension, apply compressive loads between the ends of skeletal members to apply rotational force at the pivots. In a dynamic condition, the spinal column acts like a shock absorber or an energy absorber and transmits vertical forces. The spinal column vertical forces are applied in shear and compression through ligaments to the pelvis. The pelvis, in a seated position, distributes these forces through the buttock muscle via surface area around the lower pelvic bone surface. The buttock muscle area direct beneath the ischial tuberosity is in compression across the muscle. The compression forces on the buttock and surrounding muscle compromise their ability to exchange nutritional input and metabolic by-products with the circulatory system, resulting in lactic acid accumulation, influencing stimulus of fatigue and pain (MehtaTewari, 2000) (Fig 6).

2.6.4 Effect of sustain sitting posture

Lordosed sitting posture produce potentially damaging localized peaks of compressive stress in the posterior annulus of the disc. However, this disadvantage is less significant than the disadvantage by kyphosed sitting posture in the view of spinal ligament and intervertebral disc (IVD). The study by Hedman and Fernie demonstrated that the posterior ligament force in the kyphosed sitting posture was threefold that found in the anterior ligament in the lordosed sitting posture. These massive forces lead to potential for damage to the disc and posterior ligament. There are significantly increased compressive load and shear force in the discs in the

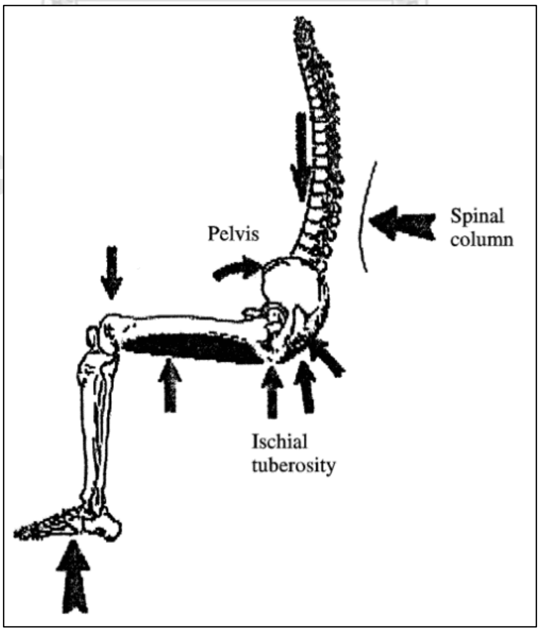

Figure 6 *Force acting on a seat worker (Pynt et al., 2001).*

kyphosed posture, as compared with the lordosed posture. Despite, the effect of the lordosed and kyphosed sitting posture on lumbar facet joints is in controversial. The intra-articular surfaces of the lumbar facet joints show two areas of impaction loading. The first area that can impact by loading is in the middle lower portion of the superior articular when performing the motion in extension or lordosed sitting posture. The other area of impaction is in the medial upper portion of the superior articular process. This area will be damaged when the facet joint are resisting anterior translation, which is component part of kyphosed sitting posture. To conclusion, first, both kyphosed and lordosed sitting posture may be injurious to spinal posture if sustained is presented. Second, both kyphosed and lordosed sitting posture result in some impingement of lumbar facet joint. The deleterious effect of extra-articular facet impingement by disc narrowing, as may occur in sustained sitting without movement, highlight the importance of movement during sitting for the maintenance of spinal posture health (Pynt et al., 2001; Pynt J, 2002).

Sitting for long time affect musculoskeletal equilibrium, especially in the maintain posture case of asymmetric posture. In an asymmetric posture, need more power and energy and if posture maintained for a long time, would result in spinal imbalance. An asymmetric posture may cause permanent spinal deformity such as kyphosis, scoliosis, lordosis, and also result in chronic low back pain as well. Common asymmetric sitting positions are sitting with crossed legs, with the chin resting on a hand, and with lying prone on a desk. Previous study found that after sitting 1 hour in asymmetrical sitting posture; chin resting on hand position, there were statistically significant differences in sagittal imbalance, coronal imbalance, pelvic obliquity, and lordosis angle (Woo et al., 2016). As the spent with the chin resting on a hand gets longer, it is more likely to cause permanent disparity of shoulder height, placement of eyes, and position of hips (AlexanderLaPier, 1998). The effects of asymmetric sitting positions represented by resting the chin on a hand and crossed legs, which are commonly observed in real life, on spinal balance were investigated at two time points. The pelvis and spine would anatomically comprise the spino-pelvic complex (Panjabi, 1992). Therefore, it was our assumption that asymmetric sitting position would affect pelvic balance and consequently spinal balance as well.

2.7 Effects of postural change while prolonged sitting on non-specific neck and low back pain in office workers

The study of relationship between discomfort and mobility in sitting indicated that great change of posture are a good indicator of discomfort (VergaraPage, 2002). Also, the previous study compared postural shifting between healthy subject and LBP subject. The study found that after 45 minute of prolong sitting, the shifted behavior is significant different between low back pain sufferers and healthy person (DunkCallaghan, 2010). This mean that a sitting person adjusts their body position after they feels discomfort. The peak discomfort, 2 on the Borg CR-10 scale, is a predictor of LBP (RR=1.79) and neck pain (RR=2.56) (Hamberg-van Reenen et al., 2008). Thus, to prevent neck and low back pain, sitting person should regularly adjust their body position before they feel/perceived discomfort.

The discomfort or pain varies directly with the time during which the tissue is subjected to the pressure. One of the most generally accepted methods of preventing pressure related discomfort is to reduce the duration of pressure on a particular site by regular repositioning (Hostens et al., 2001). Dynamic sitting has been found to minimize neck and low back discomfort (LBD) during prolonged sitting through alternating activity between different parts of the trunk muscles. The shifts in posture may allow periodic resting of the musculature through load migration between the passive tissues and to mitigate fatigue (van Dieen et al., 2001). Also, postural changing while sitting can increase subcutaneous oxygen saturation, which positively influences tissue viability (Reenalda et al., 2009). Many researchers have examined the effectiveness of sitting in dynamic chairs and found that dynamically changing the positions of the lumbar vertebrae and pelvis during sitting has been found to help reduce posture-related pain (Tanoue et al., 2016). O'Keeffe et al. compared the effects of a dynamic chair and a standard office chair designed. They reported that sitting on a dynamic chair resulted in less seated LBD than sitting on a standard office chair (O'Keeffe et al., 2013). These results can be implied that, increased LBD during sitting can be minimized through modifying chair design via the dynamic sitting approach. Mechanisms that minimize seated discomfort may be of relevance in LBP management, as part of a biopsychosocial management plan.

2.8 Devices providing postural change while sitting

In recent decades, there has been considerable emphasis on the potential role of dynamic sitting approaches to facilitate spinal micro-movement as a means of reducing LBP/LBD while sitting (van Dieen et al., 2001). Dynamic sitting approaches refers to "increase motion during sitting which is facilitated by the use of specific chair or equipment" (O'Sullivan et al., 2012). Since 1998, there are many chairs design or assistive device to facilitate movement during sitting, i.e., the Back App (O'Sullivan et al., 2012), the forward-inclined saddle chair (O'Keeffe et al., 2013), and triangular dynamic cushion (Fettweis et al., 2017).

Summarized below are five current specific chairs/device design that require the sitter to generate dynamic sitting using alternating muscle group activity (Fig 7).

1) The Core-flex chair features a longitudinally split seat pan that allows lumbo/pelvic/hip motion driven by alternating active ankle plantar/dorsi flexion and a 10° range of alternating hip flexion/extension in a simulated walking action (Pynt, 2015) (Fig 7, A).

2) The Duo balans is a modern day rocking chair that uses trunk movement to vary between reclined, upright and forward inclined postures. It is the current evolution of the original HA°G balans and Variable balans (Pynt, 2015) (Fig 7, B).

3) The Back App seat (O'Sullivan et al., 2012) and The forward-inclined saddle chair (O'Keeffe et al., 2013) is a forward-inclined saddle chair with the principles of dynamic sitting. It is flat under the ischial tuberosities, forward sloping under the thighs, thereby increasing the trunk–thigh angle, resulting in reduced hip flexion. This revisits ergonomic design and recommendations that forward tilt seating encourages lumbar lordosis and facilitates forward oriented tasks (Fig 7, C).

4) The Locus Seat is a perch sit/stand stool is an adjustable desks allowing for intermittent sitting and standing. A spring loaded leg providing forward and return movement driven by flexion and extension of the knees. It is claimed that the design places the sitter in a neutral posture creating equilibrium between spinal and abdominal musculature, decreases muscle activity, fatigue, leg edema, and pain, increases motion, respiratory and circulatory function (LeMarras, 2016) (Fig 7, D).

5) The triangular dynamic cushion is the rubber triangular dynamic cushion which was inflated with air. The triangular pelvic support help to facilitate the opening of the trunk–thighs angle and consequently the anterior tilt of the pelvis and the physiological curves of the spine. Others authors have also recommended the use of a disc inflated with air to increase dynamism in sitting position (Fettweis et al., 2017) (Fig 7, E).

Figure 7 *Specific chairs or device design for dynamic sitting.*

CHAPTER 3

The effects of postural shifting frequency on perceived musculoskeletal discomfort during 1-hour sitting in office workers

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Abstract

Objective: To evaluate the effects of postural shifting frequency on perceived musculoskeletal discomfort during 1 hour of sitting in healthy office workers.

Method: An experimental study comparing three different postural shifting frequencies was conducted in 60 healthy office workers who were asked to sit for an hour. The effects of three postural shifts (i.e., 10, 20, and 30 times/h) on discomfort, measured by Borg's CR-10 scale, were compared. A seat pressure mat was used to confirm an individual's postural shift.

Results: Postural shifting frequency of 10-30 times/h had significant effects on perceived discomfort in the neck, shoulder, upper back, and low back during 1-hour sitting. At the neck and shoulder, a postural shifting frequency of 30 times/h significantly reduced perceived discomfort compared to a postural shifting frequency of 10 times/h during 1-hour sitting. At the upper and low back, a postural shifting frequency of 20-30 times/h significantly reduced perceived discomfort compared to a postural shifting frequency of 10 times/h.

Conclusions: Postural shifts of 30 times/h provide the buffering effects on perceived musculoskeletal discomfort at the neck, shoulder, upper back, and low back. Further research on the relationship between frequency of postural shifts and the

development of musculoskeletal disorders in those required to sit for long periods should be investigated.

3.1 Introduction

Musculoskeletal disorders (MSDs), particularly in the neck and low back, are regarded as major health problems among office workers, contributing significantly to absenteeism, disability, and compensation claims (Eltayeb et al., 2007; Janwantanakul et al., 2008; James et al., 2018). The main work tasks of office workers are computer-related tasks, attending meetings, making phone calls, giving presentations, with relatively little time spent walking, standing, or lifting (Huysmans et al., 2012). Sedentary work commonly involves prolonged and static sitting, which can lead to muscle tension and fatigue (Aarås et al., 2000; Aota et al., 2007; van Dieën et al., 2009). Sitting in a fixed posture also induces passive loading onto the spine and the body. With insufficient recovery, the adverse effects of prolonged and static sitting include musculoskeletal discomfort and complaints (Callaghan and McGill, 2001; Hamberg-van Reenen et al., 2008). Discomfort, referring to the expression of sensations such as tension, fatigue, soreness, pain and numbness (De Looze et al., 2003), is understood to reflect an early noxious perception related to the biomechanical load applied to the musculoskeletal system. The signs of body perceived discomfort are a strong predictor of MSDs, i.e., neck pain (relative risk [RR] = 2.56), shoulder pain (RR = 1.90), and low back pain (RR = 1.79) (Hamberg-van Reenen et al., 2008).

Previous research has shown that perceptions of discomfort during sitting increase gradually over time. Postural changes while sitting are regarded as a natural coping response to diminish the perception of discomfort and to relieve the perceived pressure of compressed body parts (Vergara and Page, 2002; Hermann and Bubb, 2007). Dynamic sitting, defined as behaviors that facilitate spinal micro-movement, has been proposed to minimize discomfort during prolonged sitting through alternating activity in the trunk muscles (van Deursen et al., 1999; Kingmavan Dieën, 2009; O'Sullivan et al., 2012), reducing spinal loads (Callaghan and McGill, 2001), and promotion of the flow of fluids and nutrients(Reenalda et al., 2009). Average frequency of postural shifts during sitting in healthy participants have been reported to range from 8 to 19 times/hour (Linder-Ganz et al., 2007; Reenalda et al., 2009; Akkarakittichoke and Janwantanakul, 2017; Sammonds et al., 2017). Recent studies have shown that individuals with back pain exhibited a more static sitting behavior (Vergara and Page, 2002; Dankaerts et al., 2006a) and chronic low back pain workers had less frequent postural shifts than healthy workers by 43% during 1 hour of sitting (Akkarakittichoke and Janwantanakul, 2017).

To date, no study has identified the frequency of postural changes required to adequately minimize the perception of discomfort during sitting. Addressing this knowledge gap is the primary aim of the present study. Thus, the researchers sought to compare body perceived discomfort during 1-hour sitting among three different postural shifting frequencies in young healthy office workers and we hypothesized that an increase in the frequency of postural shifts would lead to a lower body perceived discomfort in young healthy workers.

3.2 Methods

A repeated measures design was utilized since three frequency rates of postural shifting (i.e., 10, 20, and 30 times/hour) were collected at multiple time points (i.e., baseline, 10th, 20th, 30th, 40th, 50th, and 60th minute).

Participants

Permission to conduct the study was granted by the University Human Ethics Committee. A pilot study using the same methods as this study was conducted to determine the sample size. A sample of 60 workers would provide sufficient power (80%) to detect a large effect (f = 0.55 - 0.7) for the comparison of body perceived discomfort during 1-hour sitting among three different postural shifting frequencies in a repeated-measures design.

Participants were included in the study if they were 20-45 years of age, had at least 5 years of work experience, had a body mass index (BMI) between 18.5-23 kg/m2 (Anuurad et al., 2003), and were able to use a computer with any style of typing (e.g., touch typing, “hunt and peck” typing, or hybrid). Exclusion criteria were having neck or low back pain in the previous week (Tsauo et al., 2007; Hush et al., 2009), having chronic neck and/or low back pain (Deyo et al., 2014), having a current or past history of spinal disorders, the presence of signs of neurological deficits (i.e., muscle weakness or loss/disturbance of sensation), or a diagnosis of conditions which are often associated with pain (e.g., osteoarthritis, rheumatoid arthritis, gout, kidney disease, abnormal spinal structure, open wound or contusion at the buttocks and posterior thigh region, hemorrhoids, or pregnancy).

Equipment

To objectively assess postural shifts, seat pressure distribution measurement was used and recorded by a seat pressure mat (ConforMat; Tekscan Inc., Boston, MA, USA) with a specific-designed program (ConforMat Research, version 7.10c; Tekscan Inc.) (Fig. 8). The seat pressure mat consists of 1024 pressure sensing elements (i.e., 32 x 32 square [15 x15 mm2]) which were calibrated with an upper limit of 32.5 kPa (250 mmHg) and a lower limit of 0.7 kPa (5 mmHg). The sampling frequency for seat pressure distribution was chosen at 5 Hz. The auto adjusted sensitivity were performed following the manufacturer's instructions.

Seat pressure distribution data were recorded by using the ConforMat Research program to identify the number of postural shifts through the dispersion index (DI). The DI is defined as a relative measure of the load on the tuberal zone divided by the total load on the sitting surface. The DI data of both ischial tuberosities were used for analysis. A MATLAB script, version 9.5 (The MathWorks Inc., Nattick, MA, USA) was employed to calculate the defined region that was expected to be an area around the ischial tuberosities; this region was defined by a zone of 6 x 6 pressure sensors (9 x 9 cm).

To define postural shift, the sum of the mean DI values of both ischial tuberosities was defined as postural shifts in sagittal planes. The ratio of the mean DI values of both ischial tuberosities was defined as postural shifts in frontal planes. A postural shift was identified when the signal exceeded the threshold, which is a ±10% for both sagittal and frontal movements. The combination of postural shift in the frontal and sagittal plan were considered as a total postural shift in 1 hour of sitting. Posture shifts that occurred within 1 minute were regarded as one postural shift (Reenalda et al., 2009).

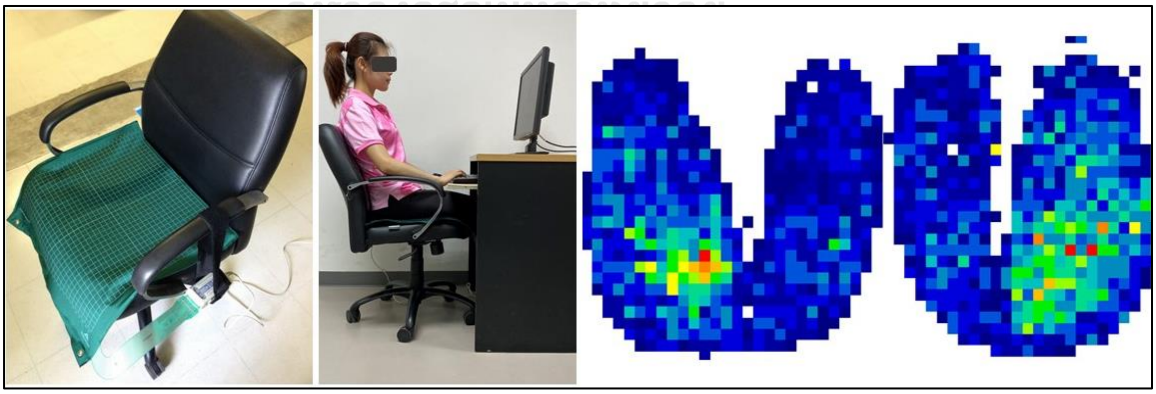

Figure 8 *Seat pressure mat (A), experimental setup for data collection (B), and seat pressure distribution (C).*

Experimental procedure

Each participant was tested in all three postural shifting frequencies (i.e., 10, 20, and 30 times/hour) on one occasion. The participant was given 20 minutes for recovery between each postural shifting frequency testing. The order of the postural shifting frequency was randomly selected using a Latin square. Before testing, the study procedures were explained to the participants, and they were allowed to practice for about 10 minutes in a room with a constant temperature of 25°C.

Participants sat on a seat pressure mat which was fixed to the adjustable office chair using Velcro® tape. The adjustable office chair (Model E61B, Modernform Group Pub Co. Ltd., Bangkok, Thailand) was made of polypropylene form (width x length x height = 45 cm x 50 cm x 11.5 cm) which had a density of 40.4 kg/m3. In the starting position, participants sat with hips and knees at 90° flexion, thigh parallel to the floor, and feet contact firmly on the floor. The distance between a monitor and the participant was kept between 18-30 inches, and screen height was approximately at eye level (Cook and Burgess-Limerick, 2003). The participants were asked to continuously type a standardized text passage at their own normal pace for an hour during which pressure distribution data were collected to assess a postural shift. The 1-hour period of testing was chosen based on previous studies showing increased physiological changes after 30 - 45 min (Dunk and Callaghan, 2010; Akkarakittichoke and Janwantanakul, 2017). During 1 hour of testing, participants were asked to change their sitting posture with constraints imposed on leg crossing or lifting the buttocks following an auditory signal which was set to alert them every 2, 3, or 6 minutes. They were told to avoid talking as well as to maintain their sitting posture as much as possible (until they were notified to change positions) during the sessions. During the 20-minute recovery period, participants were asked to stand up and move around to encourage recovery and avoid the cumulative effect of discomfort and fatigue (Le and Marras, 2016).

Outcome Measures

The Borg CR-10 scale, a tool for assessing postural discomfort, was used to determine each participant’s level of discomfort during the experimental sessions. The Borg CR-10 scale has been used in other studies as a measuring tool for musculoskeletal discomfort (Hamberg-van Reenen et al., 2008; Hiemstra-van and Mastrigt et al., 2015) and with subjects as they sit engaging in office tasks (Roossien et al., 2017). The area of body regions (i.e., the neck, shoulder, elbow, wrist, upper back, low back, buttocks, hip/thigh, knee and ankle) was defined according to a body chart from a modified Nordic questionnaire (Kuorinka, 1987). Participants were asked to identify which body regions they felt uncomfortable and how much discomfort was felt (on a scale of 0 - 10; with 0 being “No discomfort” and 10 being “Extreme discomfort”) (Borg, 1990). The Borg CR-10 was administered before and then every 10 minutes during the sitting sessions.

Statistical Analyses

Participants' characteristics, number of postural shifts, and perceived musculoskeletal discomfort score were described by means or proportions. A series of Shapiro-Wilk tests were conducted to ensure that the study variables were distributed normally, and the results of these analyses indicated normal distributions. The effects of time, postural shifting frequency, and their interaction on the composite Borg scores were evaluated using a repeated measure analysis of covariance (ANCOVA), with the Borg score at the beginning as the covariate. When a significant interaction between independent variables was found, the effect of each variable was examined separately using one-way ANCOVA. The Bonferroni procedure was performed to determine whether two selected means significantly differed from each other. Statistical analyses were performed using SPSS statistics software, version 17.0 (SPSS Inc., Chicago, IL, USA). For all tests, statistical significance was determined at the .05 level.

3.3 Results

A total of 60 sedentary workers participated in the study. Table 1 presents the characteristics of the study participants. All participants completed the study procedures without interruption and none reported any adverse effects, nor were any adverse effects (other than increased discomfort) observed. Average (±SD) number of postural shifts during 1-hour of sitting in the three groups were 13.2 (±2.5), 22.2 (±2.1), and 30.1 (±2.6) times/h.

Table 1 *Characteristics of participating office workers (n = 60).*

Characteristics	N (%)	Mean (SD)
Age (year)		30.7 (3.6)
Gender		
Male	22 (36.7)	
Female	38 (63.3)	
Weight (kg)		60.4 (9.7)
Height (cm)		165.5 (7.1)
Body mass index (kg/m2)		22.9 (1.8)
Working experience (year)		8.1 (2.6)

A repeated measures ANCOVA indicated significant interaction effect between postural shifting frequency and time on Borg score for the neck, shoulder, upper back, and low back (Table 2). Thus, follow-up analyses were conducted by using one-way ANCOVA to investigate the effect of time (i.e. at the 10th, 20th, 30th, 40th, 50th, and 60th minutes) on Borg scores in each postural shifting frequency (i.e. 10, 20, and 30 times/h) and the effect of postural shifting frequency on Borg scores at each time point.

Table 2 *A repeated measures analysis of covariance of Borg CR-10 during 1-hour sitting for postural shifting frequencies of 10, 20, and 30 times/hour.*

		Df	F	P value
Neck	Group	2	28.101	.034*
	Time	6	3.434	<.01*
	Group x Time	12	2.133	.013*
	Error	176		
	Error (Time)	1056		
Shoulder	Group	2	4.403	.014*
	Time	6	17.769	<.01*
	Group x Time	12	1.87	.034*
	Error	176		
	Error (Time)	1056		
Elbow	Group	2	2.249	.104
	Time	6	15.701	<.01*
	Group x Time	12	1.311	.206
	Error	176		
	Error (Time)	1056		
Wrist	Group	2	.798	.452
	Time	6	12.888	<.01*

	Group x Time	12	.544	.887
	Error	176		
	Error (Time)	1056		
Upper back	Group	2	4.524	.012*
	Time	6	45.054	<.01*
	Group x Time	12	2.013	.020*
	Error	176		
	Error (Time)	1056		
Low back	Group	2	5.502	.005*
	Time	6	80.826	<.01*
	Group x Time	12	5.613	<.01*
	Error	176		
	Error (Time)	1056		
Hip/thig	Group	2	1.497	.227
	Time	6	40.770	<.01*
	Group x Time	12	.944	.26
	Error	176		
	Error (Time)	1056		
Knee	Group	2	1.421	.244
	Time	6	13.6	<.01*
	Group x Time	12	1.725	.057
	Error	176		
	Error (Time)	1056		

Ankle	Group	2	1.421	.244
	Time	6	13.6	<.01*
	Group x Time	12	1.725	.057
	Error	176		
	Error (Time)	1056		

Group: postural shifting frequency 10, 20, and 30 times/hour; Time: 10, 20, 30, 40, 50, and 60 minutes; Df: Degree of freedom; F: F-statistic; * $p < .05$

Effect of time on perceived discomfort

The post hoc Bonferroni test indicated that Borg scores at the neck, shoulder, upper back, and low back was significantly affected by sitting duration ($p<.05$). Regardless of postural shifting frequency, Borg scores at the neck, shoulder, upback, and low back significantly increased after sitting for 10 minutes compared to baseline (Fig. 9).

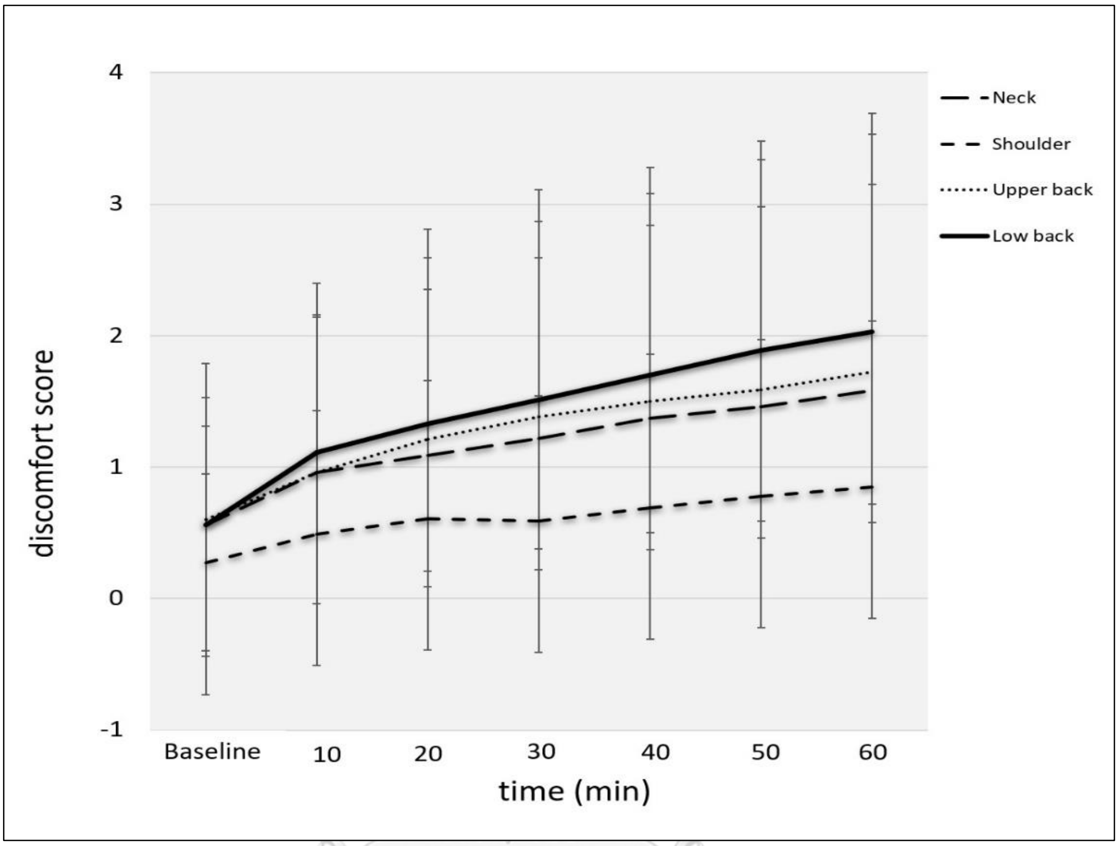

Figure 9 *Mean Borg CR-10 scores at the neck, shoulders, upper back, and lower back during 1-hour sitting (n = 60).*

Effect of postural shift frequency on perceived discomfort

At the neck, the post hoc Bonferroni test indicated significant differences ($p<.05$) in Borg scores between the postural shifting frequency of 10 and 30 times/h at the 40th - 60th minutes (Table 3 and Fig.10). At the shoulder, there were significant differences ($p<.05$) in Borg scores between the postural shifting frequency of 10 and 30 times/h at the 20th, 30th, and 60th minutes.

At the upper back, significant differences ($p<.05$) in Borg scores were found between the postural shifting frequency of 10 and 30 times/h during 60 minutes of sitting, except at the 40th minutes. Also, there were significant differences ($p<.05$) in Borg scores between the postural shifting frequency of 10 and 20 times/h at the 10th and 20th minutes.

At the low back, significant differences ($p<.05$) in Borg scores were found between the postural shifting frequency of 10 and 30 times/h at the 20th - 60th minutes. Also, there were significant differences ($p<.05$) in Borg scores between the postural shifting frequency of 10 and 20 times/h at the 40th - 60th minutes.

Table 3 Comparisons of Borg CR-10 during 1-hour sitting with postural shifting frequencies of 10, 20, and 30 times/hour.

