ผลของการยืดกล้ามเนื้อคอในขณะพักการทำงานต่ออาการปวดคอและการเปลี่ยนแปลงของ surface EMG median frequency ในกลุ่มพนักงานสำนักงาน

นายอธิพล เมธาทิพย์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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Effects of short break neck stretching on neck pain and surface EMG median frequency changes in office workers

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A Thesis Submitted in Partial Fulfillment of the Requirements
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อธิพล เมธาทิพย์ : ผลของการยืดกล้ามเนื้อคอในขณะพักการทำงานต่ออาการปวดคอและการเปลี่ยนแปลงของ surface EMG median frequency ในกลุ่มพนักงานสำนักงาน. (Effects of Short Break Neck Stretching on Neck Pain and Surface EMG Median Frequency Changes in Office Workers.) อ. ที่ปรึกษาวิทยานิพนธ์หลัก : รองศาสตราจารย์ นายแพทย์พงศ์ศักดิ์ ยุกตะนันทน์, 137 หน้า.

วัตถุประสงค์: เพื่อศึกษาการเปลี่ยนแปลงและเปรียบเทียบผลของการออกกำลังกายในขณะพักการทำงานของพนักงานสำนักงานเป็นเวลา 4 สัปดาห์ ระหว่างการยืดกล้ามเนื้อคอและการหายใจลึกเพื่อการผ่อนคลาย ต่อระดับของ pain (VAS), Surface EMG median frequency (MF), และคะแนนของอาการปวดคอและการดำเนินชีวิต (NDI)

วิธีดำเนินการ: อาสาสมัครหญิงที่มีอาการปวดคอเรื้อรังจากการทำงานด้วยคอมพิวเตอร์ตั้งโต๊ะ อายุ 25 – 35 ปี มี 2 กลุ่ม กลุ่มละ 30 คน คือกลุ่มออกกำลังกายด้วยการยืดกล้ามเนื้อคอด้านข้างและด้านหลังและกลุ่มออกกำลังกายด้วยการหายใจลึกเพื่อการผ่อนคลาย จะทำการออกกำลังกายทุกวันที่ทำงานวันละ 2 เวลา วัดผลทั้งก่อนและหลัง 4 สัปดาห์ด้วยการวัดระดับ VAS ระดับ MF และ NDI

ผลการทดลอง: VAS และ NDI ลดลงอย่างมีนัยสำคัญทางสถิติ ($p<0.001$) จากการออกกำลังกายในกลุ่มยืดกล้ามเนื้อและกลุ่มหายใจลึกเพื่อการผ่อนคลายขณะพักการทำงาน การฝึกหายใจลึกเพื่อการผ่อนคลายไม่สามารถแก้ปัญหาอาการล้าของกล้ามเนื้อได้ ($p<0.05$) ส่วนการยืดกล้ามเนื้อสามารถแก้ปัญหาอาการล้าของกล้ามเนื้อได้เฉพาะกล้ามเนื้อทางด้านซ้ายเท่านั้น ($p>0.05$)

สรุปผลการทดลอง: การยืดกล้ามเนื้อขณะพักการทำงานทำให้ระดับอาการปวด ระดับอาการล้าของกล้ามเนื้อคอ และระดับคะแนนคุณภาพชีวิตดีขึ้น ส่วนการหายใจลึกเพื่อการผ่อนคลายขณะพักการทำงานทำให้ระดับอาการปวดและระดับคะแนนคุณภาพชีวิตดีขึ้น แต่ไม่ได้ทำให้อาการล้าของกล้ามเนื้อคอดีขึ้น

สาขาวิชา เวชศาสตร์การกีฬา ลายมือชื่อนิสิต .....

ปีการศึกษา 2553 ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก .....

