Development of a device to alert for breaks to prevent musculoskeletal disorders in the neck and low back among office workers

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การพัฒนาอุปกรณ์แจ้งเตือนการพักเพื่อป้องกันโรคทางระบบกระดูกและกล้ามเนื้อบริเวณคอ/บ่าและหลังส่วนล่างในผู้ที่ทำงานในสำนักงาน

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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต
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Field of Study	Physical Therapy
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Thesis Co Advisor	Professor Allard J. van der Beek, Ph.D.

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ภูริพัฒน์ วาวเงินงาม : การพัฒนาอุปกรณ์แจ้งเตือนการพักเพื่อป้องกันโรคทางระบบกระดูกและกล้ามเนื้อบริเวณคอ/บ่าและหลังส่วนล่างในผู้ที่ทำงานในสำนักงาน. (Development of a device to alert for breaks to prevent musculoskeletal disorders in the neck and low back among office workers) อ.ที่ปรึกษาหลัก : ศ. ดร.ประวิตร เจนวรรธนะกุล, อ.ที่ปรึกษาร่วม : อัลลาร์ด ฟาน เดอ บีค

งานวิจัยฉบับนี้มีวัตถุประสงค์เพื่อพัฒนาอุปกรณ์แจ้งเตือนการพักเพื่อป้องกันโรคทางระบบกระดูกและกล้ามเนื้อบริเวณคอและหลังส่วนล่างในผู้ที่ทำงานสำนักงาน โดยงานวิจัยนี้ มีขั้นตอนการศึกษา 4 ขั้นตอน ประกอบด้วย 1) การทบทวนวรรณกรรมอย่างเป็นระบบ เพื่อศึกษาผลของการพักต่อการลดอาการปวดและความรู้สึกไม่สบายบริเวณหลัง และปริมาณงานที่ทำในพนักงานสำนักงาน 2) การศึกษารูปแบบและความสัมพันธ์ของความรู้สึกไม่สบายของร่างกายและการขยับเคลื่อนลำตัวขณะนั่งทำงานเป็นระยะเวลา 4 ชั่วโมง 3) การศึกษาผลของอุปกรณ์แจ้งเตือนการพักต่อการป้องกันโรคปวดคอและหลังส่วนล่างในพนักงานสำนักงาน โดยมีการติดตามผลระยะเวลา 6 และ 12 เดือน และ 4) การศึกษาอุบัติการณ์และปัจจัยที่เกี่ยวข้องกับการเกิดโรคปวดคอและหลังส่วนล่างในช่วงที่มีการแพร่ระบาดของโรค COVID-19 ในพนักงานสำนักงาน โดยผลการทบทวนวรรณกรรมอย่างเป็นระบบพบว่า การพักให้ผลดีในแง่ของการลดอาการปวดและความรู้สึกไม่สบายบริเวณหลัง โดยไม่ส่งผลต่อความสามารถในการทำงานในพนักงานสำนักงาน และรูปแบบการพักที่ได้ผลดีที่สุดในแง่ของการลดอาการปวดและความรู้สึกไม่สบายบริเวณหลัง คือ การพักโดยการเปลี่ยนแปลงท่าทาง ในการศึกษาที่ 2 ผลการศึกษาพบว่าการนั่งต่อเนื่องเป็นระยะเวลา 30 นาทีขึ้นไป อาจเพิ่มความเสี่ยงต่อการเกิดโรคปวดคอและหลัง จึงนำไปสู่การพัฒนาอุปกรณ์เพื่อแจ้งเตือนการพัก โดยอุปกรณ์แจ้งเตือนการพักถูกพัฒนาโดยผู้เขียนและทีมวิศวกร ประกอบด้วย 3 ส่วน คือ แผ่นรองที่นั่ง กล่องควบคุม และแอปพลิเคชันบนสมาร์ทโฟน อุปกรณ์นี้มีหน้าที่ตรวจจับระยะเวลาการนั่งและแจ้งระยะเวลาการพักให้แก่ผู้ใช้งาน โดยอุปกรณ์นี้มีค่าความเที่ยงตรงและความสอดคล้องอยู่ในระดับดีถึงดีมาก ผลการศึกษาการวัดประสิทธิภาพของอุปกรณ์ต่อการป้องกันโรคปวดคอและหลังพบว่าพนักงานสำนักงานที่ได้รับอุปกรณ์แจ้งเตือนการพัก มีอุบัติการณ์เกิดโรคปวดคอและหลังส่วนล่างน้อยกว่ากลุ่มควบคุมอย่างมีนัยสำคัญทางสถิติ ทั้งการติดตามผลระยะเวลา 6 และ 12 เดือน นอกจากนี้ อุบัติการณ์การเกิดโรคปวดคอและหลังในช่วงที่มีการแพร่ระบาดของโรค COVID-19 น้อยกว่าเมื่อเทียบกับช่วงก่อนมีการแพร่ระบาดของโรค COVID-19 โดยจำนวนวันที่ทำงานที่บ้านต่อสัปดาห์เป็นปัจจัยที่มีความสัมพันธ์ต่ออุบัติการณ์เกิดโรคปวดคอและหลังในช่วงที่มีการแพร่ระบาดของโรค COVID-19

สาขาวิชา	กายภาพบำบัด	ลายมือชื่อนิสิต	....
ปีการศึกษา	2563	ลายมือชื่อ อ.ที่ปรึกษาหลัก	....
		ลายมือชื่อ อ.ที่ปรึกษาร่วม	....

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KEYWORD: Rest break, Musculoskeletal disorders, Office workers

Pooriput Waongenngarm : Development of a device to alert for breaks to prevent musculoskeletal disorders in the neck and low back among office workers. Advisor: Prof. PRAWIT JANWANTANAKUL, Ph.D. Co-advisor: Prof. Allard J. van der Beek, Ph.D.

The objective of this thesis was to develop a device to alert for breaks to prevent musculoskeletal disorders in the neck and low back among office workers. This thesis was divided into four stages: 1) systematically review to gain insights into the effectiveness of breaks on low back pain, discomfort, and work productivity in office workers; 2) evaluation of the characteristics of perceived discomfort and postural shifts during a 4-hour sitting period; 3) evaluation of the effects of a device to alert for active breaks on preventing neck and low back pain among office workers: 6- and 12-month follow-up; and 4) evaluation of the incidences of neck and low back pain and working from home related risk factors during the COVID-19 outbreak among office workers. The results from systematic review revealed that breaks are recommended for reducing low back pain and discomfort with no disturbance in work productivity among office workers. The type of rest breaks that may be effective in reducing low back pain and discomfort was identified, namely active breaks with postural change. In the second study, our findings suggest that prolonged sitting for longer than 30 minutes possibly increase the risk of neck and low back pain, which used to develop the device to alert for breaks. The device to alert for break was developed by the author and engineering team, which consists of three components: seat pad, controller and smartphone application. This device can detect sitting time and recommend break duration during work to the user. The device had good to excellent validity and consistency. The results of the effectiveness of the device on preventing neck and low back pain showed that office workers who received the device to alert for breaks significantly reduced the 6- and 12-month incidence rate of neck and low back pain. In addition, the incidence of neck and low back pain during the COVID-19 period was lower than that for during the pre-COVID-19 period. The number of days working from home per week was associated with the incidence of neck and low back pain during COVID-19 period.

Field of Study:	Physical Therapy	Student's Signature ....
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		Co-advisor's Signature ....

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I would like to thanks my examiners Assistant Professor Premtip Thaveeratitham, Ph.D., Assistant Professor Sujitra Boonyong, Ph.D., Associate Professor Praneet Pensri, Ph.D. and Associate Professor Wattana Jalayondeja, Ph.D., for their kindness, valuable guidance and excellent suggestions.

I am thankful to my friends and members of the Work-related Musculoskeletal Injury Research Unit, who always support, help and encourage me throughout the study. I would also like to thanks my research partner: Nipaporn Akkarakittichoke, for helping me get through this long journey. I really appreciate everything you have done for me. My grateful also to my family: Pawat Suworalapakul and Saowani Saetae, my parents, for always being there for me. Completion this dissertation would not have been possible without their warm love, continued patience and endless support. Lastly, I hope this thesis is the best thing that represents my thankfulness to all them.

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CHAPTER 1

General introduction

1.1 Outline of this thesis

The thesis consists of eight 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 related literature. The third chapter is a systematic review of randomized and non-randomized controlled trials of the effects of breaks on low back pain, discomfort, and work productivity in office workers. The fourth chapter describes the perceived musculoskeletal discomfort and its association with postural shifts during 4-h prolonged sitting in office workers. The fifth chapter describes the effects of the promotion of active breaks and postural shifts on the 6-month incidence of neck and low back pain in high-risk office workers. The sixth chapter presents the study to examine whether the incidences of neck and low back pain were affected during the COVID-19 outbreak and to explore working from home related risk factors for neck and low back pain among office workers. The seventh chapter provides the effects of the active breaks on the 12-month incidence of neck and low back pain in high-risk office workers. The last chapter provides general 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 common health problems among office workers (Ortiz-Hernandez et al., 2003; Sillanpaa et al., 2003; Eltayeb et al., 2007; Janwantanakul et al., 2008). In Thailand, a study showed that annual prevalence of MSDs among office workers was 63%, and head/neck and low back were the most frequent MSDs in office workers (Janwantanakul et al., 2008). Neck pain is prevalent among office workers with 42%-69% of office workers reported neck pain annually (De Loose et al., 2008; Janwantanakul et al., 2008) and 34%-49% developed new onset of neck pain every year (Korhonen et al., 2003; Hush et al., 2009). The 6-month prevalence of chronic neck pain has been reported to range from 14% to 47%, with a point prevalence of 22% (Birse and Lander, 1998; Cote et al., 1998). Low back pain (LBP) affects 34% and 51% of office workers annually (Janwantanakul et al., 2008; Ayanniyi et al., 2010). Between 14-23% of office workers reported a new onset of LBP during the 1-year follow-up (Juul-Kristensen et al., 2004; Sitthipornvorakul et al., 2015). The annual prevalence of chronic LBP has been reported to range from 15% to 45%, with a point prevalence of 30% (Manchikanti et al., 2009). MSDs are often the cause of significant physical and psychological health impairments. It also affects work performance and social responsibilities. As a result, MSDs can be a great burden on patients and society (Manchikanti, 2000; Cote et al., 2009).

Musculoskeletal pain is predominantly related to lifestyle similar to other health conditions. Induce adaptive change in tissues are associated with everyday activities, particularly repeated movements and prolonged postures (Sahrmann, 2010). Office works usually involve with computer, participation in meeting, giving presentation, reading, phoning and few walking, standing, or lifting (IJmker et al., 2006). Thus, office workers are usually required to sit for long hours in front of a computer. 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 LBP (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).

Micro-breaks are scheduled breaks taken to prevent the onset or progression of cumulative trauma disorders in the computerized workstation environment (McLean et al., 2001). Previous research has shown that scheduled breaks can reduce self-report discomfort at the neck and low back; while maintaining, and in some cases, improving work productivity (Henning et al., 1997; McLean et al., 2001; Balci and Aghazadeh, 2004; Nakphet et al., 2014). The frequent, short, standing breaks have been shown to reduce MSDs symptoms, musculoskeletal discomfort, and mental fatigue in prolonged sitting tasks (McLean et al., 2001; Sheahan et al., 2016). During the breaks, participants are not required to remain motionless and are encouraged to shift postures. Micro-breaks have been shown to be beneficial in reducing fatigue in the neck and back muscles (McLean et al., 2001). Transitioning from a seated to a standing work posture every 30 min across the workday, relative to seated work, led to a significant reduction in fatigue levels and lower back discomfort in overweight/obese office workers, while maintaining work productivity (Thorp et al., 2014). Postural shift has been found to increase subcutaneous oxygen saturation, which positively influences tissue viability (Reenalda et al., 2009). Also, postural shift may alleviate neck and low back discomfort during prolonged sitting through alternating activity between different parts of the trunk muscles (van Dieen et al., 2001). Previous study showed increased physical activity at worksites reduced musculoskeletal symptoms among office workers (Pedersen et al., 2009; Sitthipornvorakul et al., 2015). Thus, increased daily walking steps in sedentary workers may indirectly indicate frequent breaks, allowing sufficient tissue recovery to occur. Consequently, the break program may reduce the incidence of neck and low back pain among office workers.

Accurate quantification of sitting time and break time is necessary for advancement of knowledge regarding the association between breaks at work and MSDs. Several previous studies developed different software that provide break interventions; however, these tools may be unreliable and invalid. To date, no study has investigated the long-term effect of break program for preventing MSDs in the neck and low back among office workers. Thus, the aims of the study were two folds; 1) to develop a device that can encourage breaks during work and 2) to investigate the effect of the device on prevention of the onset of neck and low back pain among healthy office workers.

1.3 Objective of the study

- To systematically review randomized and non-randomized controlled trials (RCTs) to gain insights into the effectiveness of breaks on low back pain, discomfort, and work productivity in office workers.

- To identify the type of breaks effective in reducing pain and preventing discomfort in the low back.
- To examined the characteristics of perceived discomfort and postural shifts at different magnitudes during a 4-h sitting period and the association between perceived discomfort and number of postural shifts.
- To develop a device to alert for active breaks to prevent neck and low back pain and assess the concurrent validity, consistency and test run of the device.
- To evaluate the effects of active breaks and postural shifts on the 6- and 12-month incidence of neck and low back pain in high-risk office workers.
- To examine whether the incidences of neck and low back pain were elevated during the COVID-19 outbreak and to explore working from home-related risk factors for neck and low back pain among office workers.

1.4 Scope of the study

Apart from conducting a systematic review, the experimental study was conducted in healthy office workers to examined the characteristics of perceived discomfort and postural shifts at different magnitudes during a 4-h sitting period and the association between perceived discomfort and number of postural shifts. The results were used to develop a rest breaks program for preventing neck and low back pain in office workers. Next, the development process of a device to alert for breaks was divided into 4 stages: 1) finding the engineering team to develop the device, 2) developing the prototype of the device which had 3 components (seat pad, controller and smartphone application), 3) developing the rest break algorithm, and 4) testing the validity, consistency and test run of the device. Finally, the good validity and consistency device to alert for breaks would be used to investigate the effect of the device on preventing neck and low back pain. Therefore, a prospective cohort study with 12-month follow up was conducted in a convenience sample of office workers. Participants were recruited from 6 large-scale enterprises in Bangkok. 193 participants were recruited and randomized into 3 groups (active break intervention group, postural shift intervention group, and control group). Participants in both intervention groups received the apparatus, which included the designed active breaks and postural shift program, while participants in control group received the placebo seat pad. The primary outcome measures were the 1-year incidence of non-specific neck and low back pain, and the secondary outcome measures were pain intensity and disability level. The incidence of non-specific neck and low back pain was collected by using a self-administered diary. Participants were followed until they became symptomatic, withdrew from the study, or completed the 12-month follow up. The researcher returned to collect the diary from participants every month over a 12-month period. Those who reported incidence of non-specific neck and low back pain were asked about their pain intensity and disability level. However, during the data collection, the COVID-19 outbreak occurred in Thailand by the start of March 2020. Most affected areas were Bangkok and surrounding neighborhoods. According to government regulation, many workplaces asked their employees to work from home. As part of prospective cohort study, office workers completed diaries detailing the incidence of neck and low back pain. This allowed us to evaluate the impact of working from home on the incidence of neck and low back pain, which no study has conducted to date. Thus, the study aimed to explore the incidence of and risk factors for neck and low back pain during the COVID-19 outbreak was conducted.

1.5 Benefits of the study

The finding of the present study would provide information about the effect of a device to alert for breaks and postural shifts to reduce the incidence of musculoskeletal disorders in the neck and low back among office workers, which would be essential for improving the efficacy of current intervention for preventing neck and low back pain. The device would be useful to a general population, particularly sedentary workers who have to sit for long periods of time.

CHAPTER 2

Review of Related 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 musculoskeletal disorders

Musculoskeletal disorders (MSDs) are defined as health problems of the locomotor apparatus, i.e. of muscles, tendons, the skeleton, cartilage, ligaments and nerves. MSDs include all forms of ill-health ranging from light, transitory disorders to irreversible, disabling injuries (Luttmann et al., 2003).

Work-related MSDs are supposed to be caused or intensified by work, though often activities, such as housework or sports, may also be involved (Luttmann et al., 2003).

2.1.3 Definition of non-specific neck pain

In this study, neck pain patients are defined as subjects who reported pain greater than 30 millimeters (mm) on a 100-mm visual analog scale (Tsauo et al., 2007) and 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).

Non-specific neck pain is defined as neck symptoms without signs of serious spinal disease (such as cancer, spinal infection, spinal fracture, or inflammatory arthritis), cervical 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).

2.1.4 Definition of non-specific low back pain

In this study, back pain patients are defined as subjects who reported pain greater than 30 millimeters (mm) on a 100-mm visual analog scale (Tsauo et al., 2007) and 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).

Non-specific low back pain is defined as low back pain without recognizable, pathology that can be identified as the cause of pain (such as cancer, spinal infection, spinal fracture, or inflammatory arthritis), cervical 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; Krismer and van Tulder, 2007; Leaver et al., 2007).

2.2 Pathomechanism of work-related musculoskeletal disorders and its chronicity

Several previous studies indicated that work-related musculoskeletal disorders in office workers have a multi-factorial origin. Pathomechanism of work-related musculoskeletal disorders in office workers can divide to 3 theories as follow:

2.2.1 Work-related musculoskeletal disorders in office workers theory by Wahlstrom in 2005

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 fatigue)

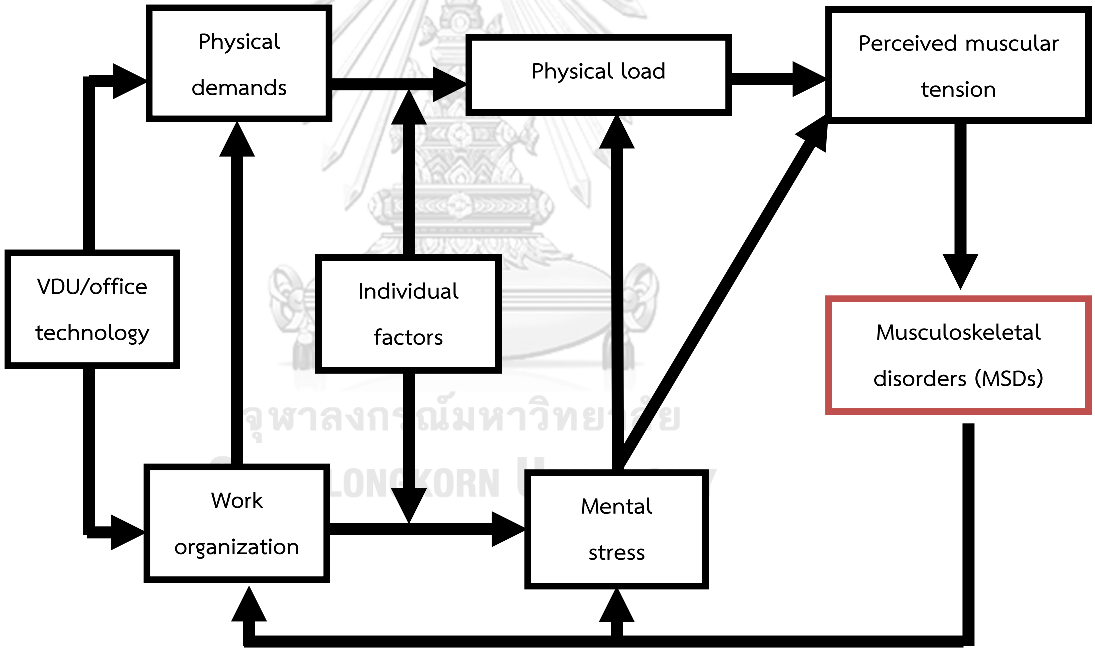

Figure 2.1 A model of musculoskeletal disorders in office workers (Wahlström, 2005)

VDU = visual display unit

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 Pathomechanism of neck pain in office workers theory by Paksaichol et al. in 2015

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 (Figure 2).

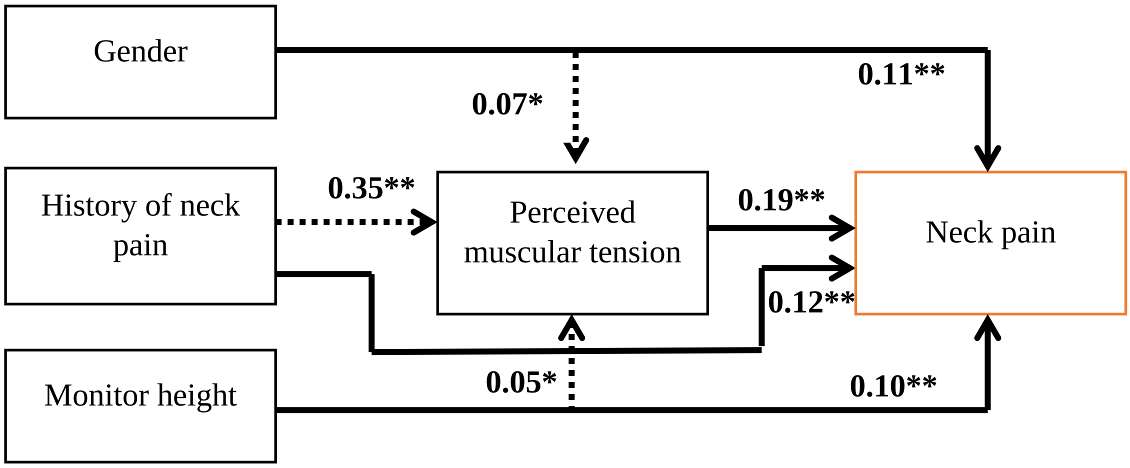

Figure 2.2 Path analysis of factors predicting onset of neck pain in office workers with standardized regression coefficients (*p<0.05, **p<0.01)

As proposed by Côté et al.in 2009, each risk factor had direct and indirect effects on the development of nonspecific neck pain in a sample of office workers (Cote et al., 2009). The recent 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 Pathomechanism of low back pain in office workers theory by Janwantanakul et al. in 2015

The result of recent study using path analysis showed that onsets of low back pain were predicted by having a history of low back pain, frequency of breaks at work, and psychological demand (Figure 3). The recent model showed that having history of low back pain, frequency of breaks at work, and psychological demand directly caused low back pain and that having history of low back pain had the strongest effect on the onset of low back pain. Apart from having a direct effect on the development of low back pain, history of low back pain, and frequency of breaks at work had indirect effects on low back pain that were mediated through psychological demand. History of low back pain 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 low back pain in office workers proposed in recent 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 low back pain (Wahlstrom et al., 2003).

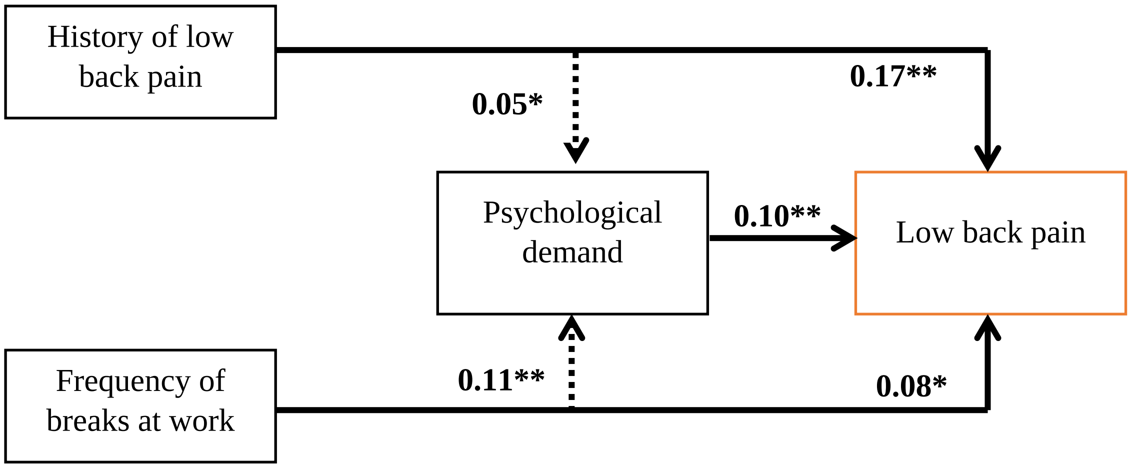

Figure 2.3 Path analysis of factors predicting onset of low back pain in office workers with standardized regression coefficients (*p<0.05, **p<0.01)

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 (Linton and van Tulder, 2001; Krismer and van Tulder, 2007; Green, 2008)

2.3.1.1 Primary prevention

Primary prevention is defined as health promotion and specific protection to a community (Linton and van Tulder, 2001; Krismer and van 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 (Linton and van Tulder, 2001; Krismer and van Tulder, 2007; Green, 2008).

2.3.1.2 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 (Linton and van Tulder, 2001; Krismer and van Tulder, 2007; Green, 2008).

2.3.1.3 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 MSD prevention research

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

- 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).