	Mean (95% CI)**			F statistics	df	P value***
	10 times/h	20 times/h	30 times/h			
Neck						
Baseline	.55 (.51, .59)	.56 (.54, .62)	.55 (.51, .59)	.499	12,1056	.608
10 min	.89 (.73, .592)	.82 (.67,.98)	.72 (.56,.87)	1.215	12,1056	.299
20 min	1.17 (.97, 1.37)	1.01 (.81, .1.21)	.87 (.66, 1.06)	2.234	12,1056	.110
30 min	1.21 (.98, 1.44)	1.07 (.83, 1.29)	.93 (.70, 1.65)	1.401	12,1056	.249
40 min	1.37 (1.11, 1.63)	1.23 (.97, .1.48)	.92 (.66, 1.17)	3.060	12,1056	.049*
50 min	1.47 (1.19, 1.75)	1.34 (1.06, 1.62)	.97 (.68, 1.24)	3.392	12,1056	.036*
60 min	1.70 (1.39, 1.9)	1.39 (1.88, 1.67)	1.07 (.76, 1.37)	4.193	12,1056	.017*
Shoulder						

Baseline	.27 (.27, .27)	.27 (.27, .27)	.27 (.27, .27)	.110	12,1056	1.000
10 min	.67 (.49, .83)	.44 (.26, .60)	.38 (.21, .55)	2.153	12,1056	.055
20 min	.83 (.61, 1.04)	.57 (.35, .77)	.42 (.21, .63)	3.705	12,1056	027*
30 min	.76 (.59, .93)	.57(.40, .74)	.42 (.26, .61)	3.532	12,1056	.031*
40 min	.86 (.61, 1.11)	.69 (.44, .93)	.53 (.28, .78)	1.672	12,1056	.191
50 min	1.05 (.81, 1.28)	.64 (.41, .87)	.65 (.41,.88)	2.850	12,1056	.053
60 min	1.17 (.91, 1.41)	.69 (.43, .93)	.71(.45, .95)	4.530	12,1056	.012*
Upper back						
Baseline	.60 (.57, .63)	.59 (.57, .61)	.59 (.57, .61)	1.718	12,1056	.104
10 min	1.20 (.71, 1.05)	.87 (.70, 1.05)	.80 (.62, .97)	4.876	12,1056	.009*
20 min	1.50 (.86, 1.32)	1.09 (.86, 1.32)	1.01 (.78, 1.25)	3.661	12,1056	.028*
30 min	1.62 (1.13, 1.67)	1.40 (1.13, 1.67)	1.10 (.83, 1.37)	2.872	12,1056	.037*
40 min	1.74 (1.22, 1.81)	1.52 (1.22, 1.81)	1.24 (.94, 1.53)	3.051	12,1056	.055
50 min	1.8 (1.28, 1.92)	1.60 (1.28, 1.92)	1.28 (.96, 1.61)	3.549	12,1056	.031*

60 min	2.09 (1.29, 2.02)	.66 (1.29, 2.02)	1.40 (1.04, 1.77)	3.984	12,1056	.037*
Low back						
Baseline	.45 (.46, .46)	.45 (.46, .46)	.45 (.46, .46)	.073	12,1056	1.000
10 min	.89 (.72, 1.06)	1.02 (.86, 1.2)	.84 (.67, 1.08)	1.321	12,1056	.269
20 min	1.44 (1.2, 1.68)	1.10 (.86, 1.35)	1.02 (.78, 1.26)	3.300	12,1056	.039*
30 min	1.64 (1.37, 1.92)	1.27 (.99, 1.55)	1.09 (.82, 1.36)	4.189	12,1056	.017*
40 min	1.90 (1.63, 2.18)	1.42 (1.15, 1.69)	1.25 (.98, 1.52)	5.965	12,1056	.003*
50 min	2.16 (1.86, 2.45)	1.61 (1.32, 1.91)	1.34 (1.05, 1.63)	7.871	12,1056	.001*
60 min	2.29 (1.97, 1.6)	1.74 (1.42, 2.05)	1.40 (1.16, 1.79)	6.727	12,1056	.002*

CI, Confidence interval; * $p < .05$; ** Bonferroni procedure; *** One-way analysis of covariance

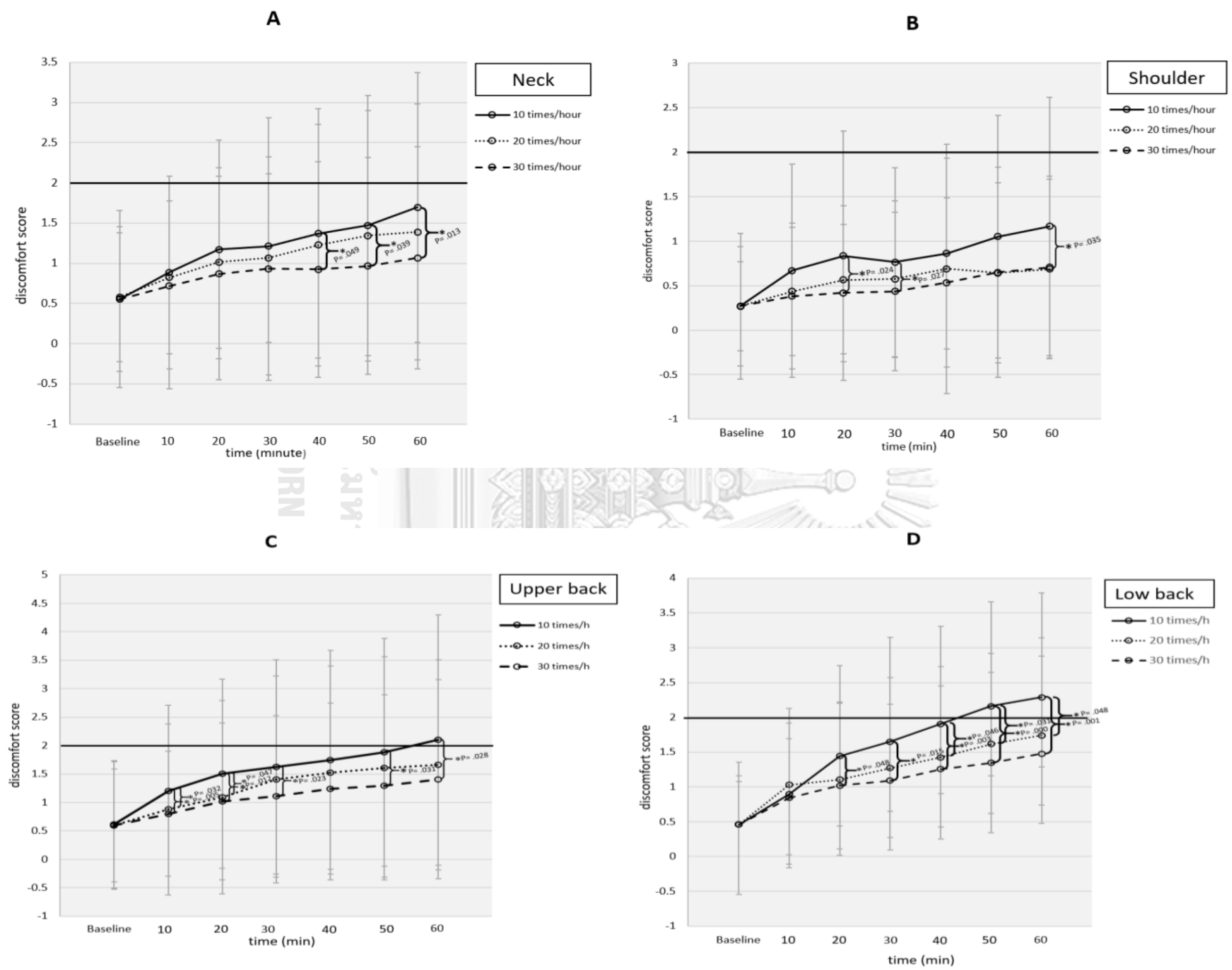

Figure 10 *Mean Borg CR-10 scores during 1-hour sitting with postural shifting frequencies of 10, 20, and 30 times/hour at the neck (A), shoulder (B), upper back (C), and low back (D) (n = 60). *Significantly different between groups; p<0.05*

3.4 Discussion

This study aimed to compare the effect of different postural shifting frequencies, i.e. 10, 20, and 30 times/h, on perceived musculoskeletal discomfort during 1 hour of sitting. The results showed that sitting for as short a period of time as 10 minutes may lead to increased perceived musculoskeletal discomfort in the neck, shoulder, upper back, and low back. A postural shift frequency of 30 times/h significantly led to lower perceived discomfort in the neck, shoulder, upper back, and low back compared to a postural shift frequency of 10 times/h during 1 hour of sitting. We also found that a postural shifting frequency of 20 times/h may be effective to reduce discomfort in the upper and low back compared to a postural shifting frequency of 10 times/h.

Several studies have found that perceived discomfort increased overtime during prolonged sitting (Vergara and Page, 2002; Sondergaard et al., 2010; Akkarakittichoke and Janwantanakul, 2017). Our findings are in line with previous studies showing that prolonged sitting leads to increased discomfort particularly in the neck, shoulder, upper back, and low back. Prolonged sitting leads to an increase in the physical load on both contractile and non-contractile tissues, which has been identified as an intrinsic factor in the development of musculoskeletal disorders (MehtaTewari, 2000; Szeto et al., 2009; MörlBradl, 2013) Continued muscle activation in long period of time during static sitting can cause localized muscle tension, muscle strains, muscle fatigue, and other soft-tissue damage (Aota et al., 2007; van Dieën et al., 2009). During sitting, most of the body weight is mainly supported down to the spinal column and this exposes the spine and intervertebral disc to a greater compressive loading, leading to discomfort in the spinal region (Mehta and Tewari, 2000; Zenk et al., 2012).

Dynamic sitting has been introduced to minimize discomfort during prolonged sitting by facilitating spinal movement and decreasing static muscle activity (van Dieen et al., 2001; O'Sullivan et al., 2012). Increased postural movement whilst sitting has been associated with less spinal load and reduced loss of disc height (Mehta and Tewari, 2000; van Dieen et al., 2001). People usually move or fidget in the seat when discomfort reaches a detection threshold. However, by the time discomfort is detected, it is possible that the process of irritation or damage to the tissues may have already begun and might be too late to benefit from postural shifts (Hermann and Bubb, 2007). Thus, individuals should be encouraged to change their sitting posture before discomfort reaches detection. Cook and Burgess-Limerick advocated that a 'correct' sitting posture should allow for dynamic behavior with frequent small postural changes, rather than one 'ideal' posture

Evidence suggests that the most common musculoskeletal complaints during prolonged sitting are neck and low back pain followed by shoulder, buttocks, and thighs (Vergara and Page, 2002). The results of the present study indicated that frequent postural shift can reduce perceived discomfort at the neck, shoulder, upper back, and low back during 1 hour of sitting. A postural shifting frequency of 30 times/h significantly led to a reduction of neck, shoulder, upper back, and low back discomfort compared to a postural shifting frequency of 10 times/h. This is the first study reporting the positive effect of postural shifting frequency on perceived discomfort in the neck and shoulder. More work is needed to validate the findings of the present study, e.g. a comparison of body perceived discomfort between different postural shifting frequencies and natural postural shifting frequency during prolonged sitting. Reduced discomfort in the neck and shoulder during 1 hour of sitting with postural shifting frequency of 30 times/h in comparison with 10 times/h may relate to alteration in neck/shoulder muscle activation (Caneiro et al., 2010) and promotion of the flow of fluids and nutrients (Reenalda et al., 2009). Changing sitting postures may mitigate postural discomfort during prolonged sitting through alternating activity between different parts of the neck and shoulder muscles. Previous studies have identified static neck posture as a possible risk factor in neck pain (Aaras et al., 1997; Szeto et al., 2009). Caneiro and colleagues investigated the influence of different sitting postures on cervico-thoracic muscle activity and found that changing sitting postures resulted in different levels of cervicothoracic muscle activity. Postural shifts may possible to allow periodic resting of the musculature through load migration between the passive tissues and to relieve fatigue (van Dieen et al., 2001; Maradei et al., 2017). Additionally, lack of movement during prolonged sitting may decreases fluid and nutrition exchanged in the intervertebral discs and may actively contribute in advancing the phases of degenerative disk disease (MörlBradl, 2013; Maradei et al., 2017). Postural shift has been shown to increase subcutaneous oxygen saturation on average by 2.2% with each posture adjustment, indicating the positive effects of posture shifts on tissue viability (Reenalda et al., 2009).

The results demonstrated that frequent postural shift reduced perceived discomfort in the upper and low back. A postural shifting frequency of 20-30 times/h significantly reduced upper and low back discomfort compared to a postural shifting frequency of 10 times/h during 1 hour of sitting. The International Standards Organization guideline ISO/FDIS 11226 for static working postures states that working in static postures should not cause discomfort exceeding 20% of the maximal holding time and a rating of 2 on the Borg CR-10 scale is the equivalent of 20% of the maximal holding time. Hamberg-van Reenen and colleagues conducted a prospective cohort study with 3-year follow-up and found that a discomfort level of 2 (little discomfort) at least once during a working day is a predictor of future neck, shoulder, and low back pain. Based on the results of the current study, postural shifting frequency of 20-30 times/h was associated with a discomfort score of less than 2 during 1 hour of sitting. Several studies have found similar trends linking increased motion with decreased discomfort in the low back during prolonged sitting (van Deursen et al., 1999; O'Keeffe et al., 2013; Maradei et al., 2017). Trunk muscle fatigue occurs when contractions as low as 2–5% maximum voluntary contraction are sustained for as little as 30 min among pain-free participants (van Dieën et al., 2009). Changing sitting postures may decrease static trunk muscle activity, resulting in reduced trunk muscle fatigue and delay the time to discomfort.

The findings of the present study support the potential importance of postural shifts during prolonged sitting to help individuals avoid the negative effects of prolonged sitting on perceived musculoskeletal discomfort. Postural shifting frequency of 30 times/h has been found to be effective in alleviating perceived discomfort, which is a strong predictor of musculoskeletal disorders, in the neck, shoulder, upper back, and low back during 1-hour sitting. Thus, to improve musculoskeletal health, breaking up long periods of sitting through frequent changes of sitting postures should be encouraged among those often required to sit for many hours on a daily basis.

Strengths and Limitations

A major strength of this study is that the characteristics of postural shift were objectively and continuously assessed using a seat pressure mat, which provided ongoing distribution measurement. However, there are a number of methodological limitations that should be taken into consideration. First, the present study only investigated body perceived discomfort with three different postural shifting frequencies in young healthy office workers. Changes in body perceived discomfort during various postural shifting frequencies in those with neck or low back pain may not follow the same pattern. Thus, extrapolation of these results to individuals with neck or low back pain should be made with caution. Further research is required to examine the effect of postural shifting frequency on body perceived discomfort in those with neck or low back pain. Second, the study was performed in a highly controlled laboratory setting. While this level of control allowed us to test the study hypotheses, the extent to which the findings generalize to real life office settings is limited. Research to study the effects of posture change frequency in real life settings is needed to help establish generalizability. Third, the primary dependent variable of this study – body perceived discomfort – was assessed using a self-report scale. Because pain and discomfort are biopsychosocial phenomenon influenced by many different factors, factors other than time and frequency of position changes likely influenced the reported scores. Research using more objective measures (e.g., observed pain behaviors in laboratory studies, work sick days in real-world studies) would help to establish the validity of the current findings. Last, there is a lack of international consensus over the operational definition of postural shift. Thus, calculating a postural shift is difficult. In our study, posture shifts that occurred within 1 minute were regarded as one postural shift, according to the methodology recommended by Reenalda and colleagues. Different results may emerge with different calculation methods of postural shift. Although this issue is beyond the scope of this study, it warrants further investigation.

3.5 Conculsion

Within the limitations of the study, the findings provide new information regarding the role of frequency of postural shifts on the development of perceived discomfort in various body regions. Consistent with previous research, we found that the longer a person spends in a sitting position, the more likely they are to report discomfort in the neck, shoulder, upper back, and low back. The impact of time on perceived discomfort is influenced by the frequency of postural shifts, with postural shifts of 30 times/h providing the buffering effects on musculoskeletal discomfort. Further research is needed to examine the role of postural shifting frequency on the development of musculoskeletal disorders, particularly in the neck and low back, in those often required to sit for many hours on a daily basis.

Authors' contributions

The authors have contributed in the following ways: NA provided the concept/research design, data collection, data analysis and manuscript writing. PW and PJ contributed to the concept/research design, data analysis and manuscript writing. All authors read and approved the final manuscript

Competing Interests

The authors declare that there are no conflicts of interest.

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Summary

This study revealed sitting for as short a period of time as 10 minutes may lead to increased perceived musculoskeletal discomfort. A postural shift frequency of 30 times/h significantly led to lower perceived discomfort in the neck, shoulder, upper back, and low back. We also found that a postural shifting frequency of 20 times/h may be effective to reduce discomfort in the upper and low back compared to a postural shifting frequency of 10 times/h (i.e., natural shifting frequency). Therefore, a postural shifting frequency of 20-30 times/h would be applied in the algorithm of smart seat in the study aimed to investigate the effect of postural shift on reducing the onset of neck and low back pain (CHAPTER 4).

CHAPTER 4

Effect of active break and postural shift intervention on prevention neck and low back pain among high-risk workers: a 12-month cluster-randomized controlled trial

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Abstract

Objective: This study aims to evaluate the effects of the active break and postural shift intervention on the 12-month incidence of the onset of neck and low back pain in high-risk office workers.

Methods: A 3-arm cluster-randomized controlled trial with 12-month follow-up was conducted in healthy but high-risk office workers. Participants were recruited from 6 large-scale enterprises (n=196) and were randomly assigned at the cluster level into active break intervention (n=47), postural shift intervention (n=46) and control (n=100) groups. Participants in the intervention group received a custom-designed apparatus to facilitate designated active break and postural shift during work. Participants in the control group received a placebo seat pad. The outcome measure was the 12-month incidence of the onset of neck and low back pain. Analyses were performed using the Cox proportional hazard models.

Results: The 12-month incidences of the onset of neck pain in the active break, postural shift, and control groups were 23%, 26%, and 52%, respectively. For new onset of low back pain, these percentages were 13%, 20%, and 45%, respectively. Hazard rate (HR) ratios after adjusting for biopsychosocial factors indicated a protective effect of the active break and postural shift interventions for neck pain [HRadj= 0.46, 95% confidence interval (CI) 0.23–0.89 for active break and HRadj 0.38, 95% CI 0.18–0.83 for postural shift] and low-back pain (HRadj= 0.33, 95% CI 0.14–0.80 for active break and HRadj=0.33, 95% CI 0.14–0.89 for postural shift).

Conclusion: Interventions to increase either active breaks or postural shift reduced new onset of neck and low back pain among high-risk office workers.

4.1 Introduction

Neck and low back pain are the most important musculoskeletal problems for office workers. Prevalence of neck pain among office workers was 46% annually (Ehsani et al., 2017) and 31% of office workers developing a new onset of neck pain every year (Areerak et al., 2018). Low back pain affects between 34% and 51% of office workers annually (Janwantanakul et al., 2008; Ayanniyi et al., 2010), while 14% reported a new episode of low back pain every year (Sitthipornvorakul et al., 2015). Neck and low back pain causes personal suffering, disability, and impaired quality of work and life in general, which contributes to a great socioeconomic burden (Manchikanti, 2000; Cote et al., 2009).

Office work mainly involves computer use, participation in meetings, reading, and phoning. A typical workday for many office workers is characterized by desk-based work, which entails several hours of sitting. Individuals with prolonged sitting have been found to experience increased musculoskeletal discomfort over time, particularly in the neck and low back (Sondergaard et al., 2010; Waongenngarm et al., 2020). Evidence suggests that signs of bodily perceived discomfort, such as tension, fatigue, soreness, or tremors, are a predictor of musculoskeletal disorders (Hamberg-van Reenen et al., 2008).

A number of interventions have been proposed to alleviate the adverse effects of prolonged sitting, including breaks (McLean et al., 2001; Sheahan et al., 2016; Waongenngarm et al., 2018), postural shifts (Reenalda et al., 2009; Zenk et al., 2012), and ergonomic intervention (Pillastrini et al., 2010). Postural shifts while sitting are regarded as a natural coping response to diminish the perception of discomfort and to relieve the perceived pressure of compressed body parts (Vergara and Page, 2002). There has been considerable emphasis on the potential role of dynamic sitting approaches to facilitate spinal micro-movement as a means of reducing MSDs while sitting. "Dynamic sitting" refers to increased trunk motion in sitting which is facilitated by the use of specific chairs or equipment (O'Sullivan et al., 2012). Postural changing while sitting or postural shift or dynamic sitting has been found to increase subcutaneous oxygen saturation, which positively influences tissue viability (Reenalda et al., 2009). Also, dynamic sitting may minimize neck and low back discomfort during prolonged sitting through alternating activity between different parts of the trunk muscles (van Dieen et al., 2001). A specific device which can promote dynamic sitting can thus be beneficial in the prevention of MSDs in the neck and low back. Previous research has found similar trends linking increased motion with decreased discomfort in the low back during prolonged sitting (O'Keeffe et al., 2013; Maradei et al., 2017). Thus, promotion of postural shifts during sitting may be an effective intervention in the reduction of neck and low back pain.

To the best of our knowledge, there has been no randomized trial investigating the efficacy of active break and postural shift interventions in the prevention of neck and low-back pain among office workers. Therefore, the aim of this study was to evaluate the effect of the promotion of active breaks and postural shifts on new onset of neck and low-back pain during 6-month follow-up among high-risk office workers. We hypothesized that participants in the intervention groups, with increases in either active breaks or postural shifts, show reduced new onset of neck and low-back pain.

4.2 Methods

Participants

A 3-arm, parallel-group, cluster-randomized controlled trial with 6-month follow-up was conducted in a convenience sample of office workers recruited from 6 organizations, which were the government excise, public relations, and public transportation departments, the Metropolitan Waterworks Authority, and two private companies importing medical equipment and products (such as drugs and diagnostic reagents). Individuals were included in the study if aged 23–55 years, worked full-time, had a body mass index (BMI) of 18.5-25 kg/m2, had at least 5 years of experience in their current position, and were at risk of nonspecific neck pain as evaluated by the Neck Pain Risk Score for Office Workers (NROW; score ≥ 2) (Paksaichol et al., 2014) and nonspecific low back pain as evaluated by Back Pain Risk Score for Office Workers (BROW; score ≥ 53) (Janwantanakul et al., 2015). Participants were excluded if they had reported musculoskeletal symptoms in the neck or low back in the previous 6 months, reported pregnancy or had planned to become pregnant in the coming 12 months, had a history of trauma or accidents in the spinal region, or had either spinal, intra-abdominal or femoral surgery in the previous 12 months. Participants who had been diagnosed with congenital anomaly of the spine, rheumatoid arthritis, infections of the spine or discs, ankylosing spondylitis, spondylolisthesis, spondylosis, spinal tumor, systemic lupus erythymatosus, or osteoporosis were also excluded from the study.

Office workers were approached and invited to participate in this study. Office workers who expressed interest completed a short screening questionnaire, assessing aforementioned inclusion and exclusion criteria using the NROW and BROW. The NROW comprises three questions concerning lifetime history of neck pain, chair adjustability, and perceived muscular tension. The NROW has scores ranging from 0 to 4. The BROW consists of two questions concerning lifetime history of low back pain and psychological demands. The BROW has scores ranging from 12 to 69. If eligible, potential participants were informed about the objectives and details of the study and were asked to provide informed consent to participate in the research.

At baseline, participants completed the self-administered questionnaire for exposure data, i.e. confounders. Participants were randomly assigned at cluster level into either the intervention A (active break), intervention B (postural shift), or control groups. A researcher with no other involvement in the trial prepared the designation of intervention by using computer-generated randomization, which was concealed from the data collectors (PW and NA). Clusters of participants were located in the same workplace to avoid contamination of the intervention and to enhance compliance within the intervention group (Andersen et al., 2008). A total of six clusters (two clusters for the intervention group A, two clusters for the intervention group B, and two clusters for the control group) were identified and the cluster size ranged from 15 to 51 participants. Participants then received a self-administered diary to record any incidence of neck or low back pain and, if occurring, its intensity and any resulting disability. The researcher collected the diaries from participants every month over a 6-month period. The study was approved by the University Human Ethics Committee and was registered in the Thai Clinical Trials Registry (TCTR20190111002).

Baseline questionnaires

The Borg CR-10 scale was used to determine perceived discomfort (Borg, 1990). Participants were asked to indicate how much discomfort was felt in the past year at the neck and low back (on a 0–10 scale; 0 denotes no discomfort and 10 denotes extreme discomfort). Neck and low back regions were defined according to a chart based on the modified Nordic questionnaire (Kuorinka et al., 1987). In addition, the following biopsychosocial characteristics were obtained: individual, work-related (physical) factors and psychosocial work characteristics. Individual factors included gender, age, marital status, education level, frequency of regular exercise or sport, smoking habits, and number of driving hours per day. Work-related (physical) factors included current job position, number of working hours, years of work experience, frequency of using a computer, adopting working postures, performing various work activities, and rest breaks. The questionnaire also asked respondents to self-rate the ergonomics of their workstations (desk, chair, and position of monitor) and work environment conditions (ambient temperature, noise level, light intensity, and air circulation). Psychosocial work characteristics were measured using the Thai version of the Job Content Questionnaire (Phakthongsuk, 2009). The questionnaire comprises 54 items in the following six areas: psychological demands (12 items), decision latitude (11 items), social support (8 items), physical demands (6 items), job security (5 items), and hazards at work (12 items). Each item has four Likert-type response options ranging from 1: strongly disagree, to 4: strongly agree, that were summarized to obtain a sum score per area.

Description of intervention

Participants in the intervention A (active break) and intervention B (postural shift) groups received a custom-designed apparatus, which consisted of three components: 1) seat pad, 2) processor, and 3) smartphone application. The seat pad was used to collect data regarding sitting behavior, including sitting and break duration as well as number of postural shifts. Data were stored in the processor, which were used to calculate recommended active breaks and postural shifts for each individual. Instructions to have active breaks were sent from the processor to the smartphone application via Bluetooth technology. Designated postural shifts were induced by the apparatus gradually pumping the air into various parts of the seat pad placed underneath a participant’s buttocks. Commands to operate the seat pad were sent from the processor to the seat pad via a cord connected between them. The apparatus was installed by the researcher at participants’ workplaces. The researcher explained and demonstrated how to use the apparatus and participants were asked to follow the instructions conveyed via the smartphone application, i.e. having active breaks or postural shifts, as much as possible.

Each participant in the intervention A (active break) group was asked to have designated active breaks during the workdays, and they were asked not to be seated in a chair when taking the breaks. The frequency and duration of breaks were based on the theoretical effects of rest breaks on the reduction of neck and low back discomfort (Waongenngarm et al., 2018), ranging from 30 secs to 15 mins per break and 0 to 30 times per workday, depending on their occupational sitting behavior. Please note that, in cases that participants had frequent active breaks by themselves, the custom-designed apparatus would not alert participants to have active breaks during the workdays (i.e. 0 times per workday).

Each participant in the intervention B (postural shift) group was asked to make designated postural shifts during each workday. The frequency of postural shifts was based on the theoretical effects of postural shifts on the reduction of neck and low back discomfort (Reenalda et al., 2009; AkkarakittichokeJanwantanakul, 2017), ranging from 20 to 60 times per hour, depending on their occupational sitting behavior. The occupational sitting behaviors of participants in both intervention groups during the trial were assessed using the aforementioned custom-designed apparatus and collected every month during follow-up.

Participants in the control group received a placebo seat pad made of polypropylene foam (width x length x height = 40 cm x 50 cm x 1 cm) to be placed on the seat pan of a chair. During the study, participants in all groups were asked to keep the level of their leisure time physical activity unchanged.

Follow-up outcome measure

The incidence of non-specific neck or low back pain, which is neck or low back pain (with or without radiation) without any specific systematic disease being detected as the underlying cause of the complaints (Borghouts et al., 1998; Krismervan Tulder, 2007), during the 6-month follow-up period was collected using a diary. Participants answered the yes/no question “Have you experienced any neck or low back pain lasting > 24 hours during the past month?”. If they answered “Yes”, follow-up questions about pain intensity measured by a visual analogue scale, and the presence of weakness or numbness in the upper limbs were asked. Those who answered “Yes” to the first question, reported pain intensity greater than 30 mm on a 100-mm visual analogue scale, and had no weakness or numbness in the upper or lower limbs were identified as cases. Participants who reported new onset neck and low back pain were also asked about their disability level as measured using the neck disability index (NDI) (Uthaikhup et al., 2011) or Roland-Morris low back disability questionnaire (RMDQ) (Pensri et al., 2005), respectively. The NDI contains 10 items on a 5-point Likert scale and the total score of the NDI ranges from 0 to 50, with higher scores indicating more severe disability. The RMDQ comprises of 24 items and the total score is the sum of the ticked boxes. The score ranges from 0 to 24, with higher scores indicating more severe disability. Participants were followed until they completed the 6-month follow-up or withdrew from the study.

Statistical analysis

Comparisons of the baseline characteristics of participants between the intervention A (active break), intervention B (postural shift), and control groups were conducted using one-way ANOVA for continuous data and $\chi 2$ test for nominal and ordinal data. All analyses followed an intention-to-treat approach. The 6-month incidence rate of neck and low back pain was calculated for each group as the proportion of new cases, reporting neck or low back pain during the 6-month follow-up. Further follow-up data of those initially identified as cases were not used any further.

Survival analysis was used to determine Kaplan-Meier survival curves for the intervention A (active break), intervention B (postural shift), and control groups. Survival time was taken as the time (in months) from the start to the incident symptoms becoming manifested. Those participants who left the study without manifesting symptoms were no longer recorded at the time they left. The two survival curves generated by the Kaplan-Meier method were compared using the log rank test.

Hazard ratios with respect to incident cases for neck and low back pain were calculated using the Cox proportional hazards model. The other 45 possible covariates were each examined in multivariate models. If the tested covariate changed the hazard ratio of the intervention variable by 0.05 or more, then it was also included in the final, adjusted model.

Health outcomes, i.e. perceived discomfort, pain intensity, and disability for those reporting neck and low back pain, were compared between the intervention A (active break), intervention B (postural shift), and control groups using one-way ANOVA. All statistical analyses were performed using SPSS for Windows Version 23.0 (SPSS Inc, Chicago, IL). Statistical significance was set at the 5% level.

4.3 Result

The trial ran from June 2019 to May 2020. Of the total 1,600 workers who received the invitation, 654 responded (response rate: 40%). In total, 217 were eligible, 193 of whom agreed to participate in the study. Of those, 174 were successfully followed for twelve months and 19 (10%) were lost during the follow-up period because they left the companies. The sample population comprised mainly females (76%) (Table 4). Their average age was 33.8 (6.3) years. Most of the participants (95%) had graduated with at least a bachelor's degree. There were no significant differences in any of the characteristics of the participants among the three groups, except for age, BMI, education level, duration of employment, psychological job demand, and social support.

Table 4 *Baseline characteristics of participants.*

Characteristic	Mean (SD)			p value
	Intervention A (active break) group (n = 47)	Intervention B (postural shift) group (n = 46)	Control group (n = 100)	
Demographic characteristics				
Age (years)	31.6 (6.1)	35.5 (7.7)	34.1 (5.3)	0.009*
Gender: female (%)	33 (70.2)	35 (76.1)	79 (79.0)	0.507
Body weight (kg)	57.3 (10.5)	60.2 (10.2)	56.4 (13.7)	0.208
Body height (cm)	163.0 (9.1)	162.9 (7.9)	161.4 (6.9)	0.376
Body mass index (kg/m2)	21.3 (2.3)	22.3 (2.3)	21.0 (2.0)	0.004*
Marital status (%)				0.340
Single	36 (76.6)	31 (67.4)	64 (64.0)	
Married	10 (21.3)	13 (28.3)	35 (35.0)	
Divorced	1 (2.1)	2 (4.3)	1 (1.0)	
Education (%)				0.001*
Lower than Bachelor's degree	2 (4.3)	2 (4.3)	5 (5.0)	

Bachelor's degree	40 (85.1)	38 (82.6)	53 (53.0)	
Higher than Bachelor's degree	5 (10.6)	6 (13.1)	42 (42.0)	
Exercise frequency in the past 12 months (%)				0.204
Never	6 (12.8)	5 (10.9)	22 (22.0)	
Occasionally	34 (72.3)	30 (35.2)	56 (56.0)	
Regularly	7 (14.9)	10 (21.8)	22 (22.0)	
Not sure	0 (0.0)	1 (2.1)	0 (0.0)	
Driving status (%)				0.052
No	37 (78.7)	35 (76.1)	53 (53.0)	
Yes	10 (21.3)	11 (23.9)	47 (47.0)	
Work-related characteristics				
Duration of employment (years)	6.9 (4.3)	10.8 (5.3)	9.1 (4.8)	0.001*
Working hours per day (hours per day)	8.0 (1.3)	8.7 (1.3)	7.8 (0.8)	0.068
Working days per week (days per week)	5.1 (0.3)	4.8 (0.6)	5.0 (0.2)	0.052
Psychosocial characteristics				

Job control	35.1 (4.5)	35.0 (5.2)	36.6 (4.3)	0.070
Psychological job demands	30.8 (4.4)	32.5 (4.2)	33.2 (4.4)	0.009*
Physical job demands	13.2 (2.7)	13.4 (3.3)	14.1 (2.6)	0.120
Job security	16.3 (1.3)	16.3 (2.9)	16.9 (1.1)	0.073
Social support	33.1 (4.4)	30.4 (3.2)	32.9 (4.4)	0.001*
Hazards at work	15.9 (3.9)	15.5 (2.5)	17.0 (3.9)	0.051

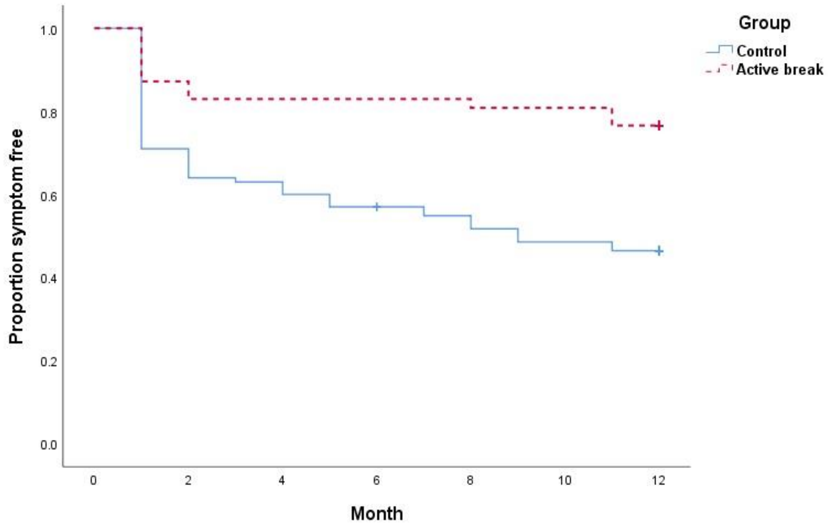
**p value < 0.05*

During March to June 2020, the COVID-19 outbreak occurred in Thailand, which forced a majority of the participants in the present study (68%) to work from home. At the time, all participants reported that they did not bring the custom-designed apparatus to use at home. Therefore, the status of working from home (yes/no) as confounder was forced into the multivariate models.