5074846230 : MAJOR SPORTS MEDICINE

KEYWORDS : STRETCHING/ CHRONIC NECK PAIN/ VISUAL ANALOG SCALE/ NECK DISABILITY INDEX/ SURFACE ELECTROMYOGRAPHY/ MEDIAN FREQUENCY/ OFFICE WORKER

ATIPON METHATIP: EFFECTS OF SHORT BREAK NECK STRETCHING ON NECK PAIN AND SURFACE EMG MEDIAN FREQUENCY CHANGES IN OFFICE WORKERS. ADVISOR: ASSOCIATE PROFESSOR PONGSAK YUKTANANDANA, M.D., 137 pp.

Objectives: To study and compare the effects of 4 weeks short break neck exercise between stretching exercise and relaxation breathing exercise on pain level (VAS), surface EMG median frequency (MF) and the neck disability index score (NDI) in chronic neck pain female office workers who are prolonged computer users.

Materials and methods: The participants were 60 Thai female office workers aged between 25 – 35 years old. Thirty of the stretching group stretched neck muscle 30 seconds for 3 times in both upper trapezius and cervical erector spinea. Thirty of the breathing exercise group did deep breathing for relaxation 5 minutes. VAS, MF, and NDI were used as parameters.

Result: VAS in both groups reduced significantly after 4 weeks of exercise ($p<0.001$). The MF of all neck muscles in both groups were shifted toward lower frequency which indicated fatigue pattern. Only left UT and left CES in the ST group showed no fatigue after training. There was significant ($p<0.001$) improvement of NDI score in both groups.

Conclusion: The effects of stretching or breathing exercise as a short break exercise at work twice a day in 4 weeks program provided improve pain level and quality of life. The stretching exercise potentially improved muscle fatigability of the neck muscles in the non-dominant side.

Field of Study : Sports Medicine Student's Signature .....

Academic Year : 2010 Advisor's Signature .....

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CHAPTER I

INTRODUCTION

Background and rationales

There are many office workers who use computer longer than 6 hours a day continuously. The intensive computer useage could cause the neck – shoulder musculoskeletal disorder. The workers may need medical service with the chief complaint of chronic neck and shoulder pain occasionally. Computer plays major and universal role in most careers, anyone could hardly avoid computer task. Each career worker spends various time of computer usage. Some career workers such as secretary, accountant, programmer, architect, typist, etc may use computer for a long period everyday. Prolong computer users need prolong neck muscle contraction and position to accommodation their vision in order to type the computer correctly. Working with computer and stress are associated and the users always develop neck pain in the workplace.

Neck pain or cervical myalgia from computer usage one of the work – related musculoskeletal disorders. This syndrome is the most common health problem among both developed and developing countries. In Canada, 54% of the Canadian female office workers suffered from neck pain (1). Around 67% of Dutch female office workers also had experienced neck pain (2). In United State, more than 600,000 office workers suffered musculoskeletal pain each year (3). Prevalence of work – related musculoskeletal in Norway working population rates 30% or even higher (4). The Denmark national research center referred the problem of neck symptoms in female office workers is 80% (5). In Thailand, there were 62.7% of office workers with work – related musculoskeletal disorder, comprised of neck and shoulder 43% lower back and wrist 36.9%, upper back 29.7%. This symptom occurred in both female and male age groups between 20 – 60 years old (6).

In term of economic impact, it was estimated that in 1995, the cost of work – related musculoskeletal disorders in the USA was approximately $215 billion (3). The cost of treating neck pain in the Netherlands in 1996 was around $868 million (2). In

1996, the total cost was added up to approximately 668 million Euro (7). In 2000, 594,000 Dutch males and 1,013,700 Dutch females were registered with chronic neck pain. The average treatment cost of chronic neck pain in Finland in 1988 was estimated to be 240 Euros and the cost due to sick leave per patient case was 653 Euros (8). For more than a million of computer office workers complaint of the arm, neck, and shoulder pain were cause of treatment cost and absentees in the USA rate $45 to $54 billion annually. Additionally, in Netherlands annual cost for occupational pain is estimated to be 2.1 billion Euros for 7 million working population (9). In Thailand, number of workers' work – related musculoskeletal disorder compensation claim from the data of the Social Security Office in 2003 was 11,737 of 55,596 claimed cases (21%) (6). The cost of insurance and the compensation for patients, employers could effect finance, economic and social.