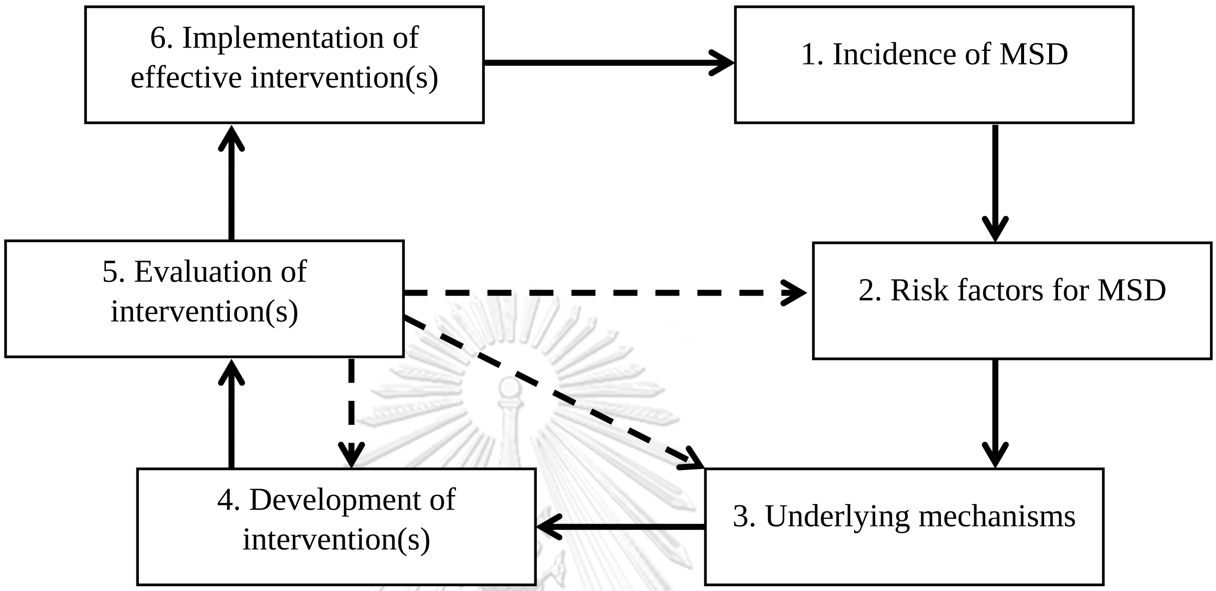

Figure 2.4 A framework describing a repeated sequence for prevention of work-related musculoskeletal disorders (MSD)—the six steps in prevention

2.4 Risk factors for neck and low back pain

2.4.1 For neck pain

Risk factors for neck pain were divided into three groups: individual, work-related physical, and work-related psychosocial risk factors. 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 For low back pain

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

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

2.5.1 Primary preventive interventions for neck pain

A few studies aiming for primary prevention of neck pain among office workers have been reported (Sihawong et al., 2014; Sitthipornvorakul et al., 2015). A 12-month prospective cluster-randomised 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 low back pain

There are few studies on primary prevention of 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, recent study from multivariate logistic regression 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 2, 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 2, B) or by creating a kyphosis of the spine by flexing without much rotation of the pelvis (Fig 2, 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 2, 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).

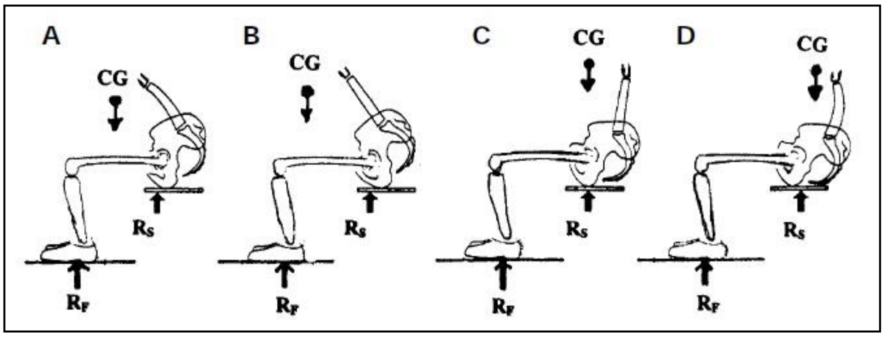

Figure 2.5 Three sitting categories on the basis of center of gravity location (Harrison et al., 1999). RS = reaction force through the seat bottom. RF = reaction force from the ground at the feet. CG = center of gravity.

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.

An office chair is an important component to encourage a good sitting posture and to prevent tissue damage. Subjects in seats with backrest inclinations of 110 to 130 degrees, with concomitant lumbar support, have the lowest disc pressures and electromyography recordings from spinal muscles. A 5-degree posterior inclination of seat-bottom and armrests can further reduce lumbar disc pressures and electromyography readings while seated (Harrison et al., 1999; Corlett, 2006). The convex backrest combined with a firm seat help maintain an erect posture (Pynt et al., 2002). The convex of backrest is usually called lumbar support, e.g. equipment puts at the lower section of backrest, such as pillow or towels. The usage of 5 and 7.5 cm thick lumbar support is found to be significantly reduced the highest seat buttock pressure (Shields and Cook, 1992). A previous study found that sitting with reduced ischial pressure and using lumbar support (i.e. off-loading sitting posture; upright sitting with the back part of seat tilted downward 20° with respect to the front part of seat, and with protruded lumbar support) reduced sitting load on lumbar spine and paravertebral muscle activity at lumbar spine, which may potentially reduce sitting-related LBP (Makhsous et al., 2009).

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 active movement 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 et al., 2002). However, the active movement 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 behaviors

The majority of office work was sedentary (over 82%). Office work was very passive, with 5% undertaken in an erect body position and only 2% walking of the total office time (Morl and Bradl, 2013). The extended period of sitting induce many changing to human body. During 1-hour sitting, office workers with and without chronic LBP appeared to assume slumped sitting postures after 20 minutes of sitting. Healthy workers had significantly more frequent postural shifts than chronic LBP workers during prolonged sitting. The frequency of postural shift in healthy participants reported in the present study (9.6 ± 8.3 times/h). Positive relationships between BPD and slump sitting posture and frequency of postural shift were also found during 1 hour of sitting in both chronic LBP and control groups (Akkarakittichoke and Janwantanakul, 2017). Also, previous study on the frequency of postural change in healthy subjects who sat in a wheelchair for 90 minute found that health subjects change their posture every 9+6 minute in the sagittal plan and every 6+2 minute in the frontal plane (Linder-Ganz et al., 2007).

2.7 Breaks

The definition of a break period is any time that is not working time. A break is an uninterrupted period during which work should not be undertaken. You should be able to move away from your workstation (International Labour Organization, 1997).

2.7.1 Type of breaks

Break in office works is defined as a cessation of computer work tasks. Break can be either passive or active. For a passive break, operators leave their computer tasks, sit, and relax during this period. For an active break, operators are required to perform specific movements, exercises, or change their posture (Nakphet et al., 2014). Previous studies compared the beneficial effects of passive and active breaks, by assessing oxygenation in muscles, muscle activity, discomfort in neck and upper extremity as well as work productivity. The results showed that break, regardless of type of activities during breaks, had a positive effect on the recovery of muscle discomfort (Crenshaw et al., 2006; Nakphet et al., 2014).

2.7.2 Effects of breaks on neck discomfort and work productivity in office workers

There are two studies conducting on the effects of break on neck discomfort in office workers. The results showed that any type of break interventions had a positive effect on the recovery of muscle discomfort in VDU operators with complaints in the neck and shoulders. No adverse effects on productivity were observed when breaks were provided. The benefit of break interventions in terms of their effect on a reduction in muscle discomfort in the neck and shoulders is unquestionable. It could have initiated a process of consciousness that possibly led to more favourable behaviour (e.g., work postures and muscle relaxation). Moreover, number of daily walking steps can reduce the incidence of non-specific neck pain in office workers (Sitthipornvorakul et al., 2015). Thus, increased daily walking steps in office workers may indirectly indicate frequent breaks, allowing sufficient tissue recovery to occur.

2.7.3 Effects of breaks on low back pain, discomfort, and work productivity in office workers

A systematic review of literature was conducted to gain insight into the effectiveness of break programs on low back pain, discomfort, and work productivity in office workers and identify type of break programs that was effective to reduce low back pain and discomfort. Eight RCTs and three non-RCTs investigating the effectiveness of break programs for low back pain, discomfort, and work productivity in office workers were reviewed and analysed. The findings revealed that low quality evidence supported the effectiveness of breaks on discomfort prevention. Moderate quality evidence was found to support there being no adverse effect of break on work productivity. The type of breaks that may be effective in reducing low back pain and discomfort while maintaining work productivity was identified, namely active breaks with postural change (For more details about the review, please see CHAPTER 3: The effects of breaks on low back pain, discomfort, and work productivity in office workers: a systematic review of randomized and non-randomized controlled trials).

2.8 Devices providing breaks intervention

Accurate quantification of sitting and break time is necessary for advancement of knowledge regarding the association between breaks at work and MSDs. To date, there are two software that provide break interventions, i.e. Time2Play and Big Stretch Reminder software.

1. Time2Play is a computer software that is required to install on computer or laptop. the function of the software is similar to a timer, which count time when a user turns on the computer. The time from the turn on of computer will show on monitor, which encourages the user to take a break to reduce the impact of working with computer for a long time. However, this program

does not have a notification system. The user must observe the amount of time by themselves.

2. Big Stretch Reminder is a computer software that is required to install on computer or laptop. The software will remind a user to take a break. However, the user is required to set the time that they want to take a break by themselves. When it notified, the user either click on the monitor to skip or take a break.

According to the functions of these two software, a user must know appropriate break protocol (i.e. when and how often) that is sufficient for tissue recovery. In addition, both software cannot detect whether the user actually took a break.

CHAPTER 3

The effects of breaks on low back pain, discomfort, and work productivity in office workers: a systematic review of randomized and non-randomized controlled trials

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Abstract

The purpose of this study was to evaluate the effectiveness of breaks on low back pain, discomfort, and work productivity in office workers.

Publications were systematically searched in several databases from 1980 to December 2016. Relevant randomized and non-randomized controlled trials were retrieved and assessed for methodological quality by two independent reviewers. Quality of evidence was assessed and rated according to the GRADE guidelines.

Eight randomized controlled trials and three non- randomized controlled trials were included in this review, of which 10 were rated as high-quality studies. The break programs were highly heterogeneous with work duration ranging from 5 minutes to 2 hours and break duration ranging from 20 seconds to 30 minutes. The results showed low-quality evidence for the conflicting effect of breaks on pain and low-quality evidence for the positive effect of breaks on discomfort. When stratified by type of breaks, moderate-quality evidence was found for the positive effect of active breaks with postural change for pain and discomfort. Moderate-quality evidence indicated that the use of breaks had no detrimental effect on work productivity.

Within a number of methodological limitations that are present in the published studies, breaks are recommended for reducing low back discomfort with no disturbance in work productivity among office workers. Active breaks with postural

change may be effective to reduce pain in patients with acute low back pain and to prevent discomfort in healthy subjects. More research is needed before any final conclusions can be reached.

Keywords: Break; Spinal pain; Musculoskeletal disorders; Computers

3.1 Introduction

One of common health problems in office workers is low back pain (LBP). Approximately 34% and 51% of office workers experienced LBP in the preceding 12 months (Janwantanakul et al., 2008; Ayanniyi et al., 2010) and the 1-year incident rate for LBP is about 14-23% (Juul-Kristensen et al., 2004; Sitthipornvorakul et al., 2015). The 1-year prevalence of chronic LBP has been reported to range from 15% to 45%, with a point prevalence of 30% (Manchikanti et al., 2009). Low back pain causes personal suffering, disability, and impaired quality of life and work in general, which can be a great socioeconomic burden on both patients and society (Manchikanti et al., 2014).

Office workers are usually required to sit for long hours working on a computer while spending most of their time in a sitting position. Occupational groups exposed to poor postures while sitting for longer than half a day have a considerably increased risk of experiencing LBP (Lis et al., 2007). Subjects with LBP are likely to be in sustained postures and have large and infrequent spinal movements, rather than subtle and regular spinal movements, while sitting (Dankaerts et al., 2006; O'Sullivan et al., 2012). The prolonged postural loading of the spine while sitting can reduce joint lubrication, fluid content of intervertebral discs, and increase stiffness, which can be detrimental to back health (Beach et al., 2005; Chan et al., 2011). Prolonged muscle activation in static sitting may lead to localized muscle tension, muscle strains, muscle fatigue, and other soft-tissue damage, causing impairment of motor coordination and control as well as increased mechanical stress on ligaments and intervertebral discs (Granata et al., 2004). Prolonged sitting also induces low back discomfort (Waongenngarm et al., 2015), which is a strong predictor of LBP (Hamberg-van Reenen et al., 2008).

Breaks are recommended for alleviating the adverse effects of prolonged sitting with poor postures. Scheduled breaks can prevent the onset or progression of cumulative trauma disorders in the computerized workstation environment (Balci and Aghazadeh, 2004; Barredo and Mahon, 2007; Sheahan et al., 2016). A break is generally defined as the cessation of computer work tasks and can be either passive or active. For a passive break, operators leave their computer tasks, sit, and relax during this period, while during active breaks, operators are required to perform specific movements, exercises, or change their posture (Nakphet et al., 2014). Previous studies compared the beneficial effects of passive and active breaks, by assessing oxygenation in muscles, muscle activity, and discomfort in the neck and upper extremity. The results showed that breaks – regardless of the type of activities during the breaks – had a positive effect on the recovery of muscle discomfort (Crenshaw et al., 2006; Nakphet et al., 2014). However, due to the impracticality and potential impact on work productivity of breaks, it is difficult in an office setting to implement the breaks without working. Thus, the standing breaks while performing computer work have been recently introduced as an option to reduce discomfort and pain in the low back while still maintains workers' productivity (Thorp et al., 2014).

To date, there has been no study on the effects of the type of breaks on pain and discomfort in the low back as well as work productivity. Thus, the primary aim of this study was to systematically review randomized and non-randomized controlled trials (RCTs) to gain insights into the effectiveness of breaks on low back pain, discomfort, and work productivity in office workers. The secondary aim was to identify the type of breaks effective in reducing pain and preventing discomfort in the low back.

3.2 Methods

Search strategy

Online searches were conducted on Web of Science, PubMed, ScienceDirect, the Cochrane Library, PEDro, and Scopus databases from 1980-December 2016. The following keywords were used: back pain, low back pain, chronic low back pain, LBP, break, pause, rest, rest break, micro-break, active break, passive break, and postural change. The search and full inclusion process was performed by two reviewers (PW and KA). After the inclusion of articles based on the selection criteria, references were searched for additional articles.

Selection of studies

The selection criteria of relevant articles were:

(1) The study design was a RCT or a non-RCT that employed break as a primary intervention.

(2) The study population was office workers, or those working with computers, visual display units, or visual display terminals.

(3) Low back pain, discomfort, or work productivity was assessed in the study. Studies on LBP due to specific underlying pathology, such as tumors, fractures, infection, dislocation, or osteoporosis were excluded.

(4) The article was a full report published in English. Letters, abstracts, books, conference proceedings, and posters were excluded.

Quality assessment of studies

The articles were evaluated for methodological quality by two reviewers (PW and KA). Risk of bias was assessed using the Cochrane Back and Neck Review Group expanded 13-item criteria (Furlan et al., 2015). A high-quality study was defined as scoring positive in at least 50% (7/13) of the items. Disagreements between the reviewers were discussed in an attempt to achieve consensus. If agreement could not be reached, a third reviewer (PJ) was consulted to achieve a final judgment.

Data extraction

Data extraction was performed by two reviewers (PW and KA). The reviewers independently extracted the data using a standardized form, including characteristics of participants, intervention parameters, outcomes, and results. The consensus method was used to resolve disagreements between the two reviewers. A third reviewer (PJ) was consulted to achieve a final judgment if disagreement persisted.

Data analysis

Conclusions were reached on the effectiveness of breaks based on the reported outcome of pain, discomfort, or work productivity using the GRADE (Grades of Recommendation, Assessment, Development and Evaluation) system, which was used to evaluate the overall quality of the evidence and the strength of the recommendations (Furlan et al., 2015). For each outcome, an a priori ranking of

'high', or 'low' was assigned depending on whether the majority of studies were categorized as randomized controlled trials or non-randomized controlled trials (Swinton et al., 2017). Five domains of quality were rated for each comparison: (1) limitations of study design; (2) inconsistency; (3) indirectness; (4) imprecision; (5) publication bias across all trials (Guyatt et al., 2011; Furlan et al., 2015). A four-point rating scale ranging from 'high quality' on one end to 'very low quality' on the other was employed. The quality of the summary of findings was rated as moderate if one, low if two, and very low if three of the criteria were not met. The following definitions of quality of evidence were applied (Balshem et al., 2011):

- High quality: We are very confident that the true effect lies close to that of the estimate of the effect,
- Moderate quality: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different,
- Low quality: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect,
- Very low quality: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of the effect.

Subgroup analysis

All relevant studies were stratified by type of breaks. Breaks were classified as 1) an active break with postural change, 2) an active break without postural change, 3) a passive break, and 4) a standing break while performing computer work. An active break with postural change was defined as operators being required to change their postures (i.e. from siting to standing) and perform specific movements or exercises in the low back. An active break without postural change was defined as operators being required to perform specific movements or exercises in the low back in the sitting position. A passive break was defined as operators leaving their computer tasks, sit, and relax during this period. A standing break while performing computer work was defined as operators being required to change their posture (from siting to standing) while still performing computer work.

Sensitivity analysis

Sensitivity analysis was conducted to assess how sensitive the results of the review were in relation to the way it was performed. For the results of qualitative analysis (using the GRADE approach), the effect of the cut-off point used in the methodological quality assessment for qualification as a high-quality study on the synthesized results was assessed by shifting the cut-off point from ≥50 to ≥60%, or shifting the cut-off point from ≥50 to ≥70%.

3.3 Result

Search strategy

A total of eleven articles were judged to meet the selection criteria (Fig. 3.1). In one included study, the authors described their study design as a quasi-experimental design (Davis and Kotowski, 2014). However, both reviewers of this systematic review (PW and KA) identified such study as an RCT design study because participants in the study were randomly assigned to groups and the control group was the conventional workstation condition. As a result, the study is included in this systematic review. All eleven articles were assessed for methodological quality and data extraction.

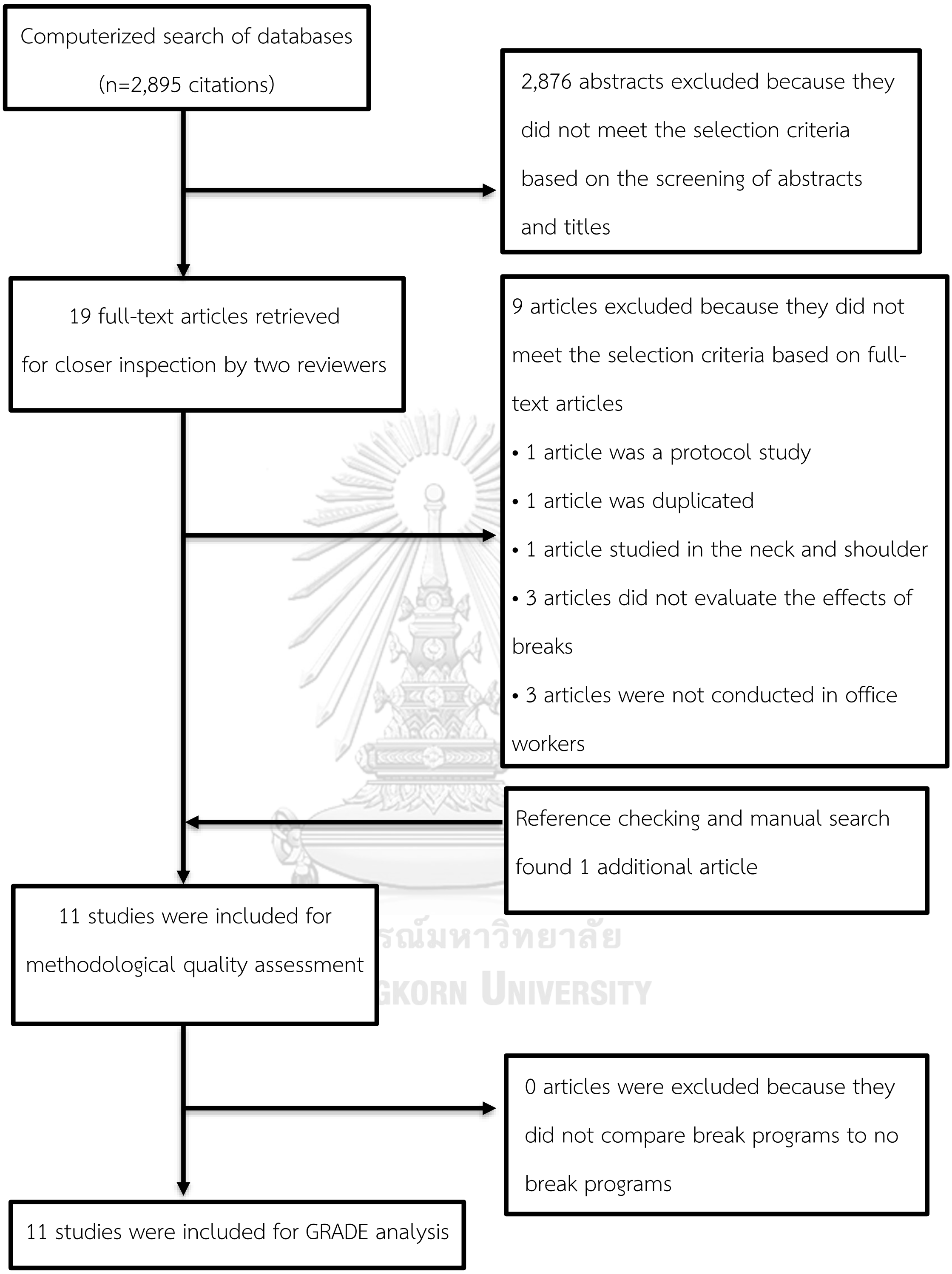

Figure 3.1 Flow diagram of the searching and screening process.

Methodological quality assessment

Eleven articles were evaluated by two reviewers (PW and KA) and the scoring of both reviewers before discussion had an agreement rate of 96.5% (138/143). The overall inter-rater agreement resulted in kappa = 0.93 with a standard error of measurement of 0.05. Following discussion, the two reviewers reached full consensus (100%; 143/143). Thus, no article was evaluated by the third reviewer (PJ). The scores for the methodological quality of the studies ranged from 6 to 9 points (Table 3.1). The median score was 8 points. Ten of 11 included studies were rated as high-quality studies. All studies were rated negative for items 3 (blinding of all participants), 4 (blinding of all therapists), and 5 (blinding of all assessors)

1 Table 3.1 Methodological quality score of the 11 included studies.

Author	Randomization	Allocation concealed	Patient blinded	Care provider blinded	Outcome assessor blinded	Drop-out rate	Intention to treat	Selective outcome reporting	Similar at baseline	Co-interventions avoided or similar	Compliance acceptable	Timing of the outcome assessment	Other bias	Total score	Quality of study
	Scores on the Cochrane Back and Neck Review Group expanded 13-item criteria														
Davis and Kotowski (2014)	+	?	-	-	-	+	+	+	+	+	+	+	+	9/13	High
Galinsky et al. (2000)	+	?	-	-	-	+	+	+	+	+	+	+	+	9/13	High
Lanhers et al. (2016)	+	+	-	-	-	+	+	+	?	+	+	+	+	9/13	High
McLean et al. (2001)	+	?	-	-	-	+	+	+	+	+	+	+	+	9/13	High
Sheahan et al. (2016)	+	?	-	-	-	+	+	+	+	+	+	+	+	9/13	High

Balci et al. (2004)	-	-	-	-	-	+	+	+	+	+	+	+	+	8/13	High
Galinsky et al. (2007)	+	?	-	-	-	+	-	+	+	+	+	+	+	8/13	High
Henning et al. (1994)	-	?	-	-	-	+	+	+	+	+	+	+	+	8/13	High
Henning et al. (1996)	-	?	-	-	-	+	+	+	+	+	+	+	+	8/13	High
Thorp et al. (2014)	+	?	-	-	-	+	-	+	+	+	+	+	+	8/13	High
Henning et al. (1997)	+	?	-	-	-	-	-	+	?	+	+	+	+	6/13	Low
Positive (%)	73	9	0	0	0	91	73	100	82	100	100	100	100		

Study characteristics

Eight of the eleven trials were RCTs and the remaining three trials were non-RCTs (Table 3.2). Follow-up periods ranged from 48 minutes to 4 months. Four RCTs were conducted in field settings (Henning et al., 1997; Galinsky et al., 2000; Galinsky et al., 2007; Lanhers et al., 2016). The remaining four RCTs and three non-RCTs were conducted in laboratory settings. Only one of 11 studies was conducted in acute LBP subjects (Sheahan et al., 2016). The remaining studies were conducted in healthy subjects who reported no LBP at baseline. Six studies compared break programs to no break programs. Four studies compared among different break programs. The remaining one study compared break programs between with and without feedback. Of the eleven included studies, eight studies showed a positive effect of breaks and three studies reported no effect of breaks.

The break interventions of included studies were classified into 4 types: active breaks with postural change, active breaks without postural change, passive breaks, and standing breaks while performing computer work (Table 3.3). Of included studies, four trials examined the effectiveness of active breaks with postural change (Galinsky et al., 2000; McLean et al., 2001; Davis and Kotowski, 2014; Sheahan et al., 2016). Three trials investigated active breaks without postural change (Balci and Aghazadeh, 2004; Galinsky et al., 2007; Lanhers et al., 2016). One trial investigated passive breaks (Henning et al., 1997). Two trials examined the effectiveness of standing breaks while performing computer work (Davis and Kotowski, 2014; Thorp et al., 2014). The remaining two trials did not clearly specify which types of break protocol were examined (Henning et al., 1994; Henning et al., 1996). The work duration ranged from 5 minutes to 2 hours or their own discretion and the break duration from 20 seconds to 30 minutes or their own discretion.

Table 3.2 Characteristics and results of the 11 included studies.