Incidence of neck and low back pain

Over the 12-month follow-up, 23% (11/47) of participants in the intervention A (active break) group, 26% (12/46) of participants in the postural shift group, and 52% (52/100) of those in the control group reported incident neck pain. For low back pain, 13% (6/47) of participants in the intervention A (active break) group, 20% (9/46) of participants in the postural shift group, and 45% (45/100) of those in the control group reported onset of low back pain. No harm or unintended effects among participants in both groups was reported.

The Kaplan–Meier survival curves for the neck and low back cohort illustrated a significant difference in time to neck and low back pain between the intervention A (active break) group and control group (log rank test probability = 0.001), and the intervention B (postural shift) group and control group (log rank test probability = 0.002; Fig 11 and 12). Participants in the control group had greater risk of neck and low back pain than those in the intervention A (active break) and intervention B (postural shift) groups.



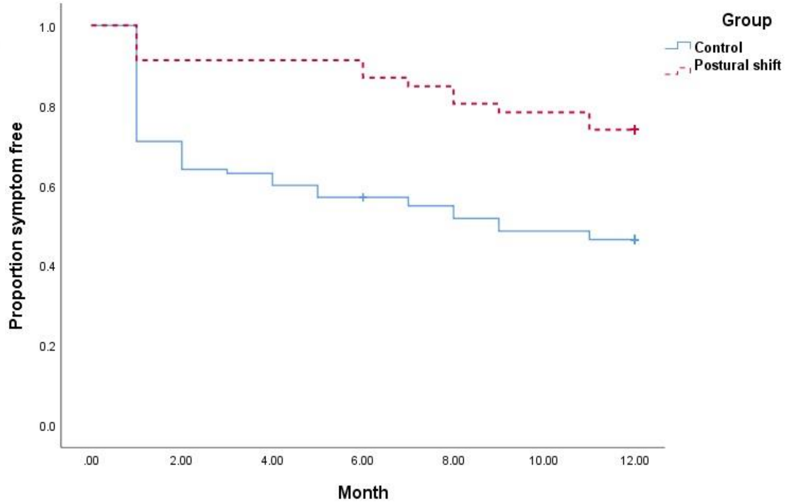


Figure 11 *The Kaplan-Meier survival curves for onset of neck pain.*

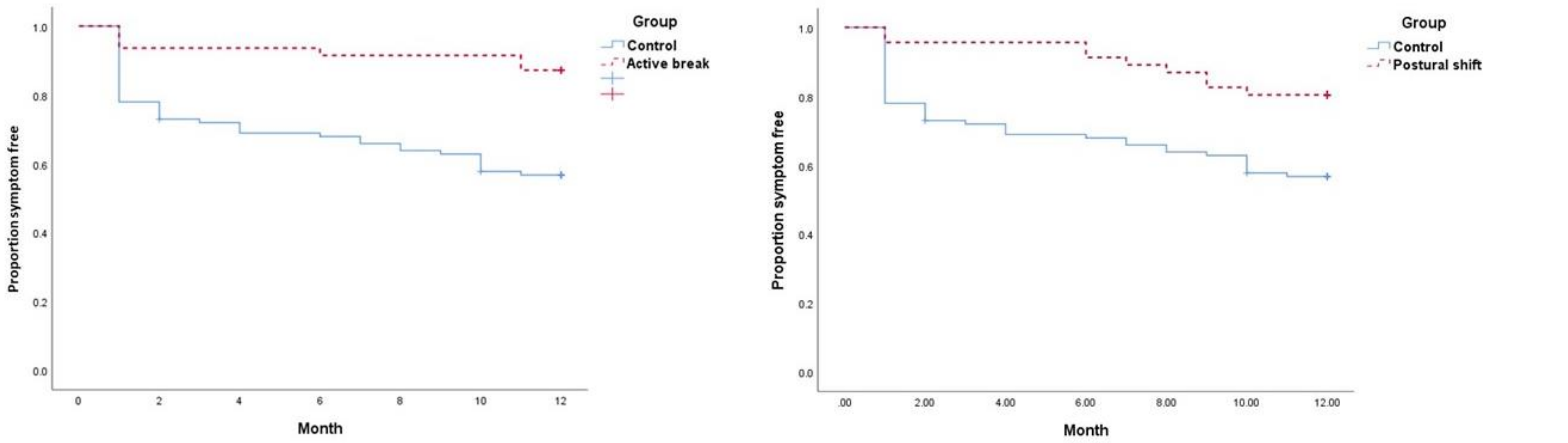


Figure 12 *The Kaplan-Meier survival curves for onset of low back pain.*

Using the Cox proportional hazard model, after adjustment covariate, the protective effects of intervention A (active break) and intervention B (postural shift) were found for neck and low back pain. Intervention A (active break) significantly reduced the risk of incident neck pain (HRadj=0.46; 95%CI 0.23 to 0.89, p=0.022) and low back pain (HRadj=0.33; 95%CI 0.14 to 0.80, p=0.014). Intervention B (postural shift) significantly reduced the risk of incident neck pain (HRadj=0.38; 95%CI 0.18 to 0.83, p=0.014) and low back pain (HRadj=0.33; 95%CI 0.14 to 0.80, p=0.022) (Table 5). Comparisons of pain intensity and disability level among the intervention A (active break), intervention B (postural shift), and control groups indicated no statistically significant difference, except for perceived discomfort (Table 6).

Table 5 *Unadjusted and adjusted HRs evaluating the effects of postural shift on incident neck and low back pain (n=147).*

Variable	Unadjusted HR (95% CI)	p value	Adjusted HR (95% CI)	p value
Neck pain				
Control group (n=100)	1.0		1.0	
Intervention A (active break) (n=47)	0.37 (0.19-0.71)	.003*	0.46 (0.23-0.89)[a]	.022*
Intervention B (postural shift) (n=46)	0.42 (0.22-0.78)	.006*	0.38 (0.18-0.83)[b]	.015*
Low back pain				
Control group (n=100)	1.0		1.0	
Intervention A (active break) (n=47)	0.25 (0.11-0.59)	.002*	0.33 (0.14-0.80)[a]	.014*
Intervention B (postural shift) (n=46)	0.39 (0.19-0.79)	.010*	0.33 (0.14-0.89)[b]	.022*

aCovariates: Working from home was forced in the final, adjusted model. In the univariate analysis, four variables changed the HR of intervention A (active break) variable by ≥0.05, including education level, lifting heavy object, job security, and psychological demand.

bCovariates: Working from home was forced in the final, adjusted model. In the univariate analysis, three variables changed the HR of postural shift variable by ≥0.05, including number of working hours per day, drug used, and appropriate noise level. *p value < 0.05

Table 6 *Perceived discomfort, pain intensity and disability of participants reporting neck and low back pain during 12-month follow-up.*

Variable	Mean ± SD			p value
	Active break intervention	Postural shift intervention	Control group	
Neck pain				
Perceived discomfort by Borg CR-10	3.7 ± 1.1 (n=11)	3.8 ± 2.6 (n=12)	4.9 ± 2.4 (n=52)	0.03*
Pain intensity measured by VAS	5.0 ± 1.7 (n=11)	5.3 ± 2.2 (n=12)	5.8 ± 1.6 (n=52)	0.070
Disability measured by NDI	6.2 ± 3.8 (n=11)	6.9 ± 3.5 (n=12)	5.0 ± 1.6 (n=52)	0.761
Low Back pain				
Perceived discomfort by Borg CR-10	3.4 ± 2.9 (n=6)	3.7 ± 1.8 (n=9)	4.5 ± 1.9 (n=45)	0.05
Pain intensity measured by VAS	4.2 ± 2.8 (n=6)	3.9 ±1.4 (n=9)	4.0 ± 2.4 (n=45)	0.525
Disability measured by RMDQ	2.4 ± 1.8 (n=6)	2.8 ± 1.1 (n=9)	2.9 ± 1.5 (n=45)	0.848

VAS, visual analogue scale; NDI, Neck disability index; RMDQ, Roland-Morris low back disability questionnaire

4.4 Discussion

This randomized controlled trial showed that the active break and postural shift intervention reduced the 12-month incidence rate of neck and low back pain among high-risk office workers. The 12-month incidence of neck and low back pain was reduced by 54-67% by the interventions. However, neither the active break nor the postural shift intervention reduced pain intensity or disability level in those experiencing neck and low back pain.

In this study, the 12-month incidences of neck and low back pain in office workers of the control group were 52% and 45%, respectively. Previous study reported 26.7% and 19.7% of participants developed incident neck pain and low back pain in one year follow-up, respectively (Sihawong et al., 2014). The discrepancy between our and the (Lapointe et al., 2009) study may be due to the difference in the inclusion criteria. Sihawong et al (2014) did not require participants to be at risk of neck or low back pain. However, in our study office workers at risk of neck and low back pain, assessed by the NROW and BROW, were included. Consequently, it is plausible that a greater number of participants experienced neck and low back pain over the course of our study. The high-risk study population also puts the present study's relatively large effect sizes in perspective; it should be kept in mind that the majority of office workers (i.e. those not at risk of neck and low back pain as well as those who reported neck or low back symptoms in the previous 6 months) were not included in the present study. Thus, it is possible that preventive intervention/strategies targeted at a high-risk group would be different from preventive efforts aimed at all employed office workers (van der Beek et al., 2017).

The present study found that active breaks can reduce the incidence of neck and low back pain by 54% and 67%, respectively. Our results showed that the average break duration of participants in the active break group was 2.7 minutes. Previous studies have found frequent active breaks with postural change, with break durations ranging from 20 seconds to 5 minutes, to be beneficial in reducing pain, discomfort, and fatigue in the neck and low back (McLean et al., 2001; Galinsky et al., 2007; Sheahan et al., 2016). The discrepancy between our and previous studies may be partly attributed to the use of the intervention apparatus. Scheduled rest breaks have been recommended to decrease musculoskeletal discomfort and pain during computer tasks (Barredo and Mahon, 2007; Sheahan et al., 2016) and active breaks with postural change were found to be effective in reducing pain and discomfort (Waongenngarm et al., 2018). Active breaks with postural change require participants to change their posture during breaks, which may lead to improvement in blood circulation in the lumbar region, change in spinal curvature, delay in the onset of any specific musculoskeletal discomfort, and increase in the flow of synovial fluid to lubricate and nourish the intervertebral disc (Marras et al., 1995; Thorp et al., 2014). Changing posture when adopting prolonged, sustained, and awkward sitting postures may prevent a reduction in the length of soft tissues and range of motion in joints, which may reduce the risk of injury (Main et al., 2008). Therefore, frequent active breaks of short duration may be sufficient to prevent the onset of neck and low back pain among high-risk office workers.

Our results indicated that the postural shifts intervention can prevent incident neck and low back pain by 62% and 67%, respectively. The number of total postural shifts found in the postural shift group of the present study was 29.1 times per hour, which was much higher than those reported in previous studies (ranging from 8 to 19 times per hour in a normal work situation (Reenalda et al., 2009; Sammonds et al., 2017). Attributed the designed custom apparatus to the participants in postural shift group played an important role to the discrepancy in number of postural shifts between our and previous studies. Evidences indicated that increased motion during prolonged sitting (i.e., dynamic sitting) has been found to decrease discomfort in the neck and low back (van Deursen et al., 1999; O'Keeffe et al., 2013). Thus, the postural shift intervention aimed to reduce discomfort during prolonged at work might provide the benefit effect to reduce incidence of neck and low back pain via this mechanism. Further research is needed to validate this finding (i.e., a mediation analysis).

It is interesting to speculate how the postural shift could mitigate the negative impact on the development of neck or low back pain. We can anticipation at least two possible reasons. First, regular performing postural shifting during prolonged sitting might keep tissue remaining in healthy stage. Evidence shown that each of postural adjustment leaded to increase subcutaneous oxygen saturation on average by 2.2%, indicating the positive effects of posture shifts on tissue viability (Reenalda et al., 2009). Also, evidences suggested that increased postural movement whilst sitting has been associated with less spinal load and reduced loss of disc height (van Dieen et al., 2001; Zenk et al., 2012). Second, changing sitting postures may impose alternating activity between different parts of the neck and shoulder muscles. Previous study indicated that static neck posture is a possible risk factor in neck pain (Szeto et al., 2009). Changing sitting postures has been found to result in different levels of cervicothoracic muscle activity (Caneiro et al., 2010) as a consequence alleviated postural discomfort during prolonged sitting. Previous study found that individuals with low back pain had less frequent postural shifts than their healthy counterparts (Dunk and Callaghan, 2005). Thus, our results suggest that frequency of postural shifts may partly be related to the decreasing of occurrence of neck and low back pain in those required to sit for long periods and at increased risk of neck and low back pain.

In the present study, no significant differences were found in average pain intensity or disability between the groups. These results support the notion that effective interventions to prevent neck and low back pain, at least in office workers, may differ from those to alleviate pain intensity and disability level in those with neck and low back pain. Disability levels due to neck or low back pain among the present study population, i.e. those who reported pain, were relatively low. Consequently, we may have encountered a floor effect, i.e. participants scored at or near the possible lower limit (Everitt, 2002). Further research should examine the effects of active break and postural shift intervention in office workers with moderate to high pain intensity or disability to validate the findings of the present study.

A major strength of this study is its randomized design and the inclusion of a broad range of psychosocial factors for their confounding effect on neck and low back pain. Moreover, use of the placebo seat pad in the control group may have reduced the placebo or Hawthorne effect on the outcomes of this study. Four methodological limitations should be taken into consideration when interpreting the results of this study. First, the present study was conducted in healthy office workers at high risk of neck and low back pain. Thus, extrapolation of these results to other populations should be made with caution. Further research on the effects of active break and postural shift intervention on the incidence of neck and low back pain in normal office worker populations or other occupations is suggested. Second, assessments of biopsychosocial factors as well as the diagnosis of neck and low back pain were subjective, which poses the risk of bias in the estimation of exposure or health outcome. Researchers should consider the inclusion of objective information from physical examination to increase data accuracy in future studies. Third, some baseline characteristics showed differences among the three study groups. Following the use of cluster randomization, participants were randomized as intact groups rather than as individuals. A small number of clusters (N=6) were randomized in this study, which had the risk of baseline imbalance between the randomized groups. Thus, further research should use stratified or pair-matched randomization of clusters (Ivers et al., 2012). Last, we did not assess participants' sitting behavior at baseline. Therefore, we did not know whether the designated active breaks and postural shifts suggested by the apparatus for individuals in the intervention A and B groups were higher or lower than their habitual daily occupational sitting behavior. Future study should examine the efficacy of active breaks and postural shifts to prevent neck and low back pain in those with poor habitual sitting behavior relative to the designated active breaks and postural shifts suggested by the apparatus to validate the present findings.

4.5 Conclusion

A 3-arm, cluster-randomized controlled trial was conducted in a convenience sample of healthy office workers with high risk of neck and low back pain. Our results suggest that the active break and postural shift interventions can effectively reduce incident neck and low back pain in these office workers. However, neither the active break nor postural shift intervention decreased pain intensity and disability in those experiencing neck and low back pain

Authors' contributions

The authors have contributed in the following ways: NA provided the concept/research design, data collection, data analysis and manuscript writing. PW contributed to the concept/research design and data collection. PJ contributed to the concept/research design, data analysis and manuscript writing. All authors read and approved the final manuscript.

Competing Interests

The authors declare that there are no conflicts of interest.

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Summary

This study evaluated the effects of the active break and postural shift intervention on the 12-month incidence of neck and low back pain in high-risk office

workers. As mention earlier, the data of active break intervention belonged to our colleague, Dr. Pooriput Waongenngarm. Thus, the summary focused only postural shift intervention.

The finding indicated that the 12-month incidences of neck pain in the postural shift intervention and control groups were 26%, and 52%, respectively. The 12-month incidences of low back pain in the postural shift intervention and control groups were 20% and 45%, respectively. Our results also indicated that the postural shifts intervention can prevent incident neck and low back pain by 62% and 67%, respectively. To sum up, the postural shift intervention is an effective intervention to reduce incident of neck and low back pain in office workers. Thus, the study aimed to investigate the efficacy of postural shift interventions on recovery duration and recurrence of neck and low back pain among high-risk office workers was conducted and reported in next CHAPTER.

CHAPTER 5

The effects of active break and postural shift interventions on recovery from and recurrence of neck and low back pain in office workers: a 3-arm cluster-randomized controlled trial

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Abstract

Objectives: To investigate the efficacy of active break and postural shift interventions aimed to reduce sitting discomfort on recovery duration and recurrence of neck and low back pain among high-risk office workers.

Methods: A 3-arm cluster-randomized controlled trial with 12-month follow-up was conducted in 193 healthy but high-risk office workers. Participants in the intervention groups received custom-designed apparatus to facilitate either active breaks or postural shifts to reduce sitting discomfort at work. Participants in a control group received a placebo seat pad. Incidence of neck and low back pain with pain intensity and disability level was recorded monthly. Main outcome measures were recovery time and recurrent rate of neck and low back pain. Analyses were performed using log rank test and Cox proportional hazard models.

Results: Median time to recovery in those receiving active break and postural shift interventions (1 month) was significantly shorter than those in the control group (2 months). Neck and low back pain recurrent rates for the active break, postural shift, and control groups were 21%, 18%, and 44%, respectively. Hazard rate (HR) ratios after adjusting for biopsychosocial factors indicated a protective effect of active break and postural shift interventions for neck and low back pain recurrence (HRadj 0.22,

95% CI 0.06–0.83 for active breaks and HRadj 0.35, 95% CI 0.16–0.77 for postural shift).

Conclusion: Active break and postural shift interventions shortened recovery time and reduced recurrence of neck and low back pain among high-risk office workers.

5.1 Introduction

Musculoskeletal disorders pose a significant burden on society due to their high prevalence and substantial costs associated with lost work days and decreased work productivity. One-year prevalence rates for neck pain among office workers range between 42%-69% and 34%-49% of them develop new onset of neck pain every year (Korhonen et al., 2003; Janwantanakul et al., 2008; Cote et al., 2009) For low back pain, one-year prevalence rates range from 31%-51%, while 14%-23% of office workers report new onset of low back pain annually (Juul-Kristensen et al., 2004; Janwantanakul et al., 2008; Sitthipornvorakul et al., 2015). Interventions are required to effectively guide the employment, healthcare, and vocational rehabilitation of these individuals (Lambeek et al., 2011).

Prognosis is fundamental to the management plan (Hansebout et al., 2009). The clinical course of non-specific neck and low back pain seems to be persistent or recurrent (i.e. with remission and exacerbations) over months and years (Côté et al., 2004; Henschke et al., 2008). Median time from treatment commencement to full recovery for neck and low back pain has been reported as 42-60 days (Henschke et al., 2008; Menezes Costa et al., 2012). Only 52% of individuals with neck pain made full recovery during the 3-month follow-up (Leaver et al., 2013) and two-thirds of those with low back pain fully recovered within a year (Henschke et al., 2008). Neck and low back pain recurrence is well documented with estimates of the 1-year recurrent rate varying from 23%-69% (Côté et al., 2004; da Silva et al., 2019). One previous study recorded median time to low back pain recurrence as 139 days (da Silva et al., 2019).

Office workers spend about one half to two thirds of their workday seated within an office environment (Jans et al., 2007). Prolonged sitting has been shown to induce neck and low back discomfort over time (Waongenngarm et al., 2020) and perceived discomfort is a strong predictor for future onset of neck and low back pain (Hamberg-van Reenen et al., 2008). Interventions have been proposed to alleviate the adverse effects of prolonged sitting on discomfort, including rest breaks (Sheahan et al., 2016), postural shifts (O'Keeffe et al., 2013), and ergonomic intervention (Pillastrini et al., 2010). A recent study showed active break and postural shift interventions reduced new onset of neck and low back pain in high-risk office workers by 55-81% during 6-month follow-up (Waongenngarm et al., 2021) . To date, no study has investigated the effects of active break and postural shift interventions on recovery from and recurrence of neck and low back pain in office workers. Thus, this study aimed to investigate whether active breaks and postural shift interventions aimed at reducing sitting discomfort shortened duration of recovery from neck and low back pain, and to determine the efficacy of interventions on the recurrence of neck and low back pain. A distinct group of office workers was selected for this study, i.e. those with high risk of neck or low back pain, to ensure participants will theoretically benefit from the interventions. We hypothesized that participants in the intervention groups, with increases in either active breaks or postural shifts, show shortened recovery duration and reduced recurrence of neck and low back pain.

5.2 Methods

Participants and procedures

This study is part of a 12-month prospective cohort study with a 3-arm, parallel-group, cluster-randomized controlled trial in a convenience sample of office workers to evaluate the efficacy of active break and postural shift interventions to prevent and alleviate neck and low back pain. Individuals without neck and low back pain at baseline were followed for 12 months and those with incident neck or low back pain during follow-up were included in this study. The study was approved by the University Human Ethics Committee and registered in the Thai Clinical Trials Registry (TCTR20190111002). A change had been made to the methods after trial commencement, i.e. the age range of potential participants was shifted from between 23-45 years to between 23-55 years.

Office workers from six organizations in Bangkok, Thailand, participated in this study, including the government excise, public relations, and public transportation, the Metropolitan Waterworks Authority, and two private companies importing medical equipment and products (such as drugs and diagnostic reagents). Individuals were included if aged 23–55 years, working full-time, had a body mass index (BMI) of 18.5-25 kg/m2, had at least 5 years-experience in their current position, reported prolonged sitting as one of the aggravating factors of neck or low back pain in one of their previous episodes, and were at risk of non-specific neck pain as evaluated by the Neck Pain Risk Score for Office Workers (NROW) (sensitivity of 82%, specificity of 48%, positive predictive value of 29%, and negative predictive value of 91%) (Paksaichol et al., 2014) or non-specific low back pain as evaluated by the Back Pain Risk Score for Office Workers (BROW) (sensitivity of 65%, specificity of 68%, positive predictive value of 16%, and negative predictive value of 95%) (Janwantanakul et al., 2015). Exclusion criteria were musculoskeletal symptoms reported in the neck or low back in the past 6 months, reporting pregnancy or plan to become pregnant in the coming 12 months, having a history of trauma or accidents in the spinal region, or having either spinal, intra-abdominal or femoral surgery in the past 12 months. Individuals diagnosed with congenital anomaly of the spine, rheumatoid arthritis, infections of the spine or discs, ankylosing spondylitis, spondylolisthesis, spondylosis, spinal tumor, systemic lupus erythematosus, or osteoporosis were excluded.

Eligible participants provided informed consent. At baseline, they completed the self-administered questionnaire to gather exposure data and were randomly assigned at cluster level by a simple randomization method into one of three groups: the intervention A (active breaks), intervention B (postural shift), and control groups.

Computer-generated randomization, which was concealed from the data collectors, was used to designate intervention. Clusters of participants were located in the same workplace to enhance compliance within the intervention group and avoid contamination of the intervention. A total of six clusters (two clusters each for intervention A, intervention B, and control groups) were identified and cluster size comprised 15-51 participants. Participants recorded incidence of neck or low back pain in a diary, including pain intensity and disability and were asked to strictly follow the group instructions until completing the 12-month follow-up or withdrawing from the study.

Questionnaires

A self-administered questionnaire was designed to gather data on individual, work-related physical, and psychosocial factors. Individual factors included gender, age, marital status, education level, frequency of regular exercise or sport, smoking habits, and number of driving hours per day. Work-related physical factors included current job position, number of working hours, years of working experience, frequency of using a computer, adopting working postures, performing various activities during work, rest breaks, perceived ergonomics of workstations and work environment conditions. Psychosocial work characteristics were measured by Job Content Questionnaire (Phakthongsuk, 2009).

Description of intervention

A custom-designed apparatus was employed to deliver intervention A (active breaks) and intervention B (postural shift). Detailed descriptions of the interventions are published elsewhere (Waongenngarm et al., 2021). In brief, the custom-designed apparatus consisted of seat pad, processor, and smartphone application. The function of seat pad was to collect data regarding sitting and break duration as well as number of postural shifts. A processor calculated recommended active breaks and postural shifts for each individual. Instructions about active breaks were sent from the processor to smartphone application via Bluetooth during the workday and instructions were displayed as a notification message on the smartphone with a warning sound, which a user could opt to turn on or off. Instructions regarding postural shifts were sent from the processor to seat pad via a cord connected between them. Postural shifts were induced by the apparatus gradually pumping air into various parts of the seat pad placed underneath a participant's buttocks. Frequency and duration of breaks as well as of postural shifts were based on the literature review (Reenalda et al., 2009; Akkarakittichoke and Janwantanakul, 2017; Waongenngarm et al., 2018). Participants were requested to strictly adhere to the instructions. Participants in the control group received a placebo seat pad made of polypropylene foam to sit on. All participants were asked to keep the level of their leisure time physical activity unchanged.

Outcome measure

Non-specific neck or low back pain is defined as neck or low back pain (with or without radiation) without any specific systematic disease detected as the underlying cause of the complaints (Borghouts et al., 1998). Incidence of neck or low back pain was identified by a series of questions in a diary given to participants. Cases were defined as those reporting incident neck or low back pain lasting at least 24 hours with pain intensity greater than 30 mm on a 100-mm visual analogue scale (VAS), with no weakness or numbness in upper or lower limbs. Disability level due to neck and low back pain was measured using the Neck Disability Index (NDI) (Uthaikhup et al., 2011) and Roland-Morris Disability Questionnaire (RMDQ) (Pensri et al., 2005), respectively.

Main outcome measures were time to recovery from neck and low back pain and recurrent rate of neck and low back pain. Full recovery was defined as being pain-free (VAS = 0) with no disability (NDI = 0 or RMDQ = 0) during the past month. Recurrence of neck and low back pain was defined as return of neck or low back pain lasting at least 24 hours with pain intensity greater than 30 mm on a 100-mm VAS following at least 30 days pain-free (Stanton et al., 2011).

Statistical analysis

Baseline characteristics of participants in three groups were compared using one-way ANOVA for continuous data and χ2 test for nominal and ordinal data. A Bonferroni post hoc comparison was employed to determine whether the two selected means differed significantly from each other. All analyses followed an intention-to-treat approach. Recurrent rate of neck or low back pain was calculated as the proportion of participants who had reported recurrence divided by total number of participants recovering fully (Machado et al., 2017). Further follow-up data of those initially identified as recovered or recurrent cases were not used any further.

The Kaplan-Meier survival curves were used to describe the median time to recovery and cases with recurrent neck and low back pain in three groups. Participants lost to follow-up were censored at the midpoint between last completed follow-up and next follow-up time (Dudley et al., 2016). Participants not recovered after 12 months were censored at this point. The survival curves were compared using the log rank test. Relationship between initial VAS score and recovery time was examined using Pearson correlation coefficients.

Hazard ratios (HR) with respect to recovery time from neck and low back pain and recurrent cases were calculated using the Cox proportional hazards model. The 45 possible covariates were each examined in multivariate models. If the tested covariate changed the HR of the intervention variable by ≥0.05 then it was also included in the final, adjusted model. All statistical analyses were performed using

SPSS for Windows Version 25.0 (SPSS Inc, Chicago, IL). Statistical significance was set at the 5% level.

5.3 Results

The trial spanned June 2019-November 2020. Of 193 workers participating, 174 (88%) were successfully followed for 12 months and 19 (12%) were lost during the follow-up period (Fig. 13). No harm or unintended effect in all three groups was reported during the 12-month follow-up. Of the participants, 33, 18, and 42 reported neck, low back, and both neck and low back pain during follow-up, respectively. At baseline, there was no significant difference in any characteristics among three groups (Table 7), except for age, BMI, education level, duration of employment, psychological job demand, and social support. For those reporting neck and/or low back pain, there was no significant difference in any characteristics among three groups, except for BMI, education level, number of working hours, job security, and social support.

During March-June 2020, the COVID-19 outbreak in Thailand forced 68% (130/193) of participants to work from home. All participants did not bring the custom-designed apparatus for use at home. Thus, the status of working from home as a confounder was forced into the multivariate models.

