EFFECTS OF ERGONOMIC INTERVENTION IN PRINTING OFFICE ON WORK–RELATED MUSCULOSKELETAL DISORDERS AND VISUAL FATIGUE

NUTTAPORN PRADITPOD

A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF SCIENCE
(PHYSICAL THERAPY)
FACULTY OF GRADUATE STUDIES
MAHIDOL UNIVERSITY
2009

COPYRIGHT OF MAHIDOL UNIVERSITY

Copyright by Mahidol University

Thesis
Entitled

EFFECTS OF ERGONOMIC INTERVENTION IN PRINTING OFFICE ON WORK-RELATED MUSCULOSKELETAL DISORDERS AND VISUAL FATIGUE

was submitted to the Faculty of Graduate Studies, Mahidol University
for the degree of Master of Science (Physical Therapy)
on
March 31, 2009

Nuttaporn Praditpod
Miss Nuttaporn Praditpod
Candidate

Lect. Sasitorn Taptagaporn,
Ph.D.
Chair

Lect. Keerin Mekhora,
Ph.D.
Member

Assoc. Prof. Chanut Akamanon,
M.A.
Member

Lect. Supalak Khemthong,
Ph.D.
Member

Prof. Banchong Mahaisavariya,
M.D.
Dean
Faculty of Graduate Studies
Mahidol University

Assoc. Prof. Roongtiwa Vachalathiti,
Ph.D.
Dean
Faculty of Physical Therapy and
Applied Movement Science
Mahidol University

Copyright by Mahidol University

Thesis
Entitled

EFFECTS OF ERGONOMIC INTERVENTION IN PRINTING OFFICE ON WORK-RELATED MUSCULOSKELETAL DISORDERS AND VISUAL FATIGUE

Nuttaporn Praditpod
Miss Nuttaporn Praditpod
Candidate

Keerin Mekhora
Lect. Keerin Mekhora,
Ph.D.
Major Advisor

K. Supalak
Lect. Supalak Khemthong,
Ph.D.
Co-advisor

B. Mahaisavariya
Prof. Banchong Mahaisavariya,
M.D.
Dean
Faculty of Graduate Studies
Mahidol University

Raweewan Lekskulchai
Asst. Prof. Raweewan Lekskulchai,
Ph.D.
Chair
Master of Physical Therapy Program
Faculty of Physical Therapy and
Applied Movement Science
Mahidol University

Copyright by Mahidol University

ACKNOWLEDGEMENTS

The success of this thesis could not have been completed without the following persons who provided valuable advice, guidance and extensive support.

I would like to express my sincere gratitude and deepest appreciation to Lecturer Keerin Mekhora (Ph.D.), my major advisor, for his excellent guideline, problem solving, invaluable suggestion, proofreading of this manuscript and encouragement throughout the study which made this thesis complete in appropriate time.

I am equally grateful and deepest appreciation to Lecturer Supalak Khemthong (Ph.D.), my co-advisor, for his worthy advice, valuable suggestion, proofreading of this manuscript and encouragement throughout the study.

Moreover, I would like to extremely thank Miss Nupporn Kurustien and Miss Praphatson Klangsin for their suggestion and great support.

I would like to give special thankfulness and deepest appreciation to my all research participants for their excellent cooperation. Especially, I would like to thank the printing office for permission to collect data and thank to safety officers of the printing office for generous assistance.

Thankfulness also goes to the staffs of the Faculty of Physical Therapy and Applied Movement Science, Mahidol University for their helpful assistance and cooperation.

I wish to thank all my friends, for their suggestion, helpful and kind support. Finally, I wish to express my gratefulness to my family for their love, understanding, warmest encouragement, assistance, and financial support throughout the study.

Nuttaporn Praditpod

Copyright by Mahidol University

EFFECTS OF ERGONOMIC INTERVENTION IN PRINTING OFFICE ON WORK–RELATED MUSCULOSKELETAL DISORDERS AND VISUAL FATIGUE

NUTTAPORN PRADITPOD 4936651 PTPT/M

M.Sc. (PHYSICAL THERAPY)

THESIS ADVISORY COMMITEE: KEERIN MEKHORA, Ph.D., SUPALAK KHEMTHONG, Ph.D.

ABSTRACT

This quasi-experimental study was aimed to study the effects of ergonomic intervention using micro-breaks and exercise on physical symptoms and visual fatigue in 131 workers who worked at a printing office.

The ergonomic intervention consisted of a five-minute break (work improvement) and specific exercise during the break (human improvement) which were provided for a one-month period. Physical examinations for Work-related Musculoskeletal Disorders (WMSDs) were performed twice before and after intervention. Visual fatigue was measured thrice; baseline (before working), pre-test (after working 2 hours before intervention), and post-test (after working 2 hours after intervention), using Critical Flicker Frequency (CFF) and Reaction Time (RT) test.

The results showed that symptoms of WMSDs and visual fatigue were improved after the intervention. The WMSD severity stage, pain scale, and the mean of CFF and RT values were also improved ($p<0.05$) while the work load remained the same.

Therefore, the ergonomic interventions could help reduce the symptoms of WMSDs and visual fatigue in printing workers. The ergonomic interventions should be applied in similar work tasks where WMSDs are presented.

KEY WORDS: WMSDs/ ERGONOMIC INTERVENTION/ CFF/ REACTION TIME

83 pages

Copyright by Mahidol University

ผลของการปรับปรุงทางการยศาสตร์ในพนักงานโรงพิมพ์ต่อความผิดปกติทางระบบกระดูกและกล้ามเนื้อที่เกี่ยวข้องกับการทำงานและความล้าทางการมองเห็น

EFFECTS OF ERGONOMIC INTERVENTION IN PRINTING OFFICE ON WORK-RELATED MUSCULOSKELETAL DISORDERS AND VISUAL FATIGUE

ณัฏฐพร ประดิษฐพจน์ 4936651 PTPT/M

วท.ม. (กายภาพบำบัด)

คณะกรรมการที่ปรึกษาวิทยานิพนธ์: คีรินท์ เมฆโหรา, Ph.D., ศุภลักษณ์ เข็มทอง, Ph.D.

บทคัดย่อ

การศึกษากึ่งการทดลองนี้มีจุดประสงค์เพื่อศึกษาผลของการปรับปรุงทางการยศาสตร์โดยใช้การพักช่วงสั้นและการออกกำลังกาย ต่ออาการแสดงของโรคทางกายและความล้าทางการมองเห็น ในพนักงานจำนวน 131 คน ซึ่งทำงานในโรงพิมพ์

การปรับปรุงทางการยศาสตร์ประกอบด้วยการพัก 5 นาที (การปรับปรุงงาน) และการออกกำลังกายแบบเฉพาะระหว่างพัก (การปรับปรุงคน) ถูกจัดให้เป็นเวลา 1 เดือน มีการตรวจร่างกายสำหรับความผิดปกติทางระบบกระดูกและกล้ามเนื้อที่เกี่ยวข้องกับการทำงาน 2 ครั้ง ในช่วงก่อนและหลังให้การปรับปรุง มีการวัดความล้าทางการมองเห็น 3 ครั้ง ในช่วงพื้นฐาน (ก่อนการทำงาน), ก่อนการทดสอบ (หลังการทำงาน 2 ชั่วโมง ก่อนได้รับการปรับปรุง) และหลังการทดสอบ (หลังการทำงาน 2 ชั่วโมง หลังได้รับการปรับปรุง) โดยใช้การทดสอบ Critical Flicker Frequency (CFF) และ Reaction Time (RT)

ผลการศึกษาแสดงให้เห็นว่าอาการความผิดปกติทางระบบกระดูกและกล้ามเนื้อที่เกี่ยวข้องกับการทำงานและความล้าทางการมองเห็นมีการเปลี่ยนแปลงในทางที่ดีขึ้นหลังได้รับการปรับปรุง ระยะความรุนแรงของโรคทางระบบกระดูกและกล้ามเนื้อที่เกี่ยวข้องกับการทำงาน ระดับความเจ็บปวด และค่าเฉลี่ยของ CFF และ RT ดีขึ้น ($p<0.05$) ในขณะที่ความหนักของงานยังคงเท่าเดิม

ดังนั้นการปรับปรุงทางการยศาสตร์สามารถช่วยลดอาการของความผิดปกติทางระบบกระดูกและกล้ามเนื้อที่เกี่ยวข้องกับการทำงานและความล้าทางการมองเห็นในพนักงานโรงพิมพ์ การปรับปรุงนี้ควรนำไปประยุกต์ใช้ในงานที่มีลักษณะคล้ายกัน ที่มีความผิดปกติทางระบบกระดูกและกล้ามเนื้อที่เกี่ยวข้องกับการทำงานเกิดขึ้น

83 หน้า

Copyright by Mahidol University

CONTENTS

		Page
ACKNOWLEDGEMENTS		**iii**
ABSTRACT		**iv**
LIST OF TABLES		**viii**
LIST OF FIGURES		**x**
LIST OF ABBREVIATIONS		**xi**
CHAPTER I	**INTRODUCTION**	**1**
	Purpose of the study	3
	Parameters of the study	3
	Scope of the study	4
	Hypothesis of the study	4
	Advantages of the study	4
CHAPTER II	**LITERATURE REVIEW**	**5**
	2.1 Work–related Musculoskeletal Disorders	5
	2.2 Factors Affecting WMSDs	11
	2.3 WMSDs in Workplace	12
	2.4 Management of WMSDs	12
	2.5 Visual Fatigue	13
	2.6 Factors Affecting Visual Fatigue	13
	2.7 Visual Fatigue in Workplace	14
	2.8 Ergonomic intervention to manage WMSDs and visual fatigue in Workplace	15
	2.9 Measurements	17
CHAPTER III	**MATERIALS AND METHODS**	**20**
	3.1 Study Design	20
	3.2 Participant	20
	3.3 Preliminary Fieldwork	21

Copyright by Mahidol University

CONTENTS (cont.)

		Page
CHAPTER III	**MATERIALS AND METHODS (cont.)**	
	3.4 Measurement Tools	24
	3.5 Procedure	27
	3.6 Data Analysis	30
CHAPTER IV	**RESULTS**	**31**
	4.1 Demographic Characteristics	31
	4.2 Physical Examination	32
	4.3 Critical Flicker Frequency (CFF) Data	39
	4.4 Reaction Time (RT) Data	43
	4.5 Amount of Workload	45
CHAPTER V	**DISCUSSION**	**46**
	5.1 Methodology	46
	5.2 Effect of Ergonomic Intervention on Reducing WMSDs	48
	5.3 Effect of Ergonomic Intervention on Reducing Fatigue	49
	5.4 Limitation of Study	52
	5.5 Suggestion for Further Study	52
CHAPTER VI	**CONCLUSION**	**54**
REFERENCES		**56**
APPENDIX		**62**
BIOGRAPHY		**83**

Copyright by Mahidol University

LIST OF TABLES

Table		Page
4.1	Demographic characteristics of the participants	31
4.2	The number report of WMSD symptoms	33
4.3	Musculoskeletal problems in nine parts of the body	33
4.4	The number report of neural tension	34
4.5	Physical examination findings of WMSDs in proof department	34
4.6	Physical examination findings of WMSDs in recycling department	35
4.7	Physical examination findings of WMSDs in total workers	35
4.8	Test Statistics of severity of WMSDs of workers in proof department	36
4.9	Test Statistics of severity of WMSDs of workers in recycling department	37
4.10	Test Statistics of severity of WMSDs of total workers	37
4.11	The CFF values among female and male workers in proof department	39
4.12	The CFF values among female and male workers in recycling department	40
4.13	The CFF values among female and male total workers	40
4.14	The statistical results of CFF values among female and male workers between baseline, pre-test and post-test	41
4.15	The RT values among female and male workers in proof and recycling department and total workers	43
4.16	The statistical results of RT values among female and male workers between baseline, pre-test and post-test	44
4.17	Amount of workload (%)	45
E.1	The data for test of CFF and RT intra rater reliability	76
E.2	Reliability of the short to long duration of Critical Flicker Frequency (CFF) test	76

Copyright by Mahidol University

LIST OF TABLES (cont.)

Table		Page
E.3	Reliability of the long to short duration of Critical Flicker Frequency (CFF) test	77
E.4	Reliability of Reaction Time (RT) test	77
F.1	WMSDs in nine parts of body	78
F.2	Neural tissue tension	82

Copyright by Mahidol University

LIST OF FIGURES

Figure		Page
2.1	A conceptual model of Armstrong	13
3.1	The workstation of a proof department (A = office desk, B = raised tray, C = inclined tray, and D = adjustable chair)	22
3.2	The workstation of a recycling department (A = 1st office desk, B = 2nd office desk, C = adjustable chair, and D = selective machine)	23
3.3	The critical flicker frequency apparatus	25
3.4	The critical flicker frequency test	25
3.5	The reaction time apparatus (A = electrical stimulation, B = stimulus, and C = response apparatus/micro-switch key)	26
3.6	The reaction time test	26
3.7	Procedure of the visual fatigue measurement	27
3.8	Flowchart of the procedural study	29
4.1	Graph and statistical results of severity of WMSDs between pre-test and post-test among female and male workers (A = Workers in proof department, B = Workers in recycling department, and C = Total workers)	38
4.2	Graph and statistical results of the long to short and short to long durations of CFF tests between baseline, pre-test and post-test among female and male workers (A = Workers in proof department, B = Workers in recycling department, and C = Total workers)	42
4.3	Graph and statistical result of RT values between baseline, pre-test and post-test among female and male workers (A = Workers in proof department, B = Workers in recycling department, and C = Total workers)	44

Copyright by Mahidol University

LIST OF ABBREVIATIONS

WMSDs	=	Work-related musculoskeletal disorders
OSHA	=	Occupational Safety and Health Administration
AET	=	Active ergonomic training
WISE	=	Work improvement in small enterprises
VDT	=	Visual display terminal
CFF	=	Critical flicker frequency
RT	=	Reaction time
MSDs	=	Musculoskeletal disorders
WRULDs	=	Work-related upper limb disorders
CTDs	=	Cumulative trauma disorders
RSI	=	Repetitive strain injury
VDU	=	Visual display unit
ADI	=	After develop inspection
AEI	=	After etching inspection
LCD	=	Liquid crystal display
cm	=	centimeter
kg	=	kilogram
ms	=	millisecond
m	=	meter
no.	=	number

Copyright by Mahidol University

CHAPTER I
INTRODUCTION

Work-related musculoskeletal disorders (WMSDs) are increasingly found in many industrial workers as well as printing workers. The WMSDs, such as clinical symptoms and visual fatigue, are impacting on human and work performance (1-3). In Thailand, the number of factories has increased from 120,145 factories in 2004 to 126,804 factories in 2007 (4, 5). This growing is certainly come along with the increased number of industrial workers, who have an opportunity to expose to risk factors for WMSDs with increasing rate of claims and injuries. In the United States, the Occupational Safety and Health Administration (6) indicated that musculoskeletal disorders account for one-third of the 1.7 million occupational injuries and illnesses every year. Moreover, the workers have experience musculoskeletal disorders causing them to be absent from the workplace. More than $45 to $60 billion in workers' indirect costs was paid for WMSDs. The average cost per claim for upper extremity and lower back musculoskeletal disorders is approximately twice that of the average non-musculoskeletal disorder workers' compensation claim (6, 7).

There are many risk factors that lead to the increase of incidence of WMSDs. Many factors affecting WMSDs were defined as individual, physical ergonomic and psychosocial factors. Individual factors are often beyond the control of workers such as age, gender, and anthropometrics. Physical ergonomic factors are work that results in a biomechanical stress on workers such as force, repetitive movement. Psychosocial factors are included job dissatisfaction, intensified workload, limited job control etc (8, 9).

The impact factors of WMSDs could be prevented and reduced by ergonomic interventions. A three-tier hierarchy of controls is widely accepted as an intervention strategy for controlling WMSDs risk factors. This includes engineering

Copyright by Mahidol University

controls, administrative controls, and personal equipment. Engineering controls that preferred approach to prevent and control WMSDs is to design the job including work station design, tool selection and design, and work task design. Administrative controls include changes in job rules and procedures such as scheduling more breaks to allow for rest and recovery, job rotation, and education for workers to recognize WMSDs risk factors and to learn techniques for reducing the stress and strain while performing their work tasks. Lastly, personal equipment, such as wrist supports or back belt, is partly supported to help reduce WMSDs (10).

The three-tier hierarchy of controls as interventions have shown some benefits to many industrial workers; for instance, a reduction of WMSDs' symptoms leading to both qualitative and quantitative improvement of industrial products (11-17). An example of ergonomic intervention can be drawn from computer users. An active ergonomic training (AET) in computer users was used as ergonomic intervention by training for six hours at the workplace for all subjects. The results showed that the subjects had less upper back pain intensity, pain frequency, and pain duration. Moreover, after receiving AET, the risk factor exposure was reduced and knowledge was increased (15). There are some studies that used the work improvement in small enterprises (WISE) technique to improve work places and workers in the small industries. Not only can the technique help improve the industries' quality and quantity of products, but also reduce the symptoms of WMSDs in the workers (11, 12). There is a study using a participatory ergonomics process to reduce the risk factors related to musculoskeletal disorders in the newspaper industry. It was found that the participatory ergonomics can be used to implement the ergonomic solution which can reduce the risk factors related to musculoskeletal disorders (17). In addition, the ergonomic interventions such as using training program to evaluate and adjust own workstation, could individually reduce the compensation costs, paid for the video display terminal (VDT) users with WMSDs, from $15,141 to $1,553 (16).

These examples of the ergonomic interventions may be applied to other similar workers such as printing workers to gain positive outcomes. However, with the complexity of printing processes and the diversity of product types, the repetitive

Copyright by Mahidol University

movement and manual visual inspection are an important task to ensure product quality. This may be different from other work tasks. The prolonged repetitive movement included inspection to search for defects tends to cause WMSDs and eye fatigue problem. Workers may have increased the physical symptoms of WMSDs and decreased physical, psychomotor, and work performances. However, research involving ergonomic interventions in printing workers is scanty, especially related to visual fatigue. Therefore, this study had an interest in examining effects of an ergonomic intervention on the physical symptoms of WMSDs (i.e. pain scale, WMSDs severity stage, and neural dynamic test) and visual fatigue in printing workers.

Purpose of the study

General objective

This study was to examine the effects of the ergonomic intervention on the clinical symptoms of WMSDs (i.e. pain scale, WMSD severity stage, and neural dynamic test) and visual fatigue in the printing workers.

Specific objectives

1. To examine the effects of the ergonomic intervention on the clinical symptoms of WMSDs (i.e. pain scale, WMSD severity stage, and neural dynamic test),
2. To examine the effects of the ergonomic intervention on visual fatigue (i.e. Critical Flicker Frequency (CFF) and Reaction Time (RT))

Parameters of the study

1. The clinical symptoms of WMSDs (i.e. pain scale, WMSD severity stage, and neural dynamic test) reported on nine body parts such as neck, shoulder, elbow, wrist/hand, upper back, lower back, hip/thigh, knee, and ankle/foot.
2. The visual fatigue measurement (i.e. CFF and RT)

Copyright by Mahidol University

Scope of the study

This study examined the effects of the ergonomic intervention on above parameters in the printing workers, who had been employed in a proof and recycling department at the Production Department, the Printing Office. This study provided the ergonomic intervention based on an agreement between the printing office and the researcher, which was accomplished within a period of the study.

Hypothesis of the study

1. The clinical symptoms of WMSDs (i.e. pain scale, WMSD severity stage, and neural dynamic test) would be different between before and after the ergonomics intervention commenced.
2. The visual fatigue would be different between before and after the ergonomic intervention commenced.

Advantages of the study

The knowledge gained in this study confirmed positive effects of the ergonomic intervention. The intervention could be used to improve quality of work performance, to reduce or prevent the physical symptoms of WMSDs and visual fatigue. Importantly, the workers in the printing office would save amount of medical payment. The intervention had a strong efficacy to be implied to another section of the printing office or working areas.