Author	**Study design (follow-up period; study setting)**	**Study population**	**Intervention**	**Outcome**	**Result**
Davis and Kotowski 2014	RCT* (4 weeks; laboratory study)	37 call center employees	I1: conventional workstation I2: conventional workstation with reminder software I3: sit-stand workstation I4: sit-stand workstation with reminders	Discomfort Work productivity	I1 vs I2 = + I1 vs I3, I4 = + I2 vs I3, I4 = + I1 vs I2 vs I3 vs I4 = 0
Galinsky et al. 2000	RCT: Pre-post experiment (4 weeks; field study)	42 data-entry operators	I: supplementary break C: conventional break	Discomfort Work productivity	I vs C = + I vs C = 0

Galinsky et al. 2007	RCT (8 weeks; field study)	51 employees VDU	I1: stretching + conventional break I2: stretching + supplementary break	Discomfort	I1 vs I2 = + I3 vs I4 = + I1 vs I3 = 0 I2 vs I4 = 0
			I3: non-stretching + conventional break I4: non-stretching + supplementary break	Work productivity	I1 vs I2 = + I3 vs I4 = + I1 vs I3 = 0 I2 vs I4 = 0
Henning et al. 1997	RCT (4 weeks; field study)	26 VDU operators for discomfort and 34 VDU operators for work productivity (larger site)	I1: breaks only I2: breaks and exercises C: no breaks or exercises	Discomfort Work productivity	I1 vs I2 vs C = 0 I1 vs I2 vs C = 0

Lanhers et al. 2016	Cluster randomized trial (4 months; field study)	200 employees VDU	I: received I-Preventive program C: received no I-Preventive program	Pain	I vs C = 0
McLean et al. 2001	RCT: Pre-post experiment (4 weeks; laboratory study)	15 office workers	I1: micro-breaks at 20 min intervals I2: micro-breaks at 40 min intervals I3: micro-breaks at their own discretion C: no breaks	Discomfort	I1 vs C = + I2 vs C = + I3 vs C = + I1 vs I2 vs I3 = 0
				Work productivity	I1 vs C = 0 I2 vs C = 0 I3 vs C = 0 I1 vs I2 vs I3 = 0

Sheahan et al. 2016	RCT: Pre-post experiment (4 days; laboratory study)	8 university students with acute LBP	I1: 5 min of standing break every 30 min I2: 2.5 min of standing break every 15 min I3: 50 s of standing break every 5 min C: no break	Pain Work productivity	I1, I2, I3 vs C = + (Sig for MCID) I1 vs I2 vs I3 vs C = 0
Thorp et al. 2014	RCT (5 days; laboratory study)	23 overweight/obese office workers	I1: SIT condition I2: STAND-SIT condition	Discomfort Work productivity	I1 vs I2 = + I1 vs I2 = 0
Balci et al. 2004	Non-RCT (150 mins; laboratory study)	10 male students	I1: 60-min work/10-min break I2: 30-min work/5-min break I3: 15- min work/30-sec break (3 times) and 3 min for the fourth	Discomfort Work productivity	I1 vs I2 vs I3 = + I1 vs I2 vs I3 = 0

			time		
Henning et al. 1994	Non-RCT (48 mins; laboratory study)	38 undergraduate psychology students	I1: regimented break I2: compensatory break	Discomfort Work productivity	I1 vs I2 = + I1 vs I2 = 0
Henning et al. 1996	Non-RCT (65 mins; laboratory study)	31 undergraduate psychology students	I1: break with feedback I2: break without feedback	Discomfort Work productivity	I1 vs I2 = 0 I1 vs I2 = 0

Positive (+) if a break intervention was demonstrated to be statistically more effective than a control group.
Negative (-) if a break intervention was demonstrated to be statistically less effective than a control group.
Neutral (0) if a break intervention did not statistically differ from a control group.
I, intervention group; I1, intervention group 1; I2 intervention group 2; I3, intervention group 3; I4, intervention group 4; C, control group.
LBP, low back pain; RCT, randomized controlled trial; Non-RCT, non-randomized controlled trial; VDU, visual display unit; MCID, minimal clinically important difference

*The study stated that their study was a quasi-experimental design study. However, both reviewers of the present systematic review (PW and KA) identified such study as an RCT design study because participants were randomly assigned to conditions and the conventional workstation condition in this study was considered the control group.

Table 3.3 Details of break interventions (n=11)

Author	Work duration	Break duration	Break protocol	Type of break
Davis and Kotowski 2014	30 min	Their own discretion	For the conventional workstation with software reminders, software was loaded onto the computers to track computer activity and participants requested to make a postural change at 30-minute intervals (stood up and moved around). Participants used discretion when taking a break but were encouraged to follow the prompts as much as possible.	Active breaks with postural change
	30 min	Their own discretion	For the sit-stand workstation condition with software reminders, participants were instructed how to use the adjustment controller. All participants were encouraged to change the workstation height during the workday. The height of the workstation could be adjusted between 61.0 cm and 130.8 cm. However, the actual height of the workstation during sit-stand conditions was self-selected and was then specifically measured.	Standing breaks while performing computer work

Galinsky et al. 2000	1 hour	5 min	Participants were encouraged to get up and took at least a short walk away from their workstations during each break.	Active breaks with postural change
Galinsky et al. 2007	1 hour	5 min	Participants were asked to perform stretching exercise. They included brief stretches targeting the neck, shoulders, back, and upper extremities, and required no more than a total of 2 min to perform.	Active breaks without postural change
Henning et al. 1997	1 hour	30s (3 times) every 15 min and 3 min for the last time	VDU operators were asked to cease all computer operations by removing their hands from the keyboard, avoiding looking at the VDU display, and also sitting back in their chairs and relaxing for the duration of the break.	Passive breaks
Lanhers et al. 2016	2 hours	30s - 1.30 min each	At regular intervals, a visual signal on the screen prompted VDU workers to take active breaks. The exercises were easy to perform and most could be carried out while seated without needing specific equipment.	Active breaks without postural change

McLean et al. 2001	20 or 40 min or their own discretion	30s	Participants were prompted to get out of their chairs during each micro-break. They were not asked to perform any particular activity during their break, but were asked to walk away from their workstation.	Active breaks with postural change
Sheahan et al. 2016	30 min, 15 min, 5 min	5 min, 2.5 min, 50s	Participants were required to stand in the middle of the room without leaning or stretching. They were permitted to access their mobile phones or converse with the researcher.	Active breaks with postural change
Thorp et al. 2014	30 min sitting work	30 min standing work	Participants were asked to perform their usual computer and/or telephone-based work tasks in a simulated office setting for 8 h/day in either a seated work posture (SIT condition) or while systematically interchanging every 30 min between a standing and seated work posture (STAND-SIT condition).	Standing breaks while performing computer work
Balci et al. 2004	60 min, 30 min, 15 min	10 min, 5 min, 30s (3 times)	Participants performed simple exercises in the break periods. The exercises included hand, head, neck, back, and shoulder regions and	Active breaks without postural

		and 3 min for the last time of each hour	were easily applicable in the offices.	change
Henning et al. 1994	5 min	20s	No information is available.	Cannot specify
Henning et al. 1996	10 min	30s	No information is available.	Cannot specify

VDU, visual display unit

Summary of effectiveness of breaks

The summary of evidence for the effectiveness of breaks and type of breaks on pain, discomfort, and work productivity are presented in Tables 3.4 and 3.5.

Evidence of the effectiveness of breaks for pain reduction

Two high-quality RCTs investigated the effectiveness of breaks in reducing low back pain (Lanhers et al., 2016; Sheahan et al., 2016). The results indicated low-quality evidence (2 RCTs, n = 208; inconsistency, imprecision) for the conflicting effect of breaks on LBP. Lanhers et al (2015) found no significant effect for an active break without postural change program on LBP reduction compared to a control group of healthy subjects (Lanhers et al., 2016). On the other hand, Sheahan et al (2016) reported a significant effect of an active break with postural change program on LBP reduction compared to a no break program in acute LBP subjects (Sheahan et al., 2016).

When stratified by break type, moderate-quality evidence (1 RCT, n = 8; imprecision) was found for the positive effect of an active break with postural change for pain reduction (Sheahan et al., 2016). Moderate-quality evidence (1 RCT, n = 200; imprecision) was found for no effect of an active break without postural change on LBP (Lanhers et al., 2016). No evidence existed concerning the effectiveness of passive breaks and standing breaks while performing computer work on LBP reduction.

Evidence of the effectiveness of breaks for discomfort prevention

Five high-quality RCTs (Galinsky et al., 2000; McLean et al., 2001; Galinsky et al., 2007; Davis and Kotowski, 2014; Thorp et al., 2014), three high-quality non-RCTs (Henning et al., 1994; Henning et al., 1996; Balci and Aghazadeh, 2004), and one low-quality RCT (Henning et al., 1997) investigated the effectiveness of breaks for preventing low back discomfort. The results indicated low-quality evidence (6 RCTs and 3 non-RCTs, n = 273; inconsistency, imprecision) for the positive effect of break programs on low back discomfort. Five high-quality RCTs (Galinsky et al., 2000; McLean et al., 2001; Galinsky et al., 2007; Davis and Kotowski, 2014; Thorp et al., 2014) and two high-quality non-RCTs (Henning et al., 1994; Balci and Aghazadeh, 2004) indicated that break programs significantly reduced discomfort of the low back compared to control groups. However, one low-quality RCT (Henning et al., 1997) and one high-quality non-RCT (Henning et al., 1996; Henning et al., 1997) reported no significant difference in low back discomfort between healthy workers who received and did not receive breaks.

When stratified by break type, moderate-quality evidence (3 RCTs, n = 94; imprecision) was found for the positive effect of active breaks with postural change for discomfort reduction (Galinsky et al., 2000; McLean et al., 2001; Davis and Kotowski, 2014). Moderate-quality evidence (1 RCT and 1 non-RCT, n = 61; imprecision) was found for the positive effect of active breaks without postural change for discomfort reduction (Balci and Aghazadeh, 2004; Galinsky et al., 2007).

Low-quality evidence (1 RCT, n = 26; limitation in study design, imprecision) was found for no effect of a passive break on low back discomfort (Henning et al., 1997). Moderate-quality evidence (2 RCTs, n = 60; imprecision) was found for the positive effect of standing breaks while performing computer work for discomfort prevention (Davis and Kotowski, 2014; Thorp et al., 2014).

Evidence of the effectiveness of breaks on work productivity

Six high-quality RCTs (Galinsky et al., 2000; McLean et al., 2001; Galinsky et al., 2007; Davis and Kotowski, 2014; Thorp et al., 2014; Sheahan et al., 2016), three high-quality non-RCTs (Henning et al., 1994; Henning et al., 1996; Balci and Aghazadeh, 2004), and one low-quality RCT (Henning et al., 1997) investigated the effectiveness of break programs on work productivity. Moderate-quality evidence (7 RCTs and 3 non-RCTs, n = 289; imprecision) indicated no effect of break programs on work productivity.

When stratified by break type, moderate-quality evidence (4 RCTs, n = 102; imprecision) indicated no effect of active breaks with postural change on work productivity (Galinsky et al., 2000; McLean et al., 2001; Davis and Kotowski, 2014; Sheahan et al., 2016). Low-quality evidence (1 RCT and 1 non-RCT, n = 61; inconsistency, imprecision) indicated no effect of active breaks without postural change on work productivity (Balci and Aghazadeh, 2004; Galinsky et al., 2007). Low-quality evidence (1 RCT, n = 34; limitation in study design, imprecision) indicated no effect of passive breaks on work productivity (Henning et al., 1997). Moderate-quality evidence (2 RCTs, n = 60; imprecision) indicated no effect of standing breaks while performing computer work on work productivity (Davis and Kotowski, 2014; Thorp et al., 2014).

Table 3.4 Summary of evidence for the effectiveness of breaks on pain, discomfort, and work productivity.

Outcome	n (# of studies)	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Quality of evidence (GRADE)
Pain	208 (2)	No serious	Serious	No serious	Serious	None	++OO low [2,4]
Discomfort	273 (9)	No serious	Serious	No serious	Serious	None	++OO low [2,4]
Work productivity	289 (10)	No serious	No serious	No serious	Serious	None	+++O moderate [4]

[1]Serious limitations of study design (e.g., >25% of participants from studies with low quality methods, risk of bias recommended by the Cochrane Back and Neck Group <7 points); [2]Serious inconsistency (e.g., opposite direction of effects); [3]Serious indirectness (e.g., existence of indirect outcome measurement); [4]Serious imprecision (e.g., fewer than 400 participants were included or only one study included).

Table 3.5 Summary of evidence for the effectiveness of active breaks with/without postural change, passive breaks, and standing breaks while performing computer work on pain, discomfort, and work productivity.

Outcome	n (# of studies)	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Quality of evidence (GRADE)
For active break with postural change							
Pain	8 (1)	No serious	No serious	No serious	Serious	None	+++O moderate [4,§]
Discomfort	94 (3)	No serious	No serious	No serious	Serious	None	+++O moderate [4]
Work productivity	102 (4)	No serious	No serious	No serious	Serious	None	+++O moderate [4]
For active break without postural change							

Pain	200 (1)	No serious	No serious	No serious	Serious	None	+++O moderate [4,§]
Discomfort	61 (2)	No serious	No serious	No serious	Serious	None	+++O moderate [4]
Work productivity	61 (2)	No serious	Serious	No serious	Serious	None	++OO low [2,4]
For passive break							
Discomfort	26 (1)	Serious	No serious	No serious	Serious	None	++OO low [1,4,§]
Work productivity	34 (1)	Serious	No serious	No serious	Serious	None	++OO low [1,4,§]
For standing breaks while performing computer work							
Discomfort	60 (2)	No serious	No serious	No serious	Serious	None	+++O moderate [4]
Work productivity	60 (2)	No serious	No serious	No serious	Serious	None	+++O moderate [4]

[1]Serious limitations of study design (e.g., >25% of participants from studies with low quality methods, risk of bias recommended by Cochrane Back and Neck Group <7 points); [2]Serious inconsistency (e.g., opposite direction of effects); [3]Serious indirectness (e.g.,

existence of indirect outcome measurement); [4]Serious imprecision (e.g., fewer than 400 participants were included or only one study included). [§] Consistency for only one study cannot be evaluated.

Sensitivity analysis

Changing the cut-off point from ≥50 to ≥60% would not have altered our conclusions at all. With a cut-off point of ≥70%, the results indicated that three conclusions would alter. First, the level of evidence for the effectiveness of breaks on discomfort would change from “low” to “very low” and on work productivity would change from “moderate” to “low”. Second, the level of evidence for the effectiveness of active breaks without postural change on discomfort would change from “moderate” to “low” and on work productivity would change from “low” to “very low”. Third, the level of evidence for the effectiveness of standing breaks while performing computer work on discomfort would change from “moderate” to “low” and on work productivity would change from “moderate” to “low”.

3.4 Discussion

The break interventions reported in this review included active breaks with postural change, active breaks without postural change, passive breaks, and standing breaks while performing computer task. This review summarized the results of seven high-quality RCTs, three high-quality non-RCTs, and one low-quality RCT investigating break interventions on low back pain, discomfort, and work productivity in office workers. We found heterogeneity among studies as to specific aspects such as study population, type of break, break protocol, method of outcome assessment, and data presentation. Thus, the analysis of the results was limited to a qualitative summary.

Methodological considerations

Of the eleven included studies, none fulfilled the blinding of participants, therapists who administered the therapy, and assessors, whereas nine of the 11 studies were unclear about the concealment of treatment allocation. Participant blinding ensures that the apparent effect (or lack thereof) of treatment is not due to the placebo or Hawthorne effects. Expectations are an important factor in placebo effects (Price et al., 1999). Participants in the control group would have had no expectations, but the intervention group was prone to expectations. Blinding of all therapists and assessors is also important to guarantee that the apparent effect of treatment is not due to the therapist's/assessor's enthusiasm or lack of enthusiasm for the intervention or control condition (Portney and Watkins, 2009). Participant, therapist, and assessor blinding are important for the internal validity of a study. However, it is very difficult – perhaps impossible – to blind participants or therapists in studies regarding break interventions and to blind assessors in self-reported outcomes (e.g. pain and discomfort).

Concealed treatment allocation is important in preventing systematic and selection bias. Concealed treatment allocation ensures that the sequence in which subjects would be allocated to treatment is not disclosed before random allocation. If treatment allocation is not concealed, the decision of whether or not to include a person in the trial could be influenced by knowledge of whether or not the subject is to receive treatment (Portney and Watkins, 2009). However, the concealment of treatment allocation was mentioned in only two of the 11 included studies. In fact, the concealment of treatment allocation is relatively easy to implement and describe in the published report (Elkins, 2013). Future research should consider the concealment of treatment allocation to reduce bias and ensures that it is stated in the reports.

Study characteristics

There was heterogeneity among the studies in terms of the population studied and break protocols. The majority of the included studies (91%) investigated the effect of breaks in healthy subjects. Although previous studies showed that both healthy and LBP subjects received benefits from breaks by reducing low back pain and discomfort (McLean et al., 2001; Sheahan et al., 2016), back pain among office workers is unlikely to originate from identical causes. Implementing the same intervention for everyone would not be appropriate. Thus, extrapolation of results from one group of subjects to another should be undertaken with caution. Further research should attempt to investigate the effectiveness of breaks by selecting a more specific group of subjects who would theoretically benefit from breaks for the study.

Different break protocols in terms of break type, work duration, and break duration were employed among the included studies. Thus, the current state of the literature limits comparability between trials. The type of break found to be effective in reducing both low back pain and discomfort was that of active breaks with postural change by reducing LBP symptoms, musculoskeletal discomfort, back muscle fatigue, and mental fatigue in prolonged sitting tasks (McLean et al., 2001; Davis and Kotowski, 2014; Sheahan et al., 2016). Active breaks have been found to lead to a more variable muscle activity pattern and increase muscle oxygenation during computer work than passive breaks (Crenshaw et al., 2006; Samani et al., 2009).

The work and break durations varied considerably, ranging from 5 minutes to 2 hours or their own discretion for work duration and from 20 seconds to 30 minutes or their own discretion for break duration. Optimal break scheduling is the proper combination of the task demands (e.g. work duration) and break duration (Kopardekar and Mital, 1994). Previous studies showed that frequent (i.e. at least once every hour) and short (i.e. less than 10 minutes) breaks lead to significant improvements in the musculoskeletal disorders in office workers (Kopardekar and Mital, 1994; Balci and Aghazadeh, 2003). Taking a break every 2 hours seems to be insufficient for adequate musculoskeletal recovery (Lanhers et al., 2016). Therefore, future studies should take into account work and break durations when setting the break protocols in the study of the effectiveness of breaks.

Evidence of the effectiveness of breaks for pain, discomfort and work productivity

All included studies investigated the effectiveness of breaks on pain, discomfort, or work productivity. Considering the effect of breaks on pain and discomfort in the low back, the current review showed that breaks seem to be effective in discomfort prevention. Conflicting evidence was found for the effect of breaks on low back pain reduction. However, when stratified by type of break, active breaks with postural change was found to be effective in reducing low back pain and discomfort. Active breaks without postural change or standing breaks while performing computer work were found to be effective in prevention of low back discomfort. Passive breaks were found to be ineffective in reducing both low back pain and discomfort. The findings are consistent with previous research showing that active breaks are better than passive breaks (Asmussen and Mazin, 1978).

Active breaks with postural change require participants to change their posture during breaks, leading 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). Deconditioning from prolonged and awkward positions, sustained postures, and repetitive movements may lead to a reduction in the length of soft tissues, which consequently limits the ranges of available motion in joints. Limited joint motion will distort normal body biomechanics. Such distortions can contribute to the risk of injury (Main et al., 2008). Thus, active breaks with postural change may hypothetically be an effective intervention in the prevention and treatment of LBP.

Breaks – either active/passive breaks or standing breaks while performing computer task – appear to have no adverse effect on work productivity. A previous study showed that breaks did not affect performance on skill-based tasks (i.e. typing and arithmetic) (Lee and Duffy, 2015). Breaks have been found to promote concentration, alertness, motivation, and activity at work (Thorp et al., 2014). Feeling relaxed and refreshed after a break has been found to have a positive effect on work productivity (Epstein et al., 2016).

Sensitivity analysis

The methodological quality of included studies ranged between 6 and 9. In this review, a priori cut-off point of >50% was used, which might have influenced the level of evidence and potentially the results of the review. Since all high-quality studies had total scores of greater than 60%, changing the cut-off point from >50 to >60% would not have altered our conclusions at all. However, shifting the cut-off point from >50 to >70% would have only five study qualifying as a high-quality study. Several conclusions about the effectiveness of breaks, active breaks without postural change, and standing breaks while performing computer work on discomfort and work productivity would alter.

This variation in the level of evidence reflects the fact that there have been a small number of very good quality studies investigating the effectiveness of breaks on discomfort and work productivity in office workers. Thus, further study is required before firm conclusions can be drawn.

Strengths and limitations of the study

The major strength of this review is that the studies were systematically searched, evaluated for their methodological quality by two independent reviewers, extracted and synthesized based on the number of studies and the quality score of the studies. However, there are three main methodological limitations of note. First, the search strategy was limited only to full published reports in English. There is the possibility that language bias may have affected the results of the review. Second, almost two third of the included studies were conducted in laboratory settings and follow-up periods were relatively short, ranging from 48 minutes to 4 months. Therefore, generalization of the results from this review to real working situations or to the long-term effects of breaks should be made with caution. Third, the researchers summarized the results from studies with substantial heterogeneity in study characteristics. This may explain the observed variation in the results among the studies. Future research is required to indicate whether differences in these aspects affect the effectiveness of breaks on pain, discomfort, and work productivity.

3.5 Conclusions

Eight RCTs and three non-RCTs investigating the effectiveness of break programs for pain, discomfort, and work productivity in office workers were reviewed and analyzed. The findings revealed that low quality evidence supported the effectiveness of breaks on discomfort prevention. Moderate quality evidence was found to support there being no adverse effect of break on work productivity. The type of rest breaks that may be effective in reducing low back pain and discomfort while maintaining work productivity was identified, namely active breaks with postural change. Literature with respect to the effect of break programs on pain, discomfort, and work productivity in office workers was heterogeneous. The design of future studies may be improved by conducting studies in real working situations with long-term follow-up periods and being more specific regarding study population, break type, and break protocol.

Authors' contributions

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

Competing interests

None.

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Summary

This review showed rest breaks were effective intervention in reducing low back discomfort and pain, while no adverse effect on work productivity. When stratified by type of breaks, only active breaks with postural change were found to be effective in reducing low back pain and discomfort. Perceived discomfort was found to be a predictor of musculoskeletal disorders. Therefore, active breaks with postural change may be an effective intervention to prevent the incidence of neck and low back pain among office workers. The study aimed to evaluate the effect of active breaks with postural change on preventing neck and low back pain in office workers are conducted (CHAPTER 5).

CHAPTER 4

Perceived musculoskeletal discomfort and its association with postural shifts during 4-h prolonged sitting in office workers.

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Abstract

This study examined the characteristics of perceived discomfort and postural shifts at different magnitudes during a 4-hour sitting period and the association between perceived discomfort and number of postural shifts.

Forty healthy participants continuously typed a standardized text passage at a computer work station for 4 hours. Subjects rated perceived body discomfort using Borg's CR-10 scale in 10 body regions (i.e. neck, shoulder, elbow, wrist/hand, upper back, lower back, buttock, thigh, knee, and ankle/foot). A seat pressure mat device was used to gather seat pressure data during sitting. Postural shifts were determined by analysis of the dispersion index of both ischial tuberosities from seat pressure data. The threshold for a postural shift was set at ±10% and ±20%.

Perceived discomfort in all body regions increased continuously during a 4-hour sitting period. The body regions with the highest perceived discomfort were the low back, buttocks, upper back, thigh, and neck. The average (±SD) numbers of postural shifts during the 1st, 2nd, 3rd, and 4th hour of sitting were 14.8±9.5, 17.8±9.4, 18.2±11.1, and 18.1±9.8 shifts per hour for the 10% threshold, and were 4.8±4.4, 6.0±5.6, 7.4±6.7, and 7.7±6.6 shifts per hour for the 20% threshold, respectively.

Prolonged sitting led to an increase in perceived musculoskeletal discomfort over time. The number of postural shifts at both magnitudes increased in the first 2

hours of sitting and, in the second 2-hour period of sitting, only the number of larger postural shifts (with 20% threshold) increased. The findings extend our understanding of sitting behaviors.

Key words: Musculoskeletal disorders; Low back pain; Computers; Office workers.

4.1 Introduction

Musculoskeletal disorders constitute an important health problem in office workers (Ortiz-Hernandez et al., 2003; Sillanpaa et al., 2003; Eltayeb et al., 2007; Janwantanakul et al., 2008). The annual prevalence of musculoskeletal disorders in office workers has been found to be 63% and the most common sites for musculoskeletal disorders are neck (42%) and low back (34%) (Janwantanakul et al., 2008). Neck and low back pain contribute significantly to sickness absenteeism, work disability, and compensation claims (Klussmann et al., 2008; Hoy et al., 2012). Consequently, musculoskeletal pain constitutes a great socio-economic burden on patients and society (Cote et al., 2009).

Office workers are often required to sit for long hours in front of a computer. Sitting for more than half a workday, in combination with poor working postures, has been found to increase the risk of experiencing low back pain (Lis et al., 2007). Furthermore, sitting at work (more than 95% of the working time) has been found to be a risk factor of neck pain in office workers (Ariens et al., 2001). Prolonged sitting in a constrained or fixed posture has been found to be associated with the development of perceived discomfort in the neck, upper extremity, and low back (Nakphet et al., 2014; Waongenngarm et al., 2015). Previous research has shown perceived musculoskeletal discomfort to be a predictor of musculoskeletal disorders (Hamberg-van Reenen et al., 2008). Research on discomfort in relation to prolonged sitting may reveal important aspects of the potential transition from discomfort to pain.

Postural shifts during sitting are regarded as a natural coping response to diminish the perception of discomfort and to relieve the perceived pressure of compressed body parts (van Deursen et al., 1999; Vergara and Page, 2002). Postural shifts have been proposed to minimize discomfort during prolonged sitting through alternating activity in the trunk muscles (van Dieen et al., 2001; O'Sullivan et al., 2012), reducing spinal loads (Callaghan and McGill, 2001), and promoting the flow of fluids and nutrients (Reenalda et al., 2009). Previous research assessed sitting postural movement in terms of sitting regularity or variability by using the variations in center of pressure (Sondergaard et al., 2010; Roerdink et al., 2011), and sitting postural shifts by using a dispersion index, which defines as a relative measure of the load on the sitting surface (Reenalda et al., 2009). There are two parameters of postural shifts, which are amplitude/magnitude and number/frequency of movements (Vergara and Page, 2002). Each postural shift at 10% threshold has been found to increase subcutaneous oxygen saturation on average 2.2%, which indicates a positive effect of posture shifts on tissue viability (Reenalda et al., 2009). Number of postural shifts during sitting in healthy participants range from 8 to 19 times/hour (Reenalda et al., 2009; Akkarakittichoke and Janwantanakul, 2017; Sammonds et al., 2017).