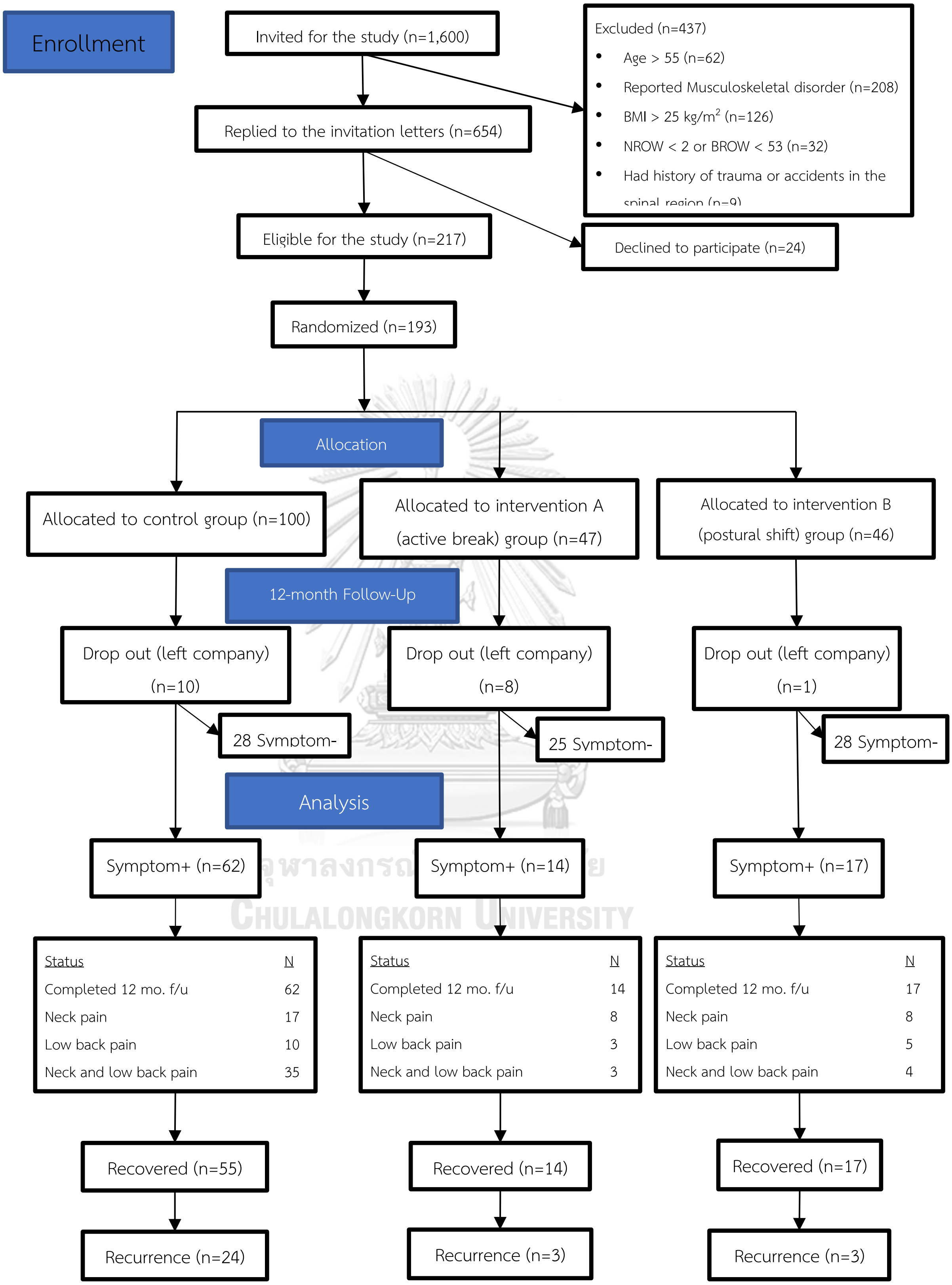

Figure 13 Consolidated Standards of Reporting Trials (CONSORT) flowchart of the study

Table 7 *Characteristics of office workers at baseline (n=193) and those reporting neck and/or low back pain (n=134).*

Characteristic	Mean (SD)						*p* value (Baseline comparison)	*p* value (Case comparison)
	Intervention A (active break)		Intervention B (postural shift)		Control			
	At baseline (n=47)	Cases (n=14)	At baseline (n=46)	Cases (n=17)	At baseline (n=100)	Cases (n=62)		
Demographic characteristics								
Age (years)	31.6 (6.1)	33.4 (7.1)	35.0 (7.7)	35.7 (5.0)	34.1 (5.3)	34.6 (4.9)	*0.008*[a]	NS
Gender: female (%)	33 (70.2)	12 (85.7)	35 (74.5)	14 (82.4)	79 (79.0)	47 (75.8)	NS	NS
BMI	21.3 (2.3)	21.6 (2.1)	22.3 (2.3)	22.8 (2.0)	21.0 (2.0)	22.1 (2.1)	*0.002*[c]	*0.01*[a]
Pain intensity at 1st episode		4.1 (1.3)		3.6 (1.0)		4.4 (1.5)		NS
Marital status (%)							NS	NS

	36 (76.6)	6 (64.3)	31 (67.4)	12 (70.6)	64 (64.0)	36 (58.1)		
Married	10 (21.3)	4 (28.6)	13 (28.3)	3 (17.6)	35 (35.0)	25 (40.3)		
Divorced	1 (2.1)	1 (7.1)	2 (4.3)	2 (11.8)	1 (1.0)	1 (1.6)		
Education (%)								
Lower than Bachelor's degree	2 (4.3)	0 (0)	2 (4.3)	1 (5.9)	5 (5.0)	4 (6.5)	NS	NS
Bachelor's degree	40 (85.1)	13 (92.9)	38 (82.6)	14 (82.4)	53 (53.0)	29 (46.8)	*<0.001*[d] *0.001*[e]	*0.014*[d] *0.009*[e]
Higher than Bachelor's degree	5 (10.6)	1 (7.1)	6 (13.0)	2 (11.8)	42 (42.0)	29 (46.8)	*0.002*[d] *0.001*[e]	*0.006*[d] *0.009*[e]
Exercise frequency in the past 12 months (%)							NS	NS
Never	6 (12.8)	2 (14.3)	5 (10.9)	2 (19.4)	22 (22.0)	14 (22.6)		

Occasionally	34 (72.3)	9 (64.3)	30 (65.2)	9 (52.7)	56 (56.0)	31 (50.0)		
Regularly	7 (14.9)	3 (21.4)	10 (21.7)	5 (29.4)	22 (22.0)	17 (27.4)		
Not sure	0 (0)	0 (0)	1 (2.2)	1 (5.9)	0 (0)	0 (0)		
Work-related characteristics								
Duration of employment (years)	6.9 (4.3)	8.6 (5.2)	10.8 (5.3)	12.2 (6.0)	9.1 (4.8)	9.5 (4.7)	*<0.001*[a] *0.039*[b]	NS
Working hours per day (hours per day)	8.0 (1.3)	8.1 (1.4)	8.7 (1.3)	8.9 (1.4)	7.8 (0.8)	7.9 (0.9)	NS	*0.004*[c]
Working days per week (days per week)	5.1 (0.3)	5.1 (0.5)	4.9 (0.6)	4.8 (0.5)	5.0 (0.2)	5.0 (0.3)	NS	NS
Psychosocial characteristics								
Job control	35.1 (4.5)	35.5 (5.6)	35.1 (5.2)	35.4 (3.6)	36.6 (4.3)	36.9 (3.8)	NS	NS

Psychological job demands	30.8 (4.4)	31.4 (3.8)	32.5 (4.2)	31.8 (4.8)	33.2 (4.4)	34.0 (4.2)	*0.007*[b]	NS
Physical job demands	13.2 (2.7)	13.7 (1.9)	13.4 (3.3)	13.4 (3.9)	14.1 (2.6)	14.5 (2.4)	NS	NS
Job security	16.3 (1.3)	16.0 (1.4)	16.3 (2.9)	15.6 (4.2)	16.9 (1.1)	17.0 (1.1)	NS	*0.042*[c]
Social support	33.1 (4.4)	32.1 (4.7)	30.4 (3.2)	29.7 (2.4)	32.9 (4.4)	33.1 (4.5)	*0.005*[a] *0.003*[c]	*0.013*[c]
Hazards at work	15.9 (3.9)	16.9 (4.9)	15.5 (2.5)	16.0 (3.2)	17.0 (3.9)	17.5 (3.6)	NS	NS

NS = no significant difference among groups using ANOVA or Chi-square test.

[a] Significant difference after Bonferroni post hoc comparisons between the intervention A and intervention B groups

[b] Significant difference after Bonferroni post hoc comparisons between the intervention A and control groups

[c] Significant difference after Bonferroni post hoc comparisons between the intervention B and control groups

[d] Significant difference after Chi-square test and pairwise comparisons between the intervention A and control groups.

[e] Significant difference after Chi-square test and pairwise comparisons between the intervention B and control groups.

Recovery time from neck and low back pain

Recovery from neck and low back pain among a sample population took a median time of 2 months (range: 1 to 8 months). The Kaplan-Meier survival curve indicated that the cumulative probability of recovery was 43%, 68%, and 93% at 1, 2, and 8 months, respectively. A significant difference in recovery time was found between intervention A (active break) and control group (log rank test probability=0.001), and between intervention B (postural shift) and control group (log rank test probability=0.001) (Fig .14). Median duration of recovery in control group was 2 months, and 1 month in intervention A (active break) and intervention B (postural shift). The Cox proportional hazard model indicated significant difference in recovery time between intervention A (active break) and control group (HRadj 2.07, 95% CI 1.05-4.07) and between intervention B (postural shift) and control group (HRadj 1.57, 95% CI 1.09-2.27) (Table 8). Significant correlation between initial pain intensity and neck and low back pain recovery time was found ($r=0.6$; $p < 0.05$), i.e. higher initial pain intensity indicated longer recovery time (Fig. 15).

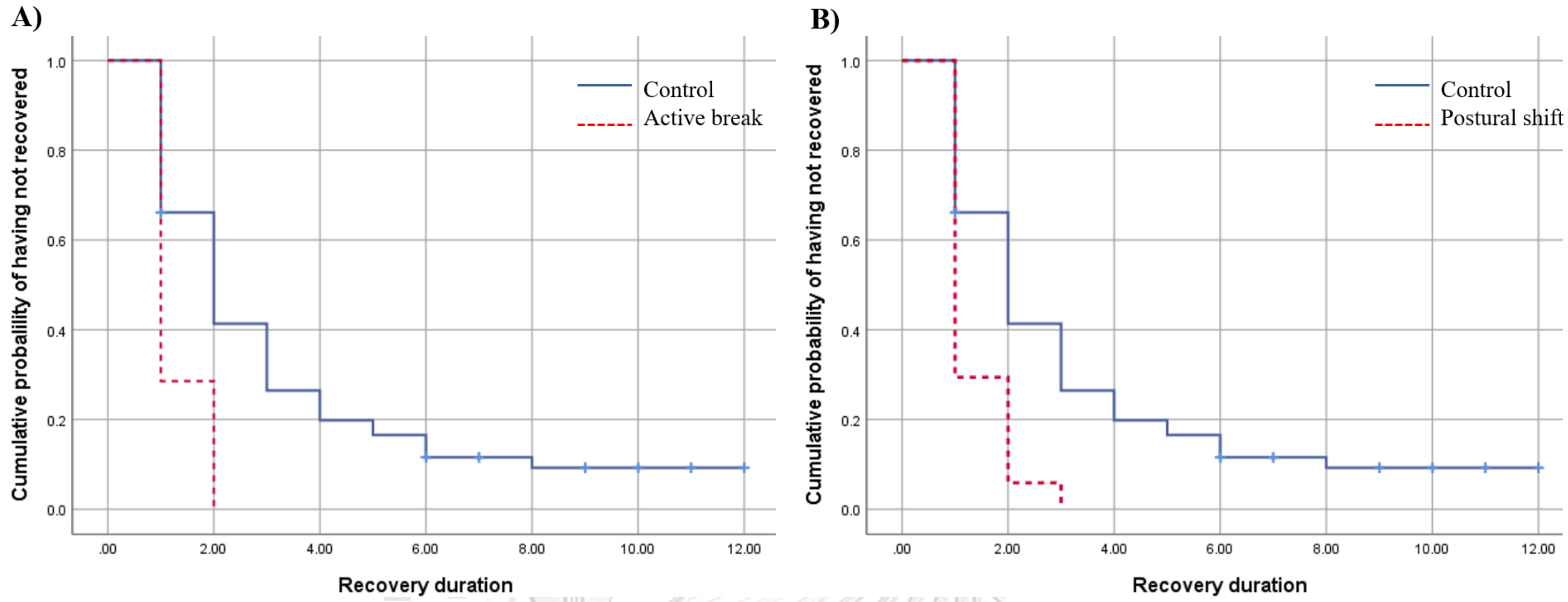

Figure 14 *Kaplan-Meier estimate of time to recovery from neck and low back pain among office workers: A) Intervention A (active break) and B) Intervention B (postural shift)*

Table 8 Unadjusted and adjusted hazard rates (HR) evaluating the effects of intervention A (active break) and intervention B (postural shift) on recovery time from neck and low back pain (n=93)

Variable	Unadjusted	p value	Adjusted	p value
	HR (95% CI)		HR (95% CI)	
Group assignment				
Control group (n=62)	1.0		1.0	
Intervention A (active break) (n=14)	2.27 (1.21-4.24)	0.03*	2.07 (1.05-4.07)[a]	.036*
Intervention B (postural shift) (n=17)	1.46 (1.1-1.95)	.01*	1.57 (1.09-2.27)[b]	.016*

[a]Covariates: Working from home was forced in the final, adjusted model. In the univariate analysis, four variables changed the HR of intervention A (active break) variable by ≥0.05, including pain intensity at the first episode, drug used, light intensity, and psychological demand.

[b]Covariates: Working from home was forced in the final, adjusted model. In the univariate analysis, eight variables changed the HR of intervention B (postural shift) variable by ≥0.05, including pain intensity at the first episode, current job position, number of working hours, lifting heavy objects, light intensity, psychological demand, social support, and hazards at work.

*p value <0.05

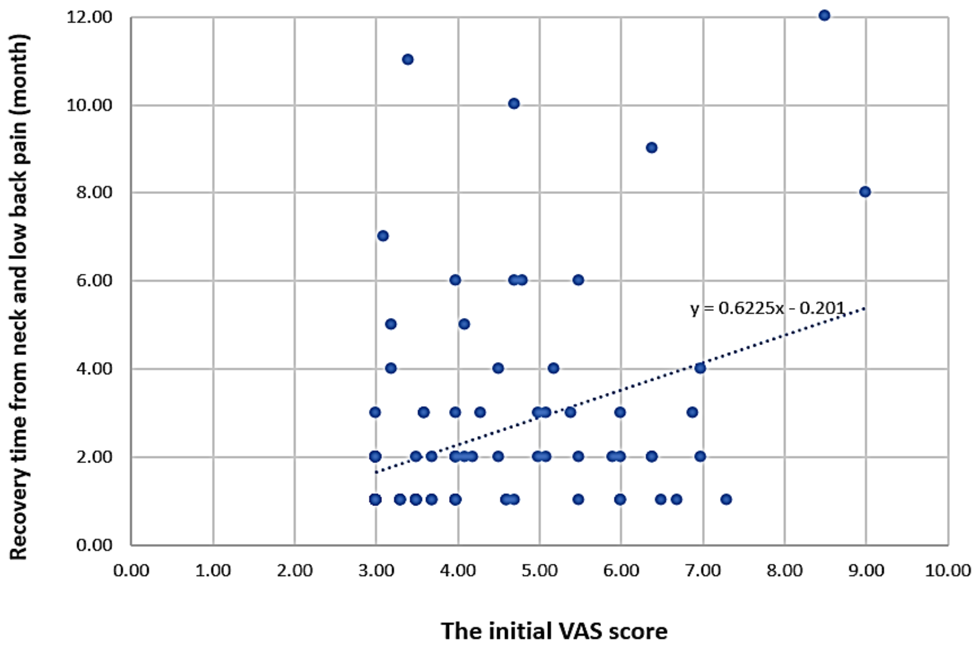

Figure 15 *Initial VAS score and time to recovery from neck and low back pain among office workers (n=93).*

Neck and low back pain recurrence

Over the 12-month follow-up, 21% (3/14), 18% (3/17), and 44% (24/55) of participants in intervention A (active break), intervention B (postural shift), and control groups reported incidence of neck and low back pain recurrence, respectively. Kaplan–Meier survival curves for the neck and low back pain cohort showed significant difference in time to recurrence between intervention A (active break) and control group (log rank test probability=0.01), and intervention B (postural shift) and control group (log rank test probability=0.014) (Fig. 16). Participants in the control group had greater risk of recurrence than those in the intervention groups.

The Cox proportional hazard model indicated the protective effects of intervention A (active break) and intervention B (postural shift) on recurrence. Intervention A (active break) and intervention B (postural shift) significantly reduced the risk of recurrence (HRadj 0.22, 95% CI 0.06–0.83 for active break and HRadj 0.35, 95% CI 0.16–0.77 for postural shift) (Table 9).

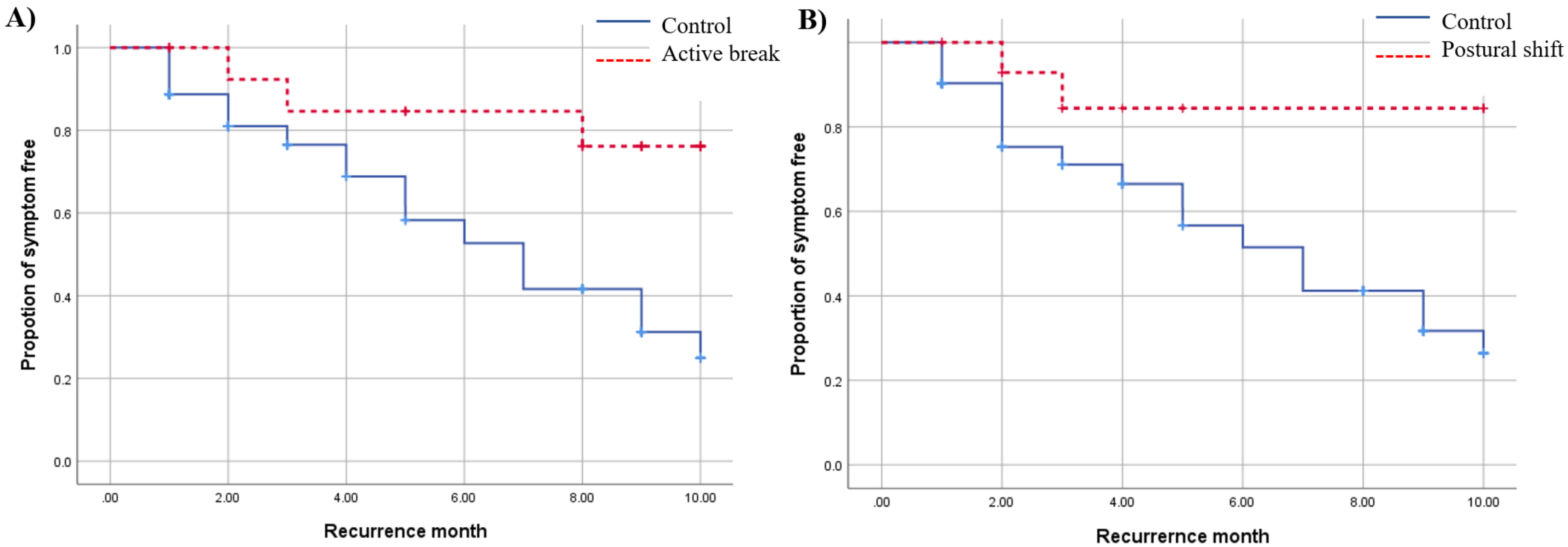

Figure 16 *Kaplan–Meier survival curves for incidence of neck and low back pain recurrence among office workers: A) Intervention A (active break) and B) Intervention B (postural shift).*

__Table 9__ Unadjusted and adjusted hazard rates (HR) evaluating the effects of intervention A (active breaks) and intervention B (postural shift) on neck and low back pain recurrence (n=86).

Variable	Unadjusted	p value	Adjusted	p value
	HR (95% CI)		HR (95% CI)	
Group assignment				
Control group (n=55)	1.0		1.0	
Intervention A (active break) (n=14)	0.25 (0.07-0.81)	.021*	0.22 (0.06-0.83)[a]	0.025*
Intervention B (postural shift) (n=17)	0.46 (0.22-0.94)	.03*	0.35 (0.16-0.77)[b]	0.009*

[a]Covariates: Working from home was forced in the final, adjusted model. In the univariate analysis, two variables changed the HR of the intervention A (active breaks) variable by ≥0.05, including education level and number of working hours.
[b]Covariates: Working from home was forced in the final, adjusted model. In the univariate analysis, only number of working hours changed the HR of the intervention B (postural) variable by ≥0.05.
*p value <0.05, CI=confidence interval.

5.4 Discussion

The study demonstrated that active break and postural shift interventions delivered by the custom-designed apparatus enhanced neck and low back pain recovery. Median recovery time for those receiving active break or postural shift interventions (1 month) was significantly shorter than those in the control group (2 months). Recurrent rate of neck and low back pain was reduced by 65-78% with active break and postural shift interventions. However, this study recruited office workers at risk of neck and low back pain. Generalization of the findings to other working populations therefore should be made with caution.

Recovery time from neck and low back pain

Median recovery time from neck and low back pain in the control group (2 months) aligns with previous studies investigating the clinical course of non-specific neck and low back pain in office workers (median 2 months) (Areerak et al., 2018) and primary care patients (median 58 days) (Henschke et al., 2008). However, recovery time of those in the intervention groups is shorter than that of Leaver and colleagues, who reported median recovery time of neck pain as 45 days in those receiving physical therapy treatment. The discrepancy between our and previous studies may be due to difference in inclusion criteria and intervention employed. Our participants were office workers and received a custom-designed apparatus to facilitate active breaks or postural shifts to reduce sitting discomfort. Participants in the previous study were a general population and received physical therapy treatment, i.e. manual therapy, multimodal physical interventions, and education.

The results showed that active break and postural shift interventions shortened recovery time from 2 months to 1 month. Our interventions aimed to improve sitting behavior by facilitating either active breaks or postural shifts during work. (Bongers et al., 2006) proposed that behavioral aspects, such as work style, are important in the etiology of musculoskeletal symptoms. (Bernaards et al., 2007) found that behavioral change with regard to body posture, workplace adjustment, breaks, and coping with high work demands was effective in improving recovery from neck-shoulder symptoms. Areerak and colleagues (2018) showed that the ability to utilize health information, a dimension of health literacy, reasonably predicted non-specific neck pain in office workers during 1-year follow-up. Previous studies showed that active breaks enhanced recovery of muscle discomfort (Nakphet et al., 2014) and breaks after about 40 minutes of sedentary work were effective in reducing muscle fatigue (Ding et al., 2020). Postural shift has been shown to increase subcutaneous oxygen saturation on average by 2.2% with each posture adjustment, indicating positive effects on tissue viability (Reenalda et al., 2009). Postural shifts may allow periodic resting of musculature through load migration between passive tissues and to relieve fatigue (van Dieen et al., 2001; Maradei et al., 2017).

A positive correlation between initial pain intensity and recovery time was found among the sample population. Previous studies showed that baseline neck pain intensity was strongly associated with prolonged recovery (Walton et al., 2013) and more intense pain at baseline significantly reduced the probability of neck and shoulder pain recovery during 3-month follow-up (Bot et al., 2005). The findings support the notion that high initial pain intensity is a predictor for chronic neck and low back pain (Sihawong et al., 2016) and a treatment to alleviate perceived discomfort may effectively enhance neck and low back pain recovery.

Neck and low back pain recurrence

Recurrent rate of neck and low back pain in the control group was 44%. Estimates of 1-year incidence of neck or low back pain recurrence varied from 23%-69% (Côté et al., 2004; Marras et al., 2007; da Silva et al., 2019). Large variation may be due to differences in defining a recurrent case. da Silva and colleagues defined an episode of low back pain recurrence as a return of low back pain following 7 consecutive days pain-free. (Chaléat-Valayer et al., 2016) defined recurrent cases as more than one episode of disabling low back pain with sick-leave during 1-year follow-up. In this study, recurrent cases were defined as a return of neck or low back pain following a minimum period of 30 days pain-free (Stanton et al., 2011). Machado and colleagues (2017), using the same definition, reported the 1-year recurrent rate of low back pain as 33%.

Active break and postural shift interventions reduced recurrent rate by 65-78% compared to the control group. Exposure to awkward posture, longer time spent sitting, and previous episode(s) of low back pain have been independent prognostic factors for low back pain recurrence (Stanton et al., 2008; Machado et al., 2017; da Silva et al., 2019). A previous 12-month prospective cohort study showed that increasing daily walking steps can prevent onset of neck pain in those with sedentary jobs (Sitthipornvorakul et al., 2015). Active break and postural shift interventions have been found to reduce new onset of neck and low back pain among high-risk office workers by 55-81%, attributed to discomfort reduction during prolonged sitting (Waongenngarm et al., 2021).

Strengths and limitations of the study

The strength of this study is use of the placebo seat pad in the control group, which may have reduced the placebo or Hawthorne effect on the outcomes. However, several limitations should be considered when interpreting the results. First, most participants were female and several baseline characteristics differed among the three study groups. Participants were randomized as entire groups rather than as individuals (i.e. cluster randomization), posing a risk of baseline imbalance between groups. Pair-matched randomization of clusters or stratified method are suggested in the future. Second, although reporting prolonged sitting as one of the aggravating factors of neck or low back pain in one of the subject's previous episodes was one of the inclusion criteria, we did not request further detail. Previous studies have demonstrated that previous pain experiences might influence future pain (Doménech-García et al., 2018). Thus, future study should consider the inclusion of previous pain experiences as a confounder. Third, the nature of several biopsychosocial factors and the diagnosis of non-specific neck and low back pain were subjective, which poses the risk of bias in the estimation of exposure or health outcome. Future studies should include objective information from physical examination to increase data accuracy. Fourth, recovery duration was measured from the onset of neck and low back pain to fully recovered, or the completed follow-up. Data from participants who did not recover at the end of follow-up were treated as censors (Clark et al., 2003). Participants had unequal durations for follow-up, which may affect estimation of recovery rate. Equal follow-up time after the onset of neck and low back pain is recommended for future study. Last, daily occupational sitting behavior of participants in the control group was not monitored and the compliance of participants in the intervention groups during the follow-up period was not assessed, which may affect the internal validity of the study. Future study should validate the findings by examining the efficacy of active breaks and postural shifts on recovery time and recurrence of neck and low back pain in those with poor habitual sitting behavior.

5.5 Conclusion

The study showed that the active break and postural shift interventions delivered by the custom-designed apparatus effectively enhanced recovery time and reduced recurrence of non-specific neck and low back pain. Thus, active breaks and postural shifts during sitting may be recommended for effective management of neck and low back pain among office workers at high risk of developing non-specific neck or low back pain. Effects of active break and postural shift interventions on neck and low back pain recovery and recurrence should be assessed in normal office worker populations or other occupations.

Authors' contributions

The authors contributed in the following ways: NA provided the concept/research design, data collection, data analysis, and manuscript writing. PW and PJ contributed to the concept/research design, data analysis, and manuscript writing. All authors read and approved the final manuscript.

Conflict of Interest

The authors developed the apparatus. The patent of the apparatus belongs to the university and funding agency. The authors declare that there are no other conflicts of interest.

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Summary

This chapter investigated the efficacy of active break and postural shift interventions on recovery duration and recurrence of neck and low back pain among high-risk office workers. The data of active break intervention belonged to our colleague, Dr. Pooriput Waongenngarm. Thus, the summary focused only postural shift intervention.

The findings suggested that postural shift interventions delivered by the custom-designed apparatus effectively enhanced recovery time as well as reduced recurrence of non-specific neck and low back pain by 65%. Thus, postural shifts during sitting may be recommended for effective management for office workers who suffered with neck or low back pain.

However, there are some participants who received postural shift intervention group reported having neck or low back pain during 12-month follow-up. Next study was then conducted to identify variables (i.e., individual factor, work-related factor, and psychosocial factor) that moderate the effects of postural shifts interventions on the development of neck and low back pain in office workers (CHAPTER 6).

CHAPTER 6

Characteristics of office workers who benefit most from interventions for preventing neck and low-back pain: A moderation analysis

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Abstract

Objective: To identify variables that moderate the effects of active breaks and postural shifts interventions on the development of neck and low back pain in office workers.

Methods: Using data from a 3-arm (active break, postural shift, and control group) cluster-randomized controlled trial (N = 193), we evaluated the moderating effects of age, job position, education level, sex, perceived psychological work demands, number of working hours, and using a chair with lumbar support, on the benefits of two interventions designed to prevent the development of neck and low back pain in office workers. Moderation analyses were conducted using the Hayes PROCESS macro, with post-hoc Johnson-Neyman techniques and logistic regressions.

Results: Significant interactions between intervention groups and three moderators assessed at baseline emerged. For the prevention of neck pain, the effect of the active break intervention was moderated by number of working hours, and the effect of the postural shift intervention was moderated by the level of perceived psychological work demands and number of working hours. For the prevention of low back pain, the effect of postural shift intervention was moderated by having or not having a chair with lumbar support.

Conclusions: The study findings can be used to help determine who might benefit the most from two treatments that can reduce the risk of developing neck and low back pain in sedentary workers, and may also help us to understand the mechanisms underlying the benefits of these interventions.

Key words: Active break, Postural Shift, Moderator, Neck pain, Low back pain, Sedentary worker

6.1 Introduction

Neck and low back pain are common in sedentary office workers. One-year prevalence rates for neck and low back pain among office workers have been shown to range from 42% to 69% (Ehsani et al., 2017; Areerak et al., 2018) and 31% to 51% (Ayanniyi et al., 2010; Sitthipornvorakul et al., 2015), respectively. Although improvement of neck and low back symptoms can occur, (Henschke et al., 2008; Leaver et al., 2013) the 1-year recurrence rate of neck and low back pain has been shown to range from 23% to 69% (Côté et al., 2004; da Silva et al., 2019). Moreover, 17% and 27% of office workers who report a new onset of neck and low back pain report that these pain problems become chronic, respectively (Sihawong et al., 2016). Given that chronic pain represents a leading cause of disability worldwide (Vos et al., 2016), and continues to be a major economic burden to society (Cote et al., 2009), identifying effective strategies to prevent neck and low back pain is of high importance. Moreover, identifying the individuals who would benefit the most from preventive treatments could improve the effectiveness and efficiency of treatment, as this information could be used to inform better individual-treatment matching.

There is evidence supporting the effectiveness of exercise programs for reducing the risk of new episodes of neck pain (de Campos et al., 2018), and that exercise combined with education reduces the risk of subsequent episodes of low back pain (Steffens et al., 2016). Research has also found that an intervention to increase daily walking steps reduced onset neck pain in high-risk office workers (Sitthipornvorakul et al., 2020). Recently, we found that two interventions – one an active break and the second a postural shift intervention –

reduced the incidence of new onset of both neck and low back pain (Waongenngarm et al., 2021). Both interventions were delivered by a custom-designed apparatus, and were aimed to minimize seat discomfort by providing (1) recommendations for taking breaks (active break intervention) or (2) making postural shifts during prolonged sitting (postural shift intervention), respectively. However, in the primary outcome paper we did not conduct analyses to identify the moderators of treatment effects. Such research is important for being able to determine who might benefit the most from these interventions.

A systematic review found that the variables with strong evidence for moderating response to low back pain treatments (including cognitive-behavioral therapy, acupuncture, and manipulation combined with exercise) were age (younger participants may gain more benefit), employment status (those who were employed benefited more), occupation type (those in sedentary occupations benefited more), back pain severity (those who are worse initial back pain status benefited more), opioid medication use (those reporting less opioid use benefited more), treatment expectation (those with a greater positive expectations benefited more), and education level (those with greater than 10 years of schooling benefited more)

(Gurung et al., 2015). Potential moderators with weaker evidence included sex, baseline psychological distress, baseline pain intensity, and baseline disability level (Gurung et al., 2015). Another study reported that individuals with low back pain with high levels of fear avoidance were more likely to benefit from an educational booklet and an exercise program than were those with lower baseline levels of fear avoidance (Klaber Moffett et al., 2004).

To the best of our knowledge, no research has sought to identify the moderators of strategies to prevent neck and low back pain in office workers. To address this knowledge gap, here we used data from a completed randomized clinical trial (Waongenngarm et al., 2021) to evaluate the moderation effects of different variables on the impact of the active break and postural shift interventions on the development of neck and low back pain. Given prior research and theory, we hypothesized that an active break intervention and postural shift approach would be more likely to reduce the risk of developing neck and low back pain in: (1) younger participants than older participants, (2) general office workers than office managers, (3) participants with higher than a bachelor’s degree than a bachelor’s degree or lower, (4) female than male workers, and (5) those endorsing more psychological work demands than those endorsing fewer psychological work demands. In exploratory analyses, we also evaluated the potential moderating effects of a number of variables that have not yet been examined in prior research. Based on the available evidence regarding the predictors of neck or low back pain, we included baseline measures of chair height adjustability and number of working hours as potential moderators of onset of neck pain (Cagnie et al., 2007; Paksaichol et al., 2015), and baseline measures of years of work experience, whether or not the participant engages in continuous standing for >2hrs/day, having a job that requires frequent trunk forward bending, and whether or not the worker's chair has lumbar support (Janwantanakul et al., 2011), as potential moderators for the effects of the active treatments on the development of low back pain.

6.2 Methods

Participants and procedures

The data for the analyses presented here came from a trial comparing the effects of active break and postural interventions designed to reduce the incidence of neck and low back pain, relative to no treatment, in office workers (Waongenngarm et al., 2021). Both the active break and postural shift interventions used a custom-designed apparatus, which consisted of three components: (1) a seat pad, (2) a processor, and (3) a smartphone application. The seat pad collected sitting behavior data, including the duration of any sitting breaks and number of postural shifts. Data were stored in the processor, and were used to compute recommended break durations and number of postural shifts for each individual. For those in the active break intervention, instructions to take breaks were sent from the processor to the smartphone application. For those in the postural shifts intervention, recommend postural shifts were induced by the apparatus gradually pumping air into various parts of the seat pad placed underneath a participant's buttocks. Commands to operate the seat pad were sent from the processor to the seat pad via a cord which connected them.

The study was a 3-arm, parallel-group, cluster-randomized controlled trial conducted using a convenience sample of 193 office workers who were at risk for developing non-specific neck or low back pain. Details about the trial are available in the prior publication (Waongenngarm et al., 2021). The protocol was registered with Thai Clinical Trials Registry (https://www.thaiclinicaltrials.org) (TCTR20190111002) and approved by the Chulalongkorn University Human Ethics Committee. Two eligibility criteria were adjusted subsequent to trial registration: (1) age (from 23-45 to 23-55 years) and (2) time needed to be pain-free (from 12 to 6 months).

Descriptive variables

Baseline descriptive data were collected using a questionnaire assessing age, sex, height and weight (from which BMI was computed), education level, frequency of exercise, and smoking status. Work-related characteristics included job position, number of working hours, years of work experience, time per day spent using a computer, average number of hours/days of continuous standing and continuous sitting, whether work involved frequently engagement in five specific activities (i.e., head extensions, head flexions, head rotations, trunk bending, and trunk rotations), and having or not having regular rest breaks. The questionnaire also asked participants to note different aspects of the ergonomics of their workstations and their work environments (i.e., whether the desk height, computer screen level, position of a keyboard and mouse were suitable, whether or not the office had a comfortable air temperature, level of light brightness, and was well-ventilated).