Copyright by Mahidol University

CHAPTER II
LITERATURE REVIEW

2.1 Work–related Musculoskeletal Disorders

Musculoskeletal disorders (MSDs) due to work are one of the most single work-related illness and problem which can be prevented or reduced by following existing health and safety regulations or guidance on good practice. WMSDs are common and occur in nearly all sectors of our economy. WMSDs have frequently affected to the hand and wrist regions. There are some reports that work-related neck and upper limb musculoskeletal disorders (WRULDs) are one of the most common work-related ailment affecting millions of European workers across employees in every type of workplace. The Bureau of Labor statistics have seriously reported about 600,000 WMSDs per year by general industry employers. Moreover, these disorders are one-third of all workers' compensation cost to employers and account for 34% of all reported injuries and illnesses (18-20).

2.1.1 Definition of WMSDs

WMSDs are injuries to the musculoskeletal system that develop gradually as a result of reported microtrauma due to poor design and the excessive use of hand tools and other equipment. In addition, WMSDs are MSDs caused or made worse by chronic (or long term) overuse or misuse of muscles, tendons, ligaments, joints, cartilage, or spinal discs during work which used by the Occupational Safety and Health Administration (OSHA) (20-23). They represent a wide range of disorders affecting muscles, joints, tendons, ligaments, bone and their related structures, as well as nerves and the localized blood circulation system (24). There are many types of MSDs including (20, 22, 23, 25): Common tendon-related MSDs, some of these are tenosynovitis, tendonitis (e.g. trigger finger, De Quervain's disease), ganglionic cyst, epicondylitis (lateral epiconclylitis/tennis elbow, medial epicondylitis/golfer's elbow), rotator cuff tendonitis, bursitis. Common nerve

Copyright by Mahidol University

and blood vessel-related MSDs, some of these are carpal tunnel syndrome, thoracic outlet syndrome, vibration syndrome (white finger/Raynaud's disease), Guyon's Tunnel syndrome, pronator teres syndrome, radial tunnel syndrome and etc.

WMSDs can cause severe and debilitating syndromes such as pain, numbness, tingling sensation, discomfort, swelling in the joint, tenderness, crepitus, pins and needles feeling, decreased mobility or grip strength, muscle weakness, muscle spasm, and a change in skin color in the hand or finger (20, 23, 24). They may take a long period of time to develop the symptoms. In addition, they can be reduced worker productivity, lost time from work, temporary or permanent disability, inability to perform job tasks, and increase in workers compensation costs which become affecting ability to the performance of task (20).

2.1.2 Terminology of WMSDs

WMSDs have many different terms that have been used to describe the observed events. Other names for WMSDs include the syndrome has also been called over-use injury, cervicobrachial disorder, cumulative trauma injury/cumulative trauma disorders (CTDs) , repetitive strain injury (RSI), repetitive motion injury, rheumatic disease, and osteoarthrosis (20, 22, 23, 26, 27).

2.1.3 Types of WMSDs

WMSDs frequently occur in hand-wrist-forearm, shoulder, neck, and back region (18, 20, 22). There are many clinical syndromes that related to WMSDs, for examples:

Carpal Tunnel Syndrome: It is the most famous repetitive strain injury. This is the result of compression and neuropathy of the median nerve inside of the carpal tunnel of the wrist by swollen tendons in the wrist. Swelling of the tendon sheath reduces the opening of the tunnel and pinches the median nerve and blood vessels. Symptoms of the carpal tunnel syndrome include pain, numbness and tingling of the hand that are innervated by the median nerve. The affected areas are, on the palmar side, thumb, index finger, middle finger and the ring finger (with the

Copyright by Mahidol University

exclusion of the side towards the little finger), and most of the palm. On the dorsal side the ulnar side of the thumb, and the upper distal two-thirds of index, middle and ring fingers (with the exclusion of the side towards the little finger) are affected. It is caused by repeated bending of the wrist, holding tools or material tightly, or constantly pressing the wrist against a hard object which the opening is also reduced, thus compressing the nerve (20, 22, 23, 25, 27).

Trigger finger: The tendon sheath of a finger is so swollen that forms a nodule and/or thickening of the pulley ligament locked, movement of the tendon is not smooth but in a snapping and jerking manner. Symptoms of trigger finger or thumb include pain and a clicking sensation when the finger or thumb is bent. Tenderness usually occurs over the area of the nodule – at the bottom of the finger or thumb. It is caused by using hand tools that have sharp hard edges or whose handles are too far apart for the user's hand so that the end segments of the fingers are flexed and the middle segments are straight. In addition, partial tendon lacerations, repeated trauma from pistol gripped power tools, or long hours grasping a steering wheel can cause triggering (20, 22, 25).

De Quervain's disease: This occurs in the abductor and extensor tendons of the thumb inside synovial sheaths. The sheath produces excessive synovial fluid which accumulates, and the sheath becomes swollen and painful. If the tendon surfaces become irritated, rough and bumpy, and the inflamed sheaths press progressively on the tendon, Symptoms of De Quervain's disease include pain on the side of the wrist and forearm just above the thumb from the two tendons. Soreness on the thumb side of the forearm, pain may spread up the forearm or down into the wrist and thumb. Due to an increase in friction, the two tendons may actually begin to squeak as they attempt to move through the constricted tunnel which is called crepitus (20, 22, 25).

Raynaud's disease: It is also known as hand-arm vibration syndrome or white finger disease. This is the result of vibrations of the body, particularly the finger-hand system that result in reduction of the diameter of arteries,

Copyright by Mahidol University

even in their complete closure. Thus, it becomes visible by blanching of the area. The symptoms can be aggravated by exposing to cold temperature because it can trigger vasospasm in the finger. Symptoms of Raynaud's disease include intermittent or continued numbness and tingling in the fingers, with the skin turning pale and cold, and eventually loss of sensation and control in the fingers. It is caused by the use of vibrating hand tool like pneumatic hammers, chainsaw, power grinders and power polishers (20, 22, 25).

Thoracic Outlet syndrome: This is the result of compression of the neurovascular bundle between the neck and shoulder. Vascular compression hence produces ischemia which particularly limits the possible duration of muscular actions and the recovery of muscles after such activities. Symptoms of thoracic outlet syndrome include pain, weakness, numbness and tingling, swelling, fatigue or coldness in the arm and hand. It is caused by repetitive activities that require the arms to be held overhead or extended forward (20, 22, 25, 27).

Guyon's tunnel syndrome: It is similar to carpal tunnel syndrome but less common and more superficial than carpal tunnel syndrome. This is results from entrapment of the ulnar nerve which passes through the Guyon tunnel in the wrist. It is caused by prolonged flexion and extension of the wrist and repeated pressure on the base of the palm (22).

Ganglionic cyst: This is results from swelling of tendon sheath that is filled with synovial fluid, or cyst on the tendon sheath or a joint membrane. Symptoms of ganglionic cyst include swollen up of the affected area, bump under the skin and frequently occur on the dorsal or radial side of the wrist (22, 25).

Lateral Epicodylitis: It is known as tennis elbow. This is tendonitis of the extensor carpi radial brevis muscle which attaches to the lateral epicondyle the hummers. The symptoms of tennis elbow include tenderness and pain that are common on the outer side of the elbow. It can radiated pain from the elbow down the forearm. It is caused by strong gripping with the elbow in an extended

Copyright by Mahidol University

position, impacting or jerky throwing motions, repeated supination and pronation of the forearm, and forceful wrist extension movements (20, 22, 25, 27).

Medial Epicondylitis: It is known as golfer's elbow. This is the results of irritation of the tendon attachments or the finger flexor muscles on the inside of the elbow. The symptoms of golfer's elbow include tenderness and pain at the medial epicondyle made worse by bending the wrist. The pain may spread down the forearm. It is caused by use the flexor muscles in a bending motion on grasping with the hand and using of hand tools continuously (20, 22, 25, 27).

Rotator cuff tendonitis: This is inflammation of the shoulder tendons that rotate the arm inward/outward. It is caused by the elbow kept in an elevated position, or with other activities that strain the shoulder tendons and bursa like reaching or lifting (22, 25).

Bursitis: This is inflammation of the bursa (small, fluid – filled sacs) in the elbow, shoulder or knee and often – used tendon, particularly if it has become roughened, may irritate its adjacent bursa, setting up an inflammatory reaction because of bursa's action. Bursa prevents rubbing between tendons and bone by providing a slippery cushion (22, 25).

Tension neck syndrome: This disorder is often found in the groups of neck muscles. It is caused by repeated or sustained overhead work, when the neck is kept in a forward – bent positive, or when heavy objects are carried (22).

Pronator teres syndrome: This is the result of compressing the median nerve where it passes through the two heads of the pronator teres in the forearm. It is caused by rapid and forceful pronation of the forearm with wrist flexion (22).

Radial tunnel syndrome: This is results from thickening of the supinator muscle that affected to the median nerve by compressing. It is caused by

Copyright by Mahidol University

repetitive rotation of forearm, repetitive wrist flexion with pronation, or wrist extension with supination (22).

Low Back Pain: This is results from poor posture of back movements. It can occur after repeated or incorrect lifting, pushing, pulling, twisting, bending, stooping, or reaching (20).

2.1.4 The Staging Symptoms of WMSDs

The symptoms of WMSDs can occur during or after work. They may be mild or can be so intense that they interfere with the performance of everyday tasks. WMSDs are progressive symptoms which their onsets can be generally characterized into three stages (22, 28, 29) as follows:

The first stage shows symptoms of aching and tenderness persist only during activity or working hour and settle at rest or overnight. This stage may last weeks or months, but is reversible and usually no reduction in work performance. Moreover, physical signs are minimal (22, 28, 29).

The second stage shows symptoms that start earlier in the working day and persist longer at night which may disturb sleep. Symptoms include recurrent pain, aching and tiredness which do not settle at rest or overnight. The capacity to perform the repetitive work reduced. Moreover, physical signs present such as swelling of tendon areas (22, 28, 29).

The third stage shows symptoms persist at rest. Symptoms include pain, aching, weakness and fatigue occurs with non-repetitive movements. Sleep is often disturbed, and the sufferer may be unable to carry out event light tasks at home or work and experiences difficulties in other tasks. This stage may last for months or years. Sometimes it is irreversible and affected to the part that is never regained. Thus, physical signs are significant (22, 28, 29).

Copyright by Mahidol University

2.2 Factors Affecting WMSDs

There are several work-related risk factors reported to be associated with the increased prevalence of WMSDs. However, the causal relationships between WMSDs and occupationally related factors remain the subject of considerable debate. WMSDs which reported in the workplace have a multi-factorial etiology with individual, physical ergonomic and psychosocial factors as contributing factors. There is strong evidence for an association between work factors and WMSDs. The exposure to multiple risk factors has an increased likelihood of developing WMSDs (19). The risk factors are the following:

Individual factors are often beyond the control of the employer. They are included age, gender, strength, smoking habit, anthropometric characteristics, physical activity (i.e. activities in the home, sports), and other recreational activities (8, 9, 11).

Many studies have found that WMSDs are more common among women than men because of the difference of occupational activities between men and women. Women are likely to have job requiring repetitive movement. In addition, household chores are still performed primarily by women, who consequently have less time to recover from the stresses associated with their works. The workstations are usually designed with male anthropometric characteristics, so that their sizes are often inappropriate for women. Moreover, the lesser mean muscle strength in women is associated with greater vulnerability to biomechanical stress (8).

Physical ergonomic factors are consistently found in workers with WMSDs that lead to profound changes in the biomechanical stresses to workers who are exposed such as force, repetitive motion and work duration (8). Jensen et al attempted to identify risk factors for musculoskeletal symptoms in the neck and hand-wrist regions among employees using computers at work. They found that limiting computer use to less than three-fourths of the work time would help to prevent hand-wrist symptoms (30). Psychosocial factors are included job dissatisfaction, intensified workload, monotonous work, limited job control, role ambiguity, and limited social support from supervisors and co-workers (9).

Copyright by Mahidol University

2.3 WMSDs in Workplace

There is reported that WMSDs could be occurred in the workplace such as computer users, call center, nurse, mining, agriculture, forestry, and fishing (26, 31, 32). Many studies indicated that VDT operators tend to have a high incidence of musculoskeletal problems, visual fatigue, and job stress (31, 32).

Iwakiri et al examined the association between VDT use and visual and musculoskeletal symptoms. The result showed that prevalence of eye strain and/or pain (72.1%) was the highest, followed by neck stiffness and/or pain (59.3%), low back stiffness and/or pain (30.0%) and hand or arm strain and/or pain (13.9%) (1).

2.4 Management of WMSDs

WMSDs continue to be an problem for individuals, organizations and researchers in terms of disability, productivity losses (33). A three-tier hierarchy of controls is widely accepted as an intervention strategy for controlling WMSDs risk factors. This includes engineering controls, administrative controls, and personal equipment. Engineering controls that preferred approach to prevent and control WMSDs is to design the job including work station design, tool selection and design, and work task design. Administrative controls include changes in job rules and procedures such as scheduling more breaks to allow for rest and recovery, job rotation, and education for workers to recognize WMSDs risk factors and to learn techniques for reducing the stress and strain while performing their work tasks. Lastly, personal equipment, such as wrist supports or back belt, is partly supported to help reduce WMSDs (10).

Moreover, Armstrong et al (34) described possible pathways that involved in development of WMSDs. Armstrong model (Figure 2.1) is useful for describing the cumulative nature of disorders. Worker activity produces inter forces acting on body (termed a dose). The dose causes a response by the body tissue such as local muscle fatigue and other various responses of a physiological and biomechanical nature. The response may increase or decrease the ability to cope with further responses. If there is

Copyright by Mahidol University

sufficient time to allow regeneration of body tissue capacity then a series of responses may further reduce capacity.

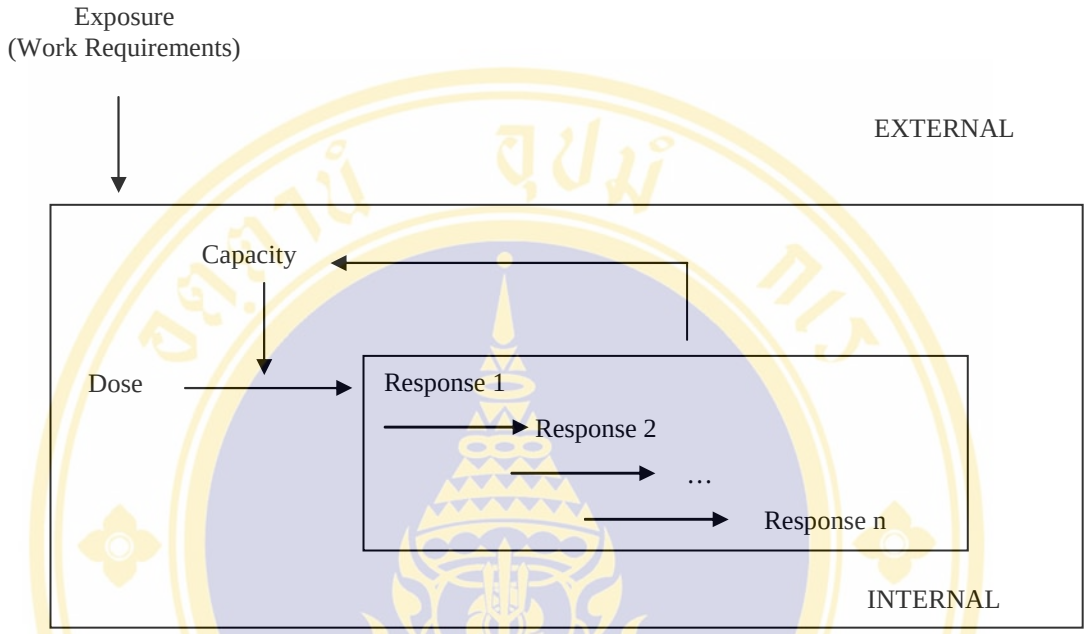


Figure 2.1 A conceptual model of Armstrong (34).

2.5 Visual Fatigue

The early literature is full of attempts to arrive at an acceptable definition of visual fatigue. Symptom of asthenopia can be grouped into ocular symptoms such as discomfort of the eyes and feeling that the eyes are tired, itchy, dry and burning. Visual symptoms are such as difficulty in focusing and blurred vision. Finally, systemic symptoms reflected in reported of headache, postural fatigue and general tiredness. Visual fatigue does not occur instantaneously but involves being subjected to the same visual task conditions over a period of time during the course of which the fatigue tends to occur. If the subject suffers from some visual defect such as uncorrected refractory errors, the time course may be rapid (35).

2.6 Factors Affecting Visual Fatigue

There are many factors that may play a role in the production of reports of visual fatigue; the present survey focuses upon visual aspects of visual display unit (VDU) use are included such as (36),

Copyright by Mahidol University

Duration of VDU use is the most factors that affected to visual fatigue. That is, the time spent on a VDU task increase more than 1 hour which result in the increase of visual fatigue.

Viewing distance, the distance between the user's eyes and the VDU (i.e., "viewing distance") is a robust treatment variable in studies reporting visual fatigue symptoms. When the viewing distance increased every 1 centimeter, the visual fatigue might be decreased. Color of the VDU characters and background, the study found that the computer users who use a color VDU had visual fatigue more than use in a green on black or white on black VDU.

Workstation variables such as glare, lighting conditions, and character legibility show a relationship with the reporting of subjective visual fatigue symptoms. An inability to see the characters displayed on a VDU prompts the user to increase visual attention, which may lead to an increase in reports of visual fatigue. Inadequate light at the workstation is a physical feature of the workspace that relates highly to reports of visual fatigue symptoms

Moreover, user demographic variables found in studies that report subjective visual fatigue resulting from VDU use include such items as the subject's level of education, years of work experience, marital status, age, and gender.

2.7 Visual Fatigue in Workplace

Many researches studied in the visual fatigue. Murata et al assess central nervous system effects and visual fatigue induced by work with visual display terminals (VDT). They found that these data suggest that VDT work is associated with impairment of the visual nervous system function (37). Moreover, Iwakiri et al found the prevalence of eye strain and/or pain (72.1%) was the highest in VDT user (1).

There is study in overseas flight of Japanese government aircraft. It reported the changes of CFF during three overseas practice flights, which are round trips, from Japan to Africa, to Europe and North America, and to Europe (38).

Copyright by Mahidol University

Moreover, in wafer factory, after develop inspection (ADI) and after etching inspection (AEI) inspectors frequently complain about visual fatigue problems. They focused on evaluating the effects of display mode, search pattern, and inspection strategy on visual fatigue and inspection performance (2).

2.8 Ergonomic intervention to manage WMSDs and visual fatigue in Workplace

Many researches supported the positive effect of ergonomic intervention on WMSD (11, 31, 39-43). Klangsin found that the WISE technique could reduce the severity of WMSD (11). Moreover, Fenety found the effect of short term use of workstation exercises. Although, the workstation exercises did not eliminate discomfort, but they curbed the rapid growth of discomfort over time (40). In addition, McLean et al examined the benefit of micro breaks. The study revealed that micro breaks had a positive effect to reduce discomfort (41). Amick et al examine the effect of office ergonomics intervention in reducing musculoskeletal symptom growth over the workday and, secondarily, pain levels throughout the day. They found that workers who received a highly adjustable chair and office ergonomics training had reduced symptom growth over the workday (44).