A strong positive association between perceived discomfort and number of postural shifts during computer work was previously reported during a 1-hour period of sitting (Liao and Drury, 2000; Akkarakittichoke and Janwantanakul, 2017). When a person first sits down, he/she feels little discomfort and moves little. However, increasing perceived discomfort has been shown to be associated with an increase in the number of postural shifts (Jensen and Bendix, 1992). A similar association between perceived discomfort and number of postural shifts has been found during 2 hours of sitting (Sammonds et al., 2017). On average, office workers sit about 77% of an 8-hour workday (Thorp et al., 2012) and a number of them sit continuously for a long duration (Blatter and Bongers, 2002). In recent years, office workers have various tasks and do not sit continuously for 4 hours, but almost 70% of office workers who are typists, secretaries, or bookkeepers had worked with a computer more than 4 hours/day and may sit continuously for more than 2 hours (Blatter and Bongers, 2002). However, previous research usually recorded discomfort and postural shifts for only 1-2 hours of sitting (Sondergaard et al., 2010; Akkarakittichoke and Janwantanakul, 2017). Therefore, the things that happen after 2 hours of sitting remain unknown.

To date, neither the characteristics of perceived discomfort in all body regions while seated continuously for a long duration, i.e. > 2 hours, nor the associations between perceived discomfort and postural shifts during such period of time have been investigated. Thus, this study aimed to identify the characteristics of perceived discomfort and different magnitudes of postural shifts during a 4-hour sitting period and to examine the association between perceived discomfort and number of postural shifts at different magnitudes. We hypothesized that perceived musculoskeletal discomfort would increase over time and perceived discomfort would positively correlate to the number of postural shifts.

4.2 Materials and Methods

Participants

Forty full-time office workers were conveniently recruited. They generally worked with a computer, participated in meetings, read documents, and contacted people by telephone. Individuals were included if they were 20–45 years of age, had at least 5 years of experience, had a body mass index (BMI) between 18.5-25 kg/m^2 (Gray et al., 2015), and were able to use a computer with any style of typing (e.g. touch typing, hunt and peck, or hybrid). Exclusion criteria were neck and low back pain in the previous week (Tsauo et al., 2007; Hush et al., 2009), chronic neck and low back pain (Deyo et al., 2014), sign of neurological deficit (i.e., muscle weakness or loss/disturbance of sensation), current or past history of known spinal disorders, rheumatoid arthritis, gout, osteoarthritis, kidney diseases, abnormal spinal structure, hemorrhoids, or pregnancy, open wound or contusion at the buttocks and posterior thigh region. All subjects were provided information about the study and signed an informed consent form prior to their participation. The study was approved by the University Human Ethics Committee.

Equipment

The Borg CR-10 scale was used to determine the rating of perceived discomfort during prolonged sitting (Borg, 1990). The body regions (i.e., the neck, shoulder, elbow, wrist, upper back, low back, buttocks, hip/thigh, knee, and ankle) were defined according to a body chart from a modified Nordic questionnaire (Tirtayasa et al., 2003). Participants indicated which parts of their body experienced discomfort and how much discomfort was felt (on a scale of 0–10; 0 denotes no discomfort and 10 denotes extreme discomfort). The main advantage of Borg CR-10 scale is the categorical verbal descriptors of each numeric point, which makes this scale satisfy the ratio scale criterion. Ratio scale data allow the usage of the parametric methods, which is considered an advantage since the non-parametric methods may increase the risk of type-II errors (Ho et al., 1996).

A seat pressure mat device was used to gather seat pressure data (ConforMat; Tekscan Inc., Boston, MA, USA) with a specifically designed program (ConforMat Research, version 7.10c; Tekscan Inc.) and sample rate of 1 Hz (Dunk and Callaghan, 2005). This seat pressure mat device consists of 1,024 (32 x 32) square (15 x 15 mm2) pressure sensors, which were calibrated with an upper limit threshold of 32.5 kPa (250 mmHg) and a lower limit threshold of 0.7 kPa (5 mmHg). Prior to data collection, the device was calibrated according to the manufacturer’s guidelines using the linear calibration method and selecting the auto-adjusting sensitivity.

Experimental procedure

At the start, a researcher asked participants to complete the Borg CR-10 scale (i.e. baseline perceived discomfort). Participants were then asked to sit on an adjustable office chair with backrest and armrest (Model E61B, Modernform Group Pub Co. Ltd., Bangkok, Thailand). The seat pan of office chair was made of polypropylene foam (width x length x height = 45 cm x 50 cm x 11.5 cm) with a density of 40.4 kg/m^3. The seat pressure mat was placed over the seat pan and fixed to the adjustable office chair with Velcro® tape, which was tested before data collection to sufficiently prevent the mat from sliding. The initial sitting position was characterized by hips and knees at 90 degrees of flexion and neutral ankle position with feet in full contact with the floor by adjusting the office chair height. The distance between the monitor and the participant was about 45-76 cm and the center of the screen was approximately at eye level. The researcher asked participants to type a standardized text passage at their own normal pace and access the internet to do their work for 4 hours. They were able to change their sitting postures freely with constraints imposed on leg crossing or lifting the buttocks. Participants were allowed to go to the toilet if required. Before data collection, we gave information about the Borg CR-10 scale and body areas on the table and instructed to the participants. The subjects were asked to verbally rate their perceived discomfort level in each body region every 10 minutes until completion of the 4-hour sitting period, which did not affect their sitting posture or postural shifts from seat pressure data. Testing was conducted during 8am to 12am and 1pm to 5pm. Room temperature was maintained at 25 ^{o}C throughout the experiment. Before testing, participants were given a practice run to ensure that they clearly understood the experiment procedure and familiarized themselves with the experimental setup.

Data analysis

The variables in this study were perceived musculoskeletal discomfort scores every 10 minutes (25-time points: at 0 min (baseline), 10 min, 20 min, ..., 230 min, and 240 min) and number of postural shifts every 60 minutes (4-time periods: 0-60 min, 61-120 min, 121-180 min, and 181-240 min). The overall perceived musculoskeletal discomfort score was calculated from the sum of perceived discomfort scores in all body regions divided by the total number of body regions. Postural shifts were determined by analysis of the dispersion index (DI) data of both ischial tuberosities (Reenalda et al., 2009). The DI is defined as a relative measure of the load on the sitting surface, it refers to the load on one tuberal zone divided by the total load on the sitting surface. Raw data from the seat pressure mat device were exported in ASCII (American Standard Code for Information Interchange) format and were determined through the DI. A MATLAB script, version R2018b (The MathWorks Inc., Natick, Massachusetts, USA) was used to define pressure peaks in a region that was expected to surround the ischial tuberosities; this region was defined by a zone of 6 x 6 pressure sensors (9 x 9 cm) to calculate the DI. To calculate posture shifts, the sum of the mean DI values of both ischial tuberosities and the ratio of the mean DI values of both ischial tuberosities were calculated to identify posture shifts in the sagittal and frontal planes, respectively. The threshold for a postural shift in both sagittal and frontal movements was set at ±10% and ±20% to determine the number of postural shifts at two different magnitudes. Posture shifts that occurred within 1 minute were regarded as one postural shift (Reenalda et al., 2009).

Statistical analysis

Participants' characteristics, perceived musculoskeletal discomfort score, and number of postural shifts were described by means or proportions. The Shapiro-Wilk test was performed to check the distribution of data; the results indicated normal distribution. A repeated measures analysis of variance (ANOVA) was used to determine the effect of sitting time on perceived discomfort scores and number of postural shifts in the sum of sagittal and frontal plane, and in each plane at different magnitudes during a 4-hour sitting period. If a significant difference was found in the ANOVA, a Bonferroni correction procedure was applied to determine where statistical significance occurred. The Pearson product-moment correlation coefficient test was employed to assess the association between perceived discomfort scores and the number of postural shifts at 10% and 20% threshold. The correlation coefficients were interpreted as follows: above 0.75 was good to excellent, 0.50-0.75 was moderate to good, 0.25-0.50 was fair, and below 0.25 was no association (Portney and Watkins, 2009). All statistical analyses were conducted using SPSS statistical software, version 23.0 (SPSS Inc, Chicago, IL, USA). The corrected p-value in this study was set at 0.05 by a mathematically equivalent adjustment from SPSS software.

4.3 Results

A total of 40 workers participated in the study. Table 4.1 shows the characteristics of the participants. The sample population comprised mainly middle-aged females. Their average BMI was in the normal range for Asians. The majority of participants (95%) were right-handed. During the 4-hour sitting period, 5 of the 40 participants went to the toilet once.

To investigate the effect of rest break by going to the toilet, we compared the results from 40 participants to 35 participants (i.e. an exclusion of 5 participants who went to the toilet once). No alteration of the findings was found between the two sets of data. Thus, the results from 40 participants (i.e. an inclusion of 5 participants who went to the toilet once) are given below.

Table 4.1 Characteristics of participating office workers (n=40)

Characteristics	N (%)	Mean (SD)
Age (years)		29 (3.9)
Gender		
Male	11 (27.5)	
Female	29 (72.5)	
Weight (kg)		57 (7.5)
Height (cm)		164 (7.9)
Body mass index (kg/m^2)		21.1 (1.7)
Hand dominance		
Right side	38 (95)	
Left side	2 (5)	

Body perceived discomfort

Table 4.2 shows the body perceived discomfort in all body regions during a 4-hour period of sitting. Body perceived discomfort increased over time (Figure 4.1). A repeated measures ANOVA indicated significant effects of sitting time on perceived discomfort scores at the neck ($F_{24,936}$ = 16.448, p<0.001, partial η^2=0.297), shoulder ($F_{24,936}$ = 11.546, p<0.001, partial η^2=0.228), upper back ($F_{24,936}$ = 30.460, corrected p<0.001, partial η^2=0.439), low back ($F_{24,936}$ = 46.571, p<0.001, partial η^2=0.557), buttocks ($F_{24,936}$ = 38.447, p<0.001, partial η^2=0.496), thigh ($F_{24,936}$ = 34.783, p<0.001, partial η^2=0.441), and overall discomfort ($F_{24,936}$ = 31.031, p<0.001, partial η^2=0.443). Thus, further analyses were performed. The *post hoc* Bonferroni test showed that, for the neck, discomfort scores after 80 minutes of sitting were significantly greater than those at baseline (corrected p<0.05). For the shoulders, upper back, lower back, buttocks, and thighs, discomfort scores were significantly greater than those at baseline after 100, 70, 30, 30, and 90 minutes, respectively (corrected p<0.05). Overall, discomfort scores after 30 minutes of sitting were significantly greater than those at baseline (corrected p<0.05). There was no statistically significant effect of sitting time on discomfort scores in the elbow, wrist/hand, knee, and ankle/foot (corrected p>0.05).

Table 4.2 Body perceived discomfort in all body regions during a 4-hour period of sitting

Area	Mean ± SD of discomfort score at each time point (minutes)																								
	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
Neck	0.28 ± 0.62	0.33 ± 0.63	0.50 ± 0.76	0.73 ± 0.87	0.69 ± 0.77	1.00 ± 1.32	0.96 ± 1.15	1.05 ± 1.32	1.20 ± 1.26*	1.16 ± 1.15*	1.38 ± 1.21*	1.33 ± 1.13*	1.38 ± 1.22*	1.39 ± 1.23*	1.41 ± 1.28*	1.45 ± 1.31*	1.46 ± 1.36*	1.53 ± 1.47*	1.65 ± 1.52*	1.74 ± 1.59*	1.84 ± 1.63*	1.93 ± 1.73*	2.00 ± 1.82*	2.04 ± 1.89*	2.15 ± 2.06*
Shoulder	0.09 ± 0.40	0.19 ± 0.48	0.33 ± 0.58	0.34 ± 0.59	0.43 ± 0.72	0.49 ± 0.78	0.52 ± 0.83	0.56 ± 0.87	0.59 ± 0.90	0.60 ± 0.97	0.69 ± 0.87*	0.87 ± 0.99*	0.80 ± 0.99*	0.91 ± 1.02*	0.82 ± 1.00*	0.78 ± 1.03*	0.89 ± 1.10*	1.03 ± 1.04*	0.97 ± 1.32*	1.08 ± 1.23*	1.13 ± 1.37*	1.19 ± 1.33*	1.18 ± 1.36*	1.29 ± 1.46*	1.29 ± 1.45*
Elbow	0.01 ± 0.08	0.08 ± 0.21	0.13 ± 0.39	0.17 ± 0.53	0.20 ± 0.56	0.18 ± 0.44	0.24 ± 0.57	0.32 ± 0.71	0.33 ± 0.69	0.31 ± 0.57	0.32 ± 0.67	0.46 ± 0.79	0.40 ± 0.70	0.43 ± 0.80	0.43 ± 0.70	0.40 ± 0.70	0.48 ± 0.74	0.50 ± 0.80	0.50 ± 0.78	0.49 ± 0.84	0.48 ± 0.75	0.51 ± 0.79	0.54 ± 0.81	0.59 ± 0.89	0.59 ± 0.90
Wrist/ hand	0.08 ± 0.35	0.10 ± 0.38	0.18 ± 0.48	0.17 ± 0.42	0.23 ± 0.43	0.23 ± 0.48	0.26 ± 0.55	0.32 ± 0.62	0.35 ± 0.66	0.38 ± 0.68	0.38 ± 0.69	0.40 ± 0.68	0.44 ± 0.72	0.50 ± 0.74	0.54 ± 0.81	0.59 ± 0.89	0.59 ± 0.89	0.60 ± 1.03	0.67 ± 1.01	0.77 ± 1.23	0.68 ± 1.14	0.72 ± 1.09	0.68 ± 1.09	0.83 ± 1.24	0.82 ± 1.24
Upper back	0.15 ± 0.40	0.30 ± 0.73	0.40 ± 0.96	0.56 ± 1.01	0.56 ± 0.92	0.73 ± 1.24	0.76 ± 1.04	0.91 ± 1.15*	1.03 ± 1.30*	1.25 ± 1.52*	1.43 ± 1.43*	1.58 ± 1.53*	1.59 ± 1.39*	1.68 ± 1.42*	1.79 ± 1.44*	1.86 ± 1.55*	1.78 ± 1.45*	2.00 ± 1.54*	2.19 ± 1.68*	2.21 ± 1.77*	2.39 ± 1.86*	2.41 ± 1.84*	2.25 ± 1.74*	2.50 ± 1.84*	2.65 ± 1.99*
Lower back	0.18 ± 0.53	0.33 ± 0.61	0.53 ± 0.76	0.67 ± 0.84*	0.91 ± 1.02*	0.95 ± 1.03*	0.97 ± 0.97*	1.11 ± 1.09*	1.26 ± 1.08*	1.47 ± 1.21*	1.68 ± 1.37*	1.83 ± 1.25*	1.95 ± 1.31*	1.99 ± 1.39*	2.29 ± 1.57*	2.32 ± 1.66*	2.49 ± 1.68*	2.64 ± 1.93*	2.76 ± 1.87*	2.84 ± 1.89*	2.99 ± 1.93*	3.08 ± 2.01*	3.26 ± 1.87*	3.41 ± 1.96*	3.62 ± 2.10*
Buttocks	0.09 ± 0.36	0.21 ± 0.55	0.33 ± 0.67	0.58 ± 0.85*	0.80 ± 1.02*	0.91 ± 1.00*	0.94 ± 0.98*	0.95 ± 0.97*	1.10 ± 1.01*	1.34 ± 1.16*	1.46 ± 1.25*	1.59 ± 1.40*	1.65 ± 1.46*	1.73 ± 1.57*	1.93 ± 1.62*	2.10 ± 1.75*	2.15 ± 1.86*	2.39 ± 2.00*	2.45 ± 2.02*	2.58 ± 2.02*	2.71 ± 2.07*	2.86 ± 2.17*	2.94 ± 2.25*	3.11 ± 2.37*	3.30 ± 2.49*
Thigh	0.13 ± 0.42	0.10 ± 0.34	0.20 ± 0.40	0.32 ± 0.64	0.43 ± 0.73	0.49 ± 0.79	0.61 ± 0.75	0.63 ± 0.84	0.62 ± 0.79	0.79 ± 0.99*	0.93 ± 1.16*	0.96 ± 1.13*	0.94 ± 1.14*	1.01 ± 1.19*	1.08 ± 1.24*	1.16 ± 1.24*	1.29 ± 1.37*	1.37 ± 1.36*	1.48 ± 1.39*	1.61 ± 1.60*	1.65 ± 1.61*	2.01 ± 1.80*	2.14 ± 1.74*	2.24 ± 1.79*	2.31 ± 1.86*
Knee	0.06 ± 0.25	0.04 ± 0.18	0.05 ± 0.19	0.09 ± 0.34	0.15 ± 0.38	0.19 ± 0.45	0.24 ± 0.59	0.30 ± 0.66	0.36 ± 0.80	0.36 ± 0.81	0.37 ± 0.81	0.51 ± 0.90	0.48 ± 0.79	0.56 ± 0.86	0.51 ± 0.79	0.54 ± 0.81	0.54 ± 0.93	0.74 ± 1.19	0.79 ± 1.30	0.88 ± 1.39	0.90 ± 1.40	1.01 ± 1.60	1.12 ± 1.64	1.13 ± 1.67	1.23 ± 1.83
Ankle/ foot	0.02 ± 0.09	0.11 ± 0.63	0.13 ± 0.64	0.11 ± 0.49	0.19 ± 0.66	0.20 ± 0.67	0.31 ± 0.79	0.33 ± 0.95	0.33 ± 0.74	0.39 ± 0.95	0.44 ± 0.90	0.44 ± 0.88	0.44 ± 0.79	0.49 ± 0.95	0.49 ± 0.88	0.51 ± 0.90	0.54 ± 1.08	0.59 ± 1.13	0.58 ± 1.05	0.64 ± 1.26	0.68 ± 1.28	0.76 ± 1.48	0.84 ± 1.59	0.82 ± 1.46	0.90 ± 1.60
Overall	0.09 ± 0.18	0.15 ± 0.31	0.23 ± 0.39	0.30 ± 0.43*	0.38 ± 0.46*	0.44 ± 0.52*	0.49 ± 0.58*	0.55 ± 0.64*	0.60 ± 0.66*	0.67 ± 0.74*	0.75 ± 0.76*	0.84 ± 0.80*	0.83 ± 0.77*	0.89 ± 0.84*	0.93 ± 0.84*	0.97 ± 0.88*	1.02 ± 0.93*	1.13 ± 0.97*	1.17 ± 1.05*	1.26 ± 1.13*	1.30 ± 1.15*	1.40 ± 1.22*	1.45 ± 1.20*	1.53 ± 1.24*	1.61 ± 1.33*

* corrected $p<0.05$, when compared to discomfort score at 0 minute of sitting

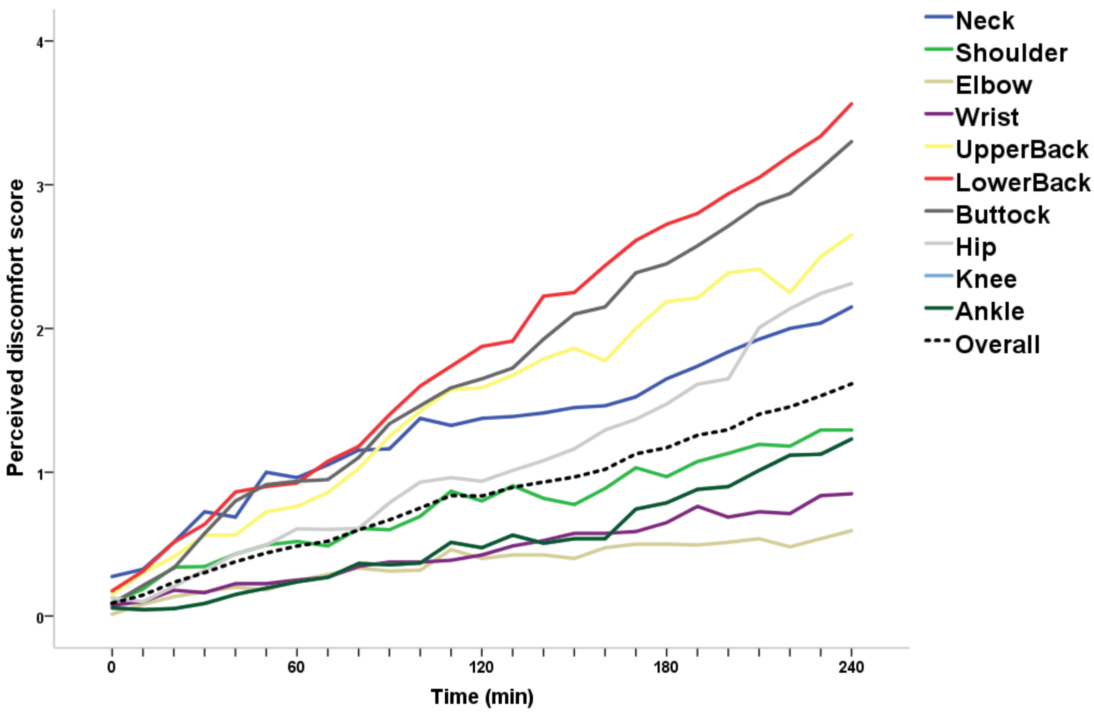


Figure 4.1 Mean perceived discomfort scores at the neck, shoulders, elbow, wrist/hand, upper back, lower back, buttocks, thighs, knees, ankles/feet, and overall over the 4-hour sitting period.

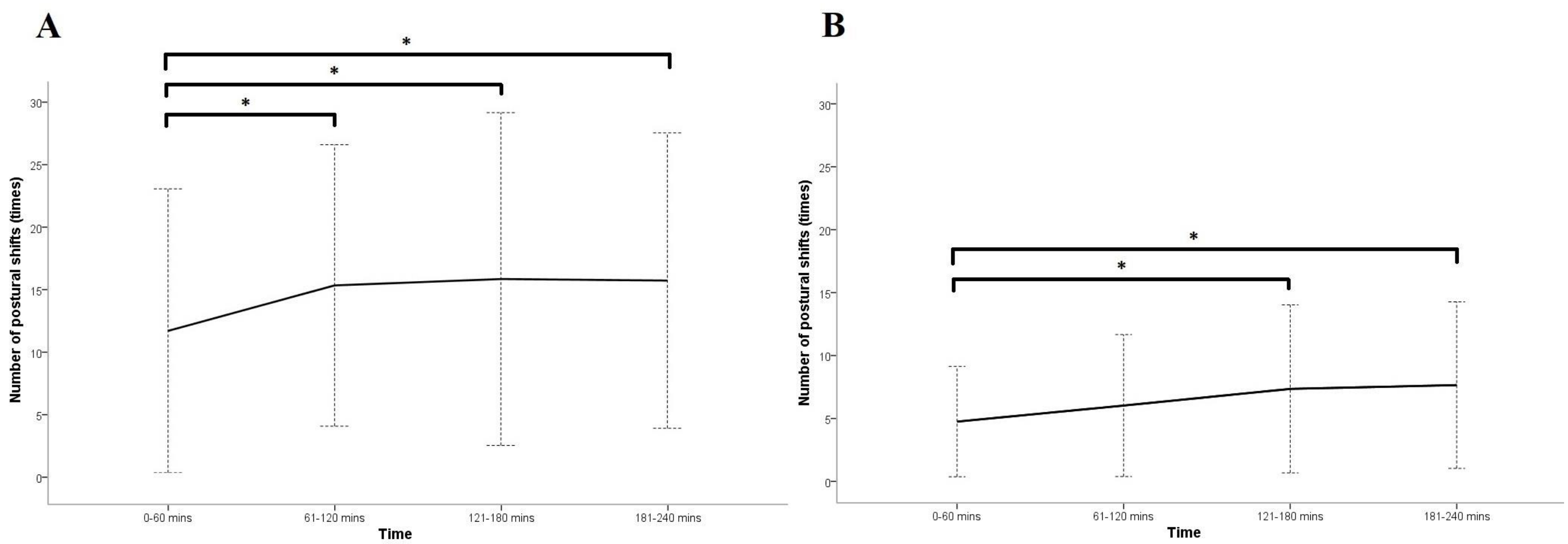
Number of postural shifts

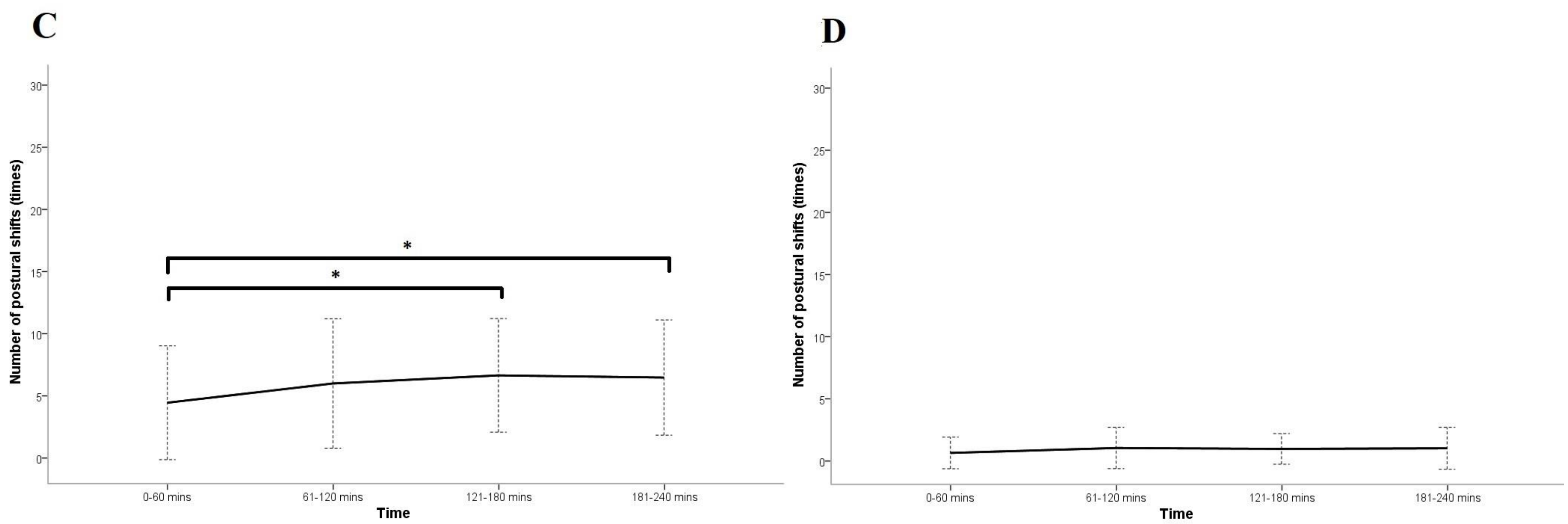
The average (±SD) numbers of postural shifts during the 1st, 2nd, 3rd, and 4th hour of sitting were 14.8±9.5, 17.8±9.4, 18.2±11.1, and 18.1±9.8 shifts per hour for the 10% threshold and were 4.8±4.4, 6.0±5.6, 7.4±6.7, and 7.7±6.6 shifts per hour for the 20% threshold, respectively (Figure 4.2(A) and 4.2(B)). A repeated measures ANOVA indicated a significant effect for sitting time on the number of postural shifts at the 10% and 20% threshold during the 4-hour sitting period ($F_{3,117}$ = 5.051, p=0.003, partial η^2=0.115 for the 10% threshold and $F_{3,117}$ = 6.940, p<0.001, partial η^2=0.151 for the 20% threshold). For the 10% threshold, the *post hoc* Bonferroni test showed that the number of postural shifts during the 2nd, 3rd, and 4th hour of sitting were significantly greater than the number of postural shifts during the 1st hour of sitting (corrected $p<0.05$). The *post hoc* Bonferroni test revealed that the number of postural shifts at the 20% threshold during the 3rd and 4th hour of sitting were significantly greater than the number of postural shifts during the 1st hour of sitting (corrected $p<0.05$).