Baseline neck and low back discomfort were assessed using the Borg CR-10 scale, which asked participants to rate the amount of perceived discomfort they felt in the past year in their neck and low back on 0 to 10 scales, with 0 = “No discomfort” and 10 = “Extreme discomfort.”(Borg, 1990) Discomfort was defined as the non-painful but still uncomfortable feelings and sensations, such as tension, fatigue, or tremors (Hamberg-Van Reenen et al., 2006), using a body chart based on the modified Nordic questionnaire (Kuorinka, 1987).

Criterion variables: Development of neck or low back pain

The two criterion variables in the current secondary analyses were new onset of non-specific neck or low back pain, with or without radiation and without a disease identified as the underlying cause of the complaints at the first episode of pain during the 12-month follow-up period using a monthly diary (Borghouts et al., 1998; Krismer et al., 2007). To assess this, the participants answered the question, “Have you experienced any neck or low-back pain lasting >24 hours during the past month?" If they answered “Yes,” a follow-up questions about pain intensity measured using a visual analogue scale (VAS), and the presence of weakness or numbness in the upper or lower limb was assessed. Those who (1) answered “Yes” to the first question (de Vet et al., 2002), (2) reported pain intensity >30 mm on a100-mm VAS (Tsauo et al., 2007), and (3) had no weakness or numbness in the upper or lower limbs (i.e., to exclude symptoms more likely to be due to a serious medical conditions of neck or low back pain) were identified as cases.

Potential moderators

The potential moderators were classified into confirmatory or exploratory moderator variables. Moderators included in the confirmatory analyses were those for which we had a specific a priori hypothesis, based on prior evidence. Moderators classified as exploratory were those that have not yet been evaluated or for which a specific theory or mechanism is lacking.

The Descriptive Variables section above described the four confirmatory moderators (age, sex, job position, and education level). The fifth confirmatory variable was the level of psychological work demands. This variable was assessed using 12-item Psychological Work Demands subscale of the Thai version of the Job Content Questionnaire (Phakthongsuk, 2009). The internal consistency of this scale in the current sample was adequate (Cronbach’s alpha = .69).

Exploratory moderators of neck pain onset included chair adjustability and number of working hours (Cagnie et al., 2007; Paksaichol et al., 2015). Exploratory moderators of the low back pain onset included years of work experience, and whether or not the participant (1) engages in continuous standing for >2 hrs/day versus ≤ 2 hrs/day, (2) describes themselves as needing to bend their trunk forward often during the work day, and (3) has a chair with lumbar support (Janwantanakul et al., 2011).

Statistical analysis

Descriptive statistics were computed to describe the sample. All analyses followed an intention-to-treat approach (i.e., last observation carried forward method). To estimate the associations between the potential moderators and the subsequent onset of non-specific neck and low back pain in a cohort office worker, analyses included Hayes’ PROCESS 4.0 macro (model 1) in SPSS Version 25 with 5000 bootstrapped samples (IBM SPSS; Preacher & Hayes, 2008). The analyses examined the interactions between the proposed moderators (i.e., age, sex, job position, education level, level of psychological work demands, and treatment group (active break, postural shift, and control) on onset of neck and low back pain criterion variables (dichotomous). During March 2020, the COVID-19 outbreak occurred in Thailand. At the time, a majority of the study participants (68%) were required to work from home and did not bring the custom-designed apparatus or placebo foam pad home with them. Thus, status of working from home (yes/no) during the study was included as a covariate. Moreover, we controlled for pre-intervention discomfort level on the dependent variables by using them as covariates to account for individual response tendencies and within-person variability. Treatment condition (i.e., intervention groups and control group) was entered as two dummy coded variables. Potential moderators were also entered (one per model tested), as was the Group X Moderator interaction.

To describe any significant moderations found, post-hoc analysis was employed including pairwise comparisons (i.e., active break vs control group, postural shift vs control group, and active break vs postural shift) through PROCESS model 1 with Johnson-Neyman technique and logistic regression analysis (alpha level of .05). All statistical analyses were performed using SPSS for Windows Version 25.0 (SPSS Inc, Chicago, IL). The regression models were constructed using the PROCESS macro version 4.0 (Andrew F. Hayes®) for SPSS. Statistical significance was set at the 5% level and 95% CI.

6.3 Results

Sample descriptive and general results of the moderator analyses

The trial spanned June 2019–November 2020. The final sample included 193 office workers with a mean age of 33.8 (SD=6.3) years. The majority of the sample were women (76%). Additional details regarding the demographic characteristics of the study participants are presented in Table 10.

Table 10 The descriptive characteristics of the study participants.

Characteristic	active break (n=47)	postural shift (n=46)	control (n=100)	p value
Demographic characteristics				
Age (years)	31.6 (6.1)	35.0 (7.7)	34.1 (5.3)	008*
Sex: female (%)	33 (70.2)	35 (74.5)	79 (79.0)	NS
BMI	21.3 (2.3)	22.3 (2.3)	21.0 (2.0)	0 02*
Education: higher than Bachelor's degree (%)	44 (95.7)	45 (95.7)	95 (95)	NS
Smoking status: no (%)	38 (80.9)	42 (91.3)	91 (91)	NS
Exercise frequency in the past 12 months: regularly (%)	7 (14.9)	10 (21.8)	22 (22.0	NS
Job position: manager level (%)	45 (95.7)	44 (95.7)	95 (95)	NS
Baseline neck discomfort measured by Borg CR-10	1.5 (1.2)	1.3 (1.1)	1.9 (1.6)	NS
Baseline low back discomfort measured by Borg CR-10	2.9 (2.2)	2.2 (2.2)	3.7 (2.4)	001*
Work-related characteristics				
Number of working hours (per day)	8.0 (1.3)	8.7 (1.3)	7.8 (0.8)	NS
Year of work experience (years)	6.9 (4.3)	10.8 (5.3)	9.1 (4.8)	<0.001*

Chair adjustability: yes (%)	46 (97.9)	43 (93.5)	64 (64)	<.0001*
Continuous standing > 2hr: no (%)	43 (91.5)	45 (97.8)	94 (94)	NS
Having or not having lumbar support: yes (%)	20 (54.1)	16 (39.0)	43 (43)	NS
Often bending trunk forward: no (%)	36 (76.6)	37 (80.4)	78 (78)	NS
Psychosocial characteristics				
Psychological job demands	30.8 (4.4)	32.5 (4.2)	33.2 (4.4)	0.009*

Three moderators, one from the list of confirmatory moderators and two from the list of exploratory moderators, emerged as significant. Table 11 presents the results of all tests of confirmatory and exploratory moderation.

Table 11 Results of analysis of preventive treatment (i.e., active break and postural shift) effect.

MODERATOR	Onset of neck pain					Onset of low back pain				
	Estimate	SE	Effect Size (f2)	95% CI	P value	Estimate	SE	Effect size (f2)	95% CI	P value
Active break versus Postural shift versus Control (n=193)										
Confirmatory moderators										
Age	.07	.04	.11	-0.01 to .16	.096	.01	.05	.05	-.78 to 0.1	.840
Sex	-.38	.64	.11	-1.13 to 1.23	.929	14.43	711.13	.06	-1379.3 to 1408.2	.984
Job position	-.87	.59	.11	-2.04 to .31	.147	1.05	.70	.05	-.32 to 2.41	.136
Education	-.55	.96	.10	-2.44 to 1.34	.568	14.81	633.57	.04	-1226.9 to 1256.6	.981
Level of work psychological demands	-.12	.06	.14	-.25 to -.05	.048*	-.00	.63	.07	-.13 to 0.12	.650

Exploratory moderators for neck pain										
Chair adjustability	1.16	.74	.11	-.29 to 2.61	.119					
Number of working hours	-.69	.34	.17	-1.35 to -.03	.040*					
Exploratory moderators for low back pain										
Years of work experience						.05	.05	.06	-.44 to .13	.323
Continuous standing						-.76	1.29	.04	-3.29 to 1.76	.554
Not having lumbar support						-1.97	.66	.09	-3.27 to -.67	.003*
Often bending trunk forward						-.38	.65	.04	-1.65 to .89	.556
Active break vs Control (n=147)										
Level of work psychological demands	-.73	.11	.14	-.29 to 0.14	.051	.05	.15	.09	-.23 to .34	.703
Number of working hours	-1.39	.55	.26	-2.47 to -.32	.010*					

Not having lumbar support						-.64	1.45	.19	-3.48 to 2.21	.635
Postural shift vs Control (n=146)										
Level of work psychological demands	-.146	.07	.14	-.28 to -.01	.030*	-.03	.06	.05	-.14 to 0.08	.650
Number of working hours	-.69	.32	.11	-1.33 to -.05	.033*					
Not having lumbar support						-2.09	.69	.11	-3.44 to -.74	.003*
Active break vs Postural shift (n=93)										
Level of work psychological demands	-1.69	.14	.05	-.45 to .11	.241	-.11	.17	.02	-.44 to .23	.532
Number of working hours	.12	.53	.09	-.93 to 1.17	.820					
Not having lumbar support						-3.14	1.81	.00	-6.69 to 0.41	.095

Number of working hours/days as a moderator

The analysis for the onset of neck pain revealed a significant Treatment Group X Number of Working Hours/Day interaction (B = -.69, SE =.34, R2 = .33, P =.040; see Fig 17). Post-hoc comparisons indicated a difference between the active break vs. control group (B = -.39, SE = .55, R2 = .44, P = .010) and postural shift vs. control group (B = -.69, SE = .32, R2 = .37, P = .033); participants who reported working more hours/day at baseline gained more benefit from both interventions, compared to those in the control group. Johnson-Neyman results indicated that participants in active break group who reported working >7.4 hours/day, and participants in the postural shift group who reported working >7.8 hours/day, were more likely benefit from the interventions to prevent the onset of neck pain in comparison to the control group, who also worked these hours at baseline (Fig 18.2A and 18.2B). Logistic regressions analyzing within treatment conditions indicated that the number of hours of work per day was a significant predictor of neck pain for the active break (B = -.6, SE = 0.28, OR = .55, 95% CI .32 to .95, R2 = .18, P = .032) and control group (B = .81, SE = 0.31, OR = 2.26, 95% CI 1.23 to 4.23, R2 = .12, P = .008; Table 12), indicating that more hours of work per day was associated with increased neck pain.

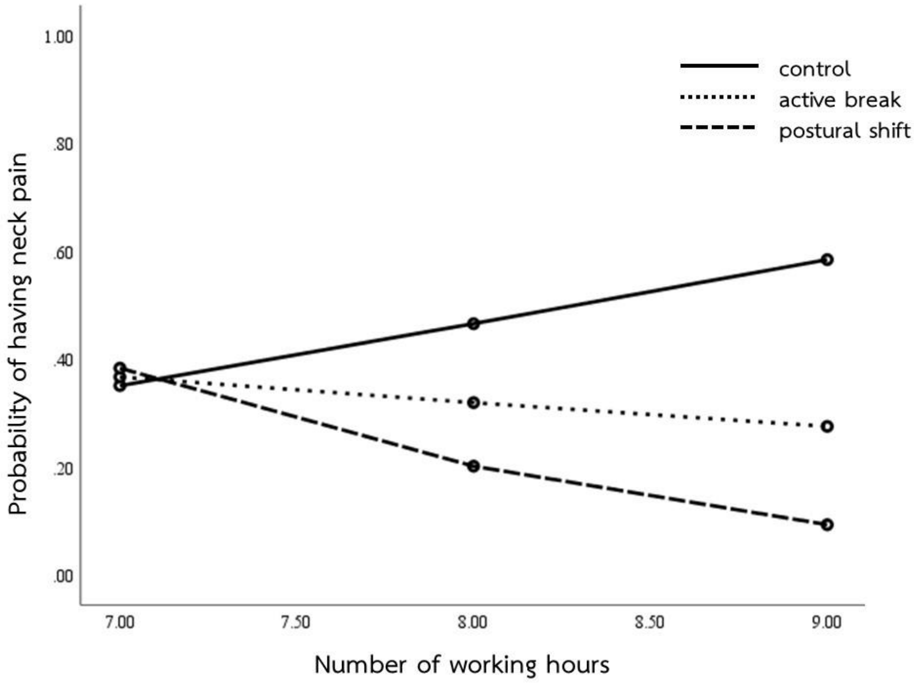


Figure 17 *Illustration of the Group X Working Hours moderation effect on the probability of having neck pain.*

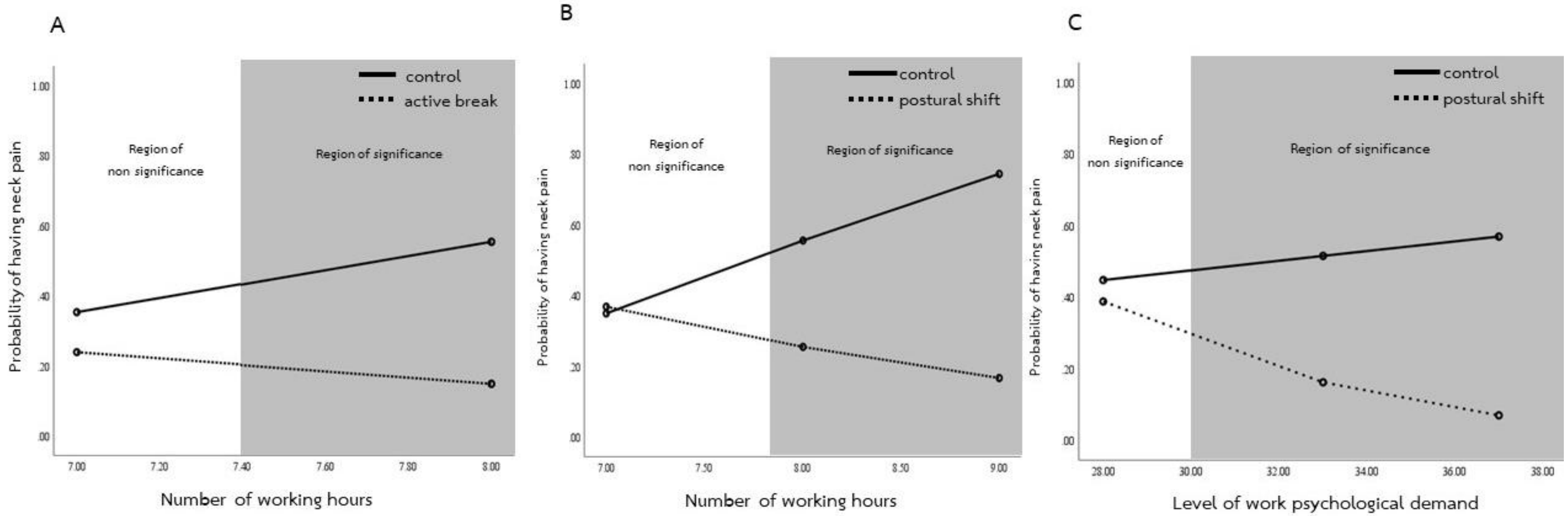


Figure 18 *Significant moderations of the differences in treatment effect and region of significance difference A) active break versus control group, B) and C) postural shift versus control group on the onset of neck pain.*

Table 12 *Within-groups simple slopes for significant tests of moderation (i.e., simple effects).*

Moderator	Active break (n=47)				Postural shift (n=46)				Control (n=100)			
	B	SE	β	P value	B	SE	β	P value	B	SE	β	P value
Non-specific neck pain												
Level of work psychological demands	.03	.89	.97	.784	-.09	-.89	.91	.297	.11	0.05	1.12	.022*
Number of working hours	-.60	.28	.55	.032*	-.49	.39	.62	.220	.81	.31	2.26	.008*
Non-specific low back pain												
Having or not having lumbar support	.93	1.27	2.53	0.465	-1.09	.87	.34	.290	1.86	.47	6.39	< .001*

Psychological work demands as a moderator

The moderation analysis for the onset of neck pain revealed a significant Treatment Group X Psychological Work Demands interaction (B = -.12, standard error [SE] = .06, R2 = .32, P = .048; see Fig.19). Post-hoc pairwise comparisons indicate a significant difference between the postural shift and control group (B = -.15, SE = .07, R2 = .37, P = .030); participants who endorsed higher levels of psychological work demands at baseline and who were assigned to the postural shift group were less likely to develop neck pain than those randomized to the control group. Johnson-Neyman results indicated participants with a level of work psychological demands >30.6 were less likely to develop the neck pain with the postural shift condition compared to those in the control condition with this same level of perceived work demands (Fig 18.2C).

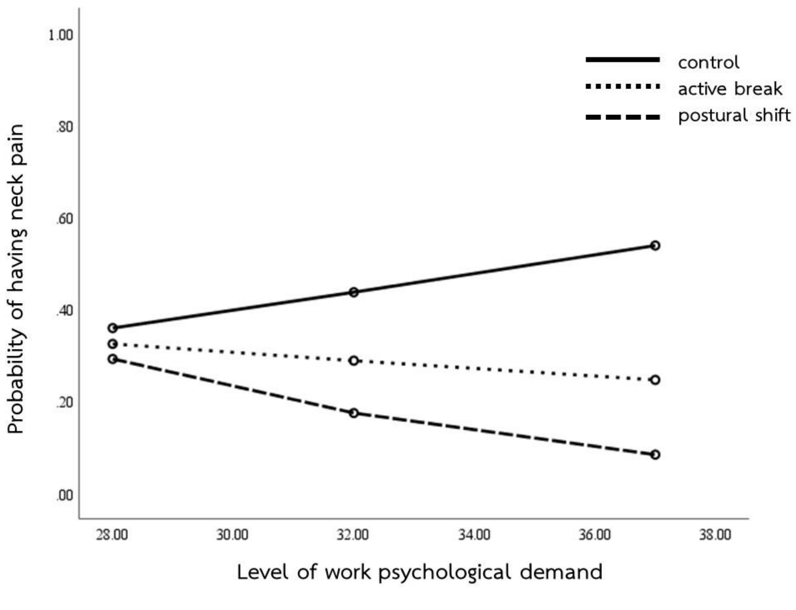


Figure 19 *Significant moderations of the differences in group conditions effect (i.e., active break, postural shift, and control group) on neck pain.*

Perceived level of psychological work demands evidenced a non-significant trend to be a moderator (B = -0.73, SE = .11, R2 = .38, P = .051) for the active break vs. control group and active break vs. postural shift group (B= -1.69, SE = .14, R2 = .22, P = .241) with respect to the development of neck pain. Logistic regressions suggested that level of work psychological demands was a significant predictor of neck pain only for the control condition (B = 0.11, SE = .05, OR = 1.12 95% CI 1.01 to 1.24, R2 = .08, P = .022; Table 12), in which more psychological demands was associated with increased neck pain.

Having or not having lumbar support as a moderator

The analysis for the onset of low back pain revealed a significant Treatment Group X Lumbar Support interaction (B = -1.97, SE = .66, R2 = .37, P = .003; see Fig 20). Post-hoc comparisons indicated a significant difference between the postural shift and control group (B = -2.09, SE = .69, R2 = .42, P = .003); participants who reported not having lumbar support gained more benefit from the postural shift intervention than those in the control group. However, having or not having lumbar support was not found to predict benefit for the active break vs. control group (B = -0.64, SE = 1.45, R2 = .42, P = .635) or active vs. postural shift group (B = -3.14, SE = 1.81, R2 = .15, P = .095). Logistic regression suggested that having or not having lumbar support was a significant predictor of low back pain for the control condition

(B = 1.86, SE = 0.47, OR = 6.39, 95% CI 2.52 to 16.20, R2 = .23, P < 0.001; Table 12); not having lumbar support was associated with increased low back pain.

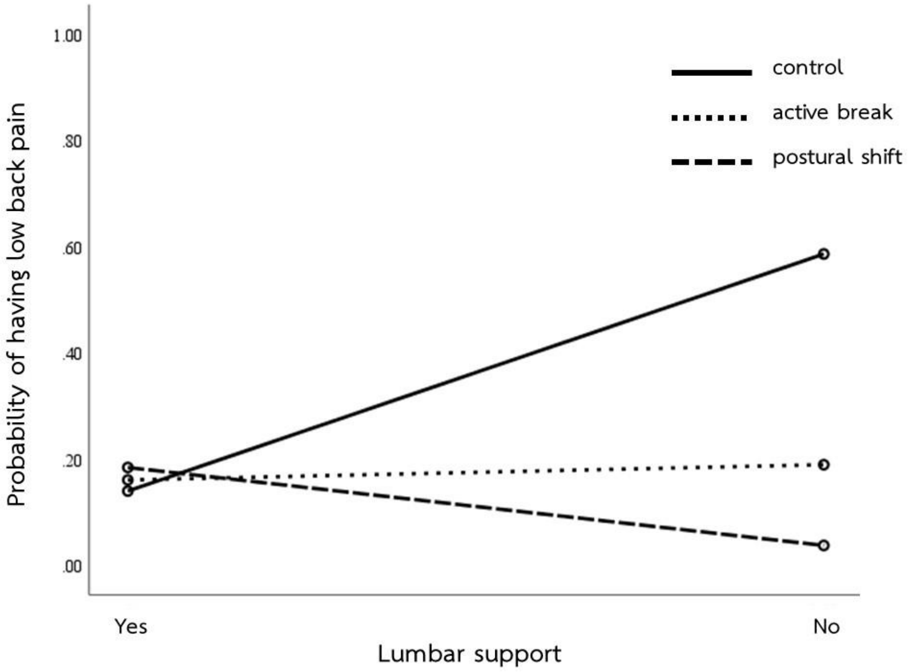


Figure 20 *Significant moderations of the differences in group conditions effect (i.e., active break, postural shift, and control group) on low back pain.*

6.4 Discussion

This study sought to identify workers more or less likely to achieve benefit from interventions designed to reduce the risk to develop neck and low back pain. With respect to neck pain, we found that workers who worked more hours/days gained more benefit from both the active break and postural shift interventions than from the control condition, and that workers who endorsed higher levels of psychological work demands gained more benefit from the postural shift intervention. The only moderator found with respect to preventing low back pain was that workers who had no lumbar support gained more benefit from the postural shift intervention than those in the control group. These findings have important implications for understanding who might benefit the most from these treatments, as well as for understanding the potential mechanisms underlying those benefits.

Moderators of prevention treatments and possible mechanism

We found that the effects of the active break and postural shift interventions on neck pain risk were moderated by number of working hours/days. Prior research shown that prolonged sitting and working time both increase the risk for the development of neck pain (Cagnie et al., 2007). The present findings suggest that the two interventions studied may mitigate the negative effects of longer working hours. Given previous findings that increasing daily walking steps reduces the onset neck pain in office workers (Sitthipornvorakul et al., 2020), it seems possible that the beneficial effects of taking breaks on neck pain could be mediated by increases in walking that could occur during those breaks. With respect to the postural shift intervention, changing sitting postures has been found to result in changes in cervicothoracic muscle activity (Caneiro et al., 2010). It is therefore possible that changing sitting postures may impose alternating activity in the neck and shoulder muscles, resulting in the alleviation of postural discomfort during prolonged sitting, and consequently reducing the risk to develop neck pain.

We also found a significant moderation effect for the level of psychological work demands on the benefits of the postural shift intervention, and a non-significant trend (p = .051) for this same moderation effect for the active break intervention. Consistent with this finding, Gurung and colleagues (2015) identified psychological distress as a potential moderator of the benefits of cognitive-behavioral therapy on back pain-related disability. Other researchers have found that negative mood and emotions, cognitive functioning, and pain behavior, are all related to the onset of neck pain and other musculoskeletal conditions (Bongers et al., 1993; Mayerl et al., 2017). We can envision two possible mechanisms for the moderation effect we observed. First, psychological stress could induce negative physical effects [e.g., muscle tension (Yaribeygi H, 2017) or postural discomfort (Wahlström, 2005), which may then be mitigated by position shifts or by taking breaks. Second, taking active breaks or postural shifts might directly reduce psychological stress. Consistent with this idea, previous research has found that breaks can reduce or prevent stress, and help to facilitate recovery from early symptoms of work-related mental and physical fatigue (Sianoja, 2016). However, research is needed to test psychological stress as a potential mediator of the beneficial effects of these treatments.

The moderation effect of lumbar support on the beneficial effects of the postural shift intervention for low back pain is consistent with prior research showing that lumbar support helps to prevent the development of low back pain

(Janwantanakul et al., 2011). Prolonged sitting with poor posture (i.e., reduced lumbar-lordotic curve) might increases strain on the back of spine consequently increased risk of hyperflexion injury to the disc and ligament (McGill and Brown, 1992; Jung et al., 2020). The negative effects of poor sitting posture can be minimized by using the lumbar support, which contributes to maintaining the natural lordotic curvature (Makhsous et al., 2003). Regularly performing postural shifts while sitting may also decrease static trunk muscle activity (Caneiro et al., 2010), reducing trunk muscle fatigue and delaying the onset of low back discomfort (O'Sullivan et al., 2012; O'Sullivan et al., 2013). The concept that sitting with poor posture can contribution to exacerbations of low back symptom is controversial (Burnett et al., 2004; Dankaerts et al., 2006a). Thus, the association between sitting posture and low back pain is remains tenuous. Additional research to clarify the roles of sitting posture, lumbar support, and postural shifts in the development of low back pain is warranted.

Variables not showing a significant moderation effect

The hypothesized moderators that did not emerge as significant included age, job position, education level, and sex. The exploratory moderators that did not emerge as significant were having an adjustable chair, years of employment, standing for more than 2 hours in a typical work day, and needing to bend one’s trunk forward frequently during work. These null findings have a number of possible explanations. First, it is possible that these factors moderate the effects of treatments that were not examined here. For example, the hypothesized moderators have been shown in prior research to moderate the effects of passive treatments such as acupuncture (i.e., age and sex) (Witt et al., 2011) and spinal manipulation (i.e., low back pain duration and baseline pain intensity) (de Zoete et al., 2021). In contrast, we examined the effects of active interventions, which may have different moderators. A second possible reason may be related to differences in the study samples. Hayden and colleagues described that having or not having heavy physical demands at work, using or not using medications, and BMI level moderated the effects of exercise treatment (Hayden et al., 2020), and Underwood et al. (2007) found that age and employment status moderated the effects of a cognitive-behavioral intervention, in individuals with low back pain. However, in the current study, the participants were office workers who were not currently reporting any neck or back pain. Additional research is needed to determine the extent to which moderators influence outcome across different samples of individuals and different types of treatment.

Implications for understanding mechanisms

The fact that the interventions studied here were moderated by two factors that appear to be biomechanical in nature (i.e., longer work day hours and lack of lumbar support) is consistent with the idea that the interventions studied reduce the risk for developing neck and back pain by reducing biomechanical stress. This idea could be tested by including objective measures of biomechanical stress (e.g., EMG activity) during treatment, and then conducting mediation analyses (Hayes and Rockwood, 2017) to test biomechanical stress as a potential mediator. It is also possible that having more work hours could impact pain via its effects on psychosocial stress. Research to examine both types of stress as potential mediators is warranted.

Study strengths and limitations

A major strength of this study is a conservative definition of neck of low back pain (i.e., pain that is moderate in intensity (Tsauo et al., 2007) and lasts for at least 24 hours (de Vet et al., 2002)) as our measure of pain onset. It is noteworthy that the results might have differed had we used or less conservative operational defection of pain onset.

The study has four primary limitations. First, we did not control for multiple testing. It is possible that some of the significant effects found emerged because of chance alone. The analyses conducted here should be repeated in other samples. Second, there are potential moderators identified in previous research that we did not evaluate here. Future research should examine these moderators. Third, the sample size for these analyses was not determined a priori, because they are secondary analysis using data from a completed study. It is possible that significant moderation effects might have gone undetected. However, we did compute the effect sizes (f2) of the moderation effects tested, which may be used to determine sample size by future researchers. Finally, the study was conducted using otherwise healthy 23- to 55 years old office workers who were pain free at the time of study enrollment. Generalization of the findings to other populations therefore should be made with caution.

6.5 Conclusions

The findings provide new and important information regarding the role that several factors play as moderators of the effects of active break and postural shift interventions. We found significant moderating roles for (1) number of working hours/days for the benefits of the active break intervention, and (2) number of working hours/days and perceived psychological work demands for the benefits of the postural shift intervention. The role of not having lumbar support was as a moderator of the effect of the postural shift intervention in the development of low back pain. These findings can be used to identify those workers who are most likely to benefit from the interventions, and provide preliminary findings that could inform future studies to evaluate the mechanisms that underlie the beneficial effects of these treatments.

Authors' contributions

NA provided the concept or research design, data collection, data analysis, and manuscript writing. PW contributed to the concept or research design and data collection. MJ and PJ contributed to the concept or research design, data analysis, and manuscript writing. AN contributed to the data analysis and manuscript writing. All authors read and approved the final manuscript.

Conflict of Interest

The authors developed the apparatus. The patent of the apparatus belongs to the university and funding agency. The authors declare that there are no other conflicts of interest.

Acknowledgements

This work was supported by Thailand Research Fund through the Royal Golden Jubilee Ph.D. Program (PHD/0180/2558 and PHD/0120/ 2559) and Industry Division (RDG6050058). Srithai Auto Seats Industry Company Limited partially provided financial support with no interference on methodology, data collection, and data analysis of the study.

Summary

This study identified variable that enhance the efficacy of active break and postural shift interventions on prevention of neck and low back pain among high-risk office workers. However, the data of active break intervention belonged to our colleague, Dr. Pooriput Waongenngarm. Thus, the summary focused only postural shift intervention.

The findings of this current study suggested that sedentary worker who reported working more hours/day and endorsed higher level of psychological work stress gained more benefits from postural shift intervention for prevention of neck pain. For the prevention of low back pain, workers who reported not having a chair with lumber support gained more benefits from postural shift intervention. This finding could improve the effectiveness and efficiency of postural shift intervention by inform better individual-treatment matching.

Chapter 7
General conclusion

7.1 Summary of the results

The aim of this study was to develop the device to facilitate postural change while sitting for the prevention of neck and low back pain in office workers. The study was divided into two phases; (1) the development of a device, and (2) the investigation of its effectiveness to prevent neck and low back pain in office workers. The device consisted of three components; seat pad, controller with DynaSit® algorithm, and smartphone application.

During the first phase of study (development phase), the author confronted with a lack of empirical evidence on the effect of postural shift frequency on the development of perceived discomfort in the neck and low back in office workers. Thus, the experiment was conducted (Chapter 3) to evaluate the effect of postural shifting frequency on perceived musculoskeletal discomfort during 1 hour of sitting in healthy office workers. The findings demonstrated that postural shifting frequency of 20-30 times/h was found to be effective in alleviating individual perceived discomfort in the neck and low back during 1-hour sitting. Thus, this information was taken into account to develop DynaSit® algorithm. The device was tested for its validity, consistency, test run, and durability. The results showed that the device had good to excellent validity and consistency as well as no problem was found during the use of device. For durability test, it was found that nineteen devices had problems during one year of data collection including air bag problem for 8 pieces, air pump problems for 2 pieces, adapter problem 10 pieces, and SD card problem for 7 pieces (Appendix A).

For a second phase (effectiveness testing), the author conducted a study to investigate the effects of the postural shift facilitation intervention on the 12-month incidence of neck and low back pain in high-risk office workers (Chapter 4). The efficacy of postural shift facilitation interventions on recovery duration and recurrence of neck and low back pain among high-risk office workers was also examined (Chapter 5). The finding indicated that the 12-month incidence of neck and low back pain was reduced by 62-67% by the interventions. Postural shift intervention shortened recovery time and reduced recurrence of neck and low back pain among office workers with neck or low back pain by 65%.

Finally, to enhance the effectiveness and efficiency of the device to prevent neck and low back pain, a study was conducted to identify those most likely to benefit from the postural shift interventions to prevent neck and low back pain (Chapter 6). For the prevention of neck pain, the effect of the postural shift intervention was moderated by the level of perceived psychological work demands and the number of working hours. For the prevention of low back pain, the effect of postural shift intervention was moderated by having or not having a chair with lumbar support.