Balci and Aghazadeh in 2003 evaluated the work-rest schedules for VDT operators considering data entry and mental arithmetic tasks. The schedules are divided into 60-minute work/10-minute rest, 30-minute work/5-minute rest, and 15-minute work/micro breaks. They found that 30-minute work/5-minute rest resulted in the lowest eyestrain and blurred vision which followed by 15-minute work/micro breaks respectively. The 15-minute work/micro breaks could reduce discomfort in the neck, lower back, and chest than other schedules for data entry task. Moreover, a 15-minute work/micro break was the most schedules that could reduce discomfort in the elbow and arm for the arithmetic task. Finally, the 15-minute work/micro breaks resulted in the highest speed, accuracy, and performance for both of the tasks (31). Henning et al studied in the effect of frequent short rest breaks from computer work: on productivity and well-being. The results showed that at the smaller work site,

Copyright by Mahidol University

productivity, eye, leg and foot comfort all improved when the short breaks included stretching exercises. These results provide evidence that frequent short breaks from continuous computer-mediated work can benefit worker productivity and well-being when the breaks integrate with task demands (45).

Cole et al assessed the ergonomic program, included employee repetitive strain injury (RSI) training, proactive assessment of workstations and workstation modifications, and encouragement of early treatment through on-site physiotherapy, could reduce in frequent and severe pain (39). Pillastrini et al revealed the efficacy of a preventive ergonomic intervention. The group which received the ergonomic intervention an informative brochure had a lower Rapid Entire Body Assessment (REBA) score and reduced lower back, neck, and shoulder symptoms compared with group which received only the brochure (43). On the other hand, Gerr et al studied the effect of two workstation and postural interventions on the incidence of musculoskeletal symptoms among computer users. They found that there was no significant difference in the incidence of musculoskeletal symptoms among the intervention groups. Their results provided evidence that postural interventions were unlikely to reduce the risk of upper extremity musculoskeletal symptoms among computer users (46).

Harrington et al study the effectiveness of a home office ergonomics training program whisch found that several participants indicated that the pain or discomfort that they had been experiencing was eliminated or reduced as a result of the training (47). The implementations of ergonomic program not only reduce the number and severity of WMSDs but also result in lower in the costs that paid for WMSDs. In addition, the ergonomic interventions such as using training program to evaluate and adjust own workstation, could individually reduce the compensation costs, paid for the video display terminal (VDT) users with WMSDs, from $15,141 to $1553 (16).

Copyright by Mahidol University

Moreover, there are many researches that study the effect of ergonomic intervention on visual fatigue. Balci and Aghazadeh evaluated the work-rest schedules for VDT operators considering data entry and mental arithmetic tasks. They found that 30-minute work/5-minute rest resulted in the lowest eyestrain and blurred vision which followed by 15-minute work/micro breaks respectively. (31). Mekhora et al found that the adjustment of their own workstations according to ergonomic recommendations could reduce the discomfort level of subjects with tension neck syndrome. They found that the greatest discomfort reduction was in the lower back, followed by the eye (42). Wang et al evaluated the effects of display mode, search pattern, and inspection strategy on visual fatigue and inspection performance. They indicated that the display mode had significant influence on visual fatigue. Using a liquid crystal display (LCD) to inspect wafer defects can reduce the visual strain and body discomfort feelings. The change in inspection strategy had a positive effect on eye fatigue and inspection performance (2).

2.9 Measurements

2.9.1 The physical examination

The physical examination was used to measured severity symptoms of WMSDs (48, 49). Hagberg described the clinical assessment and management of work related neck and upper limb disorders. The clinical assessment consists of the clinical and exposure history, the evaluation of the physical and laboratory findings. The physical examination should include the following steps: inspection; testing for range of motion, testing for muscle contraction pain and muscle strength, palpation of muscle tendons and insertions and, specific tests. They found that the scientific evidence for clinical assessment, to determine the prognosis and for successful procedures for return to work (48). In addition, Coggon study the role of physical examination in the diagnosis of work-related upper limb musculoskeletal disorders. This study considers the approaches by which epidemiologists should define and evaluate possible diagnostic systems, focusing in particular on the contribution to case definition from physical examination (49).

Copyright by Mahidol University

2.9.2 The critical flicker frequency (CFF) test

The critical flicker frequency (CFF) test is the light and dark phases of light which are alternated rapidly by continuously shining or flickering an impulse light. When the flashing frequency is low, flicker is sensed. When the frequency becomes high, the flickering fuses and appears as a continuous light (35, 50).

Many researches studied the effect of fatigue on the CFF in many fields such as VDT users, pilots, drivers and industrial workers (2, 37, 38, 51). The CFF is likely used to indicate physiological and pathological responses, such as visual processing and visual fatigue (37, 38, 52).

2.9.3 The reaction time (RT) test

The reaction time is an external indicator of ability of the sensory reception time, sensorimotor integration time, central motor outflow time and peripheral motor contraction time (53-56). The RT experiments are divided into three basic kind’s.In simple reaction time experiments; there is only one stimulus and one response. 'X at a known location,' 'spot the dot,' and 'reaction to sound' all measure simple reaction time. In recognition reaction time experiments; there are some stimuli that should be responded to (the 'memory set'), and others that should get no response (the 'distractor set'). There is still only one correct response. 'Symbol recognition' and 'tone recognition' are both recognition experiments. In choice reaction time experiments; the user must give a response that corresponds to the stimulus, such as pressing a key corresponding to a letter if the letter appears on the screen (57).

The RT likely used to indicate physiological and pathological responses, such as visual processing and visual fatigue (52). Saito developed visual reaction test (VRT) as apparatus for fatigue measurement of visual display terminal (VDT) work. The VRT is useful in measuring fatigue in the visual system, the higher nervous system and some parts of the muscular system such as shoulders, arms and hands (58).

Copyright by Mahidol University

An improvement of RT could be from the method of micro-break and exercise (59-63). To support this positive outcome, Davranche et al (62) and Collardeau et al. (61) concluded as a positive effect of exercise on reaction time. On the other hand, a few arguments showed no effect of exercise on reaction time if vigorous exercise (64) and sport skills (65, 66) are included in the intervention.

Copyright by Mahidol University

CHAPTER III
MATERIALS AND METHODS

3.1 Study Design

This study is a quasi-experimental design measuring pre and post-intervention in a focused group. A field work (interview and observation), clinical symptoms examination, and visual fatigue were conducted before and after a one-month ergonomic intervention commenced.

3.2 Participant

One-hundred and forty two printing workers were recruited as participants. They had worked in proof and recycling department, the production department of the printing office. Participants were included using the following criteria.

3.2.1 Inclusion criteria

- Having been worked in proof and recycling department for more than 6 months,
- Being able to participate to the one-month ergonomic intervention.

3.2.2 Exclusion criteria

- Having been employed less than 50% of normal working time. (<4 hr/day),
- Pregnant workers,
- Having history of neurological problems or musculoskeletal disorders which might influence work performance,
- Having an eye diseases,
- Unwilling to participate this study.

Copyright by Mahidol University

3.2.3 Withdrawal criteria

- Workers who rotated from or to the section in a production department during the study period.
- Being pregnant
- Having an accidence, any musculoskeletal disorders or neurological disorders which might influence work performance and symptoms of the disorders
- Unwilling to continue the study

3.3 Preliminary Fieldwork

An observational survey was conducted to understand the nature and process of work task in the printing office. This information would be developed for physical examination and intervention plan.

3.3.1 Proof Department

Fifty-seven workers (female = 46, male = 8) were employed in proof department to ensure the quality of the printed matter. In this department, there is the printed matter to be proofed greater than 8,000 pieces per day. The printed matter consists of five types of images (type A, B, C, D, and E) on two sizes of papers (standard and super size). The standard size is 64×55 cm whereas the super size is 72×69 cm. The workstation for this section consists of office desk, raised tray, inclined tray, and adjustable chair (Figure 3.1).

The work characteristics of female workers are to observe and seek for poor printed matter, which involves repetitive movement of hands and eyes. Whereas, the work characteristics of male workers are to transfer heavy loads of printed matter that involved manual lifting and using manual forklift with standing and walking posture.

All female workers are in sitting posture for the whole working time for manual visual inspection. Their work characteristics are repetitive movement and static posture. They work with repetitive movement of hands for a long period of

Copyright by Mahidol University

time. There are different postures of hand movement such as unfolding and lancing the printed matter. While the workers are unfolding and lancing the printed matter their necks, shoulders, backs, and legs are in static posture. At the first step, they open one piece of the printed matter for making correction in one pattern. Then, they roll over the printed matter for checking any unusual pattern upon every part of the printed matter. If they find any mistake in the printed matter, they have to pull it out from the stack and office desk to the inclining tray underneath the desk. Next, they lift the printed matter after completion of inspection from the office desk to the raised tray. At the last step, male workers carry the printed matter from the raised tray to a cage to be ready to transfer to a safe room.

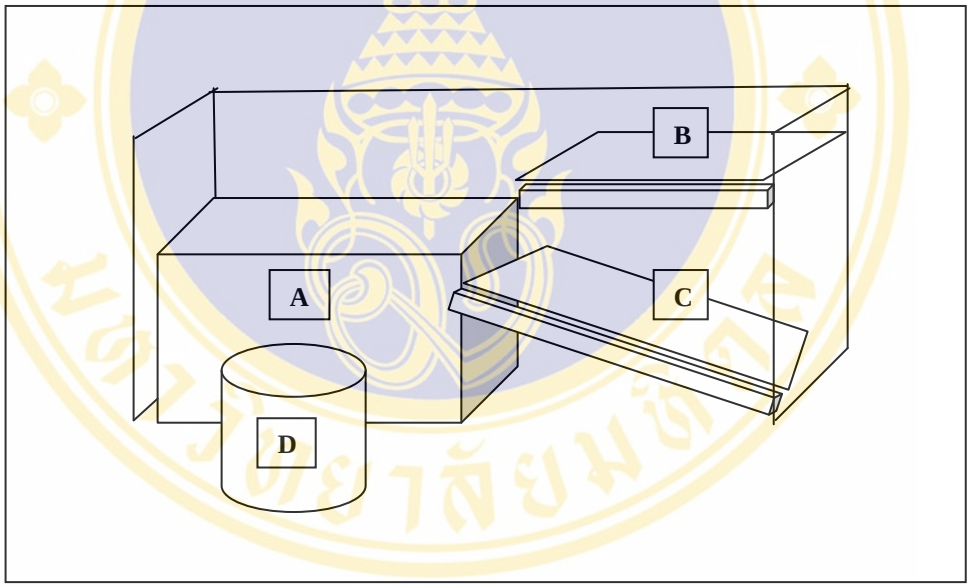


Figure 3.1 The workstation of a proof department (A = office desk, B = raised tray, C = inclined tray, and D = adjustable chair).

3.3.2 Recycling Department

Eighty five workers were employed in this section to receive the printed matter from another printing office and to check whether the printed matter is reusable. Once the reusable printed matter is checked it will be resent to another printing office. The workstation for this section consists of two office desks, adjustable chair and selective machine (Figure 3.2).

Copyright by Mahidol University

The work characteristics of female workers are repetitive movement of hands and visual to prove the print matter as same as workers in the proof department. The work characteristics of male workers in this department are to transfer heavy loads of stack of papers that involved trunk flexion, awkward posture and extreme upper extremity movement. Moreover, standing and walking posture are common working posture of male workers in recycling department.

Three workers work in each workstation from a total of 6 workstations. They perform both standing and sitting posture without back support and arm rest. Work characteristics can be described in 5 steps. At the first step, they carry a pack of the printed matter with 6.25 kg of weight, and move it to the first office desk to remove its plastic strap by using a cutter. Then, they twist and unfold the printed matter. Next, a worker decrease humidity of the printed matter using a hot air douche, while the other put the printed matter into a machine to automatically select the used printed matters with poor quality from the good quality reusable printed matter. After the printed matter come out from the selective machine, the last worker pick up the reusable printed matter. At the last step, male workers carry the reusable printed matter to arrange in series in the cage and then send the reusable printed matters to another printing office.

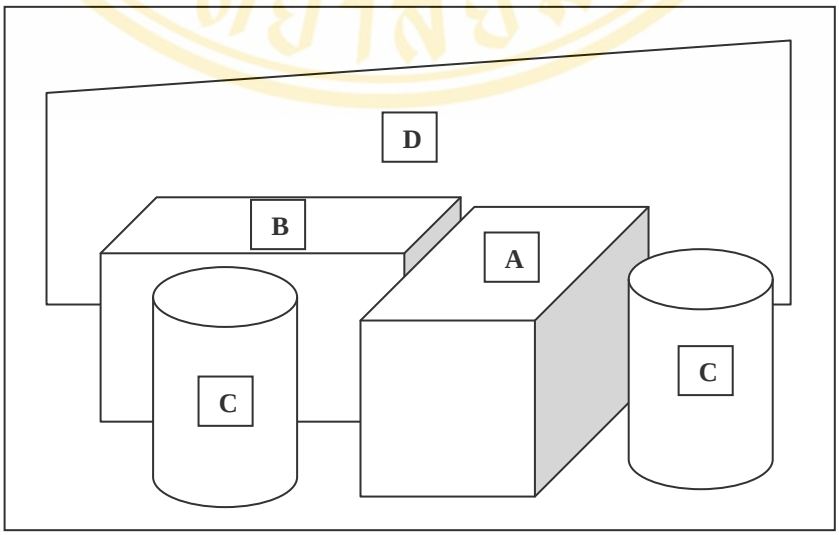


Figure 3.2 The workstation of a recycling department (A = 1st office desk, B = 2nd office desk, C = adjustable chair, and D = selective machine).

Copyright by Mahidol University

3.4 Measurement Tools

3.4.1 Physical Examination

The physical examination form (Appendix C) was developed as follows:

First Step: Two physical examination forms developed by Kurustien (2000) and Klangsin (2007) were modified.

Second Step: The modified physical examination form was tested in 10 patients with WMSDs. Ten orthopedic physical therapists were invited to use this form with their patients. The therapists were working at the Physical Therapy Clinic, Faculty of Physical Therapy and Applied Movement Science, Mahidol University.

Third Step: The form was revised. Some inappropriate items were edited by orthopedic and ergonomic physical therapists and researcher.

Fourth Step: The final version of physical examination form was approved by orthopedic and ergonomic physical therapists.

Subjective examinations such as the WMSDs severity stage, pain frequency, pain duration, and pain intensity (numerical rating scale) were accomplished. Physical examinations such as observation, palpation, active and passive movement, nerve tension, and special test were included. Physical therapists with post graduate or master qualification performed were therapists who performed the physical examination.

3.4.2 Visual Fatigue Evaluation

Critical Flicker Frequency (CFF) test and Reaction Time (RT) test are two outcome measures of visual fatigue. The CFF is defined as a light and dark phases of light are alternated rapidly by continuously shining or flickering an impulse light using a sector (shield) or neon tube or similar device. The RT test is defined as the time delayed between the presentation of an unwarned visual stimulus and the time at a detectable motor response.

Copyright by Mahidol University

The tool of CFF test was modified from the electrical stimulation that consisted of 6 pulse durations (1, 2, 5, 10, 20, and 50 ms) with 100 ms of pause duration (Figure 3.3). Subject was asked to sit and say ‘stop’ whenever a flickering light was adjusted by the examiner and he or she could see the light without any flickering (from long to short pulse duration/low to high frequency). Then the subject was asked to say ‘flickering’ whenever the light was turning to the flickering light (from short to long pulse duration/high to low frequency). Each procedure was tested for three times and averaged pulse duration in millisecond (ms) (Figure 3.4).

Figure 3.3 The critical flicker frequency apparatus.

Figure 3.4 The critical flicker frequency test.

Copyright by Mahidol University

Reaction timer and apparatuses (constructed by Jaroonsuck S, Mahidol University, Thailand) was used as a simple visual reaction time (Figure 3.4). Subject was instructed to rest his/her index finger on the micro-switch key and be ready to press the switch as fast as possible after seeing a red light. The scores of ten trials were recorded and averaged in millisecond (ms) (Figure 3.6).

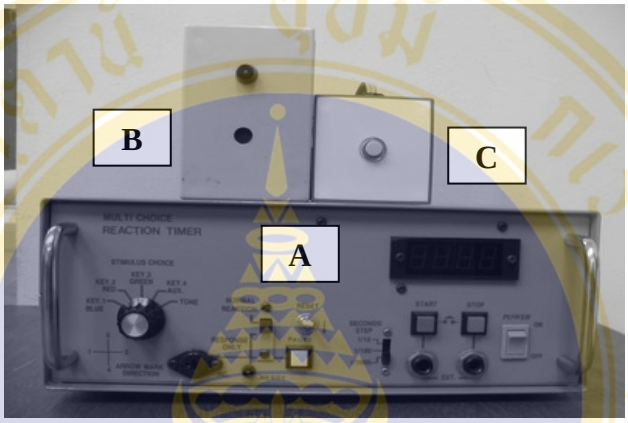


Figure 3.5 The reaction time apparatus (A = electrical stimulation, B = stimulus, and C = response apparatus/micro-switch key).

Figure 3.6 The reaction time test.

Both tests were conducted three times. The first time was measured before starting working in the morning (baseline measurement) and the second time was measured after working for 2 hours before receiving an ergonomic intervention (pre-

Copyright by Mahidol University

test measurement). The last time was measured after working for 2 hours and after receiving an ergonomic intervention (post-test measurement) as shown in Figure 3.7.

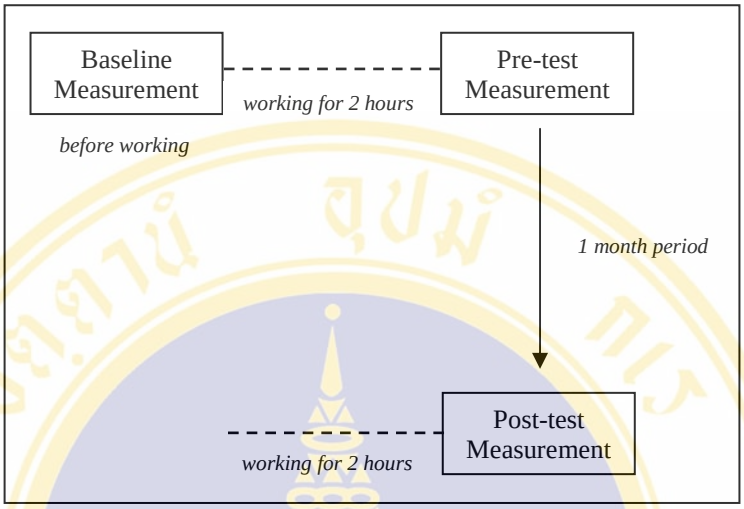


Figure 3.7 Procedure of the visual fatigue measurement

3.5 Procedure

There were 4 steps of the study detailed as follows:

Step 1: Problematic survey

The researcher surveyed working problems from the participants at the proof and recycling department, the production department of the printing office. Observation, interviews, and photograph recording were conducted.

Step 2: Physical examination and visual fatigue evaluation

The participants were asked to have physical examination in order to find out the WMSDs symptoms located at nine-body parts. Then, the visual fatigue evaluation was performed. The data recorded for this step were used as pre-test and baseline data before applying the intervention.

Step 3: Expert brainstorming for problem-solving of the WMSDs

After receiving the data from step 1-2 the researcher, orthopedic and ergonomic physical therapist analyzed risk factors and causes of the WMSDs. Then,

Copyright by Mahidol University

the researcher made a brainstorming group with ergonomic physical therapist in regard with creating the ergonomic intervention that suited to work tasks.

Step 4: Implementation of exercise intervention

The implementation of ergonomic intervention was micro break and exercise. The program exercise was analyzed from the finding of physical examination in the second step. The program exercise was shown in Appendix D. The researcher demonstrated the exercise program one time as an ergonomic intervention to the participants.

Step 5: Final evaluation and summarization

The physical examination and visual fatigue evaluation were performed after the participants had received the ergonomic intervention program for 1 month. Finally, all twice data collected in different times were analyzed and summarized.