For the sagittal plane, the mean (±SD) numbers of postural shifts during the 1st, 2nd, 3rd, and 4th hour of sitting were 4.5±4.6, 6.0±5.2, 6.7±4.6, and 6.5±4.6 shifts per hour for the 10% threshold and were 0.7±1.3, 1.1±1.7, 1.0±1.2, and 1.0±1.7 shifts per hour for the 20% threshold, respectively (Figure 4.2(C) and 4.2(D)). A repeated measures ANOVA indicated a significant effect for sitting time on the number of postural shifts in sagittal plane at the 10% threshold during the 4-hour sitting period ($F_{3,117} = 5.221$, $p=0.002$, partial $\eta^2=0.118$). The *post hoc* Bonferroni test showed that the number of postural shifts in the sagittal plane at the 10% threshold during the 3rd and 4th hour of sitting were significantly greater than the number of postural shifts during the 1st hour of sitting (corrected $p<0.05$). There was no statistically significant effect of sitting time on the number of postural shifts in the sagittal plane at the 20% threshold (corrected $p>0.05$).

For the frontal plane, the mean (±SD) numbers of postural shifts during the 1st, 2nd, 3rd, and 4th hour of sitting were 13.1±9.6, 15.5±9.4, 15.9±11.1, and 16.1±9.9 shifts per hour for the 10% threshold and were 4.7±4.4, 5.4±5.6, 6.1±6.6, and 7.1±6.6

shifts per hour for the 20% threshold, respectively (Figure 4.2(E) and 4.2(F)). Repeated measures ANOVA showed a significant effect for sitting time on number of postural shifts in the frontal plane at the 20% threshold during the 4-hour sitting period ($F_{3,117} = 3.329$, p=0.022, partial η^2=0.079). The *post hoc* Bonferroni test revealed that the number of postural shifts in the frontal plane at the 20% threshold during the 4th hour of sitting were significantly greater than the number of postural shifts during the 1st hour of sitting (corrected p=0.02). There was no statistically significant effect of sitting time on the number of postural shifts in frontal plane at the 10% threshold (corrected p>0.05).


A
B
Number of postural shifts (times)
0
5
10
15
20
25
30
0-60 mins
61-120 mins
121-180 mins
181-240 mins
Time
*


C
D
Number of postural shifts (times)
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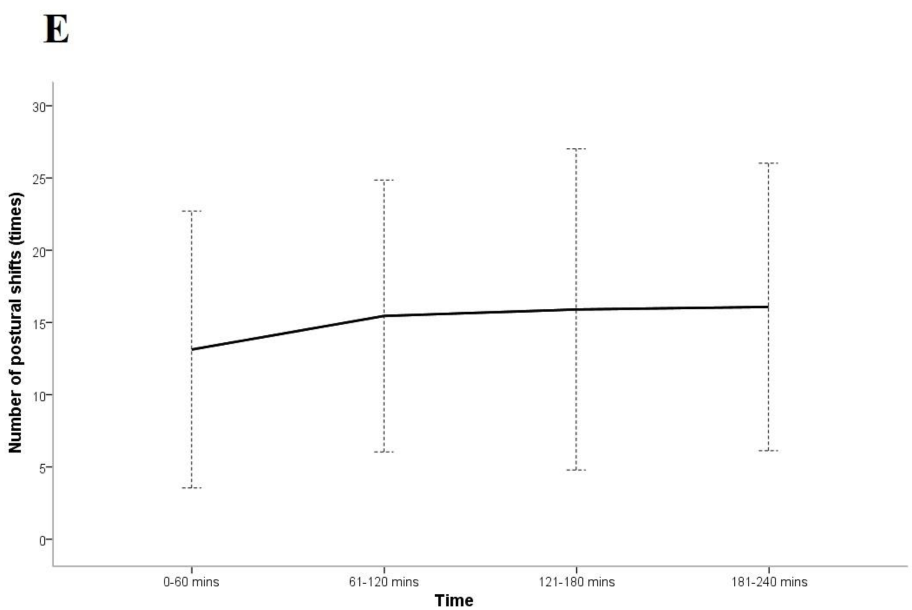
5
10
15
20
25
30
*
*
0-60 mins
61-120 mins
121-180 mins
181-240 mins
Time



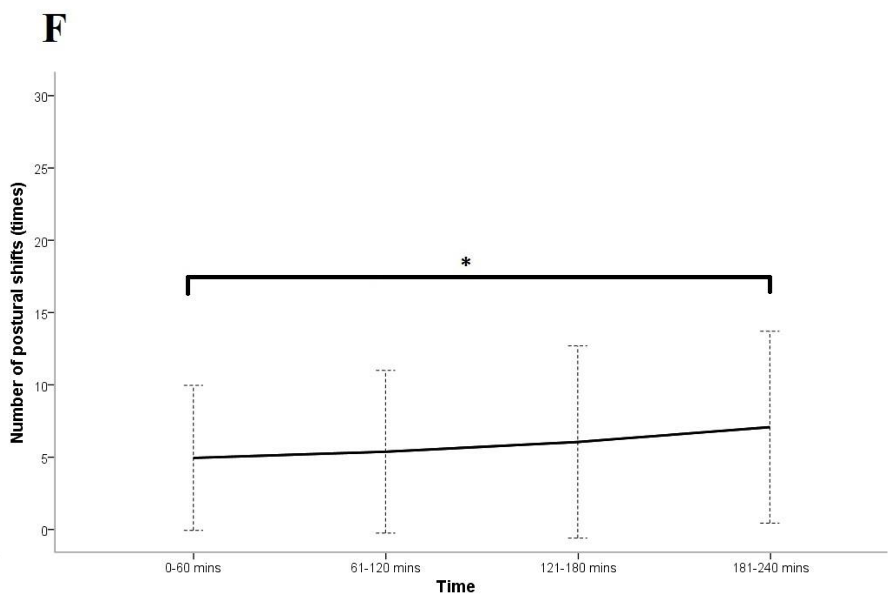


Figure 4.2 Mean and SD of the number of postural shifts during the 4-hour sitting period.

(A) sum postural shifts at the 10% threshold; (B) sum postural shifts at the 20% threshold; (C) postural shifts in sagittal plane at the 10% threshold. (D) postural shifts in sagittal plane at the 20% threshold; (E) postural shifts in frontal plane at the 10% threshold; (F) postural shifts in frontal plane at the 20% threshold.

(* corrected p<0.05)

Associations between body perceived discomfort and number of postural shifts

Significant correlations were found between perceived discomfort at each body region and number of postural shifts at the 10% threshold during the first two hours of sitting ($r=0.65-0.80$; $p<0.01$) (Table 3). However, no significant correlation between perceived discomfort score at each body region and number of postural shifts at 10% threshold was detected during the last two hours of sitting ($r=-0.18-0.03$; $p>0.05$). For the 20% threshold of postural shift, significant correlations were found between perceived discomfort score at each body region and number of postural shifts during all four hours of sitting ($r=0.80-0.88$; $p<0.01$) (Table 4.3).

Table 4.3 Pearson correlation coefficients between perceived discomfort score at each body region and number of postural shifts at different magnitudes (i.e. 10% and 20% threshold) during 0-120 and 120-240 minutes of sitting (n=40).

Area of discomfort	**Correlation (*r*) between Perceived discomfort score and Number of postural shifts at the 10% threshold**	**p-value**	**Correlation (*r*) between Perceived discomfort score and Number of postural shifts at the 20% threshold**	**p-value**
During 0-120 minutes of sitting				
Neck	0.79	0.002**	0.76	0.003**
Shoulder	0.77	0.002**	0.81	0.001**
Elbow	0.76	0.002**	0.78	0.002**
Wrist/hand	0.78	0.001**	0.79	0.001**
Upper back	0.77	0.005**	0.72	0.006**
Lower back	0.78	0.003**	0.77	0.002**
Buttocks	0.76	0.003**	0.76	0.002**
Thigh	0.71	0.003**	0.73	0.005**

Knee	0.65	0.007**	0.67	0.011**
Ankle/foot	0.65	0.016*	0.80	0.001**
Overall discomfort	0.75	0.003**	0.76	0.002**
During 120-240 minutes of sitting				
Neck	-0.09	0.773	0.89	0.000**
Shoulder	-0.13	0.686	0.85	0.041*
Elbow	-0.14	0.725	0.60	0.009**
Wrist/hand	-0.13	0.668	0.71	0.001**
Upper back	0.25	0.938	0.84	0.001**
Lower back	-0.05	0.881	0.81	0.001**
Buttocks	-0.09	0.772	0.81	0.001**
Thigh	-0.18	0.581	0.85	0.000**
Knee	-0.12	0.704	0.86	0.000**

Ankle/foot	-0.14	0.674	0.86	0.001**
Overall discomfort	-0.11	0.728	0.84	0.001**

* $p < 0.05$; ** $p < 0.01$

4.4 Discussion

The present study demonstrated that 4 hours of sitting led to increased perceived musculoskeletal discomfort in all body regions over time. The body regions with the highest perceived discomfort were the low back, buttocks, upper back, thigh, and neck. During the 4-hour sitting period, the number of postural shifts at the 10% threshold significantly increased in the first two hours and then remained relatively unchanged in the last two hours. For the 20% threshold of postural shift, the number of postural shifts significantly increased from first hour to the third hour and remained unchanged after that. The results indicate moderate to good correlation between perceived discomfort and number of postural shifts at the 10% threshold during the first two hours of sitting. There was no correlation between perceived discomfort and number of postural shifts at 10% threshold during the last two hours of sitting. However, for the 20% threshold, our results showed that good to excellent correlation between perceived discomfort at each body regions and number of postural shifts during the full 4-hour sitting period.

The predominance of discomfort was found in the low back and buttocks, confirming that the variable under investigation was an indicator of seated discomfort. These findings are in line with a previous study showing that perceived discomfort increased significantly during prolonged sitting in a chair with no backrest and armrests (Sondergaard et al., 2010). Vergara and Page (Vergara and Page, 2002) found that the most common discomfort appeared in the neck and low back, followed by buttocks, dorsal region and thighs during 100 minutes of sitting. In a seated posture, the spinal column supports the weight of the head, torso, arms, hands, and any mass suspended by the hands. Within the spinal column vertical forces are applied in shear and compression through ligaments (Harrison et al., 1999). Moreover, the buttock muscle area directly beneath the ischial tuberosity is under compression across the muscle. The compression forces applied to the whole body parts compromise their ability to exchange metabolic by-products and nutritional input with the circulatory system, potentially resulting in accumulation of lactic acid, fatigue, and pain (Mehta and Tewari, 2000). Previous studies found that neck and back muscles were activated during prolonged sitting (Nakphet et al., 2014; Waongenngarm et al., 2015). Prolonged static contraction of muscles at the submaximal level may lead to localized muscle tension, muscle fatigue, and muscle strains (Hagg, 1991). Paraspinal muscle fatigue reduces muscular support to the spinal column, potentially causing increased mechanical stress on ligaments and intervertebral discs as well as impairment of motor co-ordination and muscle control (McGill et al., 2000). Our results showed that discomfort scores at the neck, upper back, and low back after 30-80 minutes of sitting were significantly higher than those at baseline. Considering that perceived discomfort may indeed be a predictor of musculoskeletal pain among healthy subjects (Hamberg-van Reenen et al., 2008), the present findings suggest that prolonged sitting for longer than 30 and 80 minutes possibly increase the risk of neck and low back pain. However, the epidemiological literature generally reveals mixed evidence regarding prolonged sitting as risk factor for neck and low back pain. Although previous systematic reviews demonstrated that sitting duration does not seem to be related to the onset of neck and low back pain (Lis et al., 2007; Roffey et al., 2010). A recent systematic review indicated that increased sitting time at work may be a protective factor for neck and low back pain among blue-collar workers (Øverås et al., 2020). However, among office workers or white-collar workers, prolonged sitting did lead to discomfort increase reaching clinically meaningful levels in the low back and buttock areas (Baker et al., 2018). Furthermore, sitting for more than half a workday, in combination with poor working postures, has been found to increase the risk of experiencing low back pain (Lis et al., 2007). A previous systematic review also showed that sitting duration is a risk factor of upper quadrant musculoskeletal pain (Brink and Louw, 2013).

Previous study showed that the standard magnitude of postural shifts at the 10% threshold indicate the positive effect on tissue viability (Reenalda et al., 2009). However, the larger postural shifts probably indicate a greater or more effective pressure relief of the soft tissue under the buttocks and muscle/ligament tension relief of the lumbar, sacral, and gluteal body regions, which related to seated discomfort. Thus, the present study used the 10% and 20% threshold of postural shifts to determine the number of postural shifts at these two magnitudes. The number of postural shifts at the 10% threshold reported in the present study (17.1±1.9 times/hour) was in line with a previous study (18.9±1.8 times/hour)

(Sammonds et al., 2017). Previous studies also demonstrated that the number of postural shifts increased during 1-2 hours of sitting (Akkarakittichoke and Janwantanakul, 2017; Sammonds et al., 2017). Our results showed that there are 2 to 3 times more postural shifts in the frontal plane than sagittal plane. During sitting, the peak pressure is usually located at the ischial tuberosities area (Akkarakittichoke and Janwantanakul, 2017). A higher number of postural shifts in the frontal plane probably indicates a pressure relief of the ischial tuberosities area, as the peak pressure is lifted from either side, which probably relates to high discomfort at the buttock area.

No study has investigated the characteristics of postural shifts after two hours of sitting. The results showed that the number of postural shifts at the 10% threshold after 2 hours of sitting remained relatively unchanged, while the number of postural shifts at the 20% threshold after 2 hours of sitting were still increasing. Our results indicated that the magnitude of postural shifts after 2 hours of sitting became larger. A previous study showed that frequent and large displacements of the center of pressure with increased discomfort probably indicates a progressively greater need for more effective pressure relief of the soft tissue under the buttocks (Sondergaard et al., 2010). Further study should investigate the mechanism of postural shift activation and the magnitude of postural shift during prolonged sitting in healthy participants as well as in those with musculoskeletal disorders. The findings of the present study shed some light on the notion that sitting characteristics, i.e.

magnitude and frequency of postural shifts, may partly relate to the etiology of musculoskeletal disorders, particularly low back pain, in those required to sit for long periods. An intervention identified to reduce the onset and intensity of perceived musculoskeletal discomfort is that of frequent and short rest breaks (Waongenngarm et al., 2018). Further research on the effects of the number of postural shifts at different magnitudes on body perceived discomfort should be conducted enabling more precise recommendations as to these rest breaks.

Our results showed a positive association between perceived discomfort and number of postural shifts at the 10% threshold and 20% threshold in the first two hours, which was in line with a previous study (Akkarakittichoke and Janwantanakul, 2017). Hermann and Bubb (2007) proposed that subjects move unconsciously in order to relieve pressure on compressed body parts and that they initiate body movement or postural shift in the seat when discomfort reaches a detection threshold, which can be defined as a subject's acceptable discomfort level. As the number of postural shifts increases with time, this implies that, as the duration of sitting increases, subjects reach the detection threshold faster (Sammonds et al., 2017). However, we found no association between perceived discomfort and number of postural shifts at the 10% threshold and found good to excellent association between perceived discomfort and number of postural shifts at the 20% threshold. It is possible that the subjects reached a maximum number of postural shifts, so that they have to shift their posture in larger magnitude to relieve the pressure of the soft tissue under the buttocks.

A strength of the present study is the use of a seat pressure mat device, which is an objective measurement for continuously assessing the characteristics of 4-hour prolonged sitting. However, four methodological limitations are noteworthy. First, participants in this study were recruited by convenience sampling and having normal BMI, which restricts the external validity. Therefore, generalization of the findings from the present study to other working populations, in which also a proportion of overweight and obese workers, should be made with caution. Second, the design of the present study is cross-sectional, so that a causal relation between exposure and outcome cannot be established. Only the association between exposure and outcome was examined. Therefore, further studies with a prospective study design are required to validate our findings. Third, the perceived discomfort was subjective, possibly leading to data inaccuracy. Some workers may be more sensitive to somatic disturbance than others. As a result, there is a risk of over- or under-reporting of the perceived discomfort score. Thus, further studies with objective assessment are recommended to increase data accuracy. Fourth, there is a chance that random data would have yielded two "statistically significant" results ($p < 0.05$), since we are presenting 44 correlations relevant to the study. However, we presented two significance levels now (i.e., $p < 0.05$ and $p < 0.01$) to prevent interpretation of random data yielding "significant" results. With $p < 0.01$, we expect random data to yield only 0.4 "significant" results. Still, the findings from the present study should be made with caution. Finally, the threshold value of 20% was set as an arbitrary threshold. We did not have any data to support this decision. However, we analyzed with other threshold values, and this value had the possibility to detect the highest postural shifts. Further research on the effect of postural shifts at the 20% and other thresholds on trunk muscle activity and tissue viability is recommended.

4.5 Conclusions

The present study revealed that 4 hours of sitting led to an increase in the perceived discomfort in all body regions over time. The body part with the highest discomfort after this period was the lower back. The number of postural shifts at both magnitudes increased in the first two hours of sitting, while after 2 hours of sitting only the number of larger postural shifts (with 20% threshold) increased. Perceived discomfort highly correlated to the number of postural shifts only in the first two hours of sitting for the 10% threshold and in 4 hours of sitting for the 20% threshold. Further research should examine the roles of characteristics of perceived discomfort and the number of postural shifts on the development of musculoskeletal disorders in workers who are required to sit for long hours.

Authors' contributions

The authors have contributed in the following ways: PW provided the concept/research design, data collection, data analysis and manuscript writing. AvdB, NA 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 prolonged sitting during office works led to an increase in perceived musculoskeletal discomfort in all body regions over time, especially low back, buttock, upper back, thigh, and neck. Perceived discomfort is a predictor of musculoskeletal pain among healthy subjects. The present findings suggest that prolonged sitting for longer than 30 and 80 minutes possibly increase the risk of neck

and low back pain, respectively. Therefore, the minimum sitting duration for rest break protocol was 30 minutes, which would be used in the algorithm of smart seat in the study aimed to investigate the effect of active breaks on reducing the onset of neck and low back pain (CHAPTER 5).

CHAPTER 5

Effects of active break and postural shift on preventing neck and low back pain among high-risk office workers: a 6-month cluster-randomized controlled trial

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Abstract

Objective: This study evaluated the effects of the promotion of active breaks and postural shifts on the 6-month incidence of neck and low back pain in high-risk office workers.

Methods: A 3-arm cluster-randomized controlled trial with 6-month follow-up was conducted in healthy but high-risk office workers. Participants were recruited from 6 organizations (n=193) and were randomly assigned at cluster level into active break intervention (n=47), postural shift intervention (n=46), and control (n=100) groups. Participants in the intervention groups received a custom-designed apparatus to facilitate designated active breaks and postural shifts during work. Participants in the control group received a placebo seat pad. The primary outcome measure was 6-month incidence of neck and low back pain. Analyses were performed using Cox proportional hazard models.

Results: The 6-month incidences of neck pain in the active break, postural shift, and control groups were 17%, 17%, and 44%, respectively. The 6-month incidences of low back pain in the active break, postural shift, and control groups were 9%, 7%, and 33%, respectively. Hazard rate ratios after adjusting for biopsychosocial factors indicated a protective effect of the active break and postural shift interventions for neck pain (HR_{adj}=0.45; 95%CI 0.20 to 0.98 for active break and HR_{adj}=0.41, 95%CI 0.18 to 0.94 for postural shift) and low back pain (HR_{adj}=0.34, 95%CI 0.12 to 0.98 for active break and HR_{adj}=0.19, 95%CI 0.06 to 0.66 for postural shift).

Conclusion: Interventions to increase active breaks and postural shifts both reduced onset of neck and low back pain in high-risk office workers.

Key words: Musculoskeletal disorders; Postures; Computers; Sedentary workers

5.1 Introduction

Neck and low back pain are a major health problem for office workers. Neck pain is prevalent among office workers, with 46% of them reporting neck pain annually (Ehsani et al., 2017) and 31% developing a new episode 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% report new onset of low back pain every year (Sitthipornvorakul et al., 2015). Neck and low back pain are often the cause of significant physical and psychological health impairments, which affect work performance and social responsibilities. Consequently, neck and low back pain constitute a great socioeconomic burden on both individuals and society as a whole (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). A recent systematic review showed a positive effect of rest breaks with postural change or active breaks on pain and discomfort (Waongenngarm et al., 2018). 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). 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 rest breaks and 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 trial investigating the efficacy of rest 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 rest breaks and postural shifts on the 6-month incidence of neck and low back pain among high-risk office workers. We hypothesized that participants in the intervention groups, with increases in either rest breaks or postural shifts, show reduced new onset of neck and low back pain.

5.2 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/m^2, 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.

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; Akkarakittichoke and Janwantanakul, 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; Krismer and van 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 χ^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. Gender, age, and psychological scores were forced into all models to reduce confounding due to these factors. The other 40 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. pain intensity, disability and discomfort 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.

5.3 Results

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, 186 were successfully followed for six months and 7 (4%) were lost during the follow-up period because they left the companies (Figure 5.1). The sample population comprised mainly females (76%) (Table 5.1). 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. All occupational sitting behaviors from participants in both intervention groups are presented in Table 5.2.

In March 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, we had completed the 6-month follow-up for the participants in the intervention A (active break) and control groups. However, the participants in the intervention B (postural shift) group were followed up for only the first 4 months. Thus, it should be noted that data from the 5^{th} and 6^{th} months of participants in the intervention B (postural shift) group were collected while they were working from home (during March to April 2020) and these months were used for statistical analyses in this study, following the intention-to-treat principle. All participants reported that they did not bring the custom-designed apparatus for use at home.

To investigate the effect of working from home in the intervention B (postural shift) group, in a sensitivity analysis, we compared the results from the 6-month follow-up to those the from 4-month follow-up (i.e. excluding the last two months). No alteration of the findings was found between the two sets of data (results not shown). The results from the 6-month follow-up are given below.

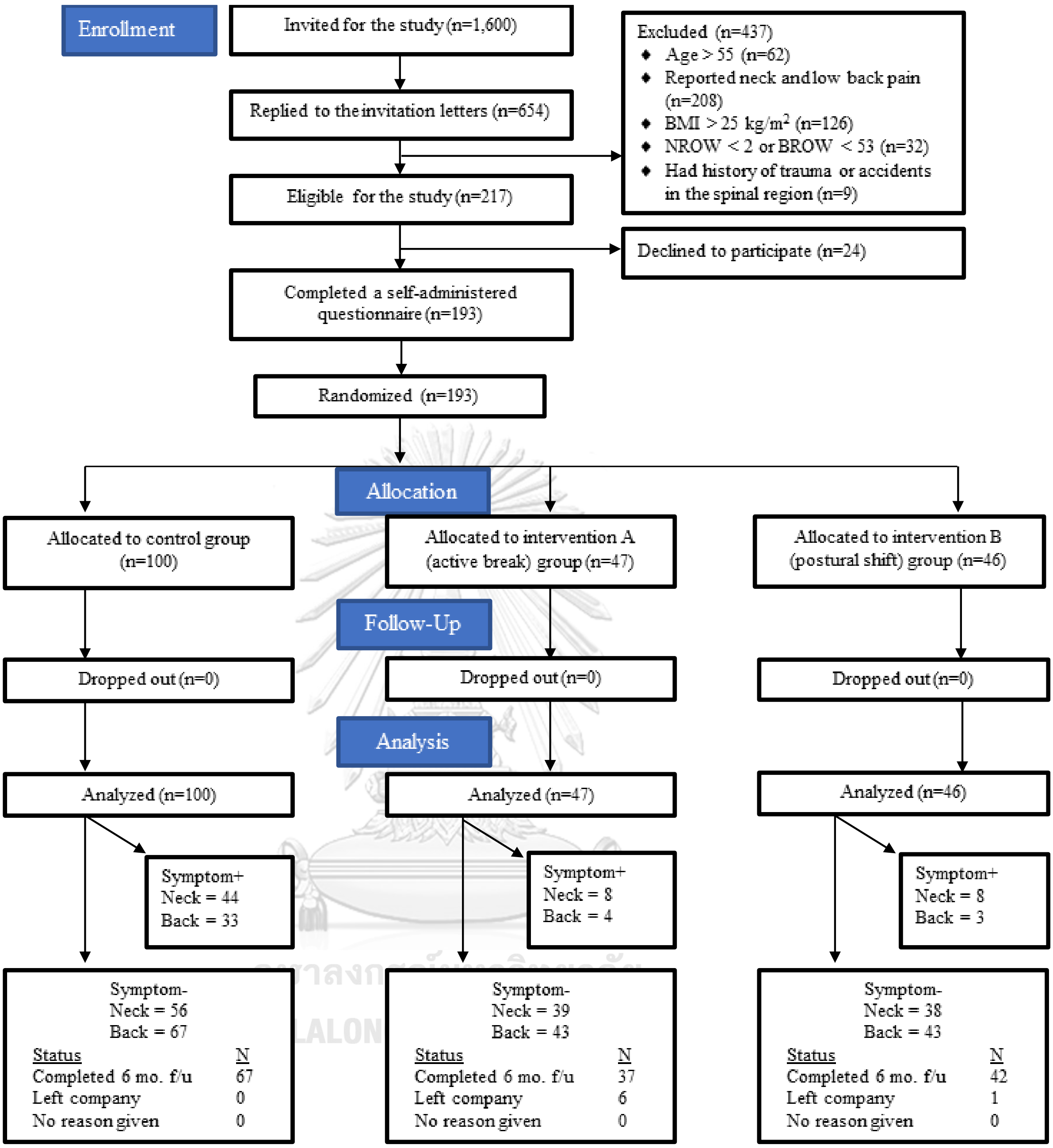

Figure 5.1 Consolidated Standards of Reporting Trials (CONSORT) flowchart of the study.