7.2 Limitations of the study and suggestions for further study

To the best of author's knowledge, this is the first study to investigate long-term effect of a specific device for preventing musculoskeletal disorders in the neck or low back in high-risk office workers. There are a number of valuable information emerged for this study, however, several methodological limitations are noteworthy.

First, the study (Chapter 3) was performed in a highly controlled laboratory setting and only investigated body perceived discomfort with three different postural shifting frequencies (i.e., 10, 20, and 30 times/h) in young healthy office workers. While this level of control allowed us to test the study hypotheses, the extent to which the findings generalize to real life office settings is limited. Research studying the effects of posture change frequency in real life settings is needed to establish generalizability. Second, the study was conducted in healthy but high risk to develop neck and low back pain office workers. Extrapolation of these results to other populations should be made with caution. Further research on the effects of postural shift intervention on the incidence of neck and low back pain in other populations is suggested. Third, some baseline characteristics showed differences among the study groups. The use of cluster randomization had the risk of baseline imbalance between the randomized groups. Thus, further research should consider stratified or pair-matched randomization of clusters. Fourth, the author did not assess participants' sitting behavior at baseline. Therefore, we did not know whether the designated postural shifts suggested by the device for individuals in the intervention group were higher or lower than their habitual daily occupational sitting behavior. Future study should examine the efficacy of postural shifts to prevent neck and low back pain in those with poor habitual sitting behavior relative to the designated postural shifts suggested by the device to validate the present findings. Last, dependent variable of each study (i.e., body perceived discomfort, incidence of neck or low back pain) was assessed using a self-report scale, which poses the risk of bias in the estimation of exposure or health outcome. Pain or discomfort are biopsychosocial phenomenon and influenced by many factors. Thus, research using more objective measures (e.g., observed pain behaviors in laboratory studies, work sick days in real-world studies) is recommended to establish the validity of the current findings.

7.3 Clinical implication

1. Postural shifts of 20 and 30 times/h provide the buffering effects on perceived musculoskeletal discomfort at the neck, shoulder, upper back, and low back among office workers.

2. A custom-designed device to facilitate designated active breaks and postural shifts during office work can be used as an intervention for preventing the development of neck and low back pain among high-risk office workers.

3. The device has a potential to shorten recovery time and reduce recurrence of neck and low back pain among high-risk office workers with neck and low back pain.

4. Office workers who worked more hours/day received more benefits from both the active break and postural shift interventions. Workers who had higher levels of psychological work demands gained more benefits from the postural shift intervention regarding neck pain prevention. Workers who had no lumbar support gained more benefits from the postural shift intervention regarding low back prevention.

APPENDIX A

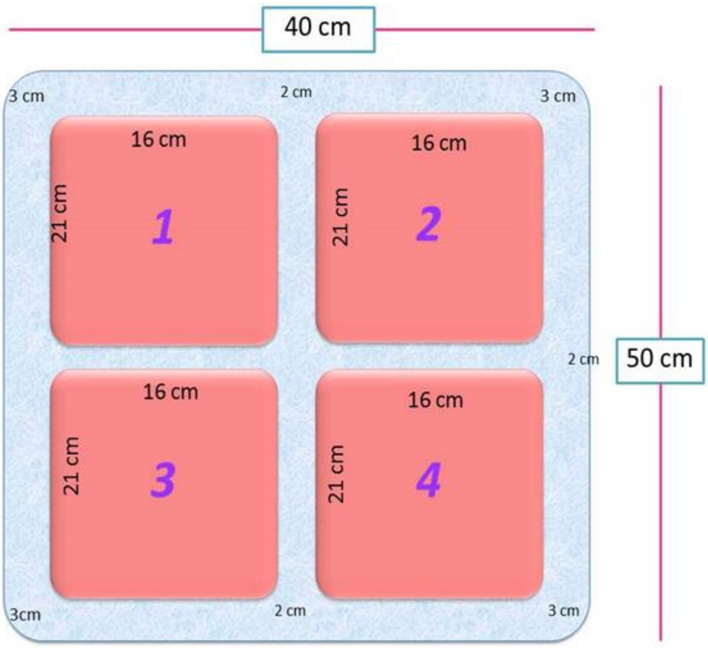
The development process of the device

The device for postural change while sitting at work was developed by the team researcher, mechanical and computer engineers. This device can detect sitting time and recommend required postural shifting during work to the user. The device consists of three components:

1) Seat pad with pressure sensors

The seat pad was assembled by a mechanical engineer from Srithai Auto Seats Industry Company. Four pressure sensors were attached to the seat pad in each quadrant. The pressure sensors would be activated when a user sits on the seat pad. The seat pad can be placed in any office chairs. The seat pad size is 40*50cm.

The seat pad was connected to a controller via a cord, which data from pressure sensors would be sent to for analysis.



2) Controller

The controller was assembled by team engineers (mechanical, computer and software engineers) from Srithai Auto Seats Industry Company and Electronic Pro Design Company. A function of controller is receiving and processing the data from the sensors of seat pad. The controller is also sending the data to a smart phone through an application named HealthySit® application. The controller is a box, which consists of a microprocessor, Bluetooth transmitter, which has a standard range of approximately 0-100 meters. The controller can be connected to the smart phone via Bluetooth. Data were stored in the controller, which were used to calculate recommended number of postural shifts for each individual. Designated postural shifts were induced by the apparatus gradually pumping the air into various parts of the seat pad placed underneath a participant's buttocks. Commands to operate the seat pad were sent from the processor to the seat pad via a cord connected between them. The postural shift algorithms were developed and were named as DynaSit® program. DynaSit® provides the individual required for a number of postural shifts which based on the theoretical effects of frequency of postural shift on the reduction of neck and low back discomfort ranging from 20-60 times per hour depending on their occupational sitting behavior.

3) HealthySit smart phone application

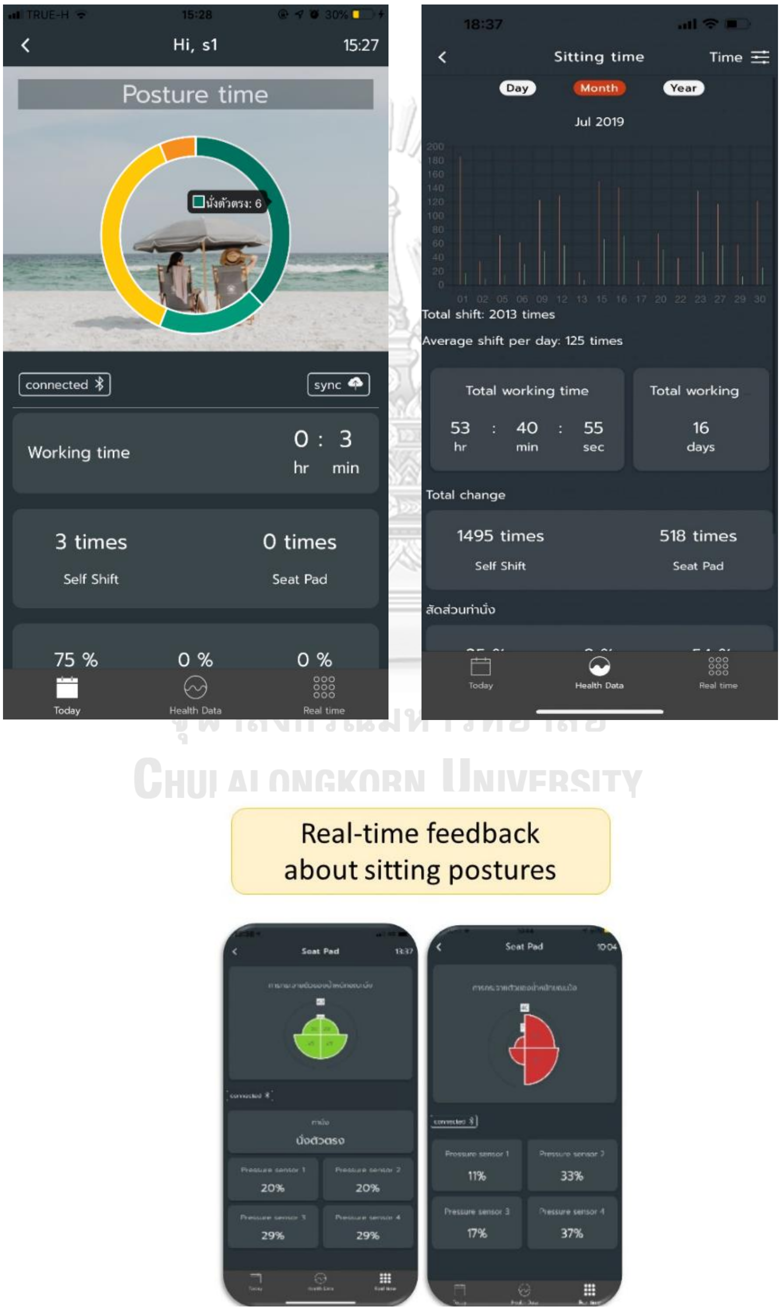
The smart phone application named HealthySit® was developed by author and computer engineering team. The application was installed in a smart phone with android or iOS systems. The HealthySit® application automatically connect to the controller when it comes in range. The HealthySit® application would remind a user to take their breaks at appropriate time. The HealthySit® application also collected data to reflect the sitting behavior of user as follow:

1. Total sitting duration per day/week/month
2. Percentage of time in each sitting posture per day/week/month

3. Frequency of user’s postural change per hour for each day/week/month

4. Frequency of smart seat help user to change user’ sitting posture

5. Real time display of seat pressure distribution (1Hz-sample rate frequency)



When three parts of the device was completed, the validity, consistency and test run of the device were assessed.

Validity test

The validity of a device for postural change while sitting was established to ensure that the system produces valid results. The concurrent validity test was conducted in laboratory. The pressure was applied to the seat pad using a standardized weight and the amount of pressure applied by a standardized weight were compared with the amount of pressure reported in the smart phone application. In addition, the sitting time that detect from the device was compared with the standard stopwatch from iPhone. The results showed that the device had good to excellent concurrent validity (Pearson's correlation coefficient=0.95-1.00, $p<0.05$).

Consistency test

The consistency of a device for postural change while sitting was conducted to ensure that the system produces consistent results. The consistency of a device for postural change while sitting was tested on two separate occasions with a 24-hour lapse between the measurements. A convenience sample of 10 office workers were selected to participate in consistency study. Subjects were asked to use a DynaSeat with DynaSit® program in laboratory for 1 hour and were asked to follow the break program (i.e., with specific sitting posture and perform postural shifting when signal alert). The results showed that the device had good to excellent consistency (ICC model [3,1] = 0.99-1.00, $p<0.05$).

Test run

The test run was conducted to ensure that a device for postural change while sitting works properly. The test run was tested in laboratory. A convenience sample of 10 office workers were recruited in this study. Subjects were asked to use a device for postural change while sitting for 1 day from 8.00 - 16.00 and were asked to follow the DynaSit® program. The result showed no problems were found during the use of the device.

APPENDIX B

Certificate of ethical approval

AF 01-12

คณะกรรมการพิจารณาจริยธรรมการวิจัยในคน กลุ่มสหสถาบัน ชุดที่ 1 จุฬาลงกรณ์มหาวิทยาลัย
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COA No. 148/2562

ใบรับรองโครงการวิจัย

โครงการวิจัยที่ 066.1/61 : การพัฒนาที่นั่งอัจฉริยะเพื่อป้องกันโรคปวดคอ/บ่าและหลังส่วนล่างจากการนั่งเป็นระยะเวลานานในผู้ที่ทำงานในสำนักงาน

ผู้วิจัยหลัก : ศาสตราจารย์ ดร.ประวิตร เจนวรรธนะกุล

หน่วยงาน : คณะสหเวชศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

คณะกรรมการพิจารณาจริยธรรมการวิจัยในคน กลุ่มสหสถาบัน ชุดที่ 1 จุฬาลงกรณ์มหาวิทยาลัย ได้พิจารณา โดยใช้หลัก ของ Belmont Report 1979, Declaration of Helsinki 2013, Council for International Organizations of Medical Sciences (CIOM) 2016, มาตรฐานคณะกรรมการจริยธรรมการวิจัยในคน (มคจค.) 2556, นโยบายแห่งชาติและแนวทางปฏิบัติการวิจัยในมนุษย์ 2558 อนุมัติให้ดำเนินการศึกษาวิจัยเรื่องดังกล่าวได้**ในระยะที่ 4 ของโครงการวิจัย**

ลงนาม ....
(รองศาสตราจารย์ นายแพทย์ปรีดา ทัศนประดิษฐ)
ประธาน

ลงนาม ....
(ผู้ช่วยศาสตราจารย์ ดร.นันทรี ชัยชนะวงศาโรจน์)
กรรมการและเลขานุการ

วันที่รับรอง : 30 พฤษภาคม 2562 **วันหมดอายุ** : 29 พฤษภาคม 2563

เอกสารที่คณะกรรมการรับรอง

1) โครงการวิจัย
2) ข้อมูลสำหรับกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัยและใบยินยอมของกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย
3) ผู้วิจัย
4) แบบสอบถาม

เลขที่โครงการวิจัย 066.1/61
วันที่รับรอง 30 พ.ค. 2562
วันหมดอายุ 29 พ.ค. 2563

<u>เงื่อนไข</u>

1. ข้าพเจ้ารับทราบว่าเป็นการผิดจริยธรรม หากดำเนินการเก็บข้อมูลการวิจัยก่อนได้รับการอนุมัติจากคณะกรรมการพิจารณาจริยธรรมการวิจัยฯ
2. หากใบรับรองโครงการวิจัยหมดอายุ การดำเนินการวิจัยต้องยุติ เมื่อต้องการต่ออายุต้องขออนุมัติใหม่ล่วงหน้าไม่ต่ำกว่า 1 เดือน พร้อมส่งรายงานความก้าวหน้าการวิจัย
3. ต้องดำเนินการวิจัยตามที่ระบุไว้ในโครงการวิจัยอย่างเคร่งครัด
4. ใช้เอกสารข้อมูลสำหรับกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย ใบยินยอมของกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย และเอกสารเชิญเข้าร่วมวิจัย (ถ้ามี) ***เฉพาะที่ประทับตราคณะกรรมการเท่านั้น***
5. หากเกิดเหตุการณ์ไม่พึงประสงค์ร้ายแรงในสถานที่เก็บข้อมูลที่ขออนุมัติจากคณะกรรมการ ต้องรายงานคณะกรรมการภายใน 5 วันทำการ
6. หากมีการเปลี่ยนแปลงการดำเนินการวิจัย ให้ส่งคณะกรรมการพิจารณารับรองก่อนดำเนินการ
7. โครงการวิจัยไม่เกิน 1 ปี ส่งแบบรายงานสิ้นสุดโครงการวิจัย (AF 02-14) และบทคัดย่อผลการวิจัยภายใน 30 วัน เมื่อโครงการวิจัยเสร็จสิ้น สำหรับโครงการวิจัยที่เป็นวิทยานิพนธ์ให้ส่งบทคัดย่อผลการวิจัย ภายใน 30 วัน เมื่อโครงการวิจัยเสร็จสิ้น

APPENDIX C

Self-Administered Questionnaire

แบบสอบถาม

รหัสผู้เข้าร่วมวิจัย................

วัน เดือน ปี ที่เก็บข้อมูล...............

คำชี้แจง

- แบบสอบถามนี้แบ่งออกเป็น 3 ส่วน ได้แก่

  <u>ส่วนที่ 1</u> ข้อมูลส่วนบุคคล

  <u>ส่วนที่ 2</u> ข้อมูลเกี่ยวกับลักษณะงานประจำของคุณ

  <u>ส่วนที่ 3</u> ข้อมูลด้านจิตใจและสังคมสิ่งแวดล้อม

- กรุณาตอบคำถามทุกข้อตามความเป็นจริง โดยเลือกเพียงคำตอบเดียว หรือใส่ข้อความสั้นๆ ที่ตรงกับตัวคุณมากที่สุด
- ในบางคำถามสามารถเลือกตอบได้มากกว่า 1 คำตอบ ซึ่งจะระบุไว้ในท้ายของคำถามข้อนั้น

ขอขอบพระคุณคุณเป็นอย่างสูงในการให้ความร่วมมือ

<u>ส่วนที่ 1</u> ข้อมูลส่วนบุคคล

คำชี้แจง กรุณาตอบคำถามทุกข้อตามความเป็นจริง โดยใส่ข้อความสั้นๆ หรือเลือกคำตอบที่สอดคล้องกับความคิดเห็นของคุณมากที่สุด โดยใส่เครื่องหมาย ✓ ใน [....] เพียง 1 คำตอบ

---

1. เพศ [....] 1. ชาย [....] 2. หญิง
2. วัน/เดือน/ปีเกิด................../................................/...............................
3. สถานภาพสมรส

    [....] 1. โสด [....] 2. สมรส

    [....] 3. หม้าย/หย่า/แยกทาง [....] 4. อื่นๆ โปรดระบุ...................................

4. วุฒิการศึกษาสูงสุด

    [....] 1. ม.3 [....] 2. ม.6

    [....] 3. ปวช./ปวท./ปวส. [....] 4. ปริญญาตรี

    [....] 5. ปริญญาโท-เอก [....] 6. อื่นๆ โปรดระบุ.................................

5. <u>ในรอบ 12 เดือนที่ผ่านมา</u> คุณออกกำลังกายบ่อยแค่ไหน (การออกกำลังกาย หมายถึง การเคลื่อนไหวร่างกายอย่างต่อเนื่องอย่างน้อย 30 นาที หรือจนรู้สึกเหนื่อย เพื่อเสริมสร้างสุขภาพร่างกายให้แข็งแรง โดยกระทำในยามว่างหรือเป็นงานอดิเรก เช่น เดินเร็ว วิ่ง ว่ายน้ำ เล่นกีฬา เป็นต้น)

    [....] 1. ไม่ได้ทำ

    [....] 2. ทำบ้าง แต่ไม่สม่ำเสมอ

    [....] 3. ทำสม่ำเสมอ โดยเฉลี่ย..............ครั้งต่อสัปดาห์

    [....] 4. ไม่แน่ใจ

6. คุณสูบบุหรี่ หรือไม่

[....] 1. ไม่สูบ

[....] 2. ไม่สูบ แต่บุคคลใกล้ชิดสูบ เช่น สมาชิกในครอบครัว หรือ เพื่อนร่วมงาน เป็นต้น

[....] 3. สูบ โปรดระบุจำนวนบุหรี่ที่สูบโดยประมาณ.................มวนต่อวัน

[....] 4. เคยสูบ แต่ปัจจุบันไม่ได้สูบแล้ว โปรดระบุจำนวนปีที่<u>หยุดสูบบุหรี่</u> ....ปี

7. ในวันทำงาน คุณขับรถยนต์ หรือไม่

[....] 1. ไม่ได้ขับรถ

[....] 2. ขับรถ โดยเฉลี่ย คุณใช้เวลาขับรถ........................ชั่วโมงต่อวัน

8. คุณมีความรู้สึกไม่สบายของร่างกายบริเวณคอ/บ่าในรอบ 1 ปีที่ผ่านมาหรือไม่

[....] 1. มี โดยมีระดับความรู้สึกไม่สบายเป็นช่วงระหว่าง 0-10 โดย 0 หมายถึง ไม่มีความรู้สึกไม่สบายเลย และ 10 หมายถึง รู้สึกไม่สบายอย่างยิ่ง (วงกลมบนหมายเลขที่ตรงกับความรู้สึก)

0 1 2 3 4 5 6 7 8 9 10

[....] 2. ไม่มี

9. คุณมีความรู้สึกไม่สบายของร่างกายบริเวณหลังส่วนล่างในรอบ 1 ปีที่ผ่านมาหรือไม่

[....] 1. มี โดยมีระดับความรู้สึกไม่สบายเป็นช่วงระหว่าง 0-10 โดย 0 หมายถึง ไม่มีความรู้สึกไม่สบายเลย และ 10 หมายถึง รู้สึกไม่สบายอย่างยิ่ง (วงกลมบนหมายเลขที่ตรงกับความรู้สึก)

0 1 2 3 4 5 6 7 8 9 10

[....] 2. ไม่มี

10. คุณรับประทานยาอะไรเป็นประจำหรือไม่

[....] 1. ใช่ โปรดระบุชื่อยา ....

[....] 2. ไม่ใช่

<u>ส่วนที่ 2</u> ข้อมูลเกี่ยวกับลักษณะงานประจำของคุณ

คำชี้แจง กรุณาตอบคำถามทุกข้อตามความเป็นจริง โดยใส่ข้อความสั้นๆ หรือเลือกคำตอบที่สอดคล้องกับความคิดเห็นของคุณมากที่สุดเพียงคำตอบเดียว โดยใส่เครื่องหมาย ✓ ใน [....] หรือช่องในตารางที่ตรงกับคำตอบของคุณ

---

1. ตำแหน่งงานปัจจุบันของคุณคือ...........................

   [....] 1. ผู้บริหาร/ผู้จัดการ/หัวหน้างาน

   [....] 2. เจ้าหน้าที่การเงิน/บัญชี

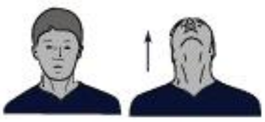
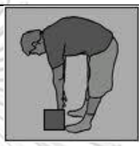
   [....] 3. เจ้าหน้าที่ธุรการ/สำนักงาน

2. ตั้งแต่อดีตจนถึงปัจจุบัน คุณเคยทำงานในสำนักงานมาแล้วเป็นเวลา..................................ปี

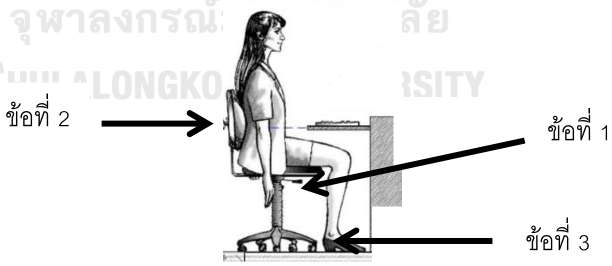
3. <u>ในรอบ 12 เดือนที่ผ่านมา</u> คุณทำงานในตำแหน่งดังกล่าวโดยเฉลี่ยวันละ...........ชั่วโมง เป็นจำนวน...............วันต่อสัปดาห์

4. <u>โดยเฉลี่ย</u>ในการทำงานแต่ละวัน คุณต้องทำกิจกรรมใดต่อไปนี้บ้าง (กรุณาตอบทุกข้อ)

หัวข้อ	ใช่	ไม่ใช่
1. เอื้อมมือหยิบของที่อยู่เหนือศีรษะบ่อยๆ		
2. ยก/หิ้วของหนักปานกลางถึงหนักมากบ่อยๆ		
3. ทำงานโดยใช้เครื่องคอมพิวเตอร์มากกว่า 4 ชั่วโมงต่อวัน		
4. นั่งทำงาน <u>ติดต่อกัน</u>เป็นเวลานานกว่า 2 ชั่วโมง		
5. ยืนทำงาน <u>ติดต่อกัน</u>เป็นเวลานานกว่า 2 ชั่วโมง		

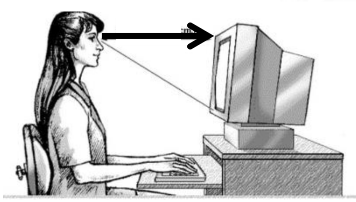
6. เงยหน้าบ่อยๆ 		
7. ก้มหน้าบ่อยๆ 		
8. หมุนคอ หรือหันหน้าไปด้านข้างบ่อยๆ 		
9. ก้มหลังบ่อยๆ เช่น ก้มหยิบของ เป็นต้น 		
10. เอี้ยวตัว หรือหมุนตัวบ่อยๆ เช่น เอี้ยวตัวหยิบของ เป็นต้น 		

5. คุณเห็นว่า ที่ทำงานของคุณ โดยส่วนใหญ่มีลักษณะตรงกับข้อใดบ้าง

หัวข้อ	ใช่	ไม่ใช่
		
1. เก้าอี้ที่คุณนั่งเป็นประจำ คุณสามารถปรับระดับความสูงได้ (ดังรูป)		
2. เมื่อคุณนั่งทำงาน คุณมีพนักพิง หรือใช้หมอน ช่วยหนุนบริเวณเอว (ดังรูป)		
3. เมื่อคุณนั่งทำงาน คุณสามารถวางเท้าบนพื้นได้พอดี (ดังรูป)		

4. โต๊ะทำงานที่คุณใช้เป็นประจำ มีความสูงพอเหมาะกับคุณ (ระดับความสูงที่สามารถวางแขนได้โดยหัวไหล่ไม่ยก)		
5. คุณมักจัดวางสิ่งของบนโต๊ะทำงานให้ง่ายต่อการหยิบจับ		
6. บริเวณใต้โต๊ะทำงานของคุณ มักจะมีสิ่งของวางเกะกะ		
7. ห้องทำงานของคุณ มักจะมีเสียงดังรบกวน		
8. ห้องทำงานของคุณ มักจะมีอุณหภูมิพอเหมาะ ไม่ร้อนหรือเย็นจนเกินไป		
9. ห้องทำงานของคุณ มักจะมีแสงสว่างเพียงพอ ไม่มืดหรือสว่างจนเกินไป		
10. ห้องทำงานมีอากาศถ่ายเทดี		
11. ในระหว่างการทำงาน คุณมีการหยุดพักเป็นระยะๆ		

12. เมื่อคุณใช้งานเครื่องคอมพิวเตอร์ ตำแหน่งจอคอมพิวเตอร์อยู่ตรงหน้า ในระดับที่เหมาะสม หรือไม่ (ดังรูป)



[....] 1. ใช่ [....] 2. ไม่ใช่

[....] 3. ไม่แน่ใจ [....] 4. ไม่ได้ใช้คอมพิวเตอร์เลย

13. เมื่อคุณใช้งานเครื่องคอมพิวเตอร์ ระยะห่างระหว่างจอคอมพิวเตอร์กับคุณ อยู่ในระยะที่เหมาะสม หรือไม่ (ดังรูป)

[....] 1. ใช่ [....] 2. ไม่ใช่

[....] 3. ไม่แน่ใจ [....] 4. ไม่ได้ใช้คอมพิวเตอร์เลย

14. เมื่อคุณใช้งานเครื่องคอมพิวเตอร์ แป้นพิมพ์และเม้าส์วางไว้ที่ระดับเดียวกับข้อศอก หรือไม่ (ดังรูป)

[....] 1. ใช่ [....] 2. ไม่ใช่

[....] 3. ไม่แน่ใจ [....] 4. ไม่ได้ใช้คอมพิวเตอร์เลย

15. โดยปกติ เมื่อต้องเคลื่อนย้ายหรือยกของหนัก คุณใช้เครื่องทุ่นแรง หรือไม่

[....] 1. ใช้

[....] 2. ไม่ใช้

[....] 3. ไม่ได้ยก หรือ เคลื่อนย้าย ของหนัก

****************มีต่อส่วนที่ 3 ****************

ส่วนที่ 3 ข้อมูลด้านจิตใจและสังคมสิ่งแวดล้อม

คำชี้แจง กรุณาอ่านประโยคต่อไปนี้ แล้วขีดเรื่องหมาย ✓ ในช่องที่ตรงกับความรู้สึกของคุณต่องาน ในกรณีที่ไม่มีคำตอบใดตรง กรุณาเลือกข้อที่ใกล้เคียงความรู้สึกที่สุดเพียงข้อเดียว **กรุณาตอบทุกข้อ**

	1. ไม่เห็นด้วยมาก	2. ไม่เห็นด้วย	3. เห็นด้วย	4. เห็นด้วยมาก
1. ในการทำงานคุณได้พัฒนาความสามารถของตนเอง	☐	☐	☐	☐
2. คุณแสดงความเห็นได้เต็มที่ในเรื่องที่เกิดขึ้นในงานของคุณ	☐	☐	☐	☐
3. งานของคุณทำให้คุณต้องค้นคิดสิ่งใหม่ๆหรือคิดสร้างสรรค์	☐	☐	☐	☐
4. คุณมีบทบาทสำคัญในการตัดสินใจในกลุ่มงานของคุณ	☐	☐	☐	☐
5. ในการทำงานคุณมีโอกาสตัดสินใจด้วยตัวเอง	☐	☐	☐	☐
6. งานที่คุณทำต้องการทักษะและความชำนาญระดับสูง	☐	☐	☐	☐
7. ในการทำงานคุณต้องเรียนรู้สิ่งใหม่ๆ	☐	☐	☐	☐
8. ที่ทำงานของคุณใช้การตัดสินแบบประชาธิปไตย	☐	☐	☐	☐
9. งานของคุณต้องใช้สมาธิมากและนาน	☐	☐	☐	☐
10. โอกาสก้าวหน้าในอาชีพหรืองานของคุณดี	☐	☐	☐	☐
11. ในเวลา 5 ปีข้างหน้า ทักษะความชำนาญของคุณยังมีคุณค่า	☐	☐	☐	☐
12. คุณต้องทำสิ่งซ้ำๆหลายๆครั้งในงาน	☐	☐	☐	☐
13. คุณต้องทำงานที่มีลักษณะหลากหลายมาก	☐	☐	☐	☐

14. คุณมีอิสระในการตัดสินใจว่าจะทำงานยังไง	☐	☐	☐	☐
15. งานของคุณยุ่งวุ่นวาย	☐	☐	☐	☐
16. งานของคุณเป็นงานหนัก	☐	☐	☐	☐
17. คุณต้องทำงานมากจนเวลาพักผ่อนไม่พอ	☐	☐	☐	☐
18. คุณมักต้องรีบทำงานให้ทันกำหนด	☐	☐	☐	☐
19. งานของคุณมักถูกขัดจังหวะก่อนเสร็จ ทำให้ต้องทำต่อทีหลัง	☐	☐	☐	☐
20. งานของคุณเป็นงานที่ต้องทำอย่างรวดเร็ว	☐	☐	☐	☐
21. เงินตอบแทนหรือค่าจ้างของคุณน้อย	☐	☐	☐	☐
22. งานของคุณต้องล่าช้าเพราะต้องคอยงานจากผู้อื่น/หน่วยอื่น	☐	☐	☐	☐
23. คุณต้องเคลื่อนไหวร่างกายอย่างรวดเร็วและต่อเนื่องในงาน	☐	☐	☐	☐

	1. ไม่เห็นด้วยมาก	2. ไม่เห็นด้วย	3. เห็นด้วย	4. เห็นด้วยมาก
24. ในงานคุณต้องพบปัญหาหรือข้อขัดแย้งที่เกิดจากผู้อื่น	☐	☐	☐	☐
25. งานของคุณมีความเสี่ยงทางการเงินเช่น ขาดทุน หมุนเงินไม่ทัน เป็นต้น	☐	☐	☐	☐
26. คุณจำเป็นต้องยกหรือเคลื่อนย้ายของหนักบ่อยๆในงาน	☐	☐	☐	☐
27. คุณมักต้องทำงานนานๆ โดยหัวและแขนอยู่ในท่าไม่เหมาะสม	☐	☐	☐	☐

28. งานของคุณเป็นงานที่ใช้แรงกายมาก	☐	☐	☐	☐
29. คุณต้องทำงานนานๆ โดยร่างกายอยู่ในท่าไม่เหมาะสม	☐	☐	☐	☐
30. งานที่คุณทำต้องแข่งขันกับผู้อื่น	☐	☐	☐	☐
31. งานคุณทำมั่นคงดี	☐	☐	☐	☐

32. งานที่คุณทำมีสม่ำเสมอตลอดปีใช่หรือไม่ (เลือกข้อใดข้อหนึ่ง)

☐ 1. ไม่ใช่ มีงานเป็นช่วง และเลิกจ้างงานบ่อยๆ ☐ 2. ไม่ใช่ เลิกจ้างงานบ่อยๆ

☐ 3.ไม่ใช่ มีงานเป็นช่วงๆ ☐ 4. มีงานทำสม่ำเสมอตลอดปี

33. ในปีที่ผ่านมา คุณเผชิญกับสถานการณ์ที่ทำให้เกือบตกงาน /ไม่มีงานทำ /เลิกจ้างบ่อยแค่ไหน

☐ 1. ปีที่แล้วฉันตกงาน/ถูกเลิกจ้าง ☐ 2. ตลอดเวลา ☐ 3. เคยบ้าง ☐ 4. ไม่มีเลย

☐ 1. มีโอกาสสูงมาก ☐ 2. มีโอกาส บ้าง ☐ 3. ไม่ค่อยมีโอกาส ☐ 4. ไม่มีโอกาสเลย

<u>การอยู่ร่วมกันเป็นสังคม ทุกคนต้องมี**ผู้ร่วมงาน**แม้จะทำงานคนเดียว</u> **ผู้ร่วมงานหมายถึง** คนที่ทำงานร่วมกับคุณ ไม่ว่าจะเป็นสามี ญาติ เพื่อนที่ทำงานด้วย ตลอดจนผู้ที่ต้องติดต่อเกี่ยวข้องในงานเช่น ร้านค้าหรือบุคคลที่คุณไปติดต่อ

	1. ไม่เห็นด้วยมาก	2. ไม่เห็นด้วย	3. เห็นด้วย	4. เห็นด้วยมาก	สำหรับนักวิจัย
35. หัวหน้าคุณเอาใจใส่ทุกข์สุขของลูกน้อง	☐	☐	☐	☐	

36. หัวหน้าคุณเก่งในการทำให้คนทำงานร่วมกันได้	☐	☐	☐	☐
37. หัวหน้าคุณช่วยเหลือให้งานสำเร็จลุล่วงไป	☐	☐	☐	☐
38. หัวหน้าคุณให้ความสนใจกับสิ่งที่คุณพูด	☐	☐	☐	☐
39. ผู้ร่วมงานของคุณช่วยเหลือกันเพื่อให้งานเสร็จ	☐	☐	☐	☐
40. ผู้ร่วมงานของคุณเป็นมิตรดี	☐	☐	☐	☐
41. ผู้ร่วมงานของคุณมีความสามารถในงานของเขาเอง	☐	☐	☐	☐
42. ผู้ร่วมงานของคุณให้ความสนใจในตัวคุณ	☐	☐	☐	☐

ในการทำงานคุณมีปัญหาต้องเจอกับ**สิ่งอันตรายใดๆ** ต่อไปนี้หรือไม่

	1. ไม่มีปัญหา	2. มีบ้าง / เป็นปัญหาน้อย	3. มี /เป็นปัญหามาก	สำหรับนักวิจัย
43. เครื่องมือ เครื่องจักร หรืออุปกรณ์ที่อันตราย	☐	☐	☐	
44. กระบวนการทำงานที่อันตราย	☐	☐	☐	
45. การถูกทำอันตรายจากความร้อน ไฟลวกหรือถูกไฟฟ้าดูด	☐	☐	☐	
46. สารเคมีอันตรายหรือสารพิษใดๆ	☐	☐	☐	

47. การติดเชื้อโรคจากงาน	☐	☐	☐
48. มลพิษทางอากาศจากฝุ่น ควัน ก๊าซ ฟูม เส้นใย หรือสิ่งอื่น	☐	☐	☐
49. การจัดวางสิ่งของหรือจัดเก็บสต็อกที่อาจก่อให้เกิดอุบัติเหตุ	☐	☐	☐
50. บริเวณงานสกปรก /รกรุงรัง /ไม่มีระเบียบ	☐	☐	☐
51.การถูกทำร้ายทางจิตใจเช่น ถูกดุด่า ถูกลวนลามทางเพศฯ	☐	☐	☐
52. สภาพจราจรติดขัดเช่น รถติด คนขับไร้วินัย	☐	☐	☐
53. การถูกทำร้ายทางกายเช่น เสี่ยงต่อการถูกปล้นจี้ ทุบตี ยิง	☐	☐	☐
54. เสียงดัง	☐	☐	☐

************ขอขอบพระคุณเป็นอย่างสูงในการให้ความร่วมมือ*****************

APPENDIX D

Self-administered diary

AHS คณะสหเวชศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

สมุดบันทึกประจำเดือนที่..................