Copyright by Mahidol University

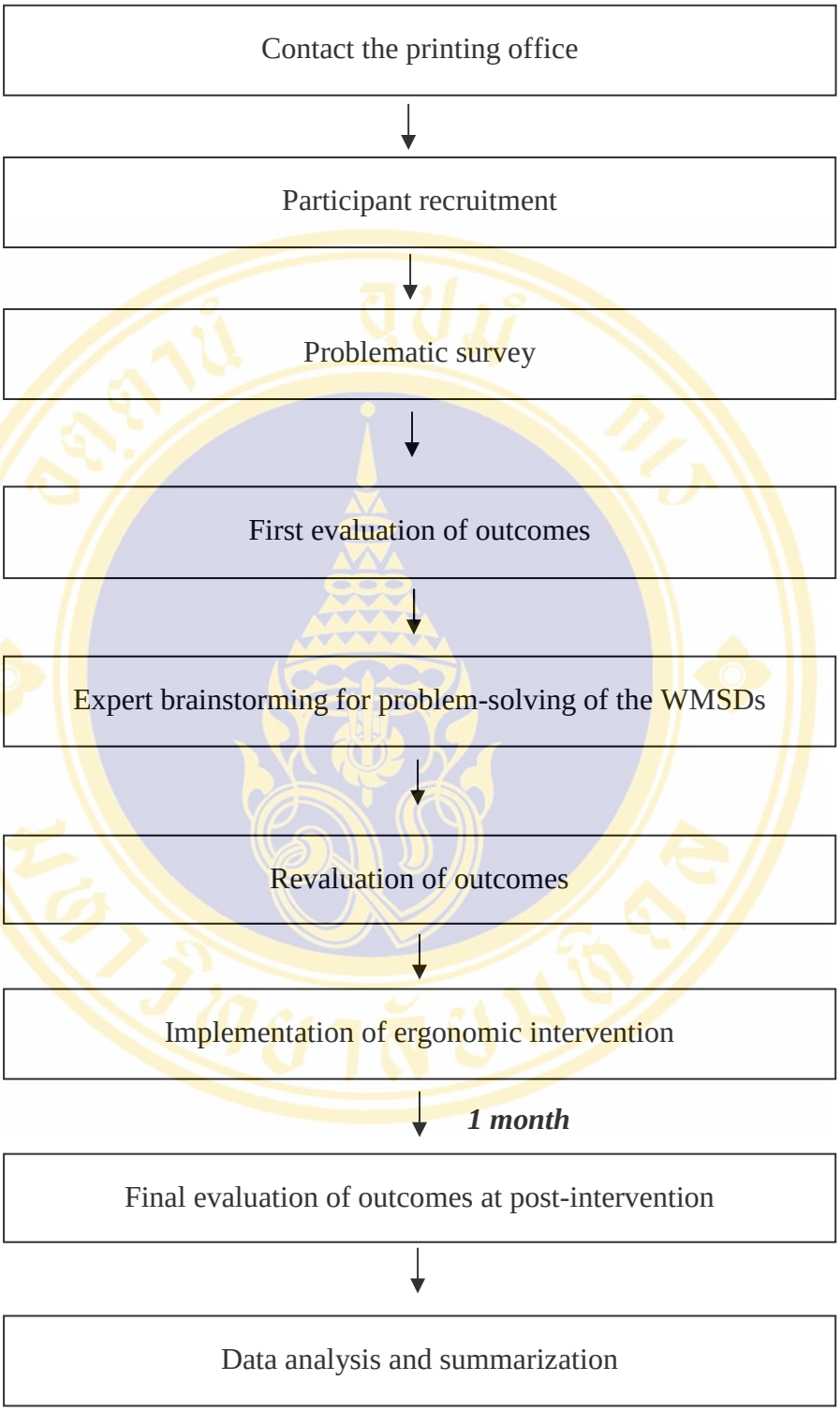


Figure 3.8 Flowchart of the procedural study.

Copyright by Mahidol University

3.6 Data Analysis

The data were analyzed using the SPSS for Window version 11.5. The level of significance will be set up at p-value less than 0.05

1. Kolmogorov-Smirnov Goodness of Fit test was used to analyze the distribution of the data.
2. Severity of WMSDs (the WMSDs severity stage, pain scale, and neural tissue tension)

- Wilcoxon Signed Ranks test was used to determine the difference between pre-test and post-test.

3. CFF value and RT value

- The repeated measurement was used to determine the difference of 3 groups (baseline, pre-test, and post-test) when the data were normal distribution.
- Friedman test was used to determine the difference of 3 groups (baseline, pre-test, and post-test) when the data were non-normal distribution and Wilcoxon Signed Ranks test was used to determine the difference between groups.

Copyright by Mahidol University

CHAPTER IV
RESULTS

The data was collected using the physical examination, the critical flicker frequency test, and the reaction time test during the period of baseline, pre and post test. Eleven workers were excluded because of the withdrawal criteria of this study: 131 workers then were included. They were 54 workers for the proof department and 77 workers for the recycling department. It was noted that the workers for the proof department performed exercise only one time a day whereas the workers for recycling department did twice exercise a day.

4.1 Demographic Characteristics

The results of demographic characteristics of the workers for the proof and the recycling department, and total workers are shown in Table 4.1.

Table 4.1 Demographic characteristics of the participants

Demographic characteristic	Proof Department		Recycling Department		Total workers	
	Female (n=46)	Male (n=8)	Female (n=58)	Male (n=19)	Female (n=104)	Male (n=27)
Age (years)						
Mean	41.33	35.57	43.33	44.63	42.45	42.19
SD	12.79	5.68	9.51	9.47	11.05	9.44
Min-Max	19-58	31-48	28-59	31-57	19-59	31-57
Weight (kg.)						
Mean	57.10	64.00	56.42	73.37	56.72	70.59
SD	9.68	6.61	10.25	13.47	9.95	12.50
Min-Max	43-87	56-73	43-83	56-107	43-87	56-107
Height (m.)						
Mean	1.57	1.68	1.57	1.67	1.57	1.68
SD	0.04	0.07	0.05	0.06	0.05	0.06
Min-Max	1.44-1.65	1.58-1.79	1.45-1.67	1.5-1.75	1.44-1.67	1.5-1.79

Copyright by Mahidol University

Table 4.1 Demographic characteristics of the participants (cont.)

Demographic characteristic	Proof Department		Recycling Department		Total workers	
	Female (n=46)	Male (n=8)	Female (n=58)	Male (n=19)	Female (n=104)	Male (n=27)
Duration of working (years)						
Mean	13.97	1.88	16.98	14.39	15.63	10.68
SD	12.59	0.36	8.24	8.21	10.47	8.98
Min-Max	1-35.08	1.08-2.25	2-39	1-28	1-39	1-28
Number of participant (percentages)						
Right handedness	43 (93.5%)	6 (75%)	56 (96.6%)	18 (94.7%)	99 (95.2%)	24 (88.9%)
Left handedness	3 (6.5%)	2 (25%)	2 (3.4%)	1 (5.3%)	5 (4.8%)	3 (11.1%)
Primary education	0 (0%)	0 (0%)	0 (0%)	3 (15.79%)	0 (0%)	3 (11.1%)
Secondary education	15 (32.6%)	6 (75%)	5 (8.62%)	7 (36.84%)	20 (19.23%)	13 (48.15%)
Diploma	1 (2.17%)	1 (12.5%)	3 (5.17%)	3 (15.79%)	4 (3.85%)	4 (14.81%)
Undergraduate	29 (63.04%)	0 (0%)	44 (75.86%)	6 (31.58%)	73 (70.19%)	6 (22.22%)
Postgraduate	1 (2.17%)	1 (12.5%)	6 (10.34%)	0 (0%)	7 (6.73%)	1 (3.7%)

4.2 Physical Examination

The physical examination was performed in order to evaluate the areas and severity of WMSDs (i.e. severity stages, pain scale and neural tissue tension). The details of WMSD severity stages and pain scale of the workers in each department and boths are shown in Appendix F – Table F.1. The neural tissue tensions of those workers are also details in Appendix F – Table F.2.

The total reported areas of WMSDs were 165 areas from 80 and 49 workers at pre and post test. Of those areas, 65 areas were from 34 and 19 workers of proof department at pre and post test and 100 areas were from 46 and 30 workers of recycling department at pre and post test (Table 4.2).

Copyright by Mahidol University

Table 4.2 The number report of WMSD symptoms

	The number report of WMSD symptoms (%)			
	Pre-test		Post-test	
	No symptom	With symptom	No symptom	With symptom
Proof Department (n=54)	20 (37.04)	34 (62.96)	35 (64.81)	19 (35.19)
Recycling Department (n=77)	31 (40.26)	46 (59.74)	47 (61.04)	30 (38.96)
Total Workers (n=131)	51 (38.93)	80 (61.07)	82 (62.60)	49 (37.40)

Frequency of musculoskeletal problems was reported in nine body areas of the participants (see Table 4.3). Shoulder, wrist and hand, and lower back indicated at the first rank of three areas of WMSDs.

Table 4.3 Musculoskeletal problems in nine parts of the body

Area of WMSDs	Proof Department		Recycling Department		Total workers	
	Female (n=45)[a]	Male (n=7)[a]	Female (n=66)[a]	Male (n=14)[a]	Female (n=)[a]	Male (n=)[a]
Neck	5 (11.11%)	0 (0%)	13 (19.70%)	1 (7.14%)	18 (16.22%)	1 (4.76%)
Shoulder	14 (31.11%)	3 (42.86%)	19 (28.79%)	6 (42.86%)	33 (29.73%)	9 (42.86%)
Elbow	3 (6.67%)	0 (0%)	4 (6.06%)	1 (7.14%)	7 (6.31%)	1 (4.76%)
Wrist/hand	9 (20%)	2 (28.57%)	16 (24.24%)	2 (14.29%)	25 (22.52%)	4 (19.05%)
Upper back	3 (6.67%)	0 (0%)	2 (3.03%)	0 (0%)	5 (4.5%)	0 (0%)
Lower back	9 (20%)	2 (28.57%)	8 (12.12%)	4 (28.57%)	17 (15.32%)	6 (28.57%)
Hip/thigh	0 (0%)	0 (0%)	3 (4.55%)	0 (0%)	3 (2.7%)	0 (0%)
Knee	2 (4.44%)	0 (0%)	1 (1.52%)	0 (0%)	3 (2.7%)	0 (0%)
Ankle/foot	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

[a] number reported areas of musculoskeletal problems

The neural tension was reported from those workers who had symptoms. However, positive neural tension indicated in this study had to be related with the symptoms complaints. The frequently reported neural tissue tension of workers in proof and recycling department and total workers are shown in Table 4.4.

Copyright by Mahidol University

Table 4.4 The number report of neural tension

	The number report of neural tension (%)			
	Pre-test		Post-test	
	Positive neural tissue tension	Negative neural tissue tension	Positive neural tissue tension	Negative neural tissue tension
Proof Department				
Female (n=10)[a]	7 (70)	3 (30)	7 (70)	3 (30)
Male (n=3)[a]	1 (33.3)	2 (66.7)	2 (66. 7)	1 (33.3)
Recycling Department				
Female (n=16)[a]	13 (81.3)	3 (18.8)	6 (37.5)	10 (62.5)
Male (n.=4)[a]	4 (100)	0 (0)	1 (25)	3 (75)
Total Workers				
Female (n= 6)[a]	20 (76.9)	6 (23.1)	13 (50)	13 (50)
Male (n=7)[a]	5 (71.4)	2 (28.6)	3 (42.9)	4 (57.1)

[a] number reported of neural tissue tension

The structural impairment gathered from physical examination was classified into 6 groups. There were no disorders, muscular disorders, tendon disorders, nerve disorders, bone/joint, ligament disorders, and mixed disorders. Muscle disorders were mostly reported, following with mixed disorders. The details of impairment of workers in proof and recycling department and total workers are shown in Table 4.5 – 4.7.

Table 4.5 Physical examination findings of WMSDs in proof department

Physical examination finding	Proof Department			
	Female (n=55)[a]		Male (n=10)[a]	
	Pre-test	Post-test	Pre-test	Post-test
No disorders	13 (23.6%)	29 (52.7%)	4 (40%)	3 (30%)
Muscular disorders	16 (29.1%)	5 (9.1%)	1 (10%)	1 (10%)
Tendon disorders	4 (7.3%)	1 (1.8%)	1 (10%)	1 (10%)
Nerve disorders	7 (12.7%)	7 (12.7%)	1 (10%)	2 (20%)
Bone/joint/ligament disorders	9 (16.4%)	9 (16.4%)	3 (30%)	1 (10%)
Mixed disorders	6 (10.9%)	4 (7.3%)	0 (0%)	2 (20%)

[a] number reported of WMSDs

Copyright by Mahidol University

Table 4.6 Physical examination findings of WMSDs in recycling department

Physical examination finding	Recycling Department			
	Female (n=82)[a]		Male (n=18)[a]	
	Pre-test	Post-test	Pre-test	Post-test
No disorders	19 (23.2%)	49 (59.8%)	3 (16.7%)	10 (55.6%)
Muscular disorders	15 (18.3%)	12 (14.6%	3 (16.7%)	3 (16.7%)
Tendon disorders	3 (3.7%)	1 (1.2%)	2 (11.1%)	0 (0%)
Nerve disorders	13 (15.9%)	6 (7.3%)	4 (22.2%)	1 (5.6%)
Bone/joint/ligament disorders	8 (9.8%)	7 (8.5%)	3 (16.7%)	1 (5.6%)
Mixed disorders	24 (29.3%)	7 (8.5%)	3 (16.7%)	3 (16.7%)

[a] number reported of WMSDs

Table 4.7 Physical examination findings of WMSDs in total workers

Physical examination finding	Total Workers			
	Female (n=137)[a]		Male (n=28)[a]	
	Pre-test	Post-test	Pre-test	Post-test
No disorders	32 (23.4%)	78 (56.9%)	7 (25%)	13 (46.4%)
Muscular disorders	31 (22.6%)	17 (12.4%)	4 (14.3%)	4 (14.3%)
Tendon disorders	7 (5.1%)	2 (1.5%)	3 (10.7%)	1 (3.6%)
Nerve disorders	20 (14.6%)	13 (9.5%)	5 (17.9%)	3 (10.7%)
Bone/joint/ligament disorders	17 (12.4%)	16 (11.7%)	6 (21.4%)	2 (7.1%)
Mixed disorders	30 (21.9%)	11 (8%)	3 (10.7%)	5 (17.9%)

[a] number reported of WMSDs

Statistical analysis of the severity of WMSDs of workers in proof and recycling department, and total workers between pre-test and post-test are shown in Table 4.8 – 4.10 and Figure 4.1.

Of the proof department, the number of areas of the WMSD severity stages in female from 45 areas, 68.89% was reported to be better, while in male from 7 areas, most of the areas (42.86%) were reported to be remained. The pain scale of those areas in female was reported 40% better and 40% remained the same, while in male only 3 cases (42.86%) of each were reported to be worse and remained the same. For the neural dynamic test, the number of cases found to have this test positive was only 10 female and 3 male. Of those cases, 40% of female were found to be remained and half of the rest were better and worse, while 66.67% of male were found to be worse. Those are shown in Table 4.8 and Figure 4.1 (A.).

Copyright by Mahidol University

For recycling department, the areas of WMSDs of female workers were found to have similar pattern as found in proof department. That is of 66 areas of female, 66.67% being better and 24.24% being worse, while of 14 areas of male, 50% being better and 28.57% remained the same. Whereas, the pain scales for both male and female, more than 40% of areas were reported to be better. Similarly, of 20 cases, both male and female workers had neural dynamic responses to be better 75% and 62.5% respectively. Those are shown in Table 4.9 and Figure 4.1 (B.).

Statistically, the results of female workers in recycling department alone and total female from both departments were found to have WMSD severity stages and pain scale being significant difference between post-test and pre-test ($p<0.001$, $p=0.003$). Whereas, there were significant differences in the WMSD severity stage between pre-test and post-test ($p=0.002$) of female workers in proof department. Those are shown in Table 4.8 - 4.10 and Figure 4.1 (C.).

Table 4.8 Test Statistics of severity of WMSDs of workers in proof department

	Post < Pre	Post > Pre	Post = Pre	p-value
WMSD severity stages				
Female (no. = 45)[a]	31 (68.89%)	11 (24.44%)	3 (6.67%)	0.002*
Male (no. = 7)[a]	2 (28.57%)	2 (28.57%)	3 (42.86%)	0.581
Pain scale				
Female (no. = 45)[a]	18 (40%)	9 (20%)	18 (40%)	0.385
Male ((no. = 7)[a]	1 (14.29%)	3 (42.86%)	3 (42.86%)	0.197
Neural dynamic test				
Female (no. = 10)[b]	3 (30%)	3 (30%)	4 (40%)	1.000
Male (no. = 3)[b]	1 (33.33%)	2 (66.67%)	0 (0%)	0.564

[a] number reported areas of musculoskeletal problems

[b] number reported of neural tissue tension

* Wilcoxon Signed Ranks test with significant level at the 0.05

Copyright by Mahidol University

Table 4.9 Test Statistics of severity of WMSDs of workers in recycling department

	Post < Pre	Post > Pre	Post = Pre	p-value
WMSD severity stages				
Female (no. = 66)[a]	44 (66.67%)	16 (24.24%)	6 (9.09%)	0.001*
Male (no. = 14)[a]	7 (50%)	3 (21.47%)	4 (28.57%)	0.107
Pain scale				
Female (no. = 66)[a]	30 (45.45%)	18 (27.27%)	18 (27.27%)	0.003*
Male ((no. = 14)[a]	6 (42.86%)	3 (21.43%)	5 (35.71%)	0.953
Neural dynamic test				
Female (no. = 16)[b]	10 (62.5%)	3 (18.75%)	3 (18.75%)	0.052
Male (no. = 4)[b]	3 (75%)	0 (0%)	1 (25%)	0.083

[a] number reported areas of musculoskeletal problems

[b] number reported of neural tissue tension

* Wilcoxon Signed Ranks test with significant level at the 0.05

Table 4.10 Test Statistics of severity of WMSDs of total workers

	Post < Pre	Post > Pre	Post = Pre	p-value
WMSD severity stages				
Female (no. = 111)[a]	75 (67.57%)	27 (24.32%)	9 (8.11%)	<0.001*
Male (no. = 21)[a]	9 (42.86%)	5 (23.81%)	7 (33.33%)	0.337
Pain scale				
Female (no. = 111)[a]	48 (43.24%)	27 (24.32%)	36 (32.43%)	0.003*
Male ((no. = 21)[a]	7 (33.33%)	6 (28.57%)	8 (38.10%)	0.574
Neural dynamic test				
Female (no. = 26)[b]	13 (50%)	6 (23.08%)	7 (26.92%)	0.108
Male (no. = 7)[b]	4 (57.14%)	2 (28.57%)	1 (14.29%)	0.414

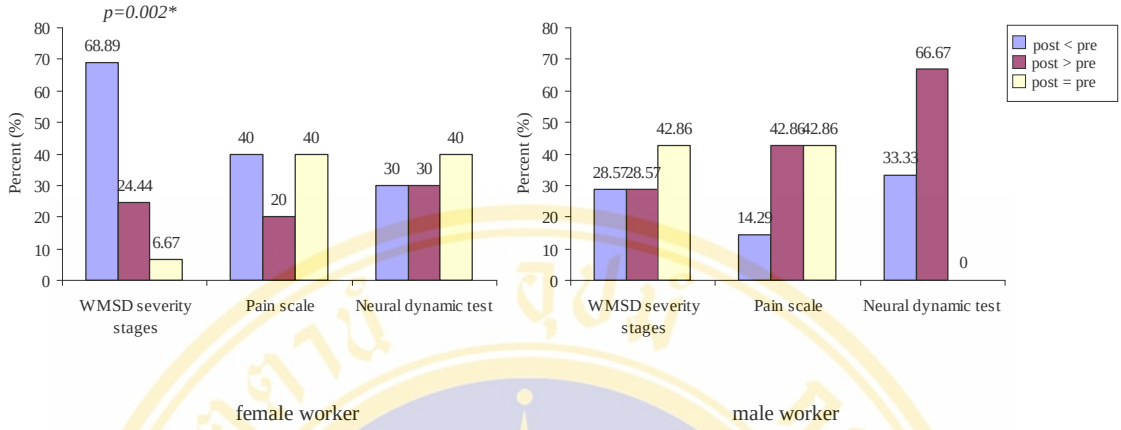
[a] number reported areas of musculoskeletal problems