Table 5.1 Baseline characteristics of participants.

Characteristic	Intervention A (active break) group (n = 47)	Intervention B (postural shift) group (n = 46)	Control group (n = 100)	*p* value
	Mean (SD)			
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

Table 5.2 Occupational sitting behaviors of the participants in both intervention groups.

Variables	Mean (SD)	
	Intervention A (active break) group (n=47)	Intervention B (postural shift) group (n=46)
Sitting duration at work per day (min)	295.8 (130.9)	263.2 (154.4)
Break duration per day (min)	85.4 (44.1)	
Average break duration (min)	3.1 (1.7)	
Number of breaks per day (times)	32.5 (20.4)	
Number of total postural shifts (times per hour)		27.3 (7.4)

Incidence of neck and low back pain

Over the 6-month follow-up, 17% (8/47) of participants in the intervention A (active break) group, 17% (8/46) of those in the intervention B (postural shift) group, and 44% (44/100) of those in the control group reported incident neck pain. For low back pain, 9% (4/47) of participants in the intervention A (active break) group, 7% (3/46) of those in the intervention B (postural shift) group, and 33% (33/100) of those in the control group reported onset of low back pain. No harmful or unintended effects were reported among the participants in the three groups.

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 = 0.002), and the intervention B (postural shift) group and control group (log rank test probability = 0.001) (Figures 5.2 and 5.3). 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.

Using the Cox proportional hazard model, after adjustment for age, gender, education level, duration of employment, seat height, and psychosocial work characteristics, 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 (HR_{adj}=0.45; 95%CI 0.20 to 0.98, p=0.047) and low back pain (HR_{adj}=0.34; 95%CI 0.12 to 0.98, p=0.047). Intervention B (postural shift) significantly reduced the risk of incident neck pain (HR_{adj}=0.41; 95%CI 0.18 to 0.94, p=0.035) and low back pain (HR_{adj}=0.19; 95%CI 0.06 to 0.66, p=0.009) (Table 5.3). Comparisons of pain intensity and disability level among the intervention A (rest break), intervention B (postural shift), and control groups indicated no statistically significant difference (Table 5.4).

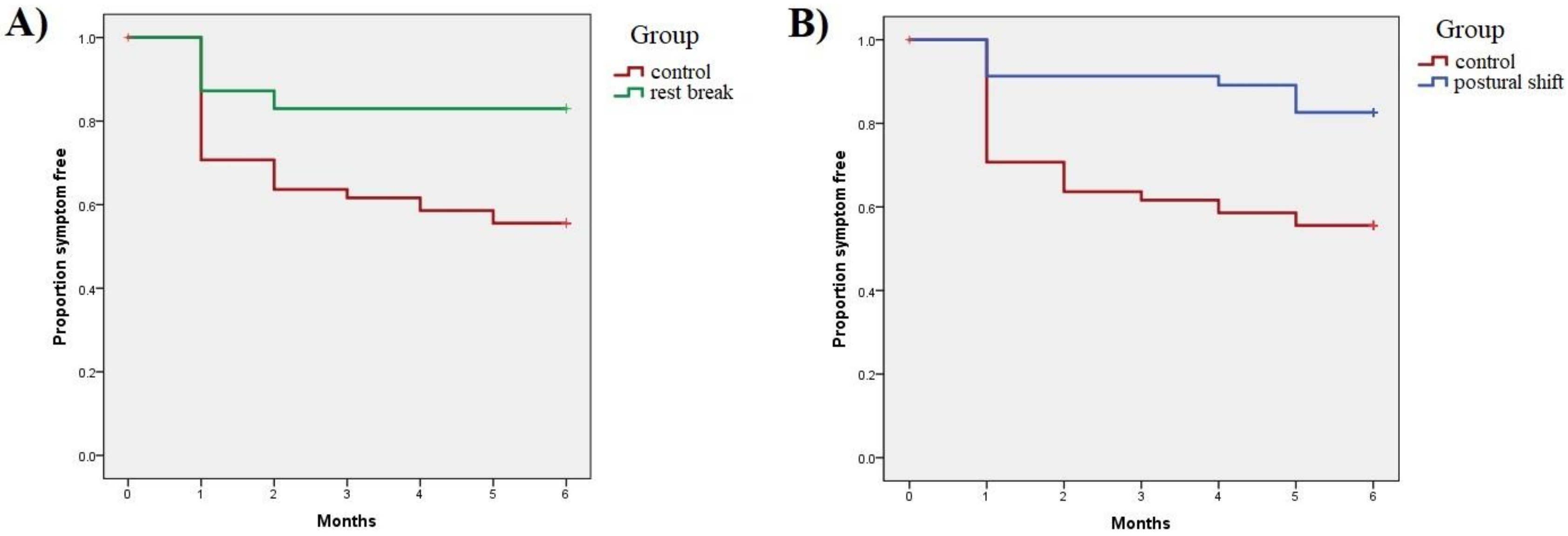

Figure 5.2 The Kaplan–Meier survival curves for onset of neck pain; A) Intervention A (active break) and B) intervention B (postural shift).

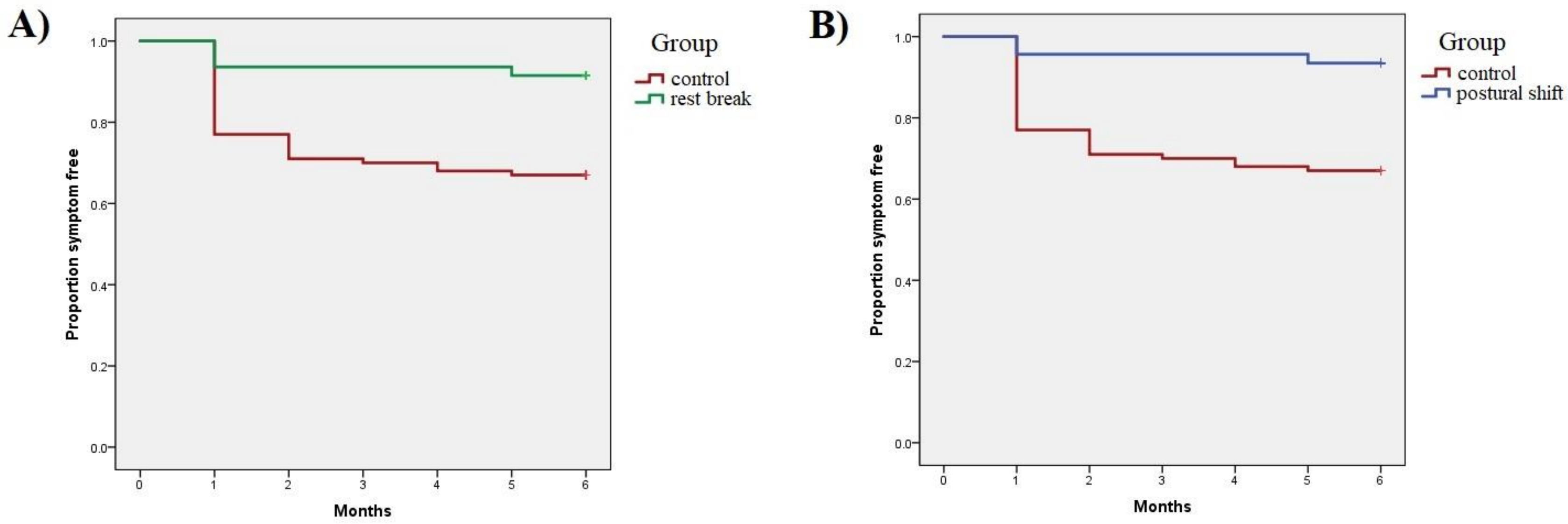

Figure 5.3 The Kaplan–Meier survival curves for onset of low back pain; A) Intervention A (active break) and B) intervention B (postural shift).

Table 5.3 Unadjusted and adjusted HRs evaluating the effects of intervention A (active break) and intervention B (postural shift) on incident neck and low back pain (n=193).

	Unadjusted HR (95% CI)	***p* value**	**Adjusted#** HR (95% CI)	***p* value**
Neck pain				
Group assignment				
Control group	1.00		1.00	
Intervention A (active break) group	0.36 (0.17-0.75)	0.007*	0.45 (0.20-0.98)	0.047*
Intervention B (postural shift) group	0.35 (0.16-0.74)	0.006*	0.41 (0.18-0.94)	0.035*
Back pain				
Group assignment				
Control group	1.00		1.00	
Intervention A (active break) group	0.24 (0.08-0.67)	0.007*	0.34 (0.12-0.98)	0.047*

Intervention B (postural shift) group	0.18 (0.06-0.59)	0.005*	0.19 (0.06-0.66)	0.009*

Variables; age, gender, education level, duration of employment, seat height, job control, psychological job demand, physical job demand, job security, social support, hazards at work, and neck/low back discomfort

*p value < 0.05

Table 5.4 Pain intensity and disability of participants reporting neck and low back pain during 6-month follow-up.

Variable	Mean ± SD			*p* value
	Intervention A (active break) group	**Intervention B (postural shift) group**	**Control group**	
Neck pain				
Pain intensity measured by VAS	3.4 ± 0.4 (n=8)	5.2 ± 1.7 (n=8)	4.0 ± 1.6 (n=48)	0.070
Disability measured by NDI	7.4 ± 2.8 (n=8)	6.0 ± 3.5 (n=8)	3.9 ± 0.6 (n=48)	0.761
Back pain				
Pain intensity measured by VAS	4.0 ± 1.4 (n=4)	3.0 ± 0.5 (n=3)	3.8 ± 1.9 (n=39)	0.725
Disability measured by RMDQ	2.7 ± 1.5 (n=4)	2.0 ± 0.0 (n=3)	1.9 ± 1.5 (n=39)	0.548

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

5.4 Discussion

This randomized controlled trial showed that the rest break and postural shift intervention reduced the 6-month incidence rate of neck and low back pain among high-risk office workers. The 6-month incidence of neck and low back pain was reduced by 55-81% by the interventions. However, neither the rest break nor the postural shift intervention reduced pain intensity or disability level in those experiencing neck and low back pain.

In this study, the 6-month incidences of neck and low back pain in office workers of the control group were 44% and 33%, respectively. These findings are in line with a previous study by Sitthipornvorakul et al. (Sitthipornvorakul et al., 2020), showing the 6-month incidence of neck pain among office workers to be 34%. However, (Lapointe et al., 2009) reported the 6-month incidence of neck and low back pain among office workers to be 18% and 14%, respectively. The discrepancy between our and the (Lapointe et al., 2009) study may be due to the difference in the inclusion criteria. (Lapointe et al., 2009) 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. Prevention targeted at a high-risk group is different from preventive efforts aimed at all employed office workers (van der Beek et al., 2017).

Sitthipornvorakul et al. (Sitthipornvorakul et al., 2020) has reported that a walking intervention can largely reduce the 6-month incidence rate of neck pain (OR_{adj}=0.22) among high-risk healthy office workers, for which the same inclusion criteria as those in the present study were used. Danquah et al. (Danquah et al., 2017) also found a reduction in the prevalence of neck pain after their 3-month intervention among office workers, who received a Take a Stand! intervention aimed to reduce sitting time (OR_{adj}=0.52). They found, however, no change in low back pain. A systematic review and meta-analysis indicated that only exercise intervention was effective for reducing the occurrence of low back pain (pooled RR=0.65) (Steffens et al., 2016). However, other systematic reviews reported that rest breaks were an effective intervention to reduce pain and discomfort in various body regions (particularly in the low back), which is secondary prevention for musculoskeletal disorders (Stock et al., 2018; Waongenngarm et al., 2018).

The present study found that active breaks can reduce the incidence of neck and low back pain by 55% and 66%, respectively. Our results showed that the average break duration of participants in the active break group was 3.1 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 number of active breaks in the active break group of the present study was 32.5 times per workday and was higher than that reported by Renaud et al. (Renaud et al., 2020), who showed 28.3 sit-stand transitions per workday. 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 59% and 81%, respectively. The number of total postural shifts found in the postural shift group of the present study was 27.3 times per hour, which was much higher than those reported in previous studies (ranging from 8 to 10 times per hour in a normal work situation) (Reenalda et al., 2009; Akkarakittichoke and Janwantanakul, 2017). Again, the discrepancy in number of postural shifts between our and previous studies may be partly attributed to the use of the apparatus. Previous studies indicated that increased motion during prolonged sitting has been found to decrease discomfort in the neck and low back (van Deursen et al., 1999; O'Keeffe et al., 2013). 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). Static neck posture is a possible risk factor in neck pain (Szeto et al., 2009). A previous study found that individuals with low back pain had less frequent postural shifts than their healthy counterparts (Dunk and Callaghan, 2005). Changing sitting postures has been found to result in different levels of cervicothoracic muscle activity (Caneiro et al., 2010). Hence, changing sitting postures may impose alternating activity between different parts of the neck and shoulder muscles resulting in alleviated postural discomfort during prolonged sitting. 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). Thus, our results suggest that frequency of postural shifts may partly be related to the 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 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.

5.5 Concluding Remarks

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: PW provided the concept/research design, data collection, data analysis and manuscript writing. NA contributed to the concept/research design and data collection. AvdB 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

At first, this study planned to evaluate the effects of the promotion of active breaks and postural shifts on the 12-month incidence of neck and low back pain in high-risk office workers. At the start of the experiment (June 2019), all measurements were collected at the office locations using a self-administered questionnaire. Participants in the three groups received a self-administered diary to record the incidence of neck and low back pain during follow-up. The researcher aimed to collect the diaries and to check that they were correctly completed every month for a 12-month period. However, by the start of March 2020, the COVID-19 outbreak occurred in Thailand. The most affected areas were Bangkok and surrounding neighborhoods. In accordance with government regulations, many workplaces asked their employees to work from home, which may affect to our results. Thus, we changed our plans to analyze these 6-month follow-up data and continuously collect the incidences of neck and low back pain and to explore working from home related risk factors for

neck and low back pain during the COVID-19 outbreak. This study showed that the 6-month incidences of neck pain in the active break, postural shift, and control groups were 17%, 17%, and 44%, respectively. The 6-month incidences of low back pain in the active break, postural shift, and control groups were 9%, 7%, and 33%, respectively. Our results suggested that the active break and postural shift interventions can effectively reduce incident neck and low back pain in these office workers. Furthermore, the study aimed to examine the incidences of neck and low back pain were affected during the COVID-19 outbreak and to explore working from home related risk factors for neck and low back pain among office workers would be conducted (CHAPTER 6).

CHAPTER 6

Incidence of and risk factors for neck and low back pain during the COVID-19 outbreak in Thailand

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Abstract

Objective: To examine whether the incidences of neck and low back pain were affected during the COVID-19 outbreak and to explore working from home related risk factors for neck and low back pain among office workers.

Design: Prospective cohort study.

Methods: In March 2020, the COVID-19 outbreak occurred in Thailand with the situation improving by July 2020. During the outbreak (March to June 2020), 193 healthy office workers, who were already taking part in a study on neck and low back pain, were asked whether they worked from home. Logistic regression models for the outcomes of the 4-month incidence of neck and low back pain were performed.

Results: Sixty-eight percent of the participants worked from home during the outbreak. The person-year incidence rates of neck and low back pain during the outbreak were lower than in the pre-outbreak period. Number of days working from home was positively associated with the 4-month incidence of neck (OR=1.84, 95%CI=1.04-3.26) and low back pain (OR=3.44, 95%CI=1.23-9.62).

Conclusion: The findings indicate that more research is needed to understand the impact of working from home on neck and low back pain among office workers during the COVID-19 outbreak.

Key words: Work from home; Neck pain; Low back pain; Office workers.

6.1 Introduction

Since the end of 2019 the infectious coronavirus disease COVID-19 emerged, disrupting lives and economies globally. COVID-19 presents an enormous challenge worldwide, resulting in social disruption, exceptional healthcare utilization, and economic instability. The spectrum of this disease ranges from mild fatigue, myalgia, fever, dry cough, and dyspnea to severe manifestations such as acute respiratory distress syndrome (ARDS), septic shock, disseminated intravascular coagulation (DIC), and acute renal failure. SARS-CoV-2 infection manifests itself more severely in elderly adults (Chen et al., 2020). According to a recent report by the World Health Organization (WHO) (August 5th, 2020), COVID-19 has been confirmed in 213 countries with a total of 18,354,342 positive cases and almost 700,000 confirmed deaths. During the same period, the total number of COVID-19 cases reported in Thailand was 3,328. Of these, about 94% (3,144) have recovered, 2% (58) have died and 4% (126) are still receiving treatment.

To slow down the spread of COVID-19, many countries, including Thailand, have published emergency guidelines to deal with this pandemic, including social distancing and working from home. The social distancing measure means keeping a safe space at least 6 feet between oneself and other people who are not from the same household. During this time, workers have been instructed to work from their homes. Many employees reported that they experience working from home to be associated with no specified worktime leading to increased working hours and poor ergonomics of workstation, compared to working at their regular location. In addition, the lack of person-to-person communication can be a challenge for some people, leading to various psychosocial problems, including stress, loneliness, isolation, and depression (Jaiswal and Arun, 2020; Rubin et al., 2020).

At the time of the COVID-19 outbreak, a cluster-randomized controlled trial investigating the effect of a rest break and postural shift intervention in preventing neck and low back pain was being conducted in office workers from Bangkok (still ongoing). Some participants in this study were asked to work from home during the COVID-19 outbreak. As part of this study, office workers completed diaries detailing the incidence of neck and low back pain. This allowed us to evaluate the impact of working from home on the incidence of neck and low back pain, which no study has conducted to date. Thus, the aims of this study were to examine whether the incidence of neck and low back pain were affected during the COVID-19 outbreak compared to the regular working situation and to explore working from home related risk factors for neck and low-back pain in a cohort of office workers. The information obtained can be used to develop suitable protective and intervention measures to prevent musculoskeletal disorders in the neck and low back among office workers who have to work from home.

6.2 Methods

Study population and procedures

In June 2019, a three-arm, parallel-group, cluster randomized controlled trial was conducted to evaluate the effect of active breaks and postural shift on preventing neck and low back pain among high-risk office workers, with a follow-up of 12 months. This study has been approved by the Chulalongkorn University Human Ethics Committee and was registered in the Thai Clinical Trials Registry (TCTR20190111002). Participating departments differed in size (ranging from 15 to 51 participants) and were located in six different offices in Bangkok. These enterprises were randomly assigned into either control or two intervention groups. In each participating workplace, subjects were conveniently sampled. Individuals were included in the study if aged 23–55 years, working full-time, had a body mass index (BMI) of 18.5-25 kg/m^2, had at least 5 years of experience in their current job, and were at risk of nonspecific neck pain as evaluated by the Neck Pain Risk Score for Office Workers (score ≥ 2) (Paksaichol et al., 2014) and nonspecific low back pain as evaluated by Back Pain Risk Score for Office Workers (score ≥ 53) (Janwantanakul et al., 2015). Participants were excluded if they had reported 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 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 kindly invited to participate in this study. Study requirements and procedures were explained in a letter to all participants and written informed consent was obtained from all participants prior to any measurements taking place.

At the start of the experiment (June 2019), all measurements were collected at the office locations using a self-administered questionnaire. Participants in the three groups received a self-administered diary to record the incidence of neck and low back pain during follow-up. The researcher aimed to collect the diaries and to check that they were correctly completed every month for a 12-month period. However, by the start of March 2020, the COVID-19 outbreak occurred in Thailand. The most affected areas were Bangkok and surrounding neighborhoods. In accordance with government regulations, many workplaces asked their employees to work from home. Thus, the last report on incidence of neck and low back pain received before the COVID-19 outbreak was in February 2020. By the start of July 2020, the COVID-19 situation in Thailand improved and participants started to return to work at their offices again. During the COVID-19 outbreak (March to June 2020), an electronic self-administered questionnaire designed to gather additional data about working from home related risk factors and the incidence of neck and low back pain was sent to participants via e-mail to be filled out.

Questionnaires

At baseline (June 2019), the following biopsychosocial characteristics were obtained using a self-administered questionnaire: individual, work-related physical, and psychosocial factors. Individual factors included gender, age, marital status, education level, frequency of regular physical 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 working from home related risk factor questionnaire consisted of 8 questions as follows: During the COVID-19 period, have you worked from home (yes or no)? How many hours per day have you worked from home? On average, has the workload while working from home differed from the workload while working in an office (same or different)? In normal circumstances, how long does it take per day to commute between your home and office? Do the ergonomics of your workstation at home differ from the office (same or different)? Does working from home differ from working in an office (same or different)? How? Has working from home increased your psychological stress level (yes or no)? During the period of working from home, have you also taken care of a child or someone at home (yes or no)?

Outcome measure

An electronic self-administered questionnaire was used to gather data on the incidence of neck and low back pain. The area of neck and low back was defined according to the picture of the body from the standardized Nordic questionnaire (Thai version) (Kuorinka et al., 1987). Participants answered the yes/no question "Have you experience any neck or low back pain lasting > 24 hours during the past month?" If they answered "Yes", they were asked follow-up questions about pain intensity measured by a visual analogue scale, and the presence of weakness or numbness in the upper limbs. Those who reported incidence of neck or low back pain were also asked about their disability level as measured by the neck disability index (NDI) (Thai version) (Uthaikhup et al., 2011) or Roland-Morris low back disability questionnaire (RMDQ) (Thai version) (Pensri et al., 2005), respectively. In this study, participants were identified as those with onset non-specific neck or low back pain, i.e. if they answered "Yes" to the question "Have you experienced any neck or low back pain lasting > 24 hours during the past month?", 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.

Statistical analyses

The COVID-19 outbreak period was defined as being between March and June 2020, while the pre-COVID-19 outbreak period was defined as being between June 2019 and February 2020. Because of the unequal duration of the follow-up period during the pre-COVID-19 and COVID-19 outbreak periods for all participants, the person-time incidence, defined as the number of new cases of neck and low back pain during a specified time interval divided by the summed person-years of observation during the specified time interval, of neck and low back pain were calculated to compare the incidences between the pre-COVID-19 outbreak and COVID-19 outbreak periods.

Data from all of those reporting no neck and low back pain at the end of February 2020 and who were affected by the COVID-19 outbreak in terms of working from home, were entered into two regression models for the outcomes of 4-month incidence of neck and low-back pain (i.e. the period between March and June 2020), respectively. For work from home-related risk factors, Chi-squared tests revealed no significant differences in answers obtained during the 4-month period. Therefore, the first month data of each participant were used for statistical analyses. The predictors included in both models were: age, gender, control vs intervention group, and work from home-related risk factors. The entered selection procedures were used in the statistical modelling. Odds ratios (OR) associated with particular factors were adjusted for the effect of all other factors in the models. Adjusted ORs and 95% confidence intervals (CI) for the final models were presented. Statistical significance was set at the 5% level. All statistical analyses were performed using SPSS statistical software, version 23.0 (SPSS Inc., Chicago, IL, USA).

6.3 Results

At baseline measurement (the pre-COVID-19 period), 654 workers responded from the total of 1,600 who received the invitation (response rate: 40%). Of these, 217 were eligible and 193 agreed to participate. At the start of the COVID-19 outbreak (March 2020), a total of 180 (93%) office workers were contacted, while 13 (7%) could not be contacted. A majority of the participants (123 from 180; 68%) reported as having worked from home during the COVID-19 outbreak (March-June 2020). The participants with no neck and low back pain at the start of COVID-19 outbreak (March 2020) contributed a total of 81 participants with observations for neck pain and 94 participants with observations for low back pain. Table 6.1 shows the characteristics of the working from home related risk factors for participating office workers. A majority of participants (78%) reported that they worked from home ≤3 days per week. For the item “Does working from home differ from working in an office?”, 90% (111/123) of participants answered “Yes”. Of these, participants reported the following advantages of working from home: comfort and relaxation (58%), flexible schedule (21%), and no need to commute between home and office (18%). On the other hand, they identified the following disadvantages of working from home: poor ergonomics of home workstation (49%), lack of working tools (25%), and lack of social contact (16%).

Table 6.1 Working from home characteristics for participating office workers (n=123)

Characteristics	n (%) / Mean (SD)
Number of participants working from home, n (%)	
In the 1^{st} month (March 2020)	91 (74.0)
In the 2^{nd} month (April 2020)	90 (73.2)
In the 3^{rd} month (May 2020)	78 (63.4)
In the 4^{th} month (June 2020)	55 (44.7)
Number of months working from home, mean (SD) months	2.6 (1.0)
Number of days working from home per week, mean (SD) days	2.9 (1.2)
1 day, n (%)	8 (6.5)
2 days, n (%)	41 (33.3)
3 days, n (%)	47 (38.2)
4 days, n (%)	5 (4.1)
5 days, n (%)	22 (17.9)

Working hours per day when working from home, mean (SD) hours	8.2 (1.5)
Working hours per day when working at the office, mean (SD) hours	7.9 (0.8)
Commute time from home to office, mean (SD) hours	1.6 (1.2)

Incidence of neck and low back pain

Table 6.2 shows the person-year incidence, pain intensity, and disability level of neck and low back pain during the pre-COVID-19 and COVID-19 periods. The person-year incidence of neck pain during the COVID-19 period was 33% less than that during the pre-COVID-19 period, whereas the person-year incidence of low back pain during the pre-COVID-19 was 37% less than that during the COVID-19 period. The severity of neck and low back pain as well as disability level due to neck and low back pain in those who reported onset neck or low back pain did not differ significantly between the pre-COVID-19 and COVID-19 periods ($p > 0.05$).