รหัสผู้เข้าร่วมวิจัย...

วันที่รับสมุดบันทึก ..../................../.................

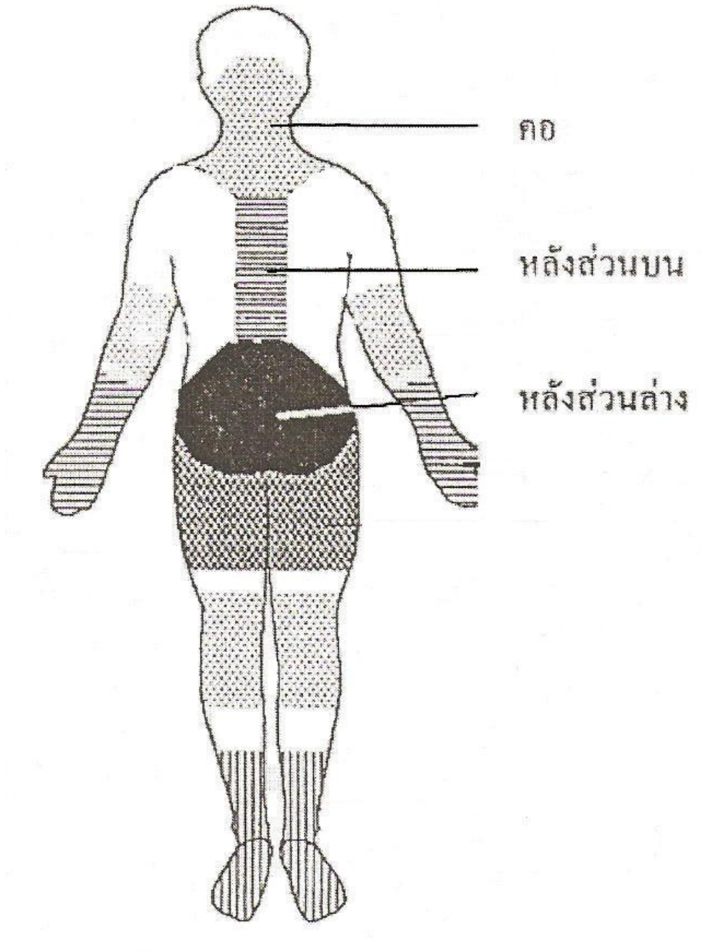
วันนัดส่งสมุดบันทึก ..../................../.................

หากมีข้อสงสัย กรุณาติดต่อ คุณภูริพัฒน์ วาวเงินงาม โทร. 080-986-6668

คำชี้แจง

สมุดบันทึกเล่มนี้ ใช้บันทึกข้อมูลสุขภาพ เกี่ยวกับอาการปวดบริเวณคอ/บ่า และหลังส่วนล่าง ในช่วงเวลา 1 เดือนที่ผ่านมา

ขอบคุณทุกท่านที่ให้ความร่วมมือในการลงบันทึก ตามที่กำหนดครับ



รูปแสดงขอบเขตของ คอ/บ่า หลังส่วนบน และหลังส่วนล่าง

บันทึกข้อมูลด้านสุขภาพในช่วง 1 เดือนที่ผ่านมา

ตอนที่ 1 ข้อมูลอาการปวดคอ/บ่า

ก) กรุณาตอบแบบสอบถามให้ครบทุกข้อ อ่านและตอบคำถามแต่ละข้อให้ถูกต้อง ตามความเป็นจริง โดยขีดเครื่องหมาย ✓ ลงในช่อง □ ที่ท่านเห็นว่าตรงกับลักษณะของท่านมากที่สุด

1. **ในรอบ 1 เดือนที่ผ่านมา** ท่านมีอาการปวด บริเวณ **<u>คอ/บ่า</u>** ติดต่อกัน**นานกว่า 1 วัน**หรือไม่

□ มี □ ไม่มี (ถ้าตอบว่า <u>ไม่มี</u> ให้ข้ามไปตอบ ข้อ ข))

2. **อาการปวด<u>คอ/บ่า</u>** ในรอบ 1 สัปดาห์ที่ผ่านมา **ครั้งที่รุนแรงที่สุด** มีระดับความรุนแรงเท่ากับเท่าใด

กรุณาทำเครื่องหมาย × ลงบนเส้นตรงด้านล่างที่ตรงกับความรู้สึกปวดของคุณ

|—————————————————————————|

ไม่ปวด ปวดมากที่สุด

3. ท่านรู้สึกว่า **แขนอ่อนแรง** หรือไม่ □ ใช่ □ ไม่ใช่

4. ท่านรู้สึกว่า **แขนชา หรือ เป็นเหน็บ** หรือไม่ □ ใช่ □ ไม่ใช่

5. ท่านต้องหยุดงาน เนื่องจาก อาการปวด**<u>บริเวณคอ/บ่า</u>** หรือไม่

□ ไม่ □ หยุดงาน เป็นเวลา....................วัน

6. อาการปวด**<u>บริเวณคอ/บ่า</u>** ทำให้ท่านต้อง **(ตอบได้มากกว่า 1 ข้อ)**

□ ไปพบแพทย์ จำนวน.................ครั้ง

□ ไปพบนักกายภาพบำบัด จำนวน.................ครั้ง

□ ซื้อยามารับประทานเอง จำนวน.................ครั้ง

□ นวด หรือประคบ จำนวน.................ครั้ง

□ อาการหายไปเองโดยไม่ต้องทำอะไร จำนวน.................ครั้ง

☐ อื่นๆ ระบุ... จำนวน................ครั้ง

7. ท่านคิดว่า อาการปวดคอ/บ่า ที่เกิดขึ้นมีสาเหตุมาจากอะไร (ตอบได้มากกว่า 1 ข้อ)

การทำงาน	สิ่งแวดล้อมในที่ทำงาน	การเล่นกีฬา	งานอดิเรก	อุบัติเหตุ	งานบ้าน	อื่นๆ ระบุ..........
☐	☐	☐	☐	☐	☐	☐

8. ท่านคิดว่า ระดับความรู้สึกไม่สบายของร่างกายบริเวณ คอ/บ่า ของท่านในรอบ 1 เดือนที่ผ่านมา มีระดับความรุนแรงเท่ากับเท่าใด (ทำเครื่องหมาย ✔ ในกล่อง ☐ ที่ตรงกับความรู้สึกของท่านมากที่สุด)

☐	0	ไม่มีความรู้สึกไม่สบายเลย	
☐	0.5	รู้สึกไม่สบายน้อยอย่างยิ่ง	เริ่มรู้สึก
☐	1	รู้สึกไม่สบายน้อยมาก	
☐	2	รู้สึกไม่สบายน้อย	เล็กน้อย
☐	3	รู้สึกไม่สบายปานกลาง	
☐	4		
☐	5	รู้สึกไม่สบายมาก	มาก
☐	6		
☐	7	รู้สึกไม่สบายมากๆ	
☐	8		
☐	9		
☐	10	รู้สึกไม่สบายอย่างยิ่ง	เกือบที่สุด
☐		รู้สึกไม่สบายมากที่สุด	

ข) ดัชนีวัดความบกพร่องความสามารถของคอ (Neck Disability Index)

แบบสอบถามนี้ใช้ในการประเมินผลกระทบของ**อาการปวดคอ**ที่มีต่อความสามารถในการจัดการชีวิตประจำวันของท่าน โปรดเลือกข้อที่ตรงกับอาการและความสามารถของท่าน**มากที่สุด**เพียงข้อเดียว และกรุณาให้ข้อมูลในทุกข้อ

ข้อที่ 1 ความรุนแรงของอาการปวด

☐ ในขณะนี้ไม่มีอาการปวด

☐ ในขณะนี้มีอาการปวดเพียงเล็กน้อย

☐ ในขณะนี้มีอาการปวดปานกลาง

☐ ในขณะนี้มีอาการปวดค่อนข้างมาก

☐ ในขณะนี้มีอาการปวดมาก

☐ ในขณะนี้มีอาการปวดมากที่สุดเท่าที่จะจินตนาการได้

ข้อที่ 2 การดูแลตนเอง (เช่น อาบน้ำ/ชำระล้างร่างกาย แต่งตัว เป็นต้น)

☐ สามารถทำเองได้ตามปกติ โดยไม่ทำให้อาการปวดเพิ่มขึ้น

☐ สามารถทำเองได้ตามปกติ แต่มีอาการปวดเพิ่มขึ้น

☐ การทำเองทำให้มีอาการปวด จึงทำให้ต้องทำอย่างช้า ๆ และระมัดระวัง

☐ ทำเองได้เป็นส่วนใหญ่ แต่จะต้องการความช่วยเหลืออยู่บ้าง

☐ ต้องการการช่วยเหลือในการดูแลตนเองเกือบทั้งหมด ทุกวัน

☐ ไม่สามารถแต่งตัวได้เอง อาบน้ำ/ชำระล้างร่างกายเองได้ด้วยความยากลำบาก และต้องอยู่บนเตียง

ข้อที่ 3 การยกของ

☐ สามารถยกของหนักได้ โดยไม่มีอาการปวดเพิ่มขึ้น

☐ สามารถยกของหนักได้ แต่มีอาการปวดเพิ่มขึ้น

☐ อาการปวดทำให้ไม่สามารถยกของหนักขึ้น จากพื้น ได้ แต่สามารถยกได้หากของนั้น อยู่ในที่ที่ เหมาะสม เช่น บนโต๊ะ

☐ อาการปวดทำให้ไม่สามารถยกของหนักขึ้น จากพื้น ได้ แต่สามารถยกได้หากของนั้น มีน้ำหนักเบาถึงปานกลาง และจัดวางอยู่ในที่ที่เหมาะสม

☐ สามารถยกของที่มีน้ำหนักเบามากๆ ได้

☐ ไม่สามารถยก/ถือ/หิ้ว/แบก/อุ้ม หรือสะพายสิ่งของใด ๆ ได้เลย

ข้อที่ 4 การอ่าน

☐ สามารถอ่านได้มากตามที่ต้องการ โดยไม่มีอาการปวดคอ

☐ สามารถอ่านได้มากตามที่ต้องการ โดยมีอาการปวดคอเพียงเล็กน้อย

☐ สามารถอ่านได้มากตามที่ต้องการ โดยมีอาการปวดคอปานกลาง

☐ ไม่สามารถอ่านได้มากตามที่ต้องการ เพราะมีอาการปวดคอปานกลาง

☐ แทบจะไม่สามารถอ่านได้เลยเพราะมีอาการปวดคอมาก

☐ ไม่สามารถอ่านได้เลย

ข้อที่ 5 อาการปวดศีรษะ

☐ ไม่มีอาการปวดศีรษะเลย

☐ มีอาการปวดศีรษะเพียงเล็กน้อย และนาน ๆ ครั้ง

☐ มีอาการปวดศีรษะปานกลาง และนาน ๆ ครั้ง

☐ มีอาการปวดศีรษะปานกลาง และบ่อยครั้ง

☐ มีอาการปวดศีรษะมาก และบ่อยครั้ง

☐ มีอาการปวดศีรษะเกือบตลอดเวลา

ข้อที่ 6 การตั้งสมาธิ

☐ สามารถตั้งสมาธิได้อย่างที่ต้องการ โดยไม่มีความยากลำบาก

☐ สามารถตั้งสมาธิได้อย่างที่ต้องการ โดยมีความยากลำบากเพียงเล็กน้อย

☐ มีความยากลำบากปานกลางในการตั้งสมาธิเมื่อต้องการ

☐ มีความยากลำบากอย่างมากในการตั้งสมาธิเมื่อต้องการ

☐ มีความยากลำบากมากที่สุดในการตั้งสมาธิเมื่อต้องการ

☐ ไม่สามารถตั้งสมาธิได้เลย

ข้อที่ 7 การทำงาน

☐ สามารถทำงานได้มากตามที่ต้องการ

☐ สามารถทำงานประจำได้เท่านั้น ไม่มากไปกว่านัั้

☐ สามารถทำงานประจำได้เกือบทั้งหมด แต่ไม่มากไปกว่านั้น

☐ ไม่สามารถทำงานประจำได้เลย

☐ แทบจะทำงานอะไรไม่ได้เลย

☐ ไม่สามารถทำงานอะไรได้เลย

ข้อที่ 8 การขับขี่รถ (หากไม่ได้ขับรถไม่ต้องตอบข้อนี้)

☐ สามารถทำได้โดยไม่มีอาการปวดคอ

☐ สามารถทำได้นานตามที่ต้องการ โดยมีอาการปวดคอเพียงเล็กน้อย

☐ สามารถทำได้นานตามที่ต้องการ โดยมีอาการปวดคอปานกลาง

☐ ไม่สามารถทำได้นานตามที่ต้องการ เพราะมีอาการปวดคอปานกลาง

☐ แทบจะทำไม่ได้เลย เพราะมีอาการปวดคอมาก

☐ ไม่สามารถทำได้เลย

ข้อที่ 9 การนอนหลับ

☐ ไม่มีความยากลำบากในการนอนหลับ

☐ การนอนหลับถูกรบกวนเพียงเล็กน้อย (นอนไม่หลับน้อยกว่า 1 ชั่วโมง)

☐ การนอนหลับถูกรบกวนเล็กน้อย (นอนไม่หลับ 1-2 ชั่วโมง)

☐ การนอนหลับถูกรบกวนปานกลาง (นอนไม่หลับ 2-3 ชั่วโมง)

☐ การนอนหลับถูกรบกวนเป็นอย่างมาก (นอนไม่หลับ 3-5 ชั่วโมง)

☐ การนอนหลับถูกรบกวนอย่างสิ้นเชิง (นอนไม่หลับ 5-7 ชั่วโมง)

ข้อที่ 10 กิจกรรมนันทนาการ/การพักผ่อนหย่อนใจ

☐ สามารถทำกิจกรรมทุกอย่างได้ โดยไม่มีอาการปวดคอเลย

☐ สามารถทำกิจกรรมทุกอย่างได้ แต่มีอาการปวดคออยู่บ้าง

☐ สามารถทำกิจกรรมได้เป็นส่วนใหญ่ แต่ไม่ทั้งหมด เพราะมีอาการปวดคอ

☐ สามารถทำกิจกรรมได้เพียงบางอย่าง เพราะมีอาการปวดคอ

☐ แทบจะทำกิจกรรมต่าง ๆ ไม่ได้เลย เพราะมีอาการปวดคอ

☐ ไม่สามารถทำกิจกรรมใด ๆ ได้เลย

ตอนที่ 2 ข้อมูลอาการปวดหลังส่วนล่าง

กรุณาตอบแบบสอบถามให้ครบทุกข้อ อ่านและตอบคำถามแต่ละข้อให้ถูกต้อง ตามความเป็นจริง โดยขีดเครื่องหมาย ✓ ลงในวงกลม O ที่ท่านเห็นว่าตรงกับลักษณะของท่านมากที่สุด

ก) กรุณาตอบแบบสอบถามให้ครบทุกข้อ อ่านและตอบคำถามแต่ละข้อให้ถูกต้อง ตามความเป็นจริง โดยขีดเครื่องหมาย ✓ ลงในช่อง ☐ ที่ท่านเห็นว่าตรงกับลักษณะของท่านมากที่สุด

1. **ในรอบ 1 เดือนที่ผ่านมา** ท่านมีอาการปวด บริเวณ **<u>หลังส่วนล่าง</u>** ติดต่อกัน**นานกว่า 1 วัน**หรือไม่

   ☐ มี ☐ ไม่มี (ถ้าตอบว่า <u>ไม่มี</u> ให้ข้ามไปตอบ ข้อ ข))

2. **อาการปวด<u>หลังส่วนล่าง</u>** ในรอบ 1 สัปดาห์ที่ผ่านมา **ครั้งที่รุนแรงที่สุด** มีระดับความรุนแรงเท่ากับเท่าใด กรุณาทำเครื่องหมาย ✕ ลงบนเส้นตรงด้านล่างที่ตรงกับความรู้สึกปวดของคุณ

   ไม่ปวด |————————————————| ปวดมากที่สุด

3. ท่านรู้สึกว่า **ขาอ่อนแรง** หรือไม่ ☐ ใช่ ☐ ไม่ใช่

4. ท่านรู้สึกว่า **ขาชา หรือ เป็นเหน็บ** หรือไม่ ☐ ใช่ ☐ ไม่ใช่

5. ท่านต้องหยุดงาน เนื่องจาก อาการปวด**<u>บริเวณหลังส่วนล่าง</u>** หรือไม่

   ☐ ไม่ ☐ หยุดงาน เป็นเวลา...................วัน

6. อาการปวด**<u>บริเวณหลังส่วนล่าง</u>** ทำให้ท่านต้อง **(ตอบได้มากกว่า 1 ข้อ)**

   ☐ ไปพบแพทย์ จำนวน................ครั้ง

   ☐ ไปพบนักกายภาพบำบัด จำนวน................ครั้ง

   ☐ ซื้อยามารับประทานเอง จำนวน................ครั้ง

   ☐ นวด หรือประคบ จำนวน................ครั้ง

☐ อาการหายไปเองโดยไม่ต้องทำอะไร จำนวน................ครั้ง

☐ อื่นๆ ระบุ... จำนวน................ครั้ง

7. ท่านคิดว่า อาการปวด<u>หลังส่วนล่าง</u> ที่เกิดขึ้นมีสาเหตุมาจากอะไร (ตอบได้มากกว่า 1 ข้อ)

การทำงาน	สิ่งแวดล้อมในที่ทำงาน	การเล่นกีฬา	งานอดิเรก	อุบัติเหตุ	งานบ้าน	อื่นๆ ระบุ..........
☐	☐	☐	☐	☐	☐	☐

8. ท่านคิดว่า ระดับความรู้สึกไม่สบายของร่างกายบริเวณหลังส่วนล่าง ของท่านในรอบ 1 เดือนที่ผ่านมา มีระดับความรุนแรงเท่ากับเท่าใด (ทำเครื่องหมาย ✓ ในกล่อง ☐ ที่ตรงกับความรู้สึกของท่านมากที่สุด)

☐	0	ไม่มีความรู้สึกไม่สบายเลย	
☐	0.5	รู้สึกไม่สบายน้อยอย่างยิ่ง	เริ่มรู้สึก
☐	1	รู้สึกไม่สบายน้อยมาก	
☐	2	รู้สึกไม่สบายน้อย	เล็กน้อย
☐	3	รู้สึกไม่สบายปานกลาง	
☐	4		
☐	5	รู้สึกไม่สบายมาก	มาก
☐	6		
☐	7	รู้สึกไม่สบายมากๆ	
☐	8		
☐	9		
☐	10	รู้สึกไม่สบายอย่างยิ่ง	เกือบที่สุด
☐		รู้สึกไม่สบายมากที่สุด	

ข) เมื่อปวดหลังท่านอาจพบว่าท่านปฏิบัติกิจวัตรประจำวันได้ค่อนข้างลำบาก ข้อความข้างล่างนี้ผู้ป่วยปวดหลังทั่วไปมักพูดเพื่อบอกอาการเมื่อเขาปวดหลัง ถ้าข้อความใดต่อไปนี้ตรงกับอาการที่<u>ท่านมีอยู่ในขณะนี้</u> กรุณาเขียนเครื่องหมาย ✓ ลงใน □ หน้าข้อความนั้น และถ้าข้อความใดไม่ตรงกับอาการของท่านใน<u>ขณะนี้</u> โปรดเว้นว่างไว้ และอ่านข้อความถัดไป

□ 1.ฉันต้องพักอยู่ที่บ้านเกือบตลอดเวลาเพราะปวดหลัง

□ 2.ฉันเปลี่ยนท่าทางบ่อยๆ เพื่อช่วยให้หลังของฉันสบายขึ้น

□ 3.ฉันเดินช้าลงกว่าปกติเพราะฉันปวดหลัง

□ 4. ฉันหยุดทำงานต่างๆที่ฉันมักทำในบ้านเพราะปวดหลัง

□ 5.ฉันต้องยึดเกาะราวบันไดขณะเดินขึ้นบันไดเพราะปวดหลัง

□ 6.อาการปวดหลังทำให้ฉันต้องลงนอนพักบ่อยๆ

□ 7.อาการปวดหลังทำให้ฉันต้องหาที่จับยึดเพื่อพยุงตัวลุกจากที่นั่ง

□ 8.ฉันแต่งตัวช้ากว่าปกติเพราะปวดหลัง

□ 9.ฉันต้องอาศัยผู้อื่นทำสิ่งต่างๆให้เพราะฉันปวดหลัง

□ 10.ฉันยืนได้ไม่นานเพราะปวดหลัง

□ 11.ฉันลุกจากเก้าอี้ลำบากเนื่องจากปวดหลัง

□ 12.เนื่องจากปวดหลัง ฉันพยายามไม่โน้มตัวไปข้างหน้า

□ 13.ฉันรู้สึกปวดหลังมากเกือบตลอดเวลา

□ 14.ฉันพลิกตัวบนเตียงลำบากเพราะปวดหลัง

□ 15.ฉันรู้สึกไม่อยากกินอาหารเมื่อปวดหลัง

□ 16. ฉันใส่ถุงเท้า รองเท้าลำบากขึ้นเพราะปวดหลัง

□ 17.ฉันเดินได้ไม่ไกลเพราะปวดหลัง

☐ 18.ฉันนอนไม่ค่อยหลับเพราะปวดหลัง

☐ 19.เนื่องจากปวดหลัง ฉันต้องขอให้ผู้อื่นช่วยฉันแต่งตัว

☐ 20.ฉันนั่งเกือบตลอดทั้งวันเพราะปวดหลัง

☐ 21.ฉันพยายามไม่ทำงานบ้านที่หนักๆเพราะปวดหลัง

☐ 22.เนื่องจากปวดหลัง ฉันหงุดหงิดและอารมณ์เสียกับผู้คนรอบข้างง่ายกว่าปกติ

☐ 23.ฉันเดินขึ้นบันไดช้ากว่าปกติเพราะปวดหลัง

☐ 24.ฉันนอนอยู่บนเตียงเกือบตลอดเวลาเพราะปวดหลัง

APPENDIX E

Screening questionnaire

แบบคัดกรอง

ชื่อโครงการวิจัย: การพัฒนาที่นั่งอัจฉริยะเพื่อป้องกันโรคปวดคอ/บ่าและหลังส่วนล่างจากการนั่งเป็นระยะเวลานานในผู้ที่ทำงานในสำนักงาน – การศึกษาลักษณะความรู้สึกไม่สบายในขณะนั่งติดต่อกันเป็นระยะเวลา 4 ชั่วโมง และผลของการเปลี่ยนท่าทางในขณะนั่งด้วยความถี่ต่างๆ ต่อความรู้สึกไม่สบาย

รหัสผู้เข้าร่วมวิจัย .... อายุ .... ปี เพศ..................

น้ำหนัก .... กก. ส่วนสูง .... ซม. ดัชนีมวลกาย .... กก/ม^2

<u>คำชี้แจง</u>: โปรดระบุเครื่องหมาย ✓ หากท่านมีภาวะดังต่อไปนี้

หัวข้อ	ใช่	ไม่ใช่
1) ท่านเป็นพนักงานสำนักงานแบบเต็มเวลา		
2) ท่านมีประสบการณ์การทำงานในตำแหน่งล่าสุดอย่างน้อย 5 ปี		
3) ท่าน มีอาการปวดคอ/บ่าหรือหลัง (มีอาการปวดมากกว่า 3 คะแนนจากแบบประเมิน visual analog scale;VAS เป็นระยะเวลาติดต่อกันนานกว่า 1 วัน)		
4) ท่านมีอาการปวดคอ/บ่าหรือหลังเรื้อรัง		
5) ท่านมีประวัติได้รับบาดเจ็บหรือเกิดอุบัติเหตุร้ายแรงบริเวณกระดูกสันหลัง เช่น อุบัติเหตุรถชน ตกจากที่สูง เป็นต้น		
6) ท่านมีประวัติการผ่าตัดบริเวณกระดูกสันหลัง ช่องท้อง หรือข้อสะโพก/ต้นขา		
7) ท่านมีอาการชาหรืออ่อนแรงที่รยางค์แขนหรือขาข้างใดข้างหนึ่งหรือทั้งสองข้าง		
8) ท่านได้รับการวินิจฉัยจากแพทย์ว่า มีความผิดปกติของกระดูกสันหลัง		
9) ท่านได้รับการวินิจฉัยว่าเป็นโรคข้ออักเสบรูมาตอยด์ (rheumatoid arthritis) โรคข้อสันหลังอักเสบชนิดยึดติด (ankylosing spondylitis) เก๊าท์ (gout) เนื้องอก (tumor) โรคเอสแอลอีหรือโรคลูปัส (systemic lupus erythymatosus (SLE)) หรือโรคกระดูกพรุน (osteoporosis)		
10) ท่านอยู่ระหว่างการตั้งครรภ์		
11) ท่านกำลังใช้ยาที่อาจส่งผลต่อระบบกระดูกและกล้ามเนื้อ		
12) ท่านมีเป็นโรคริดสีดวงทวารหรือมีแผลหรือรอยช้ำที่บริเวณก้นหรือต้นขา		

แบบคัดกรอง

ชื่อโครงการวิจัย: การพัฒนาที่นั่งอัจฉริยะเพื่อป้องกันโรคปวดคอ/บ่าและหลังส่วนล่างจากการนั่งเป็นระยะเวลานานในผู้ที่ทำงานในสำนักงาน – การศึกษาประสิทธิภาพของที่นั่งอัจฉริยะในการป้องกันโรคปวดคอ/บ่าและหลังส่วนล่างในผู้ที่ทำงานในสำนักงาน

รหัสผู้เข้าร่วมวิจัย .... อายุ .... ปี เพศ.................

น้ำหนัก .... กก. ส่วนสูง .... ซม. ดัชนีมวลกาย .... กก/ม^2

<u>**คำชี้แจง**</u>: โปรดระบุเครื่องหมาย ✓ หากท่านมีภาวะดังต่อไปนี้

หัวข้อ	ใช่	ไม่ใช่
1) ท่านเป็นพนักงานสำนักงานแบบเต็มเวลา		
2) ท่านมีประสบการณ์การทำงานในตำแหน่งล่าสุดอย่างน้อย 5 ปี		
3) การนั่งเป็นระยะเวลานานเป็นหนึ่งในตัวกระตุ้นอาการปวดคอ/บ่าหรือหลังในอดีต		
4) ท่านมีประวัติการปวดคอ/บ่าหรือหลังส่วนล่างในช่วง 1 ปีที่ผ่านมา (มีอาการปวดมากกว่า 3 คะแนนจากแบบประเมิน visual analog scale;VAS เป็นระยะเวลาติดต่อกันนานกว่า 1 วัน)		
5) ท่านมีอาการปวดคอ/บ่าหรือหลังเรื้อรัง		
6) ท่านมีประวัติได้รับบาดเจ็บหรือเกิดอุบัติเหตุร้ายแรงบริเวณกระดูกสันหลัง เช่น อุบัติเหตุรถชน ตกจากที่สูง เป็นต้น		
7) ท่านมีประวัติการผ่าตัดบริเวณกระดูกสันหลัง ช่องท้อง หรือข้อสะโพก/ต้นขา		
8) ท่านมีอาการชาหรืออ่อนแรงที่รยางค์แขนหรือขาข้างใดข้างหนึ่งหรือทั้งสองข้าง		
9) ท่านได้รับการวินิจฉัยจากแพทย์ว่า มีความผิดปกติของกระดูกสันหลัง		
10) ท่านได้รับการวินิจฉัยว่าเป็นโรคข้ออักเสบรูมาตอยด์ (rheumatoid arthritis) โรคข้อสันหลังอักเสบชนิดยึดติด (ankylosing spondylitis) เก๊าท์ (gout) เนื้องอก (tumor) โรคเอสแอลอีหรือโรคลูปัส (systemic lupus erythymatosus (SLE)) หรือโรคกระดูกพรุน (osteoporosis)		
11) ท่านอยู่ระหว่างการตั้งครรภ์		
12) ท่านกำลังใช้ยาที่อาจส่งผลต่อระบบกระดูกและกล้ามเนื้อ		
13) ท่านมีเป็นโรคริดสีดวงทวารหรือมีแผลหรือรอยช้ำที่บริเวณก้นหรือต้นขา		

APPENDIX F

The Neck pain with disability Risk score for Office Workers

แบบประเมินความเสี่ยงต่อการเป็นโรคปวดคอในผู้ที่ทำงานในสำนักงาน

The Neck pain with disability Risk score for Office Workers (The NROW)

แบบประเมินนี้ใช้สำหรับการประเมินความเสี่ยงต่อการเป็นโรคปวดคอ **ในผู้ที่ทำงานในสำนักงานเท่านั้น** โปรดตอบคำถามต่อไปนี้ ตามความเป็นจริง เพื่อตรวจผลความเสี่ยงต่อการเป็นโรคปวดคอของท่าน

1. ในอดีต ท่านเคยมีอาการปวดคอหรือไม่
    [....] เคย
    [....] ไม่เคย

2. เก้าอี้ที่ท่านนั่งเป็นประจำ สามารถปรับระดับความสูงได้
    [....] ใช่
    [....] ไม่ใช่

3. โดยปกติในระหว่างวันทำงาน ท่านมีความรู้สึกตึงบริเวณคอและบ่า บ่อยแค่ไหน
    [....] บ่อยครั้ง
    [....] บางครั้ง
    [....] นานๆ ครั้ง

คะแนนรวม เท่ากับ ....