[b] number reported of neural tissue tension

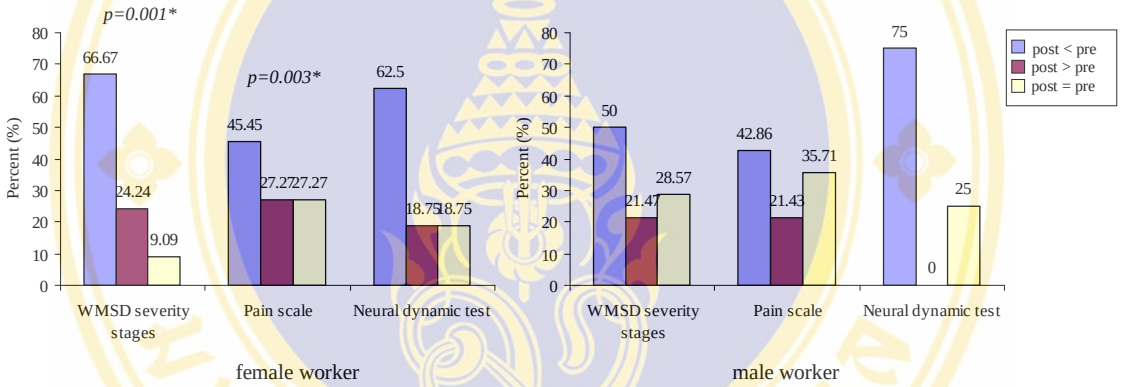
* Wilcoxon Signed Ranks test with significant level at the 0.05

Copyright by Mahidol University

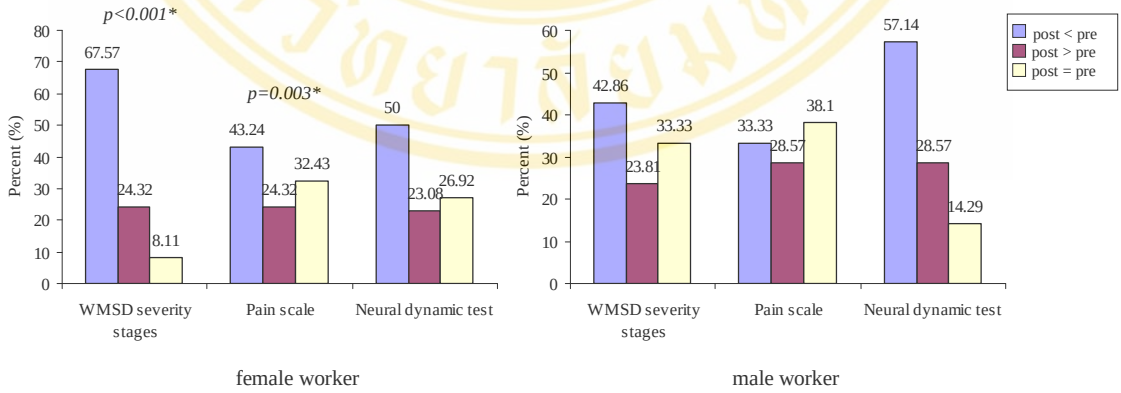
A. Workers in proof department



B. Workers in recycling department



C. Total workers



* Wilcoxon Signed Ranks test with significant level at the 0.05

Figure 4.1 Graph and statistical results of severity of WMSDs between pre-test and post-test among female and male workers (A = Workers in proof department, B = Workers in recycling department, and C = Total workers).

Copyright by Mahidol University

4.3 Critical Flicker Frequency (CFF) Data

The CFF tests were run lighting from short to long pulse duration (high to low frequency) and from long to short pulse duration (low to high frequency). The shorter duration of pulse (high frequency) indicated the tolerance of visual fatigability. The descriptive of CFF value of workers in proof and recycling department, and total workers are shown in Table 4.11 – 4.13. The CFF at the baseline was measured before workers started working. The pre test was measured before the intervention at immediately after 2 hours of working in the morning. The post test was measured after the intervention at immediately after 2 hours of working in the morning.

Descriptively, for all workers from both departments, the CFF results were quite similar. That is, the pulse duration at the post test was close to or shorter than at the baseline and shorter than at the pre test, whereas at the pre test the pulse duration was longer than at the baseline. The shorter duration of pulse indicated more flickering of the light or higher frequency which implies less tendency to fatigue.

Table 4.11 The CFF values among female and male workers in proof department

	Female (n=46)		Male (n=8)	
	Short to long pulse (ms)	Long to short pulse (ms)	Short to long pulse (ms)	Long to short pulse (ms)
Baseline				
Mean	4.93	4.77	5.21	2.67
SD	1.43	4.41	0.59	1.25
Min-Max	2.00 – 10.00	1.00 – 20.00	5.00 – 6.67	1.33 – 5.00
Pre-test				
Mean	6.36	6.35	5.63	3.88
SD	2.38	5.93	0.86	1.73
Min-Max	1.67 – 13.33	1.33 – 30.00	5.00 – 6.67	1.67 – 6.67
Post-test				
Mean	4.54	2.24	4.38	1.88
SD	1.37	1.30	1.19	0.25
Min-Max	2.00 – 10.00	1.00 – 8.33	2.00 – 5.00	1.33 – 2.00

Copyright by Mahidol University

Table 4.12 The CFF values among female and male workers in recycling department

	Female (n=58)		Male (n=19)	
	Short to long pulse (ms)	Long to short pulse (ms)	Short to long pulse (ms)	Long to short pulse (ms)
Baseline				
Mean	4.96	5.24	6.74	5.51
SD	1.63	5.86	4.97	5.66
Min-Max	2.00 – 10.00	1.67 – 36.67	2.00 – 20.00	1.67 – 20.00
Pre-test				
Mean	7.09	6.40	6.72	5.21
SD	5.19	5.01	4.17	4.18
Min-Max	2.00 – 40.00	1.00 – 20.00	2.00 – 20.00	1.00 – 20.00
Post-test				
Mean	5.36	3.16	5.09	2.37
SD	2.54	2.76	1.28	1.63
Min-Max	2.00 – 20.00	1.00 – 13.33	2.00 – 8.33	1.00 – 8.33

Table 4.13 The CFF values among female and male total workers

	Female (n=104)		Male (n=27)	
	Short to long pulse (ms)	Long to short pulse (ms)	Short to long pulse (ms)	Long to short pulse (ms)
Baseline				
Mean	4.95	5.03	6.28	4.67
SD	1.54	5.25	4.21	4.93
Min-Max	2.00 – 10.00	1.00 – 36.67	2.00 – 20.00	1.33 – 20.00
Pre-test				
Mean	6.77	6.38	6.40	4.82
SD	4.18	5.41	3.53	3.65
Min-Max	1.67 – 40.00	1.00 – 30.00	2.00 – 20.00	1.00 – 20.00
Post-test				
Mean	5.00	2.75	4.88	2.22
SD	2.14	2.27	1.27	1.38
Min-Max	2.00 – 20.00	1.00 – 13.33	2.00 – 8.33	1.00 – 8.33

Statistically, the results of CFF values between baseline, pre-test and post-test of workers in proof and recycling department, and total workers were analyzed and are shown in Table 4.14. The mean of CFF values with significant difference between baseline, pre-test and post-test of workers in proof and recycling department, and total workers are shown in Figure 4.2.

From the results of the short to long pulse duration of CFF tests, it was found that the results of total workers were similar to the results of workers in proof

Copyright by Mahidol University

and recycling department in female workers. There were significant differences between pre-test and baseline ($p<0.001$) and between post-test and pre-test ($p<0.001$), whereas, the results between post-test and baseline were not significantly different within any department. These result indicated the possible impact of intervention on CFF in female workers. After applying intervention, the mean duration of CFF could return close to baseline. However, in male workers, no statistical significance was found in any departments.

The statistical results of the long to short pulse duration of CFF tests were similar to those of the short to long pulse duration of CFF tests in female workers in proof and recycling department, and total workers. There were significant differences between pre-test and baseline ($p<0.01$), between post-test and pre-test ($p<0.001$) and between post-test and baseline ($p<0.001$). Whereas in male workers, there were significant differences between pre-test and baseline ($p<0.05$) of both departments and total workers, and between post-test and baseline ($p<0.05$) of recycling department and total workers. From the results, it was found that the mean duration of CFF at baseline was lower than the mean duration of pre-test. This could explain the possible impact of the intervention on CFF in both male and female workers, as after applying intervention, the mean duration of CFF was shorter than baseline.

Table 4.14 The statistical results of CFF values among female and male workers between baseline, pre-test and post-test

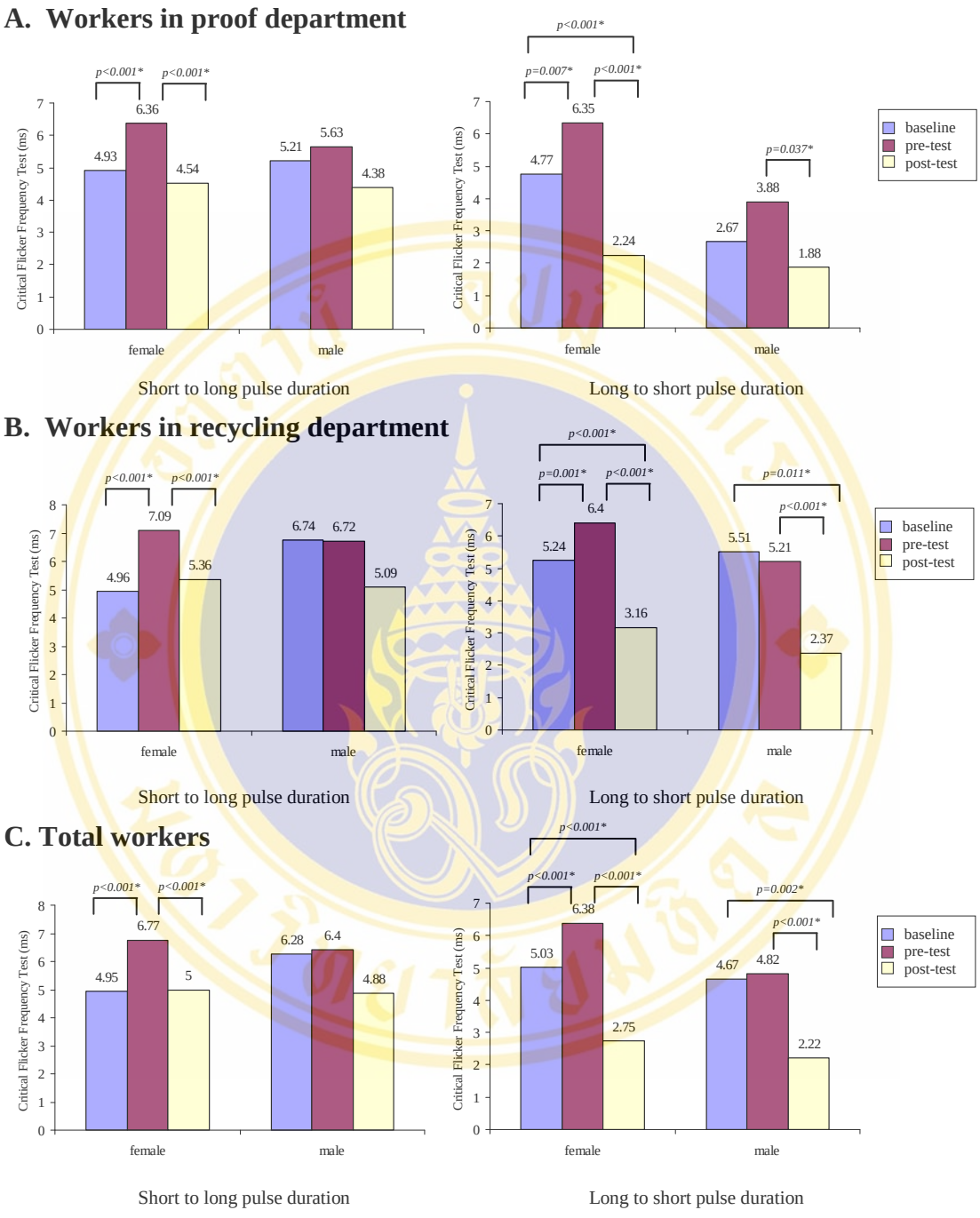
	Proof Department		Recycling Department		Total workers	
	Female (n=46)	Male (n=8)	Female (n=58)	Male (n=19)	Female (n=104)	Male (n=27)
Short to long pulse						
Pre-test – Baseline	<0.001*	NS	<0.001*	NS	<0.001*	NS
Post-test - Baseline	0.059	NS	0.506	NS	0.559	NS
Post-test – Pre-test	<0.001*	NS	<0.001*	NS	<0.001*	NS
Long to short pulse						
Pre-test – Baseline	0.007*	0.174	0.001*	0.877	<0.001*	0.495
Post-test - Baseline	<0.001*	0.310	<0.001*	0.011*	<0.001*	0.002*
Post-test – Pre-test	<0.001*	0.037**	<0.001*	<0.001*	<0.001*	<0.001*

NS - there were no significant differences of Friedman test

* Wilcoxon Signed Ranks test with significant level at the 0.05

** The mean difference is significant at the 0.05 level

Copyright by Mahidol University



* Wilcoxon Signed Ranks test with significant level at the 0.05

** The repeated measurement with significant level at the 0.05

Figure 4.2 Graph and statistical results of the long to short and short to long durations of CFF tests between baseline, pre-test and post-test among female and male workers (A = Workers in proof department, B = Workers in recycling department, and C = Total workers).

Copyright by Mahidol University

4.4 Reaction Time (RT) Data

The RT for each subject was tested for ten times. The results of RT of workers in proof and recycling department, and total workers are shown in Table 4.15. Most of workers both male and female, except male worker in proof department, performed the RT test with a better result (shorter is better) between post test and pre test, while for the post test and baseline, the RT seemed to be not much difference.

Table 4.15 The RT values among female and male workers in proof and recycling department and total workers

	Reactiom time (ms)					
	Proof Department		Recycling Department		Total workers	
	Female (n=46)	Male (n=8)	Female (n=58)	Male (n=19)	Female (n=104)	Male (n=27)
Baseline						
Mean	0.256	0.240	0.265	0.253	0.261	0.249
SD	0.04	0.03	0.06	0.04	0.05	0.04
Min-Max	0.199-0.386	0.197-0.282	0.186-0.513	0.194-0.384	0.186-0.513	0.194-0.384
Pre-test						
Mean	0.278	0.256	0.288	0.268	0.284	0.265
SD	0.05	0.03	0.06	0.05	0.06	0.04
Min-Max	0.198-0.442	0.223-0.325	0.217-0.478	0.222-0.406	0.198-0.478	0.222-0.406
Post-test						
Mean	0.264	0.261	0.263	0.249	0.263	0.253
SD	0.04	0.03	0.04	0.05	0.04	0.05
Min-Max	0.206-0.359	0.213-0.300	0.193-0.401	0.107-0.345	0.193-0.401	0.107-0.345

The statistical results of RT values between baseline, pre-test and post-test of workers in proof and recycling department, and total workers are shown in Table 4.16 and Figure 4.3.

In female workers, it was found that the results of total workers are in the same way as the results of workers in proof and recycling department. The means of RT at baseline and post test were lower than those of pre-test ($P<0.001$), except the pre test and post test of proof department that found not to be significant. Whereas those of male workers in recycling department and total workers the post tests were less than pre test, but significant differences were not found. Unlikely, in the proof department, male workers had significantly higher RT than those of baseline ($p=0.039$).

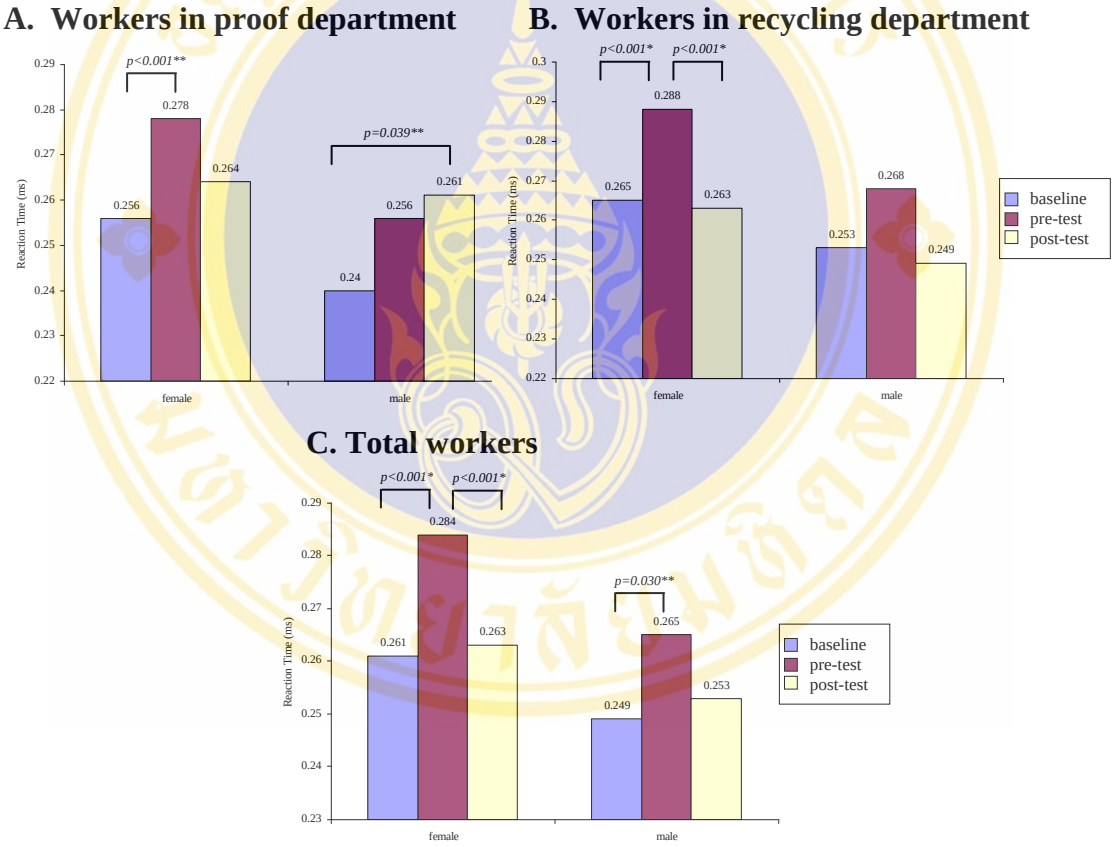
Copyright by Mahidol University

Table 4.16 The statistical results of RT values among female and male workers between baseline, pre-test and post-test

	Proof Department		Recycling Department		Total workers	
	Female (n=46)	Male (n=8)	Female (n=58)	Male (n=19)	Female (n=104)	Male (n=27)
Pre-test – Baseline	<0.001**	0.147	<0.001*	0.171	<0.001*	0.030**
Post-test - Baseline	0.219	0.039**	0.541	1.000	0.073	1.000
Post-test – Pre-test	0.060	1.000	<0.001*	0.215	<0.001*	0.415

* Wilcoxon Signed Ranks test with significant level at the 0.05

** The mean difference is significant at the 0.05 level



* Wilcoxon Signed Ranks test with significant level at the 0.05

** The mean difference is significant at the 0.05 level

Figure 4.3 Graph and statistical result of RT values between baseline, pre-test and post-test among female and male workers (A = Workers in proof department, B = Workers in recycling department, and C = Total workers).