Table 6.2 Person-year incidence of neck and low back pain during pre-COVID-19 and COVID-19 periods, with reported severity and disability levels

Body regions	**Incidence Cases/100 person-year**	**VAS Mean (SD)**	**NDI/RMDQ Mean (SD)**
Neck pain			
Pre-COVID-19 period	29.5	4.3 (1.4)	6.9 (3.6)
COVID-19 period	19.7	3.8 (1.4)	6.6 (2.9)
p-value		0.198	0.707
Back pain			
Pre-COVID-19 period	20.2	4.4 (1.8)	2.3 (1.9)
COVID-19 period	12.7	4.2 (1.3)	2.1 (2.3)
p-value		0.668	0.800

NDI: Neck Disability Index; RMDQ: Roland-Morris Disability Questionnaire; VAS: visual analogue scale.

Association between 4-month neck/low back pain and working from home related risk factors

When multivariable logistic regression was applied, number of days working from home was found to be significantly associated with the 4-month incidence of neck pain. Group assignment and number of days working from home per week were significantly associated with the 4-month incidence of low back pain. (Table 6.3). Multicollinearity was considered not to be critical according to the tolerance index (>0.10) and the variance inflation factor (<5) (O'brien, 2007).

Table 6.3 The 4-month incidence and adjusted odds ratio (ORadj) with 95% confidence intervals (95% CI) of neck and low back pain with respect to working from home related risk factors in the final model

Factors	n	4-month incidence n (%)	ORadj	95% CI	p-value
Neck pain[a]					
Age	81		1.03	0.92-1.15	0.58
Gender					
Female	62	12 (19)	1.00		
Male	19	4 (21)	0.93	0.20-4.22	0.92
Group assignment					
Control group	39	10 (26)	1.00		
Intervention group	42	6 (14)	0.30	0.07-1.22	0.09
Number of days working from home per week	**81**		**1.84**	**1.04-3.26**	**0.03***
Working hours per day (a comparison between home and office)					

Same	52	8 (15)	1.00		
Different	29	8 (27)	2.90	0.71-11.87	0.14
Workload (a comparison between home and office)					
Same	32	6 (19)	1.00		
Different	49	10 (20)	0.96	0.27-3.45	0.95
Travelling time from home to office	81		1.00	0.99-1.01	0.61
Ergonomics of workstation (a comparison between home and office)					
Same	13	1 (8)	1.00		
Different	68	15 (22)	2.95	0.31-28.35	0.35
Psychological stress (a comparison between home and office)					
Same	65	12 (18)	1.00		
Different	16	4 (25)	1.00	0.18-6.05	0.97

Taking care of someone while working from home					
No	51	9 (18)	1.00		
Yes	30	7 (23)	0.80	0.19-3.40	0.76
Back pain[a]					
Age	94		0.98	0.85-1.13	0.78
Gender					
Female	68	10 (15)	1.00		
Male	26	2 (8)	0.21	0.03-1.53	0.12
Group assignment					
Control group	**49**	**10 (20)**	**1.00**		
Intervention group	**45**	**2 (4)**	**0.03**	**0.00-0.39**	**0.01***
Number of days working from home per week	**94**		**3.44**	**1.23-9.62**	**0.02***
Working hours per day (a comparison between home and office)					
Same	60	8 (13)	1.00		

Different	34	4 (12)	0.70	0.13-3.68	0.67
Workload (a comparison between home and office)					
Same	37	5 (14)	1.00		
Different	57	7 (12)	1.06	0.23-4.81	0.94
Commuting time from home to office	94		1.00	0.99-1.01	0.73
Ergonomics of workstation (a comparison between home and office)					
Same	16	1 (6)	1.00		
Different	78	11 (14)	6.05	0.49-75.50	0.16
Psychological stress (a comparison between home and office)					
Same	74	10 (14)	1.00		
Different	20	2 (10)	0.05	0.00-1.43	0.08
Taking care of someone while working from home					

No	59	6 (10)	1.00		
Yes	35	6 (17)	4.22	0.71-25.23	0.11

[a]Factors included in the statistical modelling were: age, gender, control vs intervention group, and work from home related risk factors.

6.4 Discussion

During the COVID-19 outbreak, approximately 70% of office workers reported that they had to work from home and the average duration of working from home was 2.6 months (during the period of March–June 2020). Most participants indicated differences in the working conditions, workloads, and ergonomics of their workstation when comparing working from home with working in the office. In this study, we calculated the incidence rate of neck and low back pain as incidence cases/100 person-year, which can be compared to the 1-year incidence from previous studies. The epidemiological literature has indicated that, among office workers, the 1-year incidence of neck and low back pain is 31% (Areerak et al., 2018) and 20% (Sihawong et al., 2014), respectively. The 1-year incidences of neck and low back pain reported in the present study during the pre-COVID-19 period were similar to those aforementioned from the previous studies.

Our results indicated that the 1-year incidence of neck and low back pain during the COVID-19 period was lower than that for during the pre-COVID-19 period. Most participants in our sample (90%) indicated that working from home differed from working in an office in many aspects and they indicated several specific advantages and disadvantages of working from home. One advantage of working from home was the sense of comfort and relaxation. (Hush et al., 2009) demonstrated that high psychological stress is a risk factor of neck pain in office workers. Also, our sample of office workers reported a more flexible schedule during a day and the lack of a need to commute between home and office (about 1.5 hours per day), which may lead to more active breaks during the day and the reduced duration of prolonged sitting. A systematic review demonstrated that frequent and short active breaks reduce the onset and intensity of perceived musculoskeletal discomfort (Waongenngarm et al., 2018), which is a predictor of neck and low back pain (Hamberg-van Reenen et al., 2008). Although those working from home encountered poor workstation ergonomics and lacked social contact with their colleagues, the findings of the present study suggest that the benefits of working from home outweigh the adverse effects of working from home among office workers.

The number of days working from home per week was found to be a risk factor of neck and low back pain in this study. An increased number of days working from home may expose workers to risk factors, including poor workstation ergonomics and the lack of social contact with colleagues, for a long period. Previous studies showed that poor workstation ergonomics to be associated with musculoskeletal pain (Van Vledder and Louw, 2015; Rodrigues et al., 2017). About half of the participants working from home reported their workstations at home as being inappropriate for work. It is possible that working with a poorly designed workstation at home for an extended period of time may lead to cumulative trauma exposure, later leading to the development of neck and low back pain.

These findings highlight a need for stakeholders to pay more attention to the problem of neck and low back pain during the disease outbreak, which leads them to work from their home, in order to reduce the incidence of neck and low back pain among office workers. Prevention of neck and low back pain among those who work from home should at least focus on advising workers on how to improve their active breaks while working from home. Reducing the number of days working from home by returning to work at the office for some other days during a week, if possible, may decrease the risk of neck and low back pain.

Three main methodological limitations should be taken into consideration when interpreting the results of the present 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 incidence of neck and low back pain, when and where possible during disease outbreaks and lockdowns, in normal office workers or other occupations is suggested. Second, the findings of the present study should be taken as a preliminary result because the sample size was relatively small, increasing the likelihood of a type II error. Third, the association between work from home-related risk factors and musculoskeletal pain was based on cross-sectional data. Thus, it is not possible to establish the causal relationship between exposure and outcome.

However, conducting a prospective study in the midst of a severe disease outbreak would be extremely difficult.

In conclusion, this study found a decrease in new onset neck and low back pain among office workers during the COVID-19 outbreak. However, the number of days working from home was positively associated with the 4-month incidence of neck and low back pain. Increasing physical activities and balancing the days working from home and at office during a week may be effective in reducing the development of neck and low back pain during periods in which working from home is partly needed. Further research is required to evaluate effective interventions for preventing neck and low back pain during working from home.

Authors' contributions

The authors have contributed in the following ways: PW provided the concept/research design, data collection, data analysis and manuscript writing. NA, AvdB, 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 examined the incidences of neck and low back pain were affected during the COVID-19 outbreak and to explore working from home related risk factors for neck and low back pain among office workers. The person-year incidence rates of neck and low back pain during the COVID-19 outbreak were lower than in the pre-COVID-19 outbreak period. The number of days working from home was positively associated with the 4-month incidence of neck and low back pain during COVID-19 outbreak periods. Therefore, working from home status and the number of days working from home would be forced to the Cox regression model as confounding factors in the next study, which aimed to investigate the effect of active breaks on 12-month incidence of neck and low back pain among office workers (CHAPTER 7).

CHAPTER 7

Effects of active breaks on preventing neck and low back pain among high-risk office workers: a 12-month cluster-randomized controlled trial

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Abstract

Objective: This study evaluated the effects of the promotion of active breaks on the 12-month incidence of neck and low back pain in high-risk office workers.

Methods: A 12-month prospective cluster-randomized controlled trial was conducted in high-risk office workers. Participants were recruited from 4 large-scale enterprises (n=147) and were randomly assigned at the cluster level into active break intervention (n=47) and control (n=100) groups. Participants in the intervention groups received a custom-designed apparatus to facilitate designated active breaks during work. Participants in the control group received a placebo seat pad. The primary outcome measure was the 12-month incidence of neck and low back pain. The secondary outcomes were pain intensity and disability level. Analyses were performed using the Cox proportional hazard models.

Results: The 12-month incidences of neck pain in the active break and control groups were 17% and 45%, respectively. The 12-month incidences of low back pain in the active break and control groups were 9% and 37%, respectively. Hazard rate ratios after adjusting for biopsychosocial factors indicated a protective effect of the active break intervention for neck pain (HR_{adj}=0.44; 95%CI 0.20 to 0.97, p=0.04) and low back pain (HR_{adj}=0.32; 95%CI 0.11 to 0.95, p=0.039).

Conclusion: Interventions to increase active breaks both reduced onset of neck and low back pain in high-risk office workers.

Key words: Musculoskeletal disorders; Postures; Computers; Sedentary workers

7.1 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).

Scheduled rest breaks have been recommended to decrease musculoskeletal discomfort and pain during computer tasks (Barredo and Mahon, 2007; Sheahan et al., 2016). A recent systematic review of randomized controlled trials revealed moderate-quality evidence supporting a positive effect of active breaks with postural change on pain and discomfort (Waongenngarm et al., 2018). Thus, promotion of active breaks with postural change during sitting may be an effective intervention in the prevention of neck and low back pain.

No trial investigating the efficacy of active break intervention in the prevention of neck and low back pain among office workers has been reported. Thus, this study aimed to evaluate the effect of promotion of active breaks on the 12-

month incidence of neck and low back pain among high-risk office workers. We hypothesized that participants in the intervention groups with increases in rest breaks show the reduction of new onset of neck and low back pain.

7.2 Methods

Participants

A two-armed, parallel-group, cluster-randomized controlled trial with 12-month follow-up was conducted in a convenience sample of office workers recruited from 4 enterprises. The participating enterprises were three government offices and a private company importing medical equipment and products. The study was approved by the University Human Ethics Committee and was registered in the Thai Clinical Trials Registry (TCTR20190111002).

The inclusion criteria were individuals aged 23–55 years, working full-time, having body mass index (BMI) 18.5-25 kg/m2, having at least 5 years of experience in the current position, and at risk of nonspecific neck pain evaluated by the Neck Pain Risk Score for Office Workers (NROW; score ≥ 2) (Paksaichol et al., 2014) and nonspecific low back pain 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 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. If eligible, potential participants were informed about the objectives and details of the study and were asked to provide informed consent upon agreement to participate. At baseline, participants completed the self-administered questionnaire for exposure data, i.e. confounders. They were then asked to complete a baseline questionnaire and were randomly assigned at the cluster level into either the intervention or the control group. A researcher with no other involvement in the trial prepared the designation of intervention by using a computer-generated randomization software (www.randomizer.org) with an allocation ratio of 1:1, 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 the compliance within the intervention group (Andersen et al., 2008). A total of 4 clusters (two clusters for the intervention group 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, the intensity of neck or low back pain and disability arising from neck or low back pain. The researcher collected the diaries from participants every month over a 12-month period.

Questionnaires

The following biopsychosocial characteristics were collected, which including 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 of 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.

Intervention

Participants in the active break intervention group 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 duration, break duration and number of breaks. Data were stored in the processor, which were used to calculate active breaks each individual. Instructions to have active breaks were sent from the processor to the smartphone application via Bluetooth technology. 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 of having active breaks by the apparatus as much as possible.

In the active break group, participants were asked to have designated active breaks during the work days, and they were asked to get out of a chair when taking the breaks. The frequency and duration of break was based on the theoretical effect of rest breaks on 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 day, depending on their sitting behavior. Sitting behaviors of participants during the trial were collected every month during follow-up by using the custom-designed apparatus.

Each participant 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 both groups were asked to keep the level of their physical activity unchanged.

Outcome measure

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; Krismer and van Tulder, 2007), during the 12-month follow-up period was collected using a dairy. In this study, cases were defined as those who answered “Yes” to the question “Have you experienced any neck or low back pain lasting >24 hours in the past month?”, reported pain intensity >30 mm on a 100-mm visual analogue scale, and had no numbness or weakness in the upper or lower limbs. 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 researcher returned to collect the diaries from participants every month until completing the 12-month follow-up or withdrawing from the study.

Statistical analysis

The analysis followed an intention-to-treat approach. Comparisons of baseline characteristics of participants between intervention and control groups were conducted using independent t test for continuous data and chi-square test for nominal and ordinal data. The 12-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 12-month follow-up. Further follow-up data of those initially identified as case were not used any further.

Survival analysis was used to determine the Kaplan-Meier survival curves for the intervention and control groups. Survival time was taken as the time from the start to the incident symptoms becoming manifested. Those participants who left the study without manifesting the symptoms were censored 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. Gender, age, psychological scores, work from home condition, and number of working from home days per week were forced into all models to reduce confounding due to these factors. The other 40 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 included in the final, adjusted model.

Health outcomes, that is, pain intensity, disability and discomfort, between those reporting neck and low back pain in the intervention and control groups were compared using independent t test. Statistical significance was set at the 5% level. All statistical analyses were performed using SPSS for Windows Version 26.0 (SPSS Inc).

7.3 Results

The trial ran from June 2019 to September 2020. Of the total 1,000 workers who received the invitation, 360 responded (response rate, 36%). In total, 155 were eligible, 147 of whom agreed to participate in the study. Of those, 138 were successfully followed for twelve months and nine (7%) were lost during the follow-up period because they left the companies. The sample population comprised mainly females (76.2%) (Table 7.1). Their average age was 33.3 (5.6) years. Most of the participants (95%) had graduated with at least a bachelor’s degree. There was no significant difference in any of the characteristics of the participants between groups, except for age, BMI, education level, duration of employment, psychological job demand, and job security.

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. We explored working from home related risk factors for neck and low back pain among office workers during COVID-19 outbreak and found number of days working from home was associated with the incidence of neck and low back pain during COVID-19 outbreak periods. Therefore, working from home status and the number of days working from home would be forced to the Cox regression model as confounding factors

Table 7.1 Baseline characteristics of participants.

Characteristic	Mean (SD)		p value
	Intervention A (active break) group (n = 47)	Control group (n = 100)	
Demographic characteristics			
Age (years)	31.6 (6.1)	34.1 (5.3)	0.011*
Gender: female (%)	33 (70.2)	79 (79.0)	0.243
Body weight (kg)	57.3 (10.5)	56.4 (13.7)	0.208
Body height (cm)	163.0 (9.1)	161.4 (6.9)	0.376
Body mass index (kg/m2)	21.3 (2.3)	21.0 (2.0)	0.004*
Marital status (%)			0.222
Single	36 (76.6)	64 (64.0)	
Married	10 (21.3)	35 (35.0)	
Divorced	1 (2.1)	1 (1.0)	

Education (%)			0.001*
Lower than Bachelor's degree	2 (4.3)	5 (5.0)	
Bachelor's degree	40 (85.1)	53 (53.0)	
Higher than Bachelor's degree	5 (10.6)	42 (42.0)	
Exercise frequency in the past 12 months (%)			0.162
Never	6 (12.8)	22 (22.0)	
Occasionally	34 (72.3)	56 (56.0)	
Regularly	7 (14.9)	22 (22.0)	
Not sure	0 (0.0)	0 (0.0)	
Driving status (%)			0.052
No	37 (78.7)	53 (53.0)	
Yes	10 (21.3)	47 (47.0)	

Work-related characteristics			
Duration of employment (years)	6.9 (4.3)	9.1 (4.8)	0.011*
Working hours per day (hours per day)	8.0 (1.3)	7.8 (0.8)	0.225
Working days per week (days per week)	5.1 (0.3)	5.0 (0.2)	0.315
Psychosocial characteristics			
Job control	35.1 (4.5)	36.6 (4.3)	0.051
Psychological job demands	30.8 (4.4)	33.2 (4.4)	0.003*
Physical job demands	13.2 (2.7)	14.1 (2.6)	0.051
Job security	16.3 (1.3)	16.9 (1.1)	0.006*
Social support	33.1 (4.4)	32.9 (4.4)	0.735
Hazards at work	15.9 (3.9)	17.0 (3.9)	0.131

*p value < 0.05

Incidence of neck and low back pain

Over the 12-month follow-up, 17% (8/47) of participants in the active break group and 45% (45/100) of those in the control group reported incident neck pain. For low back pain, 9% (4/47) of participants in the active break group and 37% (37/100) 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 active break group and control group (log rank test probability = 0.002), (Figure 7.1 and 7.2). Participants in the control group had greater risk of neck and low back pain than those in the active break group.

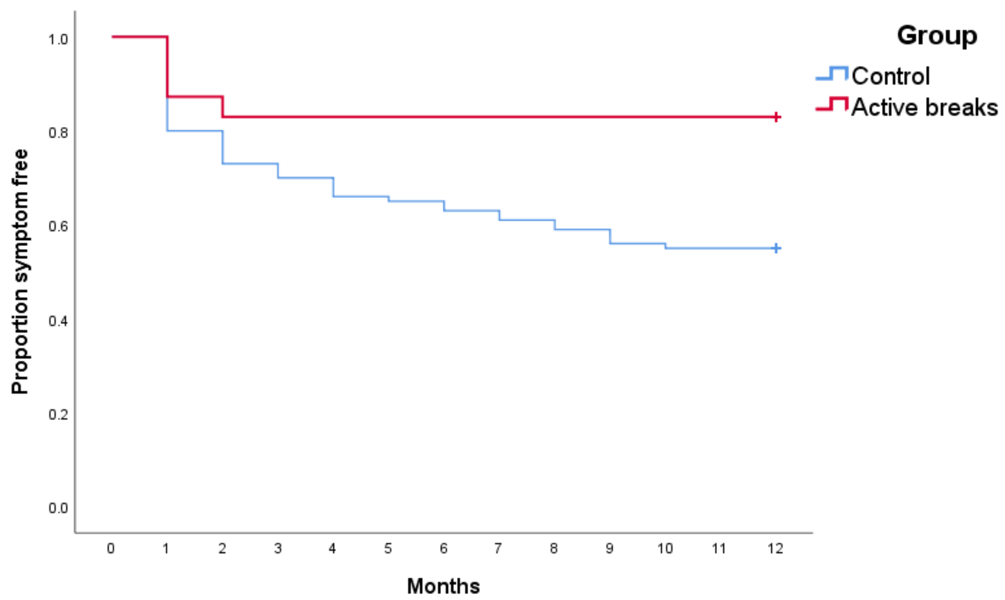

Figure 7.1 The Kaplan–Meier survival curves for onset of neck pain

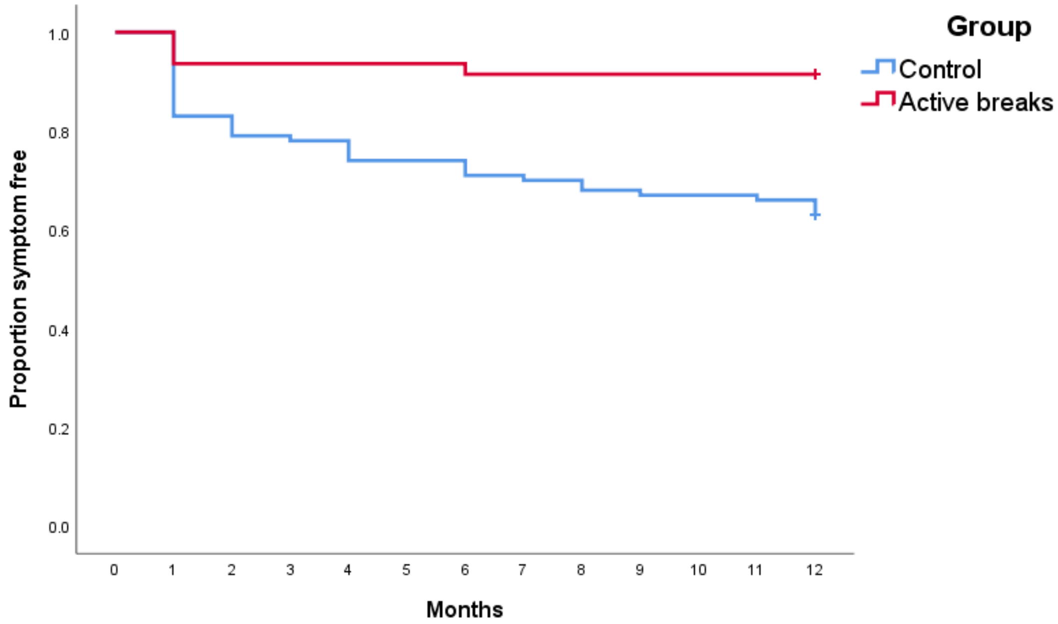

Figure 7.2 The Kaplan–Meier survival curves for onset of low back pain

Using the Cox proportional hazard model, after adjustment for age, gender, education level, duration of employment, psychosocial work characteristics, work from home status and number of working from home days per week, a protective effect of the active breaks was found for neck and low back pain. Active break intervention significantly reduced the risk of incident neck pain (HR_{adj}=0.44; 95%CI 0.20 to 0.97, p=0.041) and low back pain (HR_{adj}=0.32; 95%CI 0.11 to 0.95, p=0.039) (Table 7.2). The comparisons of pain intensity and disability level among the active break and control groups indicated no statistically significant difference.

Table 7.2 Unadjusted and adjusted HRs evaluating the effects of active breaks on incident neck and low back pain (n=147).

	Unadjusted HR (95% CI)	*p* value	Adjusted# HR (95% CI)	*p* value
Neck pain				
Group assignment				
Control group	1.00		1.00	
Intervention group	0.34 (0.16-0.73)	0.005*	0.44 (0.20-0.98)	0.041*
Back pain				
Group assignment				
Control group	1.00		1.00	
Intervention group	0.20 (0.07-0.57)	0.003*	0.32 (0.11-0.95)	0.039*

Variables; age, gender, education level, duration of employment, job control, psychological job demand, physical job demand, job security, social support, hazards at work, work from home status and number of working from home days per week

*p value < 0.05

7.4 Discussion

The efficacy of active break intervention to prevent nonspecific neck and low back pain among high-risk office workers was evaluated in this study. We found that the active break intervention reduced the 12-month incidence rate of neck and low back pain among high-risk office workers, who were identified using the Neck Pain Risk Score for Office Workers (NROW ≥ 2) (Paksaichol et al., 2014), and nonspecific low back pain evaluated by Back Pain Risk Score for Office Workers (BROW ≥ 53) (Janwantanakul et al., 2015). The 12-month incidence of neck and low back pain was reduced by 56-68% by the interventions. However, the active break intervention did not reduce pain intensity or disability level related to the neck and low back pain in those receiving the intervention and who, subsequently, experienced neck and low back pain.

Systematic reviews reported that rest breaks were an effective intervention to reduce pain and discomfort in various body regions (particularly in the low back area), which is secondary prevention for musculoskeletal disorders (Stock et al., 2018; Waongenngarm et al., 2018). Danquah et al. (Danquah et al., 2017) found a reduction in the prevalence of neck pain after their 3-month intervention among office workers, who received a Take a Stand! intervention aimed to reduce sitting time (OR_{adj}=0.52). They found, however, no change in low back pain. Moreover, Sihawong et al reported that an exercise program can reduce the 12-month incidence rate of neck and low back pain (HR_{adj}=0.45 for neck pain and 0.37 for low back pain) among office workers (Sihawong et al., 2014; Sihawong et al., 2014).

The results of this study showed that the incidence of neck and low back pain by 56% and 68% were reduced by active break intervention, respectively. Previous studies indicated that frequent rest breaks have been recommended to decrease musculoskeletal discomfort and pain during office works (Barredo and Mahon, 2007; Sheahan et al., 2016), and the type of rest break that were found to be effective in reducing pain and discomfort was active breaks with postural change (Waongenngarm et al., 2018). Active breaks with postural change require participants to change their posture during breaks such as standing from sitting, 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 in case of 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). Our results showed that average break duration of participants in the active break group was 3.1±1.7 minutes. Furthermore, the number of active breaks in the active break group of this study was 32.5±20.4 times per day. Previous study showed that frequent active breaks with postural change with break duration, ranging from 20 seconds to 5 minutes, have been proven to be beneficial in reducing pain, discomfort and fatigue in the neck and low back regions (McLean et al., 2001; Galinsky et al., 2007; Sheahan et al., 2016). Thus, our results suggest that frequent active breaks of short duration may be sufficient to prevent the onset of neck and low back pain among high-risk office workers.

In the present study, no significant differences were found in pain intensity, and 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 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.

Major strength of this study are 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 control group may have reduced the placebo or Hawthorne effect on the outcomes of this study. Several methodological limitations should be taken into consideration when interpreting the results of this study. First, some of baseline characteristics between intervention and control group were different. Because of using cluster randomization, participants are randomized as intact groups rather than as individuals. Small numbers of clusters (N=4) 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). Second, the present study was conducted in healthy office workers with 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 intervention on the incidence of neck and low back pain in normal office worker populations or other occupations is suggested. Third, we did not assess participants' sitting behavior at baseline. Therefore, we did not know whether the designated active breaks suggested by the apparatus for individuals in the intervention groups were higher or lower than their habitual daily sitting behavior. To validate the present findings, future study should examine the efficacy of active breaks to prevent neck and low back pain in those with poor habitual sitting behavior relative to the designated active breaks suggested by the apparatus. Last, assessments of biopsychosocial factors as well as the diagnosis of neck and low back pain were subjective, which poses the risk of the overestimation of exposure in some workers. Researchers should consider the inclusion of objective information from a physical examination to increase data accuracy in future studies.