APPENDIX G

The Back pain with disability Risk score for Office Workers

แบบประเมินความเสี่ยงต่อการเป็นโรคปวดหลังส่วนบั้นเอวในผู้ที่ทำงานในสำนักงาน

The Back pain with disability Risk score for Office Workers (The BROW)

แบบประเมินนี้ใช้สำหรับการประเมินความเสี่ยงต่อการเป็นโรคปวดหลังส่วนบั้นเอว **ในผู้ที่ทำงานในสำนักงานเท่านั้น** โปรดตอบคำถามต่อไปนี้ ตามความเป็นจริง เพื่อตรวจผลความเสี่ยงต่อการเป็นโรคปวดหลังส่วนบั้นเอวของท่าน

1. ในอดีต ท่านเคยมีอาการปวดหลังส่วนบั้นเอวหรือไม่
   [....] เคย
   [....] ไม่เคย

2. ข้อมูลด้านจิตใจและสังคมสิ่งแวดล้อม

<u>**คำชี้แจง**</u> กรุณาอ่านประโยคต่อไปนี้ แล้วทำเครื่องหมาย ✓ ในช่องที่ตรงกับความรู้สึกของท่านต่องานที่ทำ ในกรณีที่ไม่มีคำตอบใดตรงกับความรู้สึกของท่าน กรุณาเลือกข้อที่ใกล้เคียงความรู้สึกที่สุดเพียงข้อเดียว และกรุณาตอบทุกข้อ

	1. ไม่เห็นด้วยอย่างมาก	2. ไม่เห็นด้วย	3. เห็นด้วย	4. เห็นด้วยอย่างมาก
1. ท่านต้องทำสิ่งซ้ำๆ หลายๆ ครั้งในงาน	☐	☐	☐	☐
2. ท่านต้องทำงานที่มีลักษณะหลากหลายมาก	☐	☐	☐	☐
3. ท่านมีอิสระในการตัดสินใจว่าจะทำงานอย่างไร	☐	☐	☐	☐
4. งานของท่านยุ่งวุ่นวาย	☐	☐	☐	☐
5. งานของท่านเป็นงานหนัก	☐	☐	☐	☐
6. ท่านต้องทำงานมาก จนเวลาพักผ่อนไม่เพียงพอ	☐	☐	☐	☐
7. ท่านมักต้องรีบทำงานให้ทันกำหนด	☐	☐	☐	☐

8. งานของท่านมักถูกขัดจังหวะก่อนเสร็จ ทำให้ต้องทำต่อทีหลัง	☐	☐	☐	☐
9. งานของท่านเป็นงานที่ต้องทำอย่างรวดเร็ว	☐	☐	☐	☐
10. เงินตอบแทนหรือค่าจ้างที่ท่านได้รับนั้นน้อย	☐	☐	☐	☐
11. งานของท่านต้องล่าช้าเพราะต้องคอยงานจากผู้อื่น/หน่วยอื่น	☐	☐	☐	☐
12. ท่านต้องเคลื่อนไหวร่างกายอย่างรวดเร็วและต่อเนื่องในงาน	☐	☐	☐	☐
คะแนนรวม				

คะแนนรวม เท่ากับ ....

APPENDIX H

Borg's CR-10

สำหรับประเมินระดับความรู้สึกไม่สบายของร่างกาย

(0 คือ ไม่มีอาการเลย และ 10 คือ มีความรู้สึกไม่สบายมากที่สุด)

0	ไม่มีความรู้สึกไม่สบายเลย	
0.5	รู้สึกไม่สบายน้อยอย่างยิ่ง	เริ่มรู้สึก
1	รู้สึกไม่สบายน้อยมาก	
2	รู้สึกไม่สบายน้อย	เล็กน้อย
3	รู้สึกไม่สบายปานกลาง	
4		
5	รู้สึกไม่สบายมาก	มาก
6		
7	รู้สึกไม่สบายมากๆ	
8		
9		
10	รู้สึกไม่สบายอย่างยิ่ง	เกือบที่สุด

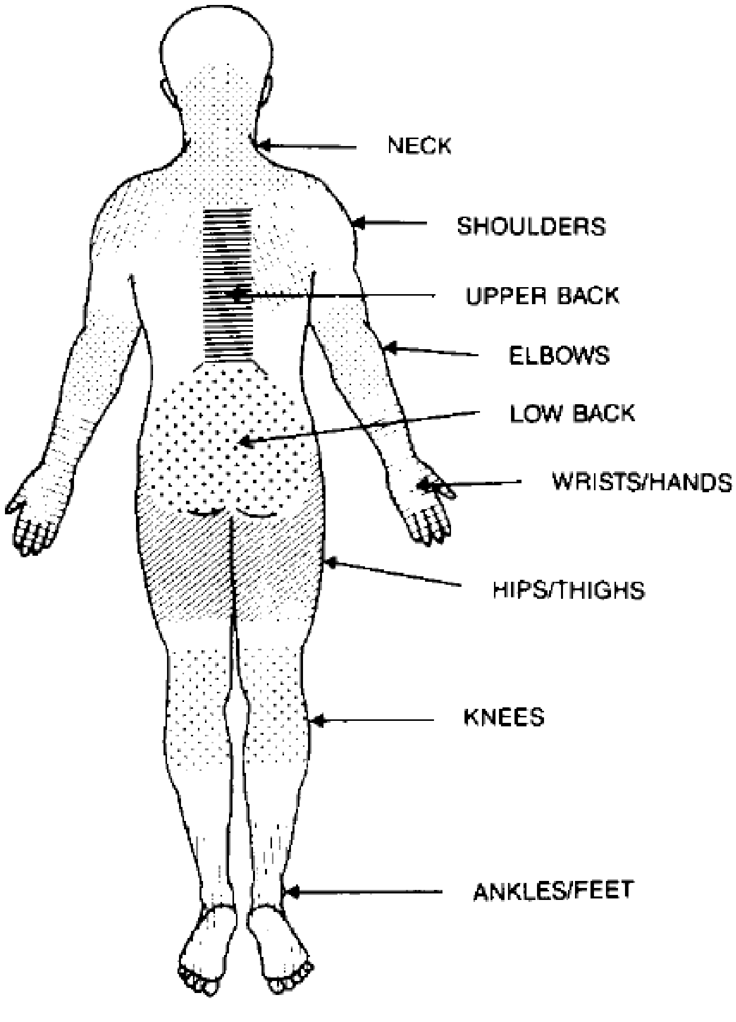
- รู้สึกไม่สบายมากที่สุด

Reference: Modified from Borg in 1990 (Borg, 1990)

APPENDIX I

Body chart

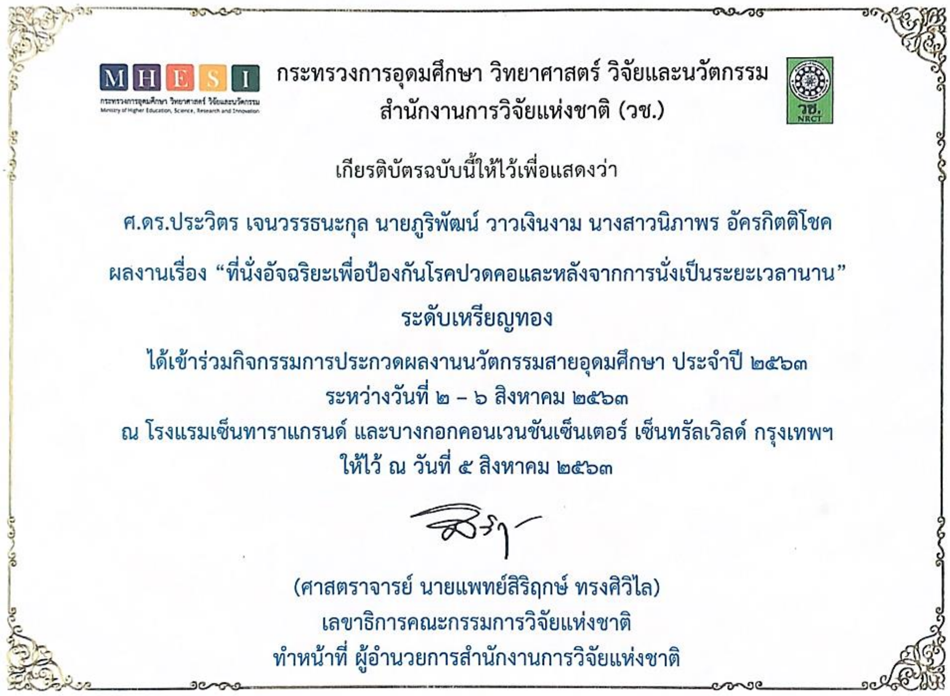
แผนภาพร่างกายใช้สำหรับการประเมินความรู้สึกไม่สบายของร่างกายร่วมกับ Borg CR-10



Reference: Kuorinka et al in 1987 (Kuorinka et al., 1987)

APPENDIX J

Research and innovation award (Thailand Research Expo 2020)


MHESI
กระทรวงการอุดมศึกษา วิทยาศาสตร์ วิจัยและนวัตกรรม
Ministry of Higher Education, Science, Research and Innovation

กระทรวงการอุดมศึกษา วิทยาศาสตร์ วิจัยและนวัตกรรม
สำนักงานการวิจัยแห่งชาติ (วช.)

วช. NRCT

เกียรติบัตรฉบับนี้ให้ไว้เพื่อแสดงว่า

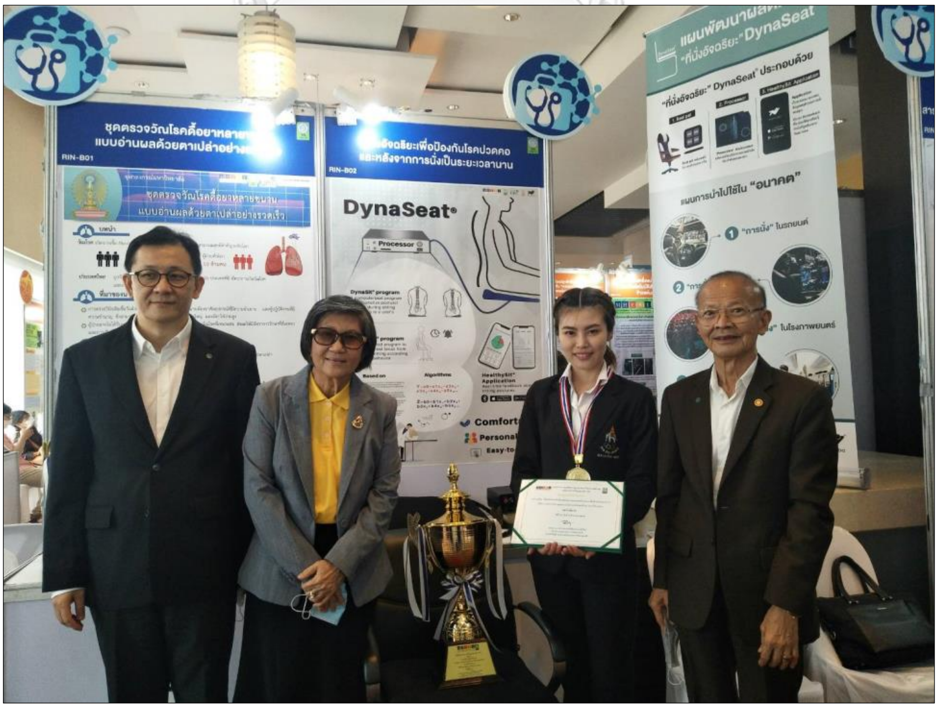
ศ.ดร.ประวิตร เจนวรรธนะกุล นายภูริพัฒน์ วาวเงินงาม นางสาวนิภาพร อัครกิตติโชค

ผลงานเรื่อง "ที่นั่งอัจฉริยะเพื่อป้องกันโรคปวดคอและหลังจากการนั่งเป็นระยะเวลานาน"

ระดับเหรียญทอง

ได้เข้าร่วมกิจกรรมการประกวดผลงานนวัตกรรมสายอุดมศึกษา ประจำปี ๒๕๖๓
ระหว่างวันที่ ๒ – ๖ สิงหาคม ๒๕๖๓
ณ โรงแรมเซ็นทาราแกรนด์ และบางกอกคอนเวนชันเซ็นเตอร์ เซ็นทรัลเวิลด์ กรุงเทพฯ
ให้ไว้ ณ วันที่ ๕ สิงหาคม ๒๕๖๓

(ศาสตราจารย์ นายแพทย์สิริฤกษ์ ทรงศิวิไล)
เลขาธิการคณะกรรมการวิจัยแห่งชาติ
ทำหน้าที่ ผู้อำนวยการสำนักงานการวิจัยแห่งชาติ



APPENDIX K

Pity patent

แบบ สป/สผ/อสป/001-ก
หน้า 1 ของจำนวน 2 หน้า

คำขอรับสิทธิบัตร/อนุสิทธิบัตร

☐ การประดิษฐ์
☐ การออกแบบผลิตภัณฑ์
☑ อนุสิทธิบัตร

ข้าพเจ้าผู้ลงลายมือชื่อในคำขอรับสิทธิบัตร/อนุสิทธิบัตรนี้ ขอรับสิทธิบัตร/อนุสิทธิบัตร ตามพระราชบัญญัติสิทธิบัตร พ.ศ. 2522 แก้ไขเพิ่มเติมโดยพระราชบัญญัติสิทธิบัตร (ฉบับที่ 2) พ.ศ. 2535 และ พระราชบัญญัติสิทธิบัตร (ฉบับที่ 3) พ.ศ. 2542

สำหรับเจ้าหน้าที่	
วันรับคำขอ 24 ก.พ. 2563	เลขที่คำขอ 2003000372
วันยื่นคำขอ 24 ก.พ. 2563	
สัญลักษณ์จำแนกการประดิษฐ์ระหว่างประเทศ	
ใช้กับแบบผลิตภัณฑ์ ประเภทผลิตภัณฑ์	
วันประกาศโฆษณา	เลขที่ประกาศโฆษณา
วันออกสิทธิบัตร/อนุสิทธิบัตร	เลขที่สิทธิบัตร/อนุสิทธิบัตร
ลายมือชื่อเจ้าหน้าที่	

1. ชื่อที่แสดงถึงการประดิษฐ์/การออกแบบผลิตภัณฑ์ เครื่องตรวจจับและแนะนำลักษณะการเปลี่ยนแปลงท่าทางของร่างกายจากการนั่งที่สัมพันธ์กับพฤติกรรมการนั่งก่อนหน้า

2. คำขอรับสิทธิบัตรการออกแบบผลิตภัณฑ์นี้เป็นคำขอสำหรับแบบผลิตภัณฑ์อย่างเดียวกันและเป็นคำขอลำดับที่ ________ ในจำนวน ________ คำขอ ที่ยื่นในคราวเดียวกัน

3. ผู้ขอรับสิทธิบัตร/อนุสิทธิบัตร ☐ บุคคลธรรมดา ☐ นิติบุคคล ☑ หน่วยงานรัฐ ☐ มูลนิธิ ☐ อื่นๆ
ชื่อ 1. สำนักงานคณะกรรมการส่งเสริมวิทยาศาสตร์ วิจัยและนวัตกรรม (สกสว.)
ที่อยู่ 979/17-21 อาคารเอสเอ็ม ทาวเวอร์ ชั้น 14 ถนน พหลโยธิน
ตำบล/แขวง สามเสนใน อำเภอ/เขต พญาไท จังหวัด กรุงเทพมหานคร รหัสไปรษณีย์ 10400 ประเทศ ไทย
อีเมล -
☐ เลขประจำตัวประชาชน ☐ เลขทะเบียนนิติบุคคล ☐ เลขประจำตัวผู้เสียภาษีอากร ☑ เพิ่มเติม (ตามแบบ)
ในกรณีที่กรมฯ สื่อสารกับท่าน ท่านสะดวกใช้ทาง ☐ อีเมลผู้ขอ ☑ อีเมลตัวแทน
3.1 สัญชาติ ไทย
3.2 โทรศัพท์ -
3.3 โทรสาร -

4. สิทธิในการขอรับสิทธิบัตร/อนุสิทธิบัตร
☐ ผู้ประดิษฐ์/ผู้ออกแบบ ☑ ผู้รับโอน ☐ ผู้ขอรับสิทธิโดยเหตุอื่น

ยกเว้นค่าธรรมเนียม

5. ตัวแทน (ถ้ามี)
ชื่อ 1. ดร.ทูนเดช ไกรฤทธิ์
ที่อยู่ 942/142-3 อาคารชาญอิสสระ ชั้น 9 ถนนพระราม 4
ตำบล/แขวง สุริยวงศ์ อำเภอ/เขต บางรัก จังหวัด กรุงเทพมหานคร รหัสไปรษณีย์ 10500 ประเทศ ไทย
อีเมล dej-udom@dejudom.com
เลขประจำตัวประชาชน 3 1 0 1 2 0 [illegible] 8 1 1 3 4 9
☑ เพิ่มเติม (ตามแบบ)
5.1 ตัวแทนเลขที่ 2235
5.2 โทรศัพท์ 02-2330055
5.3 โทรสาร 0-2236-6681

6. ผู้ประดิษฐ์/ผู้ออกแบบผลิตภัณฑ์ ☐ ชื่อและที่อยู่เดียวกันกับผู้ขอ
ชื่อ 1. ศ.ดร. ประวิตร เจนวรรธนะกุล
ที่อยู่ 154 ถนนพระราม 1 จุฬา ซอย 12
ตำบล/แขวง วังใหม่ อำเภอ/เขต ปทุมวัน จังหวัด กรุงเทพมหานคร รหัสไปรษณีย์ 10330 ประเทศ ไทย
อีเมล -
เลขประจำตัวประชาชน 3 1 0 1 7 0 2 3 7 4 2 4 0
☑ เพิ่มเติม (ตามแบบ)

7. คำขอรับสิทธิบัตร/อนุสิทธิบัตรนี้แยกจากหรือเกี่ยวข้องกับคำขอเดิม
ผู้ขอรับสิทธิบัตร/อนุสิทธิบัตร ขอให้ถือว่าได้ยื่นคำขอรับสิทธิบัตร/อนุสิทธิบัตรนี้ ในวันเดียวกับคำขอรับสิทธิบัตร
เลขที่ ________ วันยื่น ________ เพราะคำขอรับสิทธิบัตร/อนุสิทธิบัตรนี้แยกจากหรือเกี่ยวข้องกับคำขอเดิมเพราะ
☐ คำขอเดิมมีการประดิษฐ์หลายอย่าง ☐ ถูกคัดค้านเนื่องจากผู้ขอไม่มีสิทธิ ☐ ขอเปลี่ยนแปลงประเภทของสิทธิ

หมายเหตุ ในกรณีที่ไม่อาจระบุรายละเอียดได้ครบถ้วน ให้จัดทำเป็นเอกสารแนบท้ายแบบพิมพ์นี้โดยระบุหมายเลขกำกับข้อและหัวข้อที่แสดงรายละเอียดเพิ่มเติมดังกล่าวด้วย

สำหรับเจ้าหน้าที่

จำแนกประเภทสิทธิบัตร/อนุสิทธิบัตร

☐ กลุ่มวิศวกรรม	☐ กลุ่มเคมี	สิทธิบัตรการออกแบบ	อนุสิทธิบัตร
สิทธิบัตรการประดิษฐ์ (วิศวกรรม)	สิทธิบัตรการประดิษฐ์ (เคมีเทคนิค)	☐ สิทธิบัตรการออกแบบ (ออกแบบผลิตภัณฑ์ 1)	☐ อนุสิทธิบัตร (วิศวกรรม)
สิทธิบัตรการประดิษฐ์ (ไฟฟ้า)	สิทธิบัตรการประดิษฐ์ (ปิโตรเคมี)	☐ สิทธิบัตรการออกแบบ (ออกแบบผลิตภัณฑ์ 2)	☐ อนุสิทธิบัตร (เคมี)
สิทธิบัตรการประดิษฐ์ (ฟิสิกส์)	สิทธิบัตรการประดิษฐ์ (เทคโนโลยีชีวภาพ)	☐ สิทธิบัตรการออกแบบ (ออกแบบผลิตภัณฑ์ 3)	
	สิทธิบัตรการประดิษฐ์ (เภสัชภัณฑ์)		

แบบ สป/สผ/อสป/001-ก
หน้า 1 ของจำนวน 2 หน้า

คำขอรับสิทธิบัตร/อนุสิทธิบัตร

สำหรับเจ้าหน้าที่	
วันรับคำขอ 24 ก.พ. 2563	เลขที่คำขอ
วันยื่นคำขอ 24 ก.พ. 2563	2003000373
สัญลักษณ์จำแนกการประดิษฐ์ระหว่างประเทศ	
ใช้กับแบบผลิตภัณฑ์ ประเภทผลิตภัณฑ์	
วันประกาศโฆษณา	เลขที่ประกาศโฆษณา
วันออกสิทธิบัตร/อนุสิทธิบัตร	เลขที่สิทธิบัตร/อนุสิทธิบัตร
ลายมือชื่อเจ้าหน้าที่	

☐ การประดิษฐ์
☐ การออกแบบผลิตภัณฑ์
☑ อนุสิทธิบัตร

ข้าพเจ้าผู้ลงลายมือชื่อในคำขอรับสิทธิบัตร/อนุสิทธิบัตรนี้ ขอรับสิทธิบัตร/อนุสิทธิบัตร ตามพระราชบัญญัติสิทธิบัตร พ.ศ. 2522 แก้ไขเพิ่มเติมโดยพระราชบัญญัติสิทธิบัตร (ฉบับที่ 2) พ.ศ. 2535 และ พระราชบัญญัติสิทธิบัตร (ฉบับที่ 3) พ.ศ. 2542

1. ชื่อที่แสดงถึงการประดิษฐ์/การออกแบบผลิตภัณฑ์ เครื่องตรวจจับและแนะนำลักษณะการเคลื่อนไหวในท่านั่งที่สัมพันธ์กับพฤติกรรมการนั่ง

2. คำขอรับสิทธิบัตรการออกแบบผลิตภัณฑ์นี้เป็นคำขอสำหรับแบบผลิตภัณฑ์อย่างเดียวกันและเป็นคำขอลำดับที่ ______
ในจำนวน ______ คำขอ ที่ยื่นในคราวเดียวกัน

3. ผู้ขอรับสิทธิบัตร/อนุสิทธิบัตร ☐ บุคคลธรรมดา ☐ นิติบุคคล ☑ หน่วยงานรัฐ ☐ มูลนิธิ ☐ อื่นๆ ______
ชื่อ 1. สำนักงานคณะกรรมการส่งเสริมวิทยาศาสตร์ วิจัยและนวัตกรรม (สกสว.)
ที่อยู่ 979/17-21 อาคารเอสเอ็ม ทาวเวอร์ ชั้น 14 ถนน พหลโยธิน
ตำบล/แขวง สามเสนใน อำเภอ/เขต พญาไท จังหวัด กรุงเทพมหานคร รหัสไปรษณีย์ 10400 ประเทศ ไทย
อีเมล -
3.1 สัญชาติ ไทย
3.2 โทรศัพท์ -
3.3 โทรสาร -
☐ เลขประจำตัวประชาชน ☐ เลขทะเบียนนิติบุคคล ☐ เลขประจำตัวผู้เสียภาษีอากร ☑ เพิ่มเติม (ดังแนบ)
ในกรณีที่กรมฯ สื่อสารกับท่าน ท่านสะดวกใช้ทาง ☐ อีเมลผู้ขอ ☑ อีเมลตัวแทน

4. สิทธิในการขอรับสิทธิบัตร/อนุสิทธิบัตร
☐ ผู้ประดิษฐ์/ผู้ออกแบบ ☑ ผู้รับโอน ☐ ผู้ขอรับสิทธิโดยเหตุอื่น

ยกเว้นค่าธรรมเนียม
ตามกฎกระทรวง พ.ศ. ๒๕๕๙ ว่าด้วยอัตราค่าธรรมเนียมและการยกเว้นค่าธรรมเนียม และประกาศคณะกรรมการสิทธิบัตร สำหรับสิทธิบัตรหรืออนุสิทธิบัตร

5. ตัวแทน (ถ้ามี)
ชื่อ 1. ดร.พูนเดช ไกรฤทธิ์
ที่อยู่ 942/142-3 อาคารชาญอิสสระ ชั้น 9 ถนนพระราม 4
ตำบล/แขวง สุริยวงศ์ อำเภอ/เขต บางรัก จังหวัด กรุงเทพมหานคร รหัสไปรษณีย์ 10500 ประเทศ ไทย
อีเมล dej-udom@dejudom.com
เลขประจำตัวประชาชน 3 1 0 1 2 0 2 8 1 1 3 4 9
5.1 ตัวแทนเลขที่ 2235
5.2 โทรศัพท์ 02-2330055
5.3 โทรสาร 0-2236-6681
☑ เพิ่มเติม (ดังแนบ)

6. ผู้ประดิษฐ์/ผู้ออกแบบผลิตภัณฑ์ ☐ ชื่อและที่อยู่เดียวกันกับผู้ขอ
ชื่อ 1. ศ.ดร. ประวิตร เจนวรรธนะกุล
ที่อยู่ 154 ถนนพระราม 1 จุฬา ซอย 12
ตำบล/แขวง วังใหม่ อำเภอ/เขต ปทุมวัน จังหวัด กรุงเทพมหานคร รหัสไปรษณีย์ 10330 ประเทศ ไทย
อีเมล -
เลขประจำตัวประชาชน 3 1 0 1 7 0 2 3 7 4 2 4 0
☑ เพิ่มเติม (ดังแนบ)

7. คำขอรับสิทธิบัตร/อนุสิทธิบัตรนี้แยกจากหรือเกี่ยวข้องกับคำขอเดิม
ผู้ขอรับสิทธิบัตร/อนุสิทธิบัตร ขอให้ถือว่าได้ยื่นคำขอรับสิทธิบัตร/อนุสิทธิบัตรนี้ ในวันเดียวกับคำขอรับสิทธิบัตร
เลขที่ ______ วันยื่น ______ เพราะคำขอรับสิทธิบัตร/อนุสิทธิบัตรนี้แยกจากหรือเกี่ยวข้องกับคำขอเดิมเพราะ
☐ คำขอเดิมมีการประดิษฐ์หลายอย่าง ☐ ถูกคัดค้านเนื่องจากผู้ขอไม่มีสิทธิ ☐ ขอเปลี่ยนแปลงประเภทของสิทธิ

หมายเหตุ ในกรณีที่ไม่อาจระบุรายละเอียดได้ครบถ้วน ให้จัดทำเป็นเอกสารแนบท้ายแบบพิมพ์นี้โดยระบุหมายเลขกำกับข้อและหัวข้อที่แสดงรายละเอียดเพิ่มเติมดังกล่าวด้วย

สำหรับเจ้าหน้าที่

จำแนกประเภทสิทธิบัตร/อนุสิทธิบัตร

☐ กลุ่มวิศวกรรม	☐ กลุ่มเคมี	สิทธิบัตรการออกแบบ	อนุสิทธิบัตร
สิทธิบัตรการประดิษฐ์ (วิศวกรรม)	สิทธิบัตรการประดิษฐ์ (เคมีเทคนิค)	☐ สิทธิบัตรการออกแบบ (ออกแบบผลิตภัณฑ์ 1)	☐ อนุสิทธิบัตร (วิศวกรรม)
สิทธิบัตรการประดิษฐ์ (ไฟฟ้า)	สิทธิบัตรการประดิษฐ์ (ปิโตรเคมี)	☐ สิทธิบัตรการออกแบบ (ออกแบบผลิตภัณฑ์ 2)	☐ อนุสิทธิบัตร (เคมี)
สิทธิบัตรการประดิษฐ์ (ฟิสิกส์)	สิทธิบัตรการประดิษฐ์ (เทคโนโลยีชีวภาพ)	☐ สิทธิบัตรการออกแบบ (ออกแบบผลิตภัณฑ์ 3)	
	สิทธิบัตรการประดิษฐ์ (เภสัชภัณฑ์)		

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PUBLICATION	1. Akkarakittichoke, N., Jensen, M.P., Waongenngarm, P., Janwantanakul, P., 2022 Mediators and moderators of a walking intervention to prevent neck pain among high-risk office workers. Pain Rep 3(7), e1014. 2. Akkarakittichoke, N., Janwantanakul, P., Kanlayanaphotporn, R., Jensen M.P, 2022 Responsiveness of the UW Concerns-About-Pain (UW-CAP6) and UW Pain-Related Self-Efficacy Scale (UW-PRSE6) in individuals with chronic low back pain. Clin J Pain 2022 38(7), 476-483. 3. Waongenngarm, P., van der Beek, A.J., Janwantanakul, P., Akkarakittichoke, N., Coenen. P., 2022 Can the Borg CR-10 scale for neck and low back discomfort predict neck and low back pain among high-risk office workers? Int Arch Occup Environ Health. doi: 10.1007/s00420-022-01883-3. 4. Akkarakittichoke, N., Waongenngarm, P., Janwantanakul, P., 2021. The effects of active break and postural shift interventions on recovery from and recurrence of neck and low back pain in office workers: A 3-arm cluster-randomized controlled trial. Musculoskelet Sci Pract 56,102451. 5. Waongenngarm, P., Akkarakittichoke, N., Janwantanakul P. 2021. Effects of an active break and postural shift intervention on preventing neck and low back pain among high-risk office workers: a 3-arm cluster-randomized controlled trial. Scand J

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9. Akkarakittichoke, N., Khutok. K., Kanlayanaphotporn, R., Jensen M.P, Janwantanakul, P., Pain-related self-efficacy, pain catastrophizing, and function in individuals with chronic low back pain. Asia Pac J Sci Technol. In press

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AWARD RECEIVED

1. การประกวดผลงานนวัตกรรมสายอุดมศึกษา ประจำปี พ.ศ. 2563 ได้รับรางวัลระดับดีมาก (ถ้วยทอง) จากสำนักงานวิจัยแห่งชาติ (วช.) เมื่อวันที่ 5 สิงหาคม พ.ศ. 2563

2. การประกวดผลงานนวัติกรรมสายอุดมศึกษา ประจำปี พ.ศ. 2563 นำเสนอผลงานเรื่อง “ที่นั่งอัจฉริยะเพื่อป้องกันโรคปวดคอและหลังจากการนั่งเป็นระยะเวลานาน” ได้รับรางวัล ระดับเหรียญทอง จากสำนักงานการวิจัยแห่งชาติ (วช.) กระทรวงการอุดมศึกษา วิทยาศาสตร์ วิจัยและนวัตกรรม (อว.) เมื่อวันที่ 2-6 สิงหาคม พ.ศ.2563