Copyright by Mahidol University

4.5 Amount of Workload

Amount of workload was defined in four groups; 0 – 25% in the first group, 26 – 50% in the second group, 51 – 75% in the third group and 76 – 100% in the fourth group, to refer to maximal workload (100%) as reference. The results showed that the amount of workload were not significant differences between pre-test and post-test. The details are shown in Table 4.17.

Table 4.17 Amount of workload (%)

	Pre-test				Post-test				p-value
	0-25%	26-50%	51-75%	76-100%	0-25%	26-50%	51-75%	76-100%	
Proof Department									
Female (n=46)[a]	2.4	24.4	34.1	39	7	25.6	37.2	30.2	0.079
Male (n=8)[b]	-	-	-	100	-	-	28.6	71.4	1.000
Recycling Department									
Female (n=58)[c]	1.9	29.6	33.3	35.2	-	23.9	45.7	30.4	0.682
Male (n=19)[d]	-	9.1	63.6	27.3	-	33.3	16.7	50	0.564
Total Worker									
Female (n=104)[e]	2.1	27.4	33.7	36.8	3.4	24.7	41.6	30.3	0.339
Male (n=27[f]	-	6.3	43.8	50	-	21.1	21.1	57.9	0.564

* Wilcoxon Signed Ranks test with significant level at the 0.05

[a] missing data at pre-test (n=5), post-test (n=3), [b] missing data at pre-test (n=3), post-test (n=1),

[c] missing data at pre-test (n= 4), post-test (n=12), [d] missing data at pre-test (n=8), post-test (n=7),

[e] missing data at pre-test (n= 9), post-test (n=15), [f] missing data at pre-test (n=11), post-test (n=8)

Copyright by Mahidol University

CHAPTER V
DISCUSSION

5.1 Methodology

With the complexity of printing processes and the diversity of product types in the printing office, the repetitive movements of head, neck and upper extremities with visual inspection are important tasks to ensure product quality. The repetitive movement and prolonged inspection to search for defects tends to cause WMSDs and eye fatigue problems (2). Therefore, this study had tried out to reduce repetitive movement and prolonged posture by providing micro-break. Exercises for workers related to workers' complaint were provided over one month period. Those interventions served as work and human improvements. Work improvement was schedule more micro-break (11, 12). Human improvement was to train an exercise for workers (11, 44, 47).

This study was conducted in proof and recycling departments of print matter at the printing office. These subjects in both departments were included in this study because of the requirement of company to improve workers' health. This study was a part of research service of the Faculty of Physical Therapy and Applied Movement Science, Mahidol University as funded by the printing office. Consequently, all subjects must receive an ergonomic intervention without any control group. This study, therefore, used a quasi-experimental design to measure pre and post intervention in a specific group. The subjects included in this study must have worked in this department for more than 6 months. This 6 month time limit was set because the chiefs of proof and recycling departments gave the information that skill of workers would be improved after 6 months of work period.

Copyright by Mahidol University

The objective measurements such as physical examination, the CFF and the RT tests were used to determine the intervention effect. The physical examination was used to measure severity symptoms of WMSDs (48, 49). The use of physical examination was found in many studies to confirm signs and symptoms of WMSDs collected from administrated questionnaire survey (11, 48, 49). Moreover, physical examination would explore the impairments of WMSDs, which could be used as information to find out solutions to manage WMSDs

The objective eye fatigue measurements of this study were taken using the CFF and the RT tests as the measurement of fatigue that presented in previous studies (2, 30, 37, 38, 51, 54, 58). Other researches studied the effect of fatigue on the CFF and the RT test in various fields such as VDT users, pilots, drivers and industrial workers (2, 37, 38, 51). Some studies found that the CFF test was a good parameter for estimations of visual fatigue (2, 37, 58).

The ergonomic interventions in this study were micro-break and exercise which showed a benefit to reduce WMSDs (11, 31, 40, 41, 45). The time period of micro-break in this study was 5-minute break. The rest period are vary in many studies (31, 41, 45). Henning et al suggested that many short work-rest periods were better than fewer long work-rest cycles which can benefit worker productivity and well-being (45). Moreover, there were reports about a conflict between exercise break demands and job demands which led to the difficulty in finding a suitable period to do the exercise among workers that caused poor adherence to exercise program. Although, their results showed that exercise could reduce the discomfort (40, 45). In this study, the schedule with more micro-break was designed to accomplish this problem by providing sound signal for each department as the organization policy. All workers had to stop their continuing works and performed the exercise. The exercise program was created from the finding of physical examination in printing workers. The exercise program consisted of upper extremity and trunk exercise, neck and shoulder exercise, wrist and hand exercise, trunk exercise, lower extremity exercise and nerve mobilization exercise.

Copyright by Mahidol University

In addition, the evaluation was applied within one month period. The duration of evaluation was long period enough to see the change of severity symptoms of WMSDs (11, 41).

5.2 Effect of Ergonomic Intervention on Reducing WMSDs

The basic ergonomic interventions were a three-tier hierarchy of controls. These included engineering controls, administrative controls and personal equipment (10). In this study, the micro-break and exercise were administrative controls. The micro-break and exercise were provided to solve the severity symptoms of WMSDs in the printing workers. This study added specific schedule for micro-breaks and exercise as the organization policy to allow all workers in each department to promptly exercise.

The results of this study supported the hypothesis that the severity symptoms of WMSDs would be different between before and after the ergonomics intervention commenced. This study found that the micro-break and exercise reduced the WMSD severity stage, pain scale, and neural tissue tension while the amount of work load still remained the same between pre-test and post-test. In addition, the majority of WMSD severity stage, pain scale, and neural tissue tension were reduced. This reduction could be a consequence of the micro-break and exercise program. According to the exposure model of Armstrong, the micro-break in this study was a direct change of work requirement which could reduce dose and capacity that lead to WMSDs (34).

From Green’s review, the sustained contraction of a muscle can result in the fibers losing their tension producing capacity. Additional motor units are then needed to maintain the total tension state of the muscle. An increased number of active motor units is achieved by increased tension in the muscle spindle sensory systems. Thus, the facilitating central nervous system commands to the motor units that produce movement and tension. The metabolites produced through muscle contraction

Copyright by Mahidol University

are unable to be removed through normal capillary exchange because of the reduction in blood flow due to the muscle contraction. The accumulation of these metabolites stimulates nociceptor endings in the muscle and is interpreted as muscle pain (33). That is, when the micro-break and exercise were given, they might allow muscles to contact and relax and improve the circulation in the muscles. Therefore the rate of removal of waste products and flow nutrition could be increased, resulting in the improvement of WMSD symptoms (42).

Whereas, this study found there were significant differences in the WMSD severity stage and pain scale in female workers more than in male workers. In addition, the results showed the neural tissue tension seemed to be reduced after interventions but there were no significant differences between pre-test and post-test. These might be explained by the number of male workers and the workers who had positive neural tissue tension were too small. In addition, it might be explained both the workers did not perform exercise in a maximum performance and they might have other underlying disease which affected to the WMSD symptoms.

Therefore, this study indicated ergonomic intervention by using micro-break and exercise could reduce severity symptoms of WMSDs in workers as presented in previous studies (11, 31, 40, 41).

5.3 Effect of Ergonomic Intervention on Reducing Fatigue

The work characteristics in printing office are repetitive work and visual inspection which requires an unnatural working posture. This work tasks result in neuromuscular fatigue of the neck, arms, hands, and eyes. (58). That is, the micro-break and exercise were provided to solve the fatigue especially visual fatigue. The results of this study supported the hypothesis that the visual fatigue would be different between before and after the ergonomic intervention commenced. This study suggested that the micro-break and exercise could reduce visual fatigue among female workers while the amount of work load was still similar between pre-test and post-test.

Copyright by Mahidol University

The results in this study supported a study of Balci and Aghazadeh. They evaluated the work-rest schedules for VDT operators considering data entry and mental arithmetic tasks. They found that 30-minute work/5-minute rest resulted in the lowest eyestrain and blurred vision when compared with 15-minute work/micro breaks (31). That is, when the micro-break was given, the physiological load which was external exposure (work requirement) may be decreased and lead to decreases of physical work and mental fatigue (34, 58). When exercise was given, it might facilitate blood removal resulting in increasing nutrition and less fatigue of the muscle. The exercise program could reduce the visual fatigue as the results of the adaptation of individuals to any intervention will involve multiple adjustments of anatomical segments (42). Moreover, the micro-break could interrupt cumulative pathways which involved in the pathogenesis of WMSDs. They could reduce exposure and capacity which led to reduce symptoms. In addition, it might have been great enough to break through the mechanism of the occurrence of WMSDs (34, 42).

This study found the mean of RT at post-test was lower than that at pre-test. An improvement of RT could be from the method of micro-break and exercise (59-63). To support this positive outcome, Davranche et al (62) and Collardeau et al. (61) concluded as a positive effect of exercise on reaction time. It can be noted that the RT is fractionated into premotor time and motor time. Premotor time includes time needed for visual information processing, perceptual and central motor process. Motor time includes movement time for response. Soichi reviewed that exercise increases brain neurotransmitters such as catecholamine, serotonin, or dopamine, which one of the candidates may affect arousal level and improve the efficiency of central information processing and thus it can improve the RT (60). That is, activation of serotonergic system is associated with increases in sensory and cognitive arousal. Moreover, exercise increased heart rate produces adrenaline which prepares the body for fight or flight response and results in pupil dilation. Increased pupil dilation is a strategy enables one to see farther and a faster response to stimuli. As exercise was provided in this study, the premotor time was decreased. The decrease in motor time may be due to muscles having enough time to recover themselves from prolonged contraction or repetitive movement. In addition, exercise induces physiological

Copyright by Mahidol University

changes of circulatory and metabolic which result in increase nutrition and improved the removal of lactate (59, 60, 63). As a consequence, the movement time will be faster.

Surprisingly, the results of this study found that the mean of RT test of male workers in proof department was increasing over time, while the amount of work load remained the same. The micro-break and exercise did not show any reduction of the fatigue in the male group. This might be because the male workers had repetitive hand work which requires an unnatural working posture. This resulted in neuromuscular fatigue which sometimes it was followed by central nervous fatigue that could not reduce (54, 58). As noted in the chapter IV that the proof department had only one time of exercise a day which was less than the recycling department. This might explain why male workers in proof department did not have the fatigue improved.

Whereas, this study found that there were significant differences in the mean of CFF and RT test in female workers more than in male workers. These results may be either the cause of male subjects in each department was too small. Therefore, the results could indicate the effect of ergonomic intervention on reduction of eye fatigue in workers as presented in previous studies (31, 42). Moreover, this study found that the mean of CFF and RT test were improved after receiving ergonomic intervention but there were no significant differences between pre-test and post-test. The reason for explaining these results might be the difference of work characteristics between female and male workers. The work characteristics of male workers are transferring heavy loads of printed matter that involved manual lifting and using forklift with standing and walking in awkward posture. Whereas, many work characteristics of female workers are manual visual inspection to prove the print matter for a long period of time. That is, when measured by the CFF and the RT tests, female workers were more affected from interventions than male workers because their work characteristics involve visual activity to prove the print matter.

Copyright by Mahidol University

5.4 Limitation of Study

This study was conducted in a printing office where continuous working process and variation of work tasks were undertaken with high level of security procedure. Therefore, any intervention might be difficult to control the problems and could not be applied to modify the workplace. Ergonomic interventions in this study were simple work and human improvement (micro-break and exercise) which could be immediately provide to workers. Whereas, other work and human improvement such as work station, hand tool, personal equipment (e.g. wrist and back support) could be later provide. They could not be immediately provided, because of the limit of time of this project, the security, the policy of organization, and budgets. Due to the high security, the printing office did not allow any person who did not have a permit to go to worksite. Because of these limit of this project, the CFF apparatus in this study was modified from the electrical stimulation which was not international apparatus for the CFF measurements. For further study, CFF apparatus should be used for measurement visual fatigue which could interpret a precise explanation of results.

Moreover, there were uncontrollable factors such as variation of subjects, daily activity, medical treatment, part time jobs or exercise that aside from intervention. This current study could not control those factors. However, using subjects as their own control could help minimize the effects of those factors.

5.5 Suggestion for Further Study

This study was a quasi experimental design which was chosen to study the effect of ergonomic intervention by using micro-break and exercise on physical symptoms and visual fatigue. For the further study, it should be an experimental design to compare the effects of ergonomic intervention between controlled and experimental groups. It might show a clear effect of ergonomic intervention.

Copyright by Mahidol University

In addition, it is important in the assessment of fatigue that objective and subjective measurements should be included. So, the further study should use the specific subjective measurements of eye fatigue. Fatigue should be evaluated by a multidisciplinary approach rather than simply measured such as evaluation of eye muscle movement, evaluation of muscular fatigue, etc. Moreover, the CFF test should be measured with visual analog scale which can be serve as subjective measurement of visual fatigue.

Finally, this study was undertaken over one month period. For the further study, the longer period of follow up is interesting to study the effect of ergonomic intervention which may be useful to industrial factory.

Copyright by Mahidol University

CHAPTER VI
CONCLUSION

This study was a guideline of ergonomic intervention by using micro-break and exercise which were applied in a printing office. The printing office was interesting to be intervened in this current study because the characteristics of work consisted of various activities leading to WMSDs risk factors. Most workers had to work with repetitive movement of the upper extremities, sustained the same posture for the whole day, and lift the printed matter in awkward posture.

Consequently, the pre and post quasi-experimental design was chosen to examine the effect of ergonomic intervention by using micro-break and exercise on physical symptom and visual fatigue which conducted in printing workers.

The ergonomic interventions which applied in this study were provided from the step of expert brainstorming for problem-solving of the WMSDs. These interventions were micro-break and exercise, served as work and human improvement. The two of 5 minute breaks were provided for workers to perform a set of exercise specifically related to the frequently reported symptoms found in those workers for reducing WMSDs.

The results of this study before applying intervention revealed the symptoms of WMSDs and impact of visual fatigue in printing workers. The physical examination showed that the top three of reported areas of WMSDs problems were shoulder, wrist and hand, and lower back areas in printing workers. Moreover, the mean of CFF and RT value at pre-test was higher than at baseline. The CFF and RT tests showed that workers in both department and total workers might be the impact of visual fatigue.

Copyright by Mahidol University

The results of this study after applying intervention showed that the severity of WMSDs (WMSDs severity stage and pain scale) were significant differences between pre-test and post-test in female workers. More than 65% of female workers of both department and 40% of total workers had the WMSDs severity stage and pain scale better. However, in male workers, no statistical significance was found in any departments as number of male workers was small. Moreover, the CFF and RT value were significant difference between pre-test and post-test. After applying intervention, the mean of CFF and RT value at post-test was lower than at pre-test indicating the reduction of visual fatigue. Whereas, the results of amount of workload was not significant difference between pre-test and post-test, indicating the amount of workload during those two periods was about the same.

In conclusion, this current study demonstrated the benefit of micro-break and exercise program as an ergonomic intervention, served as work and human improvement to reduce WMSDs and visual fatigue in printing workers. The ergonomic intervention could be provided to any workers or industrials to start with basic knowledge of prevention and self treatment to minimize their problems by themselves. These impacts of ergonomic intervention could be then benefit to workers in a long run.

Copyright by Mahidol University

REFERENCES

1. Iwakiri K, Mori I, Sotoyama M, Horiguchi K, Ochiai T, Jonai H, et al. Survey on visual and musculoskeletal symptoms in VDT workers. Sangyo Eiseigaku Zasshi. 2004 Nov;46(6):201-12.
2. Wang MJ, Huang CL. Evaluating the eye fatigue problem in wafer inspection. IEEE Transactions Semiconductor Manufacturing. 2004;17(3):444-7.
3. Woods V. Musculoskeletal disorders and visual strain in intensive data processing workers. Occup Med (Lond). 2005 Mar;55(2):121-7.
4. Statistics I. Total number of factory in 2004. 2004 [cited 2008 Oct 4]; Available from: www.diw.go.th/diw_web/html/file_excel/จำนวนโรงงานสะสม47.xls
5. Statistics I. Total number of factory in 2007. 2007 [cited 2008 Oct 4]; Available from: www.diw.go.th/diw_web/html/file_excel/ss_type_cl50.xls
6. OSHA. Preventing Work-Related Musculoskeletal Disorders. [cited 2008 Sep 21]; Available from: www.safetycenter.navy.mil/osh/ergonomics/downloads/ergofactnew.pdf
7. FOH. Investment Benefits of an Ergonomics Porgram. [cited 2008 Sep 21]; Available from: www.foh.dhhs.gov/Public/factsheets/Ergoinvestments.pdf
8. Aptel M, Aublet-Cuvelier A, Cnockaert JC. Work-related musculoskeletal disorders of the upper limb. Joint Bone Spine. 2002 Dec;69(6):546-55.
9. Rosecrance L, Cork T. Upper extremity musculoskeletal disorders: association and a Model for prevention. CEJOEM. 1998;4(3):214-31.
10. NIOSH. Elements of Ergonomics Programs: A Primer Based on Workplace Evaluations of Musculoskeletal Disorders. [cited 2008 Aug 10]; Available from: www.cdc.gov/niosh/docs/97-117/epstep5.html
11. Klangsin P. Ergonomic intervention for reducing work-related musculoskeletal disorders by WISE technique in a cardboard box factory [M.S. thesis]. Faculty of graduate studies: Mahidol university; 2007.