In conclusion, a 12-month prospective, 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 intervention can effectively reduce incident neck and low back pain in high-risk office workers. However, active break intervention did not decrease pain intensity and disability in those receiving the intervention compared to the control group.

Authors' contributions

The authors have contributed in the following ways: PW provided the concept/research design, data collection, data analysis and manuscript writing. NA contributed to the concept/research design and data collection. AvdB 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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CHAPTER 8

General conclusion

8.1 Summary of the results

Firstly, the aim of this study was to develop the device to alert for breaks that had good validity and consistency to detect the sitting time and can promote the rest breaks during works. Thus, the author systematically reviewed randomized controlled trials to gain insight the effectiveness of breaks on low back pain, discomfort, and work productivity in office workers and to identify which types of breaks are effective for reducing pain and discomfort (Chapter 3). This review showed moderate-quality evidence was found for the positive effect of active breaks with postural change for pain and discomfort while had no detrimental effect on work productivity. The knowledge from a systematic review that active breaks with postural change may be an effective intervention to prevent neck and low back pain using to develop the device to alert for breaks.

Then, many ideas were concerned such as the technology to create the innovation, the processer and sensors which can detect the sitting time accurately, the interface of the smartphone application that is easy to use and user friendly, and the algorithm of rest breaks that effective in reducing pain and discomfort which leads to preventing neck and low back pain. Therefore, the author conducted a study to examine the characteristics of perceived discomfort during 4-hour of sitting

(Chapter 4). The results revealed that perceived discomfort in all body regions increased continuously during a 4-hour sitting period. The body regions with the highest perceived discomfort were the low back, buttocks, upper back, thigh, and neck. Our results showed that discomfort scores at the neck, upper back, and low back after 30 minutes of sitting were significantly higher than those at baseline, which possibly increase the risk of neck and low back pain. So, the minimum sitting duration for rest break protocol was 30 minutes, which would be used in the algorithm of a device to alert for breaks in the next study aimed to investigate the effect of active breaks on reducing the onset of neck and low back pain.

Next, the device to alert for breaks or "DynaSeat" was developed, which had 3 components (seat pad, controller, and HealthySit smart phone application). The DynaSeat was tested the concurrent validity, consistency and test run, which showed good to excellent validity and consistency. No problem was found during the use of device. Thus, on the June 2019, the author conducted a study to investigate the effects of the promotion of active breaks on the 12-month incidence of neck and low back pain in high-risk office workers. However, during the follow-up of aforementioned study (by the start of March 2020), the COVID-19 outbreak occurred in Thailand. The most affected areas were Bangkok and surrounding neighborhoods. In accordance with government regulations, many workplaces asked their employees to work from home. On July 2020, COVID-19 situation in Thailand improved and participants started to return to work at their offices again. At that time, the author collected data about work from home related risk factors, which use to conduct an additional study. This study aimed to examine whether the incidences of neck and low back pain were affected during the COVID-19 outbreak and to explore working from home related risk factors for neck and low back pain among office workers. The results of this study indicated that the person-year incidence rates of neck and low back pain during the COVID-19 period were lower than that for during the pre-COVID-19 period. Number of days working from home per week was positively associated with the 4-month incidence of neck and low back pain. Therefore, the working from home status and the number of working from home per week were forced to the final adjusted model for the Cox proportional hazard model in the 12-month follow-up data. Finally, for the effects of a device to alert for breaks study, our results suggest that DynaSeat or a device to alert for breaks can effectively reduce incident neck and low back pain in these office workers. The 6- and 12-month incidence of neck and low back pain was reduced by 56-68% by the interventions. These findings suggest that DynaSeat or interventions to increase active breaks with postural change can reduce onset of neck and low back pain in high-risk office workers.

8.2 Limitations of the study and suggestions for further study

In the first study (systematic review), First, the search strategy was limited only to full published reports in English. There is the possibility that language bias may have affected the results of the review. Second, almost two third of the included studies were conducted in laboratory settings and follow-up periods were relatively short, ranging from 48 minutes to 4 months. Therefore, generalization of the results from this review to real working situations or to the long-term effects of breaks should be made with caution. Third, the researchers summarized the results from studies with substantial heterogeneity in study characteristics. This may explain the observed variation in the results among the studies. Future research is required to indicate whether differences in these aspects affect the effectiveness of breaks on pain, discomfort, and work productivity.

In the second study, i.e. examination the characteristics of perceived discomfort and postural shifts at different magnitudes during a 4-hour sitting period and the association between perceived discomfort and number of postural shifts. Four methodological limitations are noteworthy. First, participants in this study were recruited by convenience sampling and having normal BMI, which restricts the external validity. Therefore, generalization of the findings from the present study to other working populations, in which also a proportion of overweight and obese workers, should be made with caution. Second, the design of the present study is cross-sectional, so that a causal relation between exposure and outcome cannot be established. Only the association between exposure and outcome was examined. Therefore, further studies with a prospective study design are required to validate our findings. Third, the perceived discomfort was subjective, possibly leading to data inaccuracy. Some workers may be more sensitive to somatic disturbance than others.

As a result, there is a risk of over- or under-reporting of the perceived discomfort score. Thus, further studies with objective assessment are recommended to increase data accuracy. Fourth, there is a chance that random data would have yielded two "statistically significant" results ($p < 0.05$), since we are presenting 44 correlations relevant to the study. However, we presented two significance levels now (i.e., $p < 0.05$ and $p < 0.01$) to prevent interpretation of random data yielding "significant" results. With $p < 0.01$, we expect random data to yield only 0.4 "significant" results. Still, the findings from the present study should be made with caution. Finally, the threshold value of 20% was set as an arbitrary threshold. We did not have any data to support this decision. However, we analyzed with other threshold values, and this value had the possibility to detect the highest postural shifts. Further research on the effect of postural shifts at the 20% and other thresholds on trunk muscle activity and tissue viability is recommended.

In the third study, i.e. evaluation the effects of the promotion of active breaks and postural shifts on the 6-month incidence of neck and low back pain in high-risk office workers. 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 with 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. Because of using 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.

In the fourth study, i.e. investigation the incidences of neck and low back pain were affected during the COVID-19 outbreak and to explore working from home related risk factors for neck and low back pain among office workers. Three main methodological limitations should be taken into consideration when interpreting the results of the present 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 incidence of neck and low back pain, when and where possible during disease outbreaks and lockdowns, in normal office workers or other occupations is suggested. Second, the findings of the present study should be taken as a preliminary result because the sample size was relatively small, increasing the likelihood of a type II error. Third, the association between work from home-related risk factors and musculoskeletal pain was based on cross-sectional data. Thus, it is not possible to establish the causal relationship between exposure and outcome. However, conducting a prospective study in the midst of a severe disease outbreak would be extremely difficult.

In the fifth study, i.e. evaluation the effects of the promotion of active breaks on the 12-month incidence of neck and low back pain in high-risk office workers. There are several methodological limitations should be taken into consideration. First, some of baseline characteristics among three group were different. Because of using cluster randomization, participants are randomized as intact groups rather than as individuals. Small numbers 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). Second, the present study was conducted in healthy office workers with 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. Third, we did not assess participants' sitting behavior at baseline. Therefore, we did not know whether the designated active breaks suggested by the apparatus for individuals in the intervention groups were higher or lower than their habitual daily sitting behavior. To validate the present findings, future study should examine the efficacy of active breaks to prevent neck and low back pain in those with poor habitual sitting behavior relative to the designated active breaks suggested by the apparatus. Last, assessments of biopsychosocial factors as well as the diagnosis of neck and low back pain were subjective, which poses the risk of the overestimation of exposure in some workers. Researchers should consider the inclusion of objective information from a physical examination to increase data accuracy in future studies.

8.3 Clinical implication

1. Our developed device that provided active breaks with postural change can be used as an intervention for preventing the neck and low back pain in office workers.

2. Prolonged sitting for longer than 30 minutes possibly increase the risk of neck and low back pain.

3. Balancing the days working from home and at office during a week may be effective in reducing the development of neck and low back pain during periods in which working from home is partly needed.

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APPENDICES

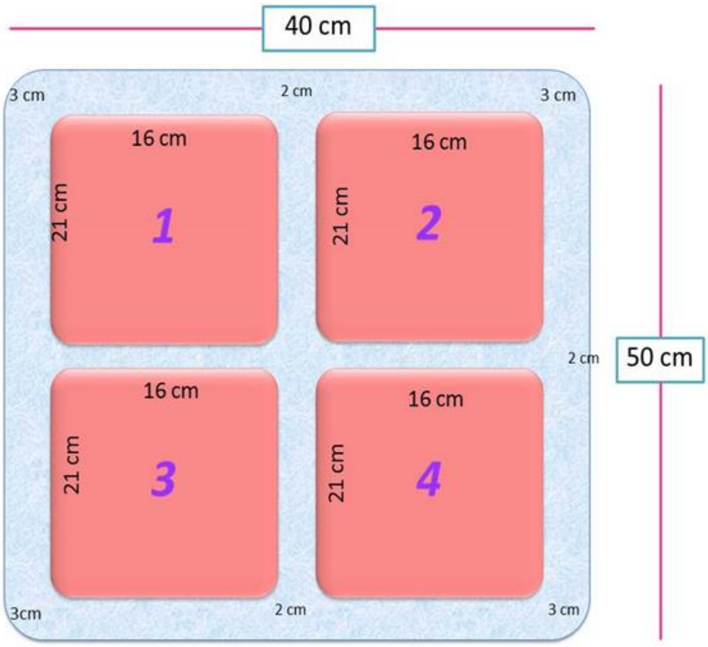
APPENDIX A

The development process of the device

The device to alert for break was developed by the team researcher, mechanical and computer engineers. This device can detect sitting time and recommend break duration 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.



Seat pad size

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 active breaks for each individual. Instructions to have active breaks were sent from the processor to the smartphone application via Bluetooth technology. The break algorithms were developed and were named DynaRest® program, which provided 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.

3) HealthySit smart phone application

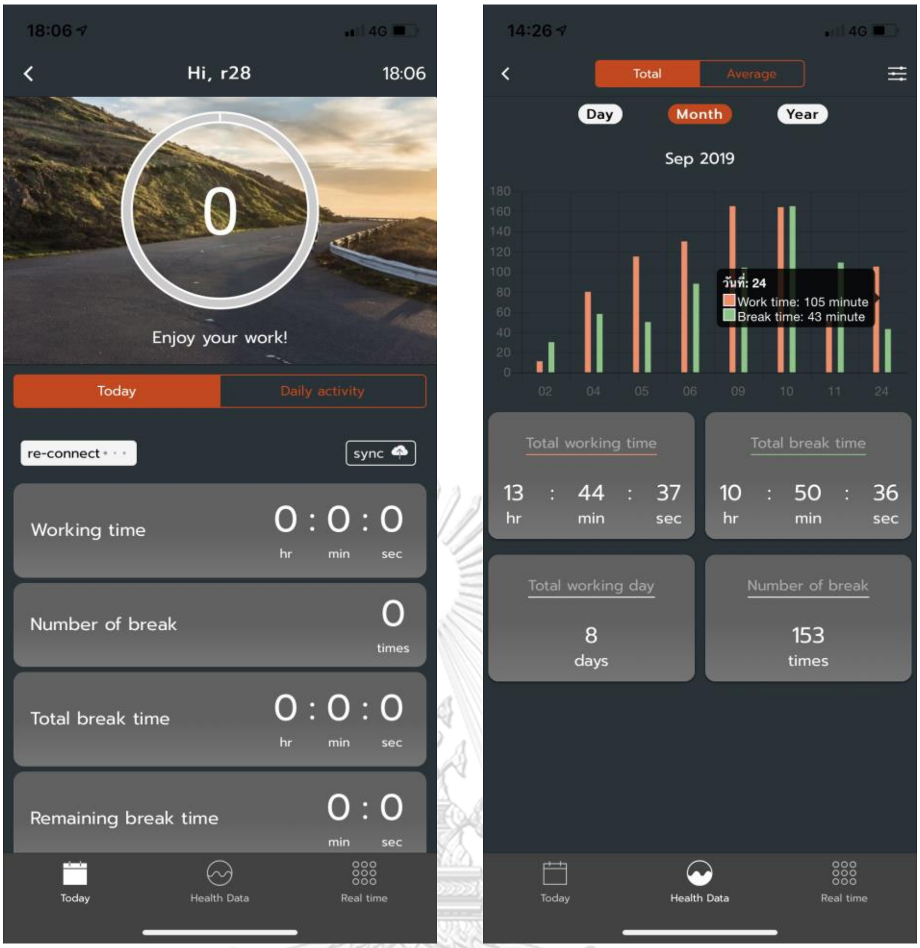
The smart phone application named HealthySit® was developed by a computer engineer. The application was installed in a smart phone with android or iOS systems. The HealthySit® application automatically connect to the controller when it comes in range. The HealthySit® application would remind a user to 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. Total break duration per day/week/month

3. Break duration in each time

4. Number of break per day/week/month



HealthySit® application

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

- **Validity**

The validity of a device to alert for breaks 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=0.97-1.00, $p<0.05$).

- **Consistency**

The consistency of a device to alert for breaks was conducted to ensure that the system produces consistent results. The consistency of a device to alert for breaks 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 device to alert for breaks in laboratory for 1 hour and were asked to follow the break program. 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 to alert for breaks 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 to alert for breaks for 1 hour and were asked to follow the break 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

  ส่วนที่ 1 ข้อมูลส่วนบุคคล

  ส่วนที่ 2 ข้อมูลเกี่ยวกับลักษณะงานประจำของคุณ

  ส่วนที่ 3 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

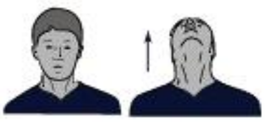
   [....] 3. เจ้าหน้าที่ธุรการ/สำนักงาน

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

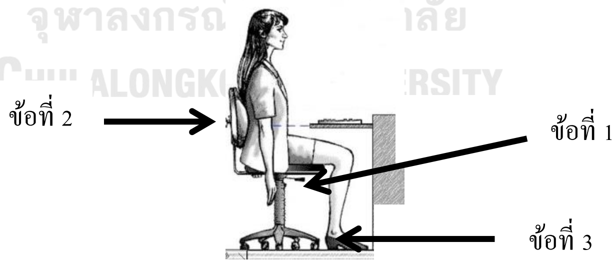
3. <u>ในรอบ 12 เดือนที่ผ่านมา</u> คุณทำงานในตำแหน่งดังกล่าวโดยเฉลี่ยวันละ...........ชั่วโมง เป็นจำนวน...............วันต่อสัปดาห์

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		

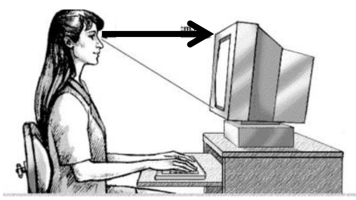
6. เงยหน้าบ่อยๆ 		
7. ก้มหน้าบ่อยๆ 		
8. หมุนคอ หรือหันหน้าไปด้านข้างบ่อยๆ 		
9. ก้มหลังบ่อยๆ เช่น ก้มหยิบของ เป็นต้น 		
10. เอี้ยวตัว หรือหมุนตัวบ่อยๆ เช่น เอี้ยวตัวหยิบของ เป็นต้น 		

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** คนที่ทำงานร่วมกับคุณไม่ว่าจะเป็นสามี 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 เสี่ยงต่อการถูกปล้น จี้ ทุบตี ยิง	☐	☐	☐
54. เสียงดัง	☐	☐	☐

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

APPENDIX D

Self-administered diary

AHS คณะสหเวชศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

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

รหัสผู้เข้าร่วมวิจัย...

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

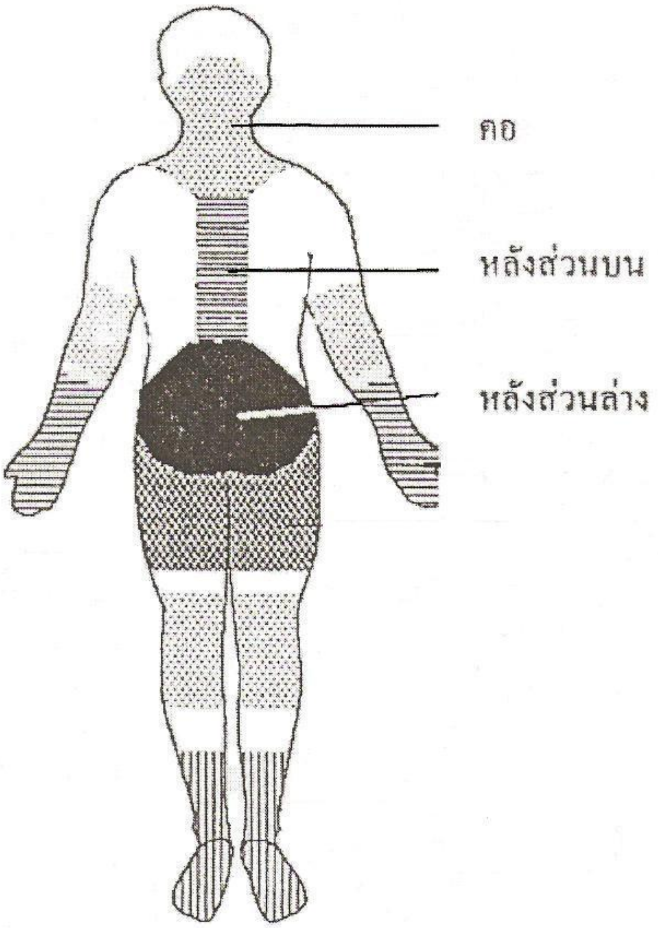
วันนัดส่งสมุดบันทึก ..../................../................

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 อาการปวด<u>คอ/บ่า</u> 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 ไม่มากไปกว่านั้

☐ 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 ○ 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

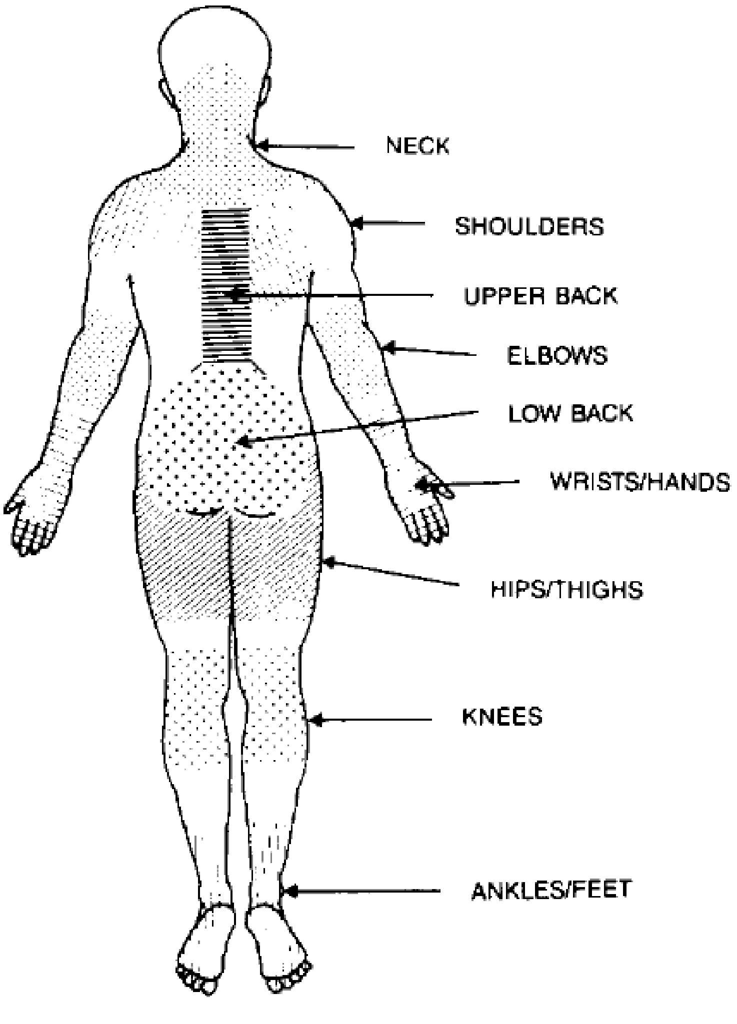
- รู้สึกไม่สบายมากที่สุด

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

APPENDIX I

Body chart

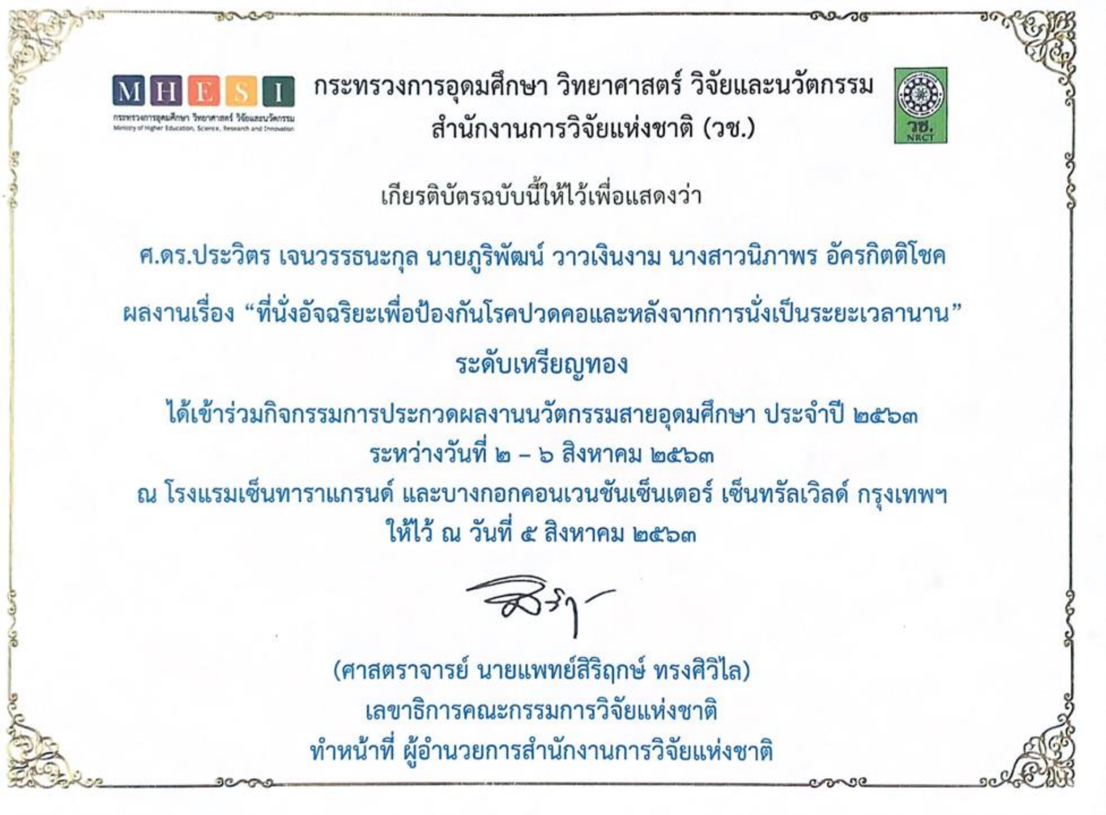
แผนภาพร่างกายใช้สำหรับการประเมินความรู้สึกไม่สบายของร่างกายร่วมกับ Borg CR-10



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

APPENDIX J

Research and innovation award


กระทรวงการอุดมศึกษา วิทยาศาสตร์ วิจัยและนวัตกรรม
สำนักงานการวิจัยแห่งชาติ (วช.)

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
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PUBLICATION	1. Waongenngarm, P., van der Beek, A.J., Akkarakittichoke, N., Janwantanakul, P., 2020. Perceived musculoskeletal discomfort and its association with postural shifts during 4-h prolonged sitting in office workers. Appl Ergon 89, 103225. 2. Sitthipornvorakul, E., Waongenngarm, P., Lohsoonthorn, V., Janwantanakul, P., 2020. Is the number of daily walking steps in sedentary workers affected by age, gender, body mass index, education, and overall energy expenditure? Work 66, 637-644. 3. Sitthipornvorakul, E., Sihawong, R., Waongenngarm, P., Janwantanakul, P., 2020. The effects of walking intervention on preventing neck pain in office workers: A randomized controlled trial. J Occup Health 62, e12106. 4. Waongenngarm, P., Areerak, K., Janwantanakul, P., 2018. The effects of breaks on low back pain, discomfort, and work productivity in office workers: A systematic review of randomized and non-randomized controlled trials. Appl Ergon 68, 230-239. 5. Waongenngarm, P., Rajaratnam, B.S., Janwantanakul, P., 2016. Internal Oblique and Transversus Abdominis Muscle Fatigue Induced by Slumped Sitting Posture after 1 Hour

of Sitting in Office Workers. Saf Health Work 7, 49-54.
6. Waongenngarm, P., Rajaratnam, B.S., Janwantanakul, P., 2015. Perceived body discomfort and trunk muscle activity in three prolonged sitting postures. J Phys Ther Sci 27, 2183-2187.

AWARD RECEIVED

1. การประกวดผลงานนวัตกรรมสายอุดมศึกษา ประจำปี พ.ศ. 2563 ได้รับรางวัลระดับดีมาก (ถ้วยทอง) จากสำนักงานการวิจัยแห่งชาติ (วช.) เมื่อวันที่ 5 สิงหาคม พ.ศ. 2563
2. การประกวดผลงานนวัตกรรมสายอุดมศึกษา ประจำปี พ.ศ. 2563 นำเสนอผลงานเรื่อง “ที่นั่งอัจฉริยะเพื่อป้องกันโรคปวดคอและหลังจากการนั่งเป็นระยะเวลานาน” ได้รับรางวัล ระดับเหรียญทอง จากกระทรวงการอุดมศึกษา วิทยาศาสตร์ วิจัยและนวัตกรรม สำนักงานการวิจัยแห่งชาติ (วช.) เมื่อวันที่ 2-6 สิงหาคม พ.ศ. 2563