Copyright by Mahidol University

12. Muchori F. Workplace improvements in small-scale industries in Kenya archieved by WISE methodology. Kenya Occupational Health and Safety Services. 1995.
13. Palmer K, Cooper C, Walker-Bone K, Syddall H, Coggon D. Use of keyboards and symptoms in the neck and arm: evidence from a national survey. Occup Med. 2001;51(5):392-5.
14. Southard S, Freeman J, Drum J, Mirka G. Ergonomic interventions for the reduction of back and shoulder biomechanical loading when weighing calves. Int J Ind Ergon. 2007;37:103-10.
15. Greene BL, DeJoy DM, Olejnik S. Effects of an active ergonomics training program on risk exposure, worker beliefs, and symptoms in computer users. Work. 2005;24(1):41-52.
16. Lewis R, Krawiec M, Ellen C, Agopsowicz D, Crandall E. Musculoskeletal disorder worker compensation costs and injuries before and after an office ergonomics program. Int J Ind Ergon. 2002;29:95-9.
17. Rosecrance JC, Cook TM. The use of participatory action research and ergonomics in the prevention of work-related musculoskeletal disorders in the newspaper industry. Appl Occup Environ Hyg. 2000 Mar;15(3):255-62.
18. NIOSH. Preventing Work-Related Musculoskeletal Disorders. 2000 [cited 2007 Oct 8]; Available from: http://osha.eu.int
19. AREAS NPR. Musculoskeletal Disorders of the Upper Extremities. 1996 Apr [cited 2007 Oct 8]; Available from: http://www.cdc.gov/niosh/docs/96-115/diseas.html#skels
20. Rutgers I. Musculoskeletal Disorders. [cited 2007 Oct 8]; Available from: www.NTIONLINE.com
21. Industries WSDoLa. Musculoskeletal Disorders: Safety & Health Assessment & Research for Prevention (SHARP) — Promoting Safer, Healthier Workplaces. [cited 2007 Oct 8]; Available from: http://www.lni.wa.gov /Safety/Research/OccHealth/MuscDis/default.asp

Copyright by Mahidol University

22. Kroemer KHE. Cumulative trauma disorders: Their recognition and ergonomics measures to avoid them. [cited 2007 Oct 8]; Available from: http://www.rainin.com/pdf/tr2001_7.pdf
23. Wikipedia. Repetitive strain injury. 2008 Jan 2 [cited 2007 Jan 26]; Available from: http://en.wikipedia.org/wiki/Repetitive_strain_injury
24. Work EAfSaHa. Work-related neck and upper limb disorders. [cited 2007 May 21]; Available from: http://ew2007.osha.europa.eu
25. Hedge A. Work-related Musculoskeletal Disorders. [cited 2007 Dec 16]; Available from: http://ergo.human.cornell.edu/studentdownloads/DEA325 pdfs/wrmsd.pdf
26. NIOSH. Work-Related Musculoskeletal Disorders. 1997 July [cited 2007 Doc 16]; Available from: http://www.cdc.gov/niosh/muskdsfs.html
27. Stavroudis C. Facts about Cumulative Trauma Disorders. 2004 Nov 10 [cited 2007 Dec 16]; Available from: http://palimpsest.stanford.edu/waac/wn/ wn15/wn15-2/wn15-211.html
28. HANDBOOK GSR. Work-Related Upper Limb Disorders (WRULDs). 1999 Jul [cited 2007 Apr 16]; Available from: http://www.poptel.org.uk/gpmu/ learning/login/dox/h_and_s_3.pdf
29. Physiotherapy OV. Office Ergonomics and Repetitive Strain Injuries: What you need to know. [cited 2007 Dec 16]; Available from: ovphysio.com
30. Jensen C. Development of neck and hand-wrist symptoms in relation to duration of computer use at work. Scand J Work Environ Health. 2003 Jun;29(3):197-205.
31. Balci R, Aghazadeh F. The effect of work-rest schedules and type of task on the discomfort and performance of VDT users. Ergonomics. 2003 Apr 15;46(5):455-65.
32. Halford V, Cohen HH. Technology use and psychosocial factors in the self-reporting of musculoskeletal disorder symptoms in call center workers. J Safety Res. 2003 Apr;34(2):167-73.
33. Green N. Work-Related Musculoskeletal Disorders (WMSD) and Breaks. [cited 2009 Jan 12]; Available from: http://www.workpace.com/ MOREWORKRELATEDMUSCULOSKE

Copyright by Mahidol University

34. Armstrong TJ, Buckle P, Fine LJ, Hagberg M, Jonsson B, Kilbom A, et al. A conceptual model for work-related neck and upper-limb musculoskeletal disorders. Scand J Work Environ Health. 1993 Apr;19(2):73-84.
35. Wilson JR, E.N. C. Evaluation of human work. second ed: Taylor&Francis.
36. Maneerat R. The factors related to visual fatigue in visual display terminal operators. Bangkok: Mahidol university; 1995.
37. Murata K, Araki S, Kawakami N, Saito Y, Hino E. Central nervous system effects and visual fatigue in VDT workers. Int Arch Occup Environ Health. 1991;63(2):109-13.
38. Kiyohiko A, Yoshinor T, Satoshi M, Fumiko K, Hiroshi O. The effect of overseas flight on CFF (Critical Fusion Frequency/Critical Flicker Frequency). Reports of Aeromedical Laboratory. 2002;42(4):71-80.
39. Cole D, Hogg-Johnson S, Manno M, Ibrahim S, Wells R, Ferrier S. Reducing musculoskeletal burden through ergonomic program implementation in a large newspaper. Int Arch Occup Environ Health. 2006;80(2):98-108.
40. Fenety A, Walker JM. Short-term effects of workstation exercises on musculoskeletal discomfort and postural changes in seated video display unit workers. Phys Ther. 2002 Jun;82(6):578-89.
41. McLean L, Tingley M, Scott RN, Rickards J. Computer terminal work and the benefit of microbreaks. Appl Ergon. 2001;32:225-37.
42. Mekhora K, Liston CB, Nanthavanij S, Cole JH. The effect of ergonomic intervention on discomfort in computer users with tension neck syndrome. Int J Ind Ergon. 2000;26:367-79.
43. Pillastrini P, Mugnai R, Farneti C, Bertozzi L, Bonfiglioli R, Curti S, et al. Evaluation of two preventive interventions for reducing musculoskeletal complaints in operators of video display terminals. Phys Ther. 2007 May;87(5):536-44.
44. Amick BC, Robertson MM, DeRango K, Bazzani L, Moore A, Rooney T, et al. Effect of office ergonomics intervention on reducing musculoskeletal symptoms. Spine. 2003 Dec 15;28(24):2706-11.

Copyright by Mahidol University

45. Henning RA, Jacques P, Kissel GV, Sullivan AB, Alteras-Webb SM. Frequent short rest breaks from computer work: effects on productivity and well-being at two field sites. Ergonomics. 1997 Jan;40(1):78-91.
46. Gerr F, Marcus M, Monteilh C, Hannan L, Ortiz D, Kleinbaum D. A randomised controlled trial of postural interventions for prevention of musculoskeletal symptoms among computer users. Occup Environ Med. 2005 Jul;62(7):478-87.
47. Harrington SS, Walker BL. The effects of ergonomics training on the knowledge, attitudes, and practices of teleworkers. J Safety Res. 2004;35(1):13-22.
48. Hagberg M. Clinical assessment, prognosis and return to work with reference to work related neck and upper limb disorders. G Ital Med Lav Ergon. 2005 Jan-Mar;27(1):51-7.
49. Coggon D. The role of physical examination in the diagnosis of work-related upper limb musculoskeletal disorders. Med Lav. 2007 Mar-Apr;98(2):94-7.
50. Schwin R, Hill S, Goodwin D, Marihuana P. CFF: evidence for perceptual sharpening. J Nerv Ment Dis. 1974;158:142-4.
51. Li Z, Jiao K, Chen M, Wang C. Reducing the effects of driving fatigue with magnitopuncture stimulation. Accid Anal Prev. 2004;36:501-5.
52. Khemthong S. Psychomotor effects of exercise in blind, deaf, and non-handicapped adolescents. Bangkok: Mahidol; 1999.
53. Aley L, Miller EW, Bode S, Hall L, Markusic J, Nicholson M, et al. Effects of Age, Task Complexity, and Exercise on Reaction Time of Women During Ambulation Tasks. J Geriatr Phys Ther. 2007;30(1):3-7.
54. Milroy TH. Fatigue studied in reaction time experiments. Belfast: Queen's University; 1909.
55. Spirduso W. Physical fitness, aging, and psychomotor speed: A review. J Geronto. 1980;35(6):850-65.
56. Wood GA. Electrophysiological correlates of local muscular fatigue effects upon human visual reaction time. Eur J Appl Physiol. 1979;21(4):247-57.
57. Kosinski RJ. A Literature Review on Reaction Time: Clemson University; 2008.

Copyright by Mahidol University

58. Saito K. Measurement of fatigue in industries. Ind Health. 1999;37:134-42.
59. Ando S, Kokubu M, Kimura T, Moritani T, Araki M. Effects of acute exercise on visual reaction time. Int J Sports Med. 2008 Dec;29(12):994-8.
60. Ando S, Yamada Y, Tanaka T, Oda S, Kokubu M. Reaction time to peripheral visual stimuli during exercise under normoxia and hyperoxia. Eur J Appl Physiol. 2009 Jan 31.
61. Collardeau M, Brisswalter J, Audiffren M. Effects of a prolonged run on simple reaction time of well trained runners. Percept Mot Skills. 2001 Dec;93(3):679-89.
62. Davranche K, Audiffren M, Denjean A. A distributional analysis of the effect of physical exercise on a choice reaction time task. J Sports Sci. 2006 Mar;24(3):323-9.
63. Davranche K, Burle B, Audiffren M, Hasbroucq T. Physical exercise facilitates motor processes in simple reaction time performance: an electromyographic analysis. Neurosci Lett. 2006 Mar 20;396(1):54-6.
64. Kashihara K, Nakahara Y. Short-term effect of physical exercise at lactate threshold on choice reaction time. Percept Mot Skills. 2005 Apr;100(2):275-91.
65. Lemmink KA, Visscher C. Effect of intermittent exercise on multiple-choice reaction times of soccer players. Percept Mot Skills. 2005 Feb;100(1):85-95.
66. McMorris T, Graydon J. The effect of incremental exercise on cognitive performance. Int J Sport Psychol. 2000;31:66-81.

Copyright by Mahidol University

APPENDIX

Copyright by Mahidol University

APPENDIX A
PARTICIPANT INFORMATION SHEET

เอกสารชี้แจงอาสาสมัครผู้เข้าร่วมการวิจัย

(Participant information sheet)

ในเอกสารนี้อาจมีข้อความที่ท่านอ่านแล้วยังไม่เข้าใจ โปรดสอบถามหัวหน้าโครงการวิจัยหรือผู้แทนให้ช่วยอธิบายจนกว่าจะเข้าใจดี ท่านอาจจะขอเอกสารนี้กลับไปอ่านที่บ้านเพื่อปรึกษาหารือกับญาติพี่น้อง เพื่อนสนิท แพทย์ประจำตัวของท่าน หรือแพทย์ท่านอื่น เพื่อช่วยในการตัดสินใจเข้าร่วมการวิจัย

ชื่อโครงการ	ผลของการปรับปรุงทางการยศาสตร์ในพนักงานโรงพิมพ์ต่อความผิดปกติทางระบบกระดูกและกล้ามเนื้อที่เกี่ยวข้องกับการทำงานและความล้าทางการมองเห็น
หัวหน้าโครงการ	นางสาวณัฏฐพร ประดิษฐพจน์
สถานที่วิจัย	โรงพิมพ์ จังหวัด นครปฐม 73120
ผู้ให้ทุน	มี

โครงการวิจัยนี้ทำขึ้นโดยมีจุดมุ่งหมายเพื่อทำการเปรียบเทียบผลก่อนและหลังจากการได้รับการปรับปรุงทางการยศาสตร์ในพนักงานโรงพิมพ์ ซึ่งประโยชน์ที่คาดว่าจะได้รับคือช่วยลดอาการทางกาย, ความล้าทางการมองเห็นและค่าใช้จ่ายในการรักษาพยาบาลของความผิดปกติทางระบบกระดูกและกล้ามเนื้อที่เกี่ยวข้องกับการทำงานในพนักงาน

ท่านได้รับเชิญให้เข้าร่วมการวิจัยนี้เพราะเป็นพนักงานในแผนกที่เป็นเป้าหมายของการวิจัยที่ทำในโรงพิมพ์ ซึ่งจะมีผู้เข้าร่วมการวิจัยทั้งสิ้นประมาณ 131 คน โดยมีลำดับขั้นตอนการวิจัยดังนี้

Copyright by Mahidol University

ขั้นตอนที่ 1 การตรวจร่างกายและการประเมินความล้าทางการมองเห็น

พนักงานแต่ละแผนกจะได้รับการตรวจร่างกายเพื่อประเมินปัญหาความผิดปกติทางระบบกระดูกและกล้ามเนื้อที่เกี่ยวข้องกับการทำงาน ในการตรวจร่างกายให้แก่พนักงานจะกระทำโดยนักกายภาพบำบัด 2 คน ซึ่งเป็นผู้ที่มีประสบการณ์ในการทำงานมาไม่น้อยกว่า 3 ปี และได้รับประกาศนียบัตรเฉพาะทางที่เกี่ยวข้องกับทางระบบกระดูกและกล้ามเนื้อ ซึ่งผู้วิจัยจะเป็นคนจัดพนักงานเพื่อทำการตรวจร่างกายให้แก่นักกายภาพบำบัดทั้ง 2 คน โดยที่นักกายภาพบำบัดทั้ง 2 คน จะไม่ทราบมาก่อนว่าตนเองจะต้องตรวจพนักงานคนใด

นอกจากนี้ผู้วิจัยและนักกายภาพบำบัดอีก 2 คน จะทำการประเมินความล้าทางการมองเห็นโดยใช้การวัดความล้าทางสายตา การวัดความไวในการตอบสนองต่อตัวกระตุ้น ซึ่งผู้วิจัยจะทำการตรวจประเมินความล้าทางสายตาและความไวในการตอบสนองต่อตัวกระตุ้น

วิธีการตรวจความล้าทางสายตาสามารถทำได้โดย ให้ผู้เข้าร่วมการวิจัยนั่งบนเก้าอี้ที่สามารถมองเห็นสัญญาณไฟจากเครื่องทดสอบในระดับสายตา ซึ่งเครื่องที่ใช้ในการทดสอบจะทำการประยุกต์มาจากเครื่องกระตุ้นไฟฟ้าที่สามารถปรับความถี่ได้ตามที่ต้องการ หลังจากนั้นเริ่มทำการทดสอบโดยให้ผู้เข้าร่วมการวิจัยมองไปที่สัญญาณไฟสีแดงที่ปรากฏอยู่บนเครื่องทางด้านหน้าเพื่อบอกการเปลี่ยนแปลงของลักษณะแสงไฟ ซึ่งได้แก่ การเปลี่ยนแปลงจากแสงไฟที่หยุดนิ่งไปเป็นแสงไฟที่มีการกระพริบ จากนั้นจึงบอกการเปลี่ยนแปลงจากแสงไฟที่มีการกระพริบไปเป็นแสงไฟที่หยุดนิ่ง ผู้เข้าร่วมการวิจัยจะได้รับการทดสอบ 3 ครั้ง

วิธีการวัดความไวในการตอบสนองต่อตัวกระตุ้นสามารถทำได้โดย ให้ผู้เข้าร่วมการวิจัยนั่งบนเก้าอี้ แล้ววางนิ้วชี้ที่ปุ่มกดซึ่งวางอยู่ทางด้านหน้าบนโต๊ะทดสอบ จากนั้นให้มองไปที่เครื่องวัดทางด้านหน้า ซึ่งจะมีสัญญาณไฟสีแดงปรากฏขึ้นเมื่อเริ่มการทดสอบและทันทีที่ผู้เข้าร่วมการวิจัยเห็นแสงไฟสีแดงปรากฏขึ้น จะต้องใช้นิ้วชี้กดที่ปุ่มดังกล่าวให้เร็วที่สุดเท่าที่จะทำได้ โดยใช้มือข้างที่ถนัดกดปุ่ม ผู้เข้าร่วมการวิจัยจะได้รับการทดสอบ 10 ครั้ง

ขั้นตอนที่ 2 การให้โปรแกรมการออกกำลังกายแก่พนักงาน

ทางผู้วิจัยนำข้อมูลการสำรวจปัญหาที่ได้จากทางโรงพิมพ์ มาทำการระดมความคิดร่วมกับนักกายภาพบำบัด 3 คน ซึ่งเป็นผู้มีความชำนาญทางด้านระบบกระดูกและกล้ามเนื้อและทางด้านการยศาสตร์ เพื่อร่วมกันออกแบบโปรแกรมท่าทางการออกกำลังกายที่เหมาะสมแก่

Copyright by Mahidol University

พนักงานในแต่ละแผนก ซึ่งโปรแกรมการออกกำลังกายของแต่ละแผนกจะถูกจัดทำขึ้นเป็นโปสเตอร์ และนำไปติดไว้ ในแต่ละแผนก โดยมีการสาธิตท่าทางการออกกำลังกายให้แก่พนักงานทุกคนจนเป็นที่เข้าใจและปฏิบัติได้อย่างถูกต้อง โดยทางโรงพิมพ์ได้กำหนดเป็นนโยบายให้พนักงานทุกคนออกกำลังกายตามโปรแกรมที่กำหนดทุกวันครั้งละ 5 นาที 1-2 ครั้งต่อวัน เป็นเวลา 1 เดือน

ขั้นตอนที่ 3 การตรวจร่างกายและการประเมินความล้าทางการมองเห็นซ้ำ

หลังจากพนักงานออกกำลังกายครบ 1 เดือน ทางผู้วิจัยจะทำการตรวจร่างกายและประเมินความล้าทางการมองเห็นซ้ำอีกครั้งหนึ่งด้วยวิธีการเดิมในขั้นตอนที่ 1 ซึ่งพนักงานทุกคนจะได้รับการตรวจร่างกายและประเมินความล้าทางการมองเห็นโดยนักกายภาพบำบัดคนเดิม

เมื่อท่านเข้าร่วมการวิจัยแล้ว ท่านจะต้องปฏิบัติตามขั้นตอนการดำเนินการวิจัยในทุกขั้นตอนซึ่งการวิจัยครั้งนี้ไม่ก่อให้เกิดความเสี่ยงหรืออันตรายใดๆ แก่ผู้เข้าร่วมการวิจัยที่เข้าร่วมการวิจัย หากท่านเกิดความกังวลหรือไม่ยินยอมในการเข้าร่วมการวิจัยนี้ ท่านสามารถขอถอนตัวจากการวิจัยนี้ได้ตามต้องการ

หากผู้เข้าร่วมการวิจัยมีข้อข้องใจที่ต้องการสอบถามเกี่ยวข้องกับการวิจัยหรือเกิดเหตุการณ์ไม่พึงประสงค์ใดๆจากการวิจัยครั้งนี้ สามารถติดต่อสอบถามได้ที่ นางสาวณัฏฐพร ประดิษฐพจน์ อาคารสำนักงานมหาวิทยาลัยมหิดล (เดิม) ชั้น 4 198/2 ถ.เชิงสะพานพระปิ่นเกล้า แขวงบางยี่ขัน เขตบางพลัด กทม. 10700 เบอร์โทรศัพท์ 02-433-7090-2 ได้ทุกเวลา

การวิจัยนี้ไม่มีค่าตอบแทนที่จะได้รับ และไม่มีค่าใช้จ่ายใด ๆ ที่ผู้เข้าร่วมการวิจัยจะต้องรับผิดชอบ

หากมีข้อมูลเพิ่มเติมทั้งด้านประโยชน์และโทษที่เกี่ยวข้องกับการวิจัยนี้ ผู้วิจัยจะแจ้งให้ทราบโดยเร็วไม่ปิดบัง

ข้อมูลส่วนตัวของผู้เข้าร่วมการวิจัยจะถูกเก็บรักษาไว้ ไม่เปิดเผยต่อสาธารณะเป็นรายบุคคลแต่จะรายงานผลการวิจัยเป็นข้อมูลส่วนรวม ข้อมูลของผู้เข้าร่วมการวิจัย เป็นรายบุคคลอาจจะมีคณะบุคคลบางกลุ่มเข้ามาตรวจสอบได้ เช่น ผู้ให้ทุนวิจัย หรือสถาบันหรือองค์กรของรัฐที่มีหน้าที่ตรวจสอบ เป็นต้น

ผู้เข้าร่วมการวิจัยมีสิทธิ์ถอนตัวออกจากโครงการการวิจัยเมื่อใดก็ได้ โดยไม่ต้องแจ้งให้ทราบล่วงหน้า และการไม่เข้าร่วมการวิจัยหรือถอนตัวออกจากโครงการวิจัยนี้จะไม่มีผลกระทบใด ๆ ต่อท่าน

Copyright by Mahidol University

ข้าพเจ้าได้อ่านรายละเอียดในเอกสารนี้ครบถ้วนแล้ว และยินยอมในการเข้าร่วมในการศึกษาวิจัยครั้งนี้ด้วยความสมัครใจ

ลงชื่อ...../วันที่.....

(.....)

Copyright by Mahidol University

APPENDIX B
CONSENT FORM

หนังสือแสดงเจตนายินยอมเข้าร่วมโครงการวิจัย

(Consent form)

การวิจัยเรื่อง ผลของการปรับปรุงทางการยศาสตร์ในพนักงานโรงพิมพ์ต่อความผิดปกติทางระบบกระดูกและกล้ามเนื้อที่เกี่ยวข้องกับการทำงานและความล้าทางการมองเห็น

วันให้คำยินยอม วันที่.....เดือน.....พ.ศ. .....

ก่อนที่จะลงนามในใบยินยอมให้ทำการวิจัยนี้ ข้าพเจ้าได้รับการอธิบายจากผู้วิจัยถึงวัตถุประสงค์ของการวิจัย วิธีการวิจัย อันตราย หรืออาการที่อาจเกิดขึ้นจากการวิจัย รวมทั้งประโยชน์ที่จะเกิดขึ้นจากการวิจัยอย่างละเอียดและมีความเข้าใจดีแล้ว

ผู้วิจัยรับรองว่าจะตอบคำถามที่ข้าพเจ้าสงสัยด้วยความเต็มใจ ไม่ปิดบังซ่อนเร้นจนข้าพเจ้าพอใจ

ข้าพเจ้ามีสิทธิที่จะบอกเลิกการเข้าร่วมโครงการวิจัยนี้เมื่อใดก็ได้ และเข้าร่วมโครงการวิจัยนี้ด้วยความสมัครใจ และการบอกเลิกการเข้าร่วมการวิจัยนี้ จะไม่มีผลต่อการทำงานของข้าพเจ้าต่อไป

ผู้วิจัยรับรองว่าจะเก็บข้อมูลเฉพาะที่เกี่ยวกับตัวข้าพเจ้าเป็นความลับ และจะเปิดเผยได้เฉพาะในรูปแบบที่สรุปผลการวิจัย การเปิดเผยข้อมูลเกี่ยวกับตัวข้าพเจ้าต่อหน่วยงานต่าง ๆ ที่เกี่ยวข้อง กระทำได้เฉพาะกรณีจำเป็นด้วยเหตุผลทางวิชาการเท่านั้น

Copyright by Mahidol University

ผู้วิจัยรับรองว่าหากเกิดอันตรายใด ๆ จากการวิจัยดังกล่าว ข้าพเจ้าจะได้รับการรักษาพยาบาล โดยไม่คิดมูลค่าตามมาตรฐานวิชาชีพ และจะได้รับการชดเชยรายได้ที่สูญเสียไประหว่างการรักษาพยาบาลดังกล่าว ตลอดจนเงินทดแทนความพิการที่อาจเกิดขึ้น

ผู้วิจัยรับรองว่าหากมีข้อมูลเพิ่มเติมที่ส่งผลกระทบต่อการวิจัย ข้าพเจ้าจะแจ้งให้ทราบโดยไม่ปิดบังซ่อนเร้น

ข้าพเจ้าได้อ่านข้อความข้างต้นแล้ว และมีความเข้าใจดีทุกประการและได้ลงนามในใบยินยอมนี้ด้วยความเต็มใจ

ลงนาม ..... ผู้ยินยอม
ลงนาม ..... พยาน
ลงนาม ..... พยาน

ในกรณีที่ผู้ยินยอมตนให้ทำการวิจัยไม่สามารถอ่านหนังสือได้ จะต้องได้รับการยินยอมในขณะที่ยังมีสติสัมปชัญญะและระบุข้อความไว้ตามนี้ ข้าพเจ้าไม่สามารถอ่านหนังสือได้ แต่ผู้วิจัยได้อ่านข้อความในใบยินยอมนี้ให้แก่ข้าพเจ้าฟังจนเข้าใจดีแล้ว ข้าพเจ้าจึงลงนามหรือประทับลายนิ้วแม่มือขวาของข้าพเจ้าในใบยินยอมนี้ด้วยความเต็มใจ

ลงนาม ..... ผู้ยินยอม
ลงนาม ..... พยาน
ลงนาม ..... พยาน

Copyright by Mahidol University

APPENDIX C
DATA COLLECTION FORM

EXAMINATION FORM

สำรวจความผิดปกติทางระบบกระดูกและกล้ามเนื้อที่สัมพันธ์กับการทำงานและสิ่งแวดล้อมในการทำงานในพนักงาน *จากการตรวจร่างกายโดยนักกายภาพบำบัด*

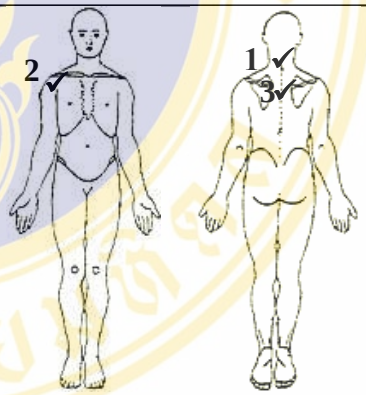
วันที่.....ชื่อ – นามสกุล.....

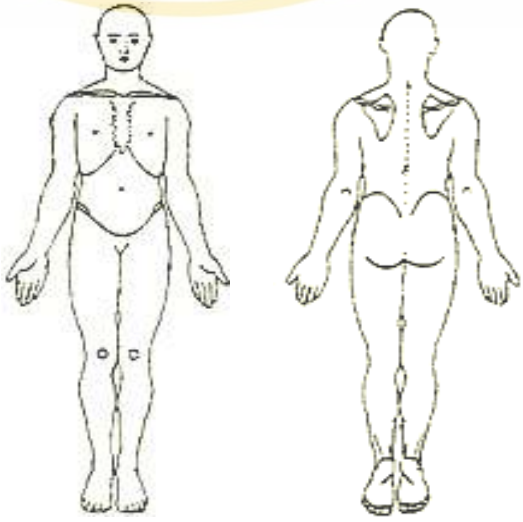
แผนก.....ตำแหน่งงาน.....

---

1. กรุณาแรเงา ลงในแผนภาพแสดงส่วนต่าง ๆ ของร่างกายให้ตรงกับบริเวณที่ท่านมีอาการผิดปกติ และโปรดระบุตัวเลข บนตำแหน่งที่ท่านมีอาการ (หากท่านมีอาการมากกว่า3 ตำแหน่ง กรุณาระบุตำแหน่งที่มีอาการมากที่สุด 3 อันดับแรก)

ตัวอย่าง : ถ้ามีอาการปวดคอทางด้านหลัง, ไหล่ขวาทางด้านหน้าและปวดหลัง โดยมีอาการปวดคอมากที่สุด และมีอาการปวดไหล่และหลังรองลงมาตามลำดับ ให้แรเงา ลงในภาพ พร้อมทั้งใส่เลข 1-3 ดังรูป





Copyright by Mahidol University

	Chief complaint	History	Pain scale ขณะที่ตรวจ	Stage ของโรค	คุณคาดว่าอาการที่คุณเป็นมีสาเหตุมาจากอะไร	Aggravate and Ease	Irritability (T_1, T_2, T_3)
1st Area							
2nd Area							
3rd Area							

หมายเหตุ - Stage ของโรค: ระยะที่ 1 มีอาการขณะทำงาน อาการหายไปเมื่อพัก ไม่มีอาการคงค้างเมื่อตื่นนอนตอนเช้า

ระยะที่ 2 มีอาการทั้งในขณะทำงานและขณะพัก มีอาการคงค้างเมื่อตื่นนอนตอนเช้า

ระยะที่ 3 ไม่สามารถทำงานเมื่อจะเป็นงานที่เบาได้ มีอาการขณะพัก และรบกวนการนอน

Copyright by Mahidol University

Palpation

☐ Guarding of muscle

……

☐ Tenderness of (area or structure) / Trigger point at

……

Nerve tension

☐ Negative

☐ Positive of

……

Other tests

……

……

สรุป	1st Area	2nd Area	3rd Area
Impairment			
สิ่งที่ตรวจพบ			

ผู้ตรวจ……

Copyright by Mahidol University

CRITICAL FLICKER FREQUENCY AND REACTION TIME DATA COLLECTION FORM

ชื่อ-นามสกุล..... แผนก..... วันที่ตรวจ.....

CFF test

ครั้งที่	Short to long duration (ms.)	Long to short duration (ms.)
1		
2		
3		
เฉลี่ย		

RT test

ครั้งที่	Left	Right
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
เฉลี่ย		

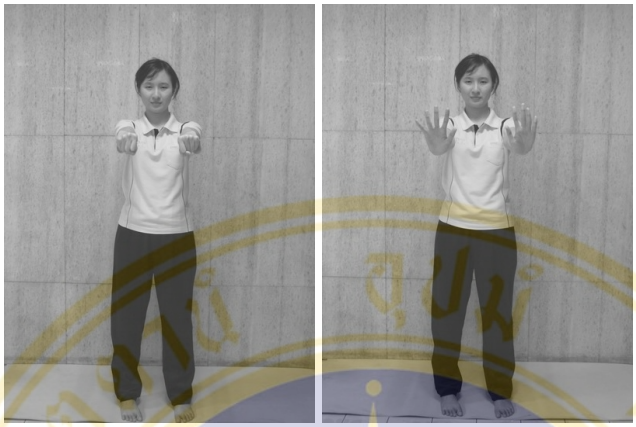
Copyright by Mahidol University

APPENDIX D
EXERCISE PROGRAM

1. Upper Extremity and Trunk exercise

Copyright by Mahidol University

2. Wrist and Hand exercise



3. Neck and Shoulder exercise

Copyright by Mahidol University

4. Nerve mobilization exercise

Copyright by Mahidol University

APPENDIX E
RELIABILITY ANALYSIS OF CRITICAL FLICKER FREQUENCY AND REACTION TIME TESTS

Table E.1 The data for test of CFF and RT intra rater reliability

	CFF test (ms)				RT test (ms)	
	short to long duration		long to short duration			
	pre	post	pre	post	pre	post
1	5.00	5.00	2.00	5.00	0.213	0.217
2	2.00	3.00	2.00	4.00	0.231	0.213
3	1.33	1.67	2.00	1.67	0.264	0.269
4	2.00	5.00	2.00	3.00	0.322	0.325
5	3.00	6.67	3.00	6.67	0.275	0.273
6	5.00	6.67	1.33	1.67	0.240	0.274
7	5.00	5.00	4.00	4.00	0.259	0.283
8	5.00	6.67	5.00	5.00	0.215	0.227
9	5.00	6.67	5.00	6.67	0.238	0.250
10	5.00	5.00	5.00	5.00	0.246	0.250

Table E.2 Reliability of the short to long duration of Critical Flicker Frequency (CFF) test

	Intraclass Correlation(a)
Single Measures	.687(b)

a Type C intraclass correlation coefficients using a consistency definition-the between-measure variance is excluded from the denominator variance.
b The estimator is the same, whether the interaction effect is present or not.

Copyright by Mahidol University

Table E.3 Reliability of the long to short duration of Critical Flicker Frequency (CFF) test

	Intraclass Correlation(a)
Single Measures	.633(b)

a Type C intraclass correlation coefficients using a consistency definition-the between-measure variance is excluded from the denominator variance.
b The estimator is the same, whether the interaction effect is present or not.

Table E.4 Reliability of Reaction Time (RT) test

	Intraclass Correlation(a)
Single Measures	.909(b)

a Type C intraclass correlation coefficients using a consistency definition-the between-measure variance is excluded from the denominator variance.
b The estimator is the same, whether the interaction effect is present or not.

Copyright by Mahidol University

APPENDIX F
RAW DATA OF THE STUDY

Table F.1 WMSDs in nine parts of body

Number of case	Sex	Area	Pain scale		WMSD severity stage		WMSD findings*	
			pre	post	pre	post	pre	post
1	1	neck	4	3	1	1	1	1
2	1	neck	0	0	1	0	1	0
3	1	neck	0	6	0	1	0	4
4	1	neck	0	0	1	0	1	0
5	1	neck	0	0	0	1	0	1
6	1	shoulder	4	0	1	0	1	0
7	1	shoulder	0	0	1	0	1	0
8	1	shoulder	0	0	1	0	1	0
9	1	shoulder	5	0	1	0	4	0
10	1	shoulder	0	5	0	1	0	1
11	1	shoulder	6	2	3	1	5	5
12	1	shoulder	0	0	1	0	1	0
13	1	shoulder	4	7	2	1	1	4
14	1	shoulder	0	8	0	2	0	4
15	1	shoulder	3	0	1	0	5	0
16	1	shoulder	0	0	1	0	1	0
17	1	shoulder	0	0	2	0	1	0
18	1	shoulder	0	0	1	0	4	0
19	1	shoulder	5	0	1	0	1	0
20	1	elbow	0	0	1	0	2	0
21	1	elbow	3	0	0	0	1	0
22	1	elbow	3	0	2	0	1	0
23	1	wrist/hand	0	4	0	1	0	2
24	1	wrist/hand	7	7	2	1	2	4
25	1	wrist/hand	6	0	1	0	4	0
26	1	wrist/hand	2	6	1	1	2	5
27	1	wrist/hand	6	0	2	1	5	5
28	1	wrist/hand	6	0	1	0	5	0
29	1	wrist/hand	5	0	1	0	5	0
30	1	wrist/hand	0	0	1	0	2	0
31	1	wrist/hand	0	0	0	1	0	1
32	1	upper back	4	0	1	0	4	0
33	1	upper back	0	0	1	0	1	0

Copyright by Mahidol University

Number of case	Sex	Area	Pain scale		WMSD severity stage		WMSD findings*	
			pre	post	pre	post	pre	post
34	1	upper back	0	0	0	1	0	1
35	1	lower back	0	0	1	0	4	0
36	1	lower back	5	4	1	2	1	5
37	1	lower back	0	0	0	1	0	4
38	1	lower back	0	7	0	1	0	4
39	1	lower back	0	2	2	1	4	4
40	1	lower back	7	7	2	1	5	4
41	1	lower back	0	8	0	1	0	4
42	1	lower back	3	0	2	0	4	0
43	1	lower back	5	0	1	0	1	0
44	1	knee	3	0	1	0	4	0
45	1	knee	4	0	2	0	4	0
46	1	neck	0	5	0	1	0	1
47	1	neck	0	5	0	3	0	5
48	1	neck	0	4	0	1	0	1
49	1	neck	0	0	1	.0	1	0
50	1	neck	0	4	0	1	0	4
51	1	neck	10	10	3	2	1	5
52	1	neck	0	4	0	1	0	1
53	1	neck	8	0	1	0	5	0
54	1	neck	7	0	2	0	4	0
55	1	neck	5	0	1	0	5	0
56	1	neck	5	0	1	0	5	0
57	1	neck	4	7	2	1	4	5
58	1	neck	5	0	2	0	5	0
59	1	shoulder	7	0	3	0	5	0
60	1	shoulder	8	0	2	0	5	0
61	1	shoulder	0	3	1	2	1	1
62	1	shoulder	0	0	2	0	5	0
63	1	shoulder	8	0	1	0	5	0
64	1	shoulder	3	0	1	0	5	0
65	1	shoulder	0	0	1	0	5	0
66	1	shoulder	4	0	1	0	1	0
67	1	shoulder	0	0	2	0	1	0
68	1	shoulder	5	0	1	0	1	0
69	1	shoulder	0	3	0	2	0	1
70	1	shoulder	3	0	2	0	5	0
71	1	shoulder	4	0	1	0	1	0
72	1	shoulder	6	5	1	1	1	1
73	1	shoulder	0	3	0	2	0	5
74	1	shoulder	9	8	1	1	4	5
75	1	shoulder	0	2	0	1	0	1
76	1	shoulder	4	7	2	1	1	5

Copyright by Mahidol University

Number of case	Sex	Area	Pain scale		WMSD severity stage		WMSD findings*	
			pre	post	pre	post	pre	post
77	1	shoulder	5	5	2	1	1	5
78	1	elbow	4	0	1	0	5	0
79	1	elbow	0	7	0	2	0	4
80	1	elbow	8	0	2	0	5	0
81	1	elbow	0	4	0	0	0	1
82	1	wrist/hand	0	0	1	0	5	0
83	1	wrist/hand	0	0	2	0	1	0
84	1	wrist/hand	7	0	2	0	4	0
85	1	wrist/hand	0	0	2	0	5	0
86	1	wrist/hand	0	9	0	3	0	4
87	1	wrist/hand	5	0	1	0	2	0
88	1	wrist/hand	0	0	0	1	0	1
89	1	wrist/hand	0	0	1	0	2	0
90	1	wrist/hand	0	0	0	1	0	1
91	1	wrist/hand	0	0	0	1	0	1
92	1	wrist/hand	3	4	1	1	1	1
93	1	wrist/hand	2	0	1	0	1	0
94	1	wrist/hand	0	0	1	0	5	0
95	1	wrist/hand	1	3	1	1	2	4
96	1	wrist/hand	0	0	0	0	5	0
97	1	wrist/hand	6	0	1	0	5	0
98	1	upper back	8	0	1	0	5	0
99	1	upper back	9	0	1	0	4	0
100	1	lower back	6	0	3	0	5	0
101	1	lower back	5	0	1	0	5	0
102	1	lower back	0	4	0	1	0	4
103	1	lower back	7	0	1	0	5	0
104	1	lower back	6	0	1	0	1	0
105	1	lower back	6	0	1	0	5	0
106	1	lower back	6	0	2	0	5	0
107	1	lower back	6	7	2	1	4	4
108	1	hip/thigh	0	0	0	1	0	2
109	1	hip/thigh	2	2	2	1	4	4
110	1	hip/thigh	10	0	1	0	1	0
111	1	knee	0	0	1	0	4	0
112	2	shoulder	0	0	2	0	1	0
113	2	shoulder	0	7	0	3	0	5
114	2	shoulder	0	4	0	2	0	1
115	2	wrist/hand	4	4	2	2	2	2
116	2	wrist/hand	7	3	1	1	4	4
117	2	lower back	0	5	1	1	4	5
118	2	lower back	0	0	1	0	4	0
119	2	neck	4	0	2	0	4	0

Copyright by Mahidol University

Number of case	Sex	Area	Pain scale		WMSD severity stage		WMSD findings*	
			pre	post	pre	post	pre	post
120	2	shoulder	7	2	2	2	1	1
121	2	shoulder	5	0	2	0	5	0
122	2	shoulder	8	0	2	0	1	0
123	2	shoulder	4	3	1	1	1	4
124	2	shoulder	0	0	3	0	4	0
125	2	shoulder	0	8	0	1	0	1
126	2	elbow	0	7	0	2	0	5
127	2	wrist/hand	4	0	1	0	2	0
128	2	wrist/hand	0	0	2	0	2	0
129	2	lower back	0	0	0	1	0	1
130	2	lower back	0	0	1	0	4	0
131	2	lower back	0	8	1	1	5	5
132	2	lower back	6	6	2	2	5	5

* WMSD findings (0=no disorders, 1=muscular disorders, 2=tendon disorders, 3=nerve disorders, 4=bone/joint/ligament disorders, 5=mix disorders)

Copyright by Mahidol University

Table F.2 Neural tissue tension

Number of report	Sex	pre	post
1	1	-	radial
2	1	-	median
3	1	sciatic	-
4	1	-	dural
5	1	dural	radial
6	1	median	median
7	1	radial	-
8	1	radial	-
9	1	dural	dural
10	1	median	median
11	1	dural	-
12	1	median	median
13	1	median	-
14	1	radial	-
15	1	median	-
16	1	median	median
17	1	median	-
18	1	ulnar	-
19	1	median	median
20	1	dural	-
21	1	-	median
22	1	median	-
23	1	median	-
24	1	-	median
25	1	median	-
26	1	-	median
27	2	dural	-
28	2	-	dural
29	2	-	dural
30	2	ulnar	-
31	2	radial	radial
32	2	dural	-
33	2	dural	-

Copyright by Mahidol University

BIOGRAPHY

NAME	Miss Nuttaporn Praditpod
DATE OF BIRTH	2 July 1984
PLACE OF BIRTH	Bangkok, Thailand
INSTITUTIONS ATTENED	Mahidol University, 2002-2005 Bachelor of Science (Physical Therapy) with the second class honors Mahidol University, 2006-2008 Master of Science (Physical Therapy)
SCHOLARSHIP	Grant to Support Graduate Students in Academic Presentations in Thailand Academic Year 2008
HOME ADDRESS	429/23 Soi Sathupradit 57, Bangpongpang, Yannawa, Bangkok, 10120
PUBLICATION	Oral Presentation at the 9th Southeast Asian Ergonomics Society Conference 21-24 October 2008, the Ergonomics Society of Thailand and Thammasat University

Copyright by Mahidol University