The common behavior of computer users in offices is continuous computer use during workdays; chronic repetitive computer works such as data entry were associated with the increasing risk of the chronic neck pain symptoms. The hypothesis postulates that prolong low – level workloads with too short period of muscle resting can result overuse of low – threshold muscle fibers that leads to WRMSDs (10). Consequently, patients suffer chronic neck – shoulder fatigue due to this working type. The symptoms originate and exacerbate are related with the accumulation of muscle fatigue because continuous low – level muscle contraction of the corresponding muscle in the static posture for a long period of time contributes poor microcirculation (11). Blood circulation then becomes so poor that it effects the lack of essential and oxygen in soft tissue, moreover, some waste products from metabolism are collected in muscle tissue. Conventional wisdom has assumed that the pain was a consequence of a sustained spasm of musculoskeletal due to muscle fiber activity induce energy crisis. Laser – Dropper Flowmetry (LDF) was used to explain this statement, so, the data indicated pain was associated with trapezius vasodilation but not with muscle activity. Relationship between blood vessels and norciceptors might be important in stimulation of muscle nociceptors in the case of chronic neck – shoulder pain (4). If muscle got insufficient oxygen, lactic acid would be produced.

Acid is commonly considered a painful stimulus as ischemic pain mediation (12). So, muscle acidosis can lead to local and referred pain and hyperalgesia (13). Finally, muscle will be exhausted, fatigue, and injured. Moreover, the nature of computer task needs intensive concentration which causes the lost of relationship among colleagues. This situation could cause mental stress, easy – spasm muscle and injury (6).

Upper trapezius muscle is frequently involved in the neck/shoulder discomfort prevalence in computer users, for example, patients with chronic neck pain demonstrate reduced motion and pattern changes of muscle control in the cervical flexor and upper trapezius muscle during specific tasks. According to most investigating research, work – related neck or shoulder pain focus on the trapezius muscle the most (14). Because upper trapezius muscle is a superficial muscle, the surface EMG is often used in researches related to occupational health.

The method of (15) study includes an isometric task selective for the upper trapezius muscle at different force levels and one fatiguing contraction (15). The fatigue characteristics of trapezius due to computer work are explained in many studies that investigated both of perceived exertion and localized muscle fatigue. Because it was still unclear why and how chronic muscle fatigue could be induced from transitory muscle fatigue, further study was needed to reveal whether discrepancy could be a major factor and to determine some guidelines in preventing computer work – related chronic muscle fatigue in trapezius muscle (11). To understand the biomechanical exposure in this postural stability model and its development to WRMSD in visual display terminals (VDTs), activity of trapezius of computer users have been assessed in many studies. Patterns of increased muscle activity in the upper trapezius were found in symptomatic workers during typing task and the pain increased during prolonged typing (16). The computer users with muscle tension showed significantly higher median trapezius EMG activity and tendency toward lower degree of muscle rest. These surface EMG signals were recorded bilaterally upper trapezius muscles during keyboard typing, edit, precision, and color word stress task in female Denmark and Sweden who are 46 – 65 years old (10).

There are many ways to solve this problem; medicine, acupuncture, massage, and exercise. The first three solutions have cost in the treatment. In fact, this syndrome can be prevented in the save way by physical exercise for good physical fitness, good work environment, good ergonomic, and enough breaking time. Flexibility is a part of physical fitness that attributes stretching exercise. Stretching exercise is a common part of treatment for neck pain, which has been suggested as a treatment of musculoskeletal disorder which is possible for home program or exercise at work (17, 18).

Prevention and self treatment of work – related musculoskeletal disorder gave many advantage including; reduce cost of treatment, reduce absent from work days, reduce injury claim, being able to work and earn, and improve quality of life.

Thai Health Promotion Foundation actively campaigns the prevention of office syndrome or computer syndrome. This health promotion includes articles via website and flyers, activity, road show, and consultation in its own website (www.Thaihealth.or.th). The information in website and publications are usually exercise program or healthy ways of living.

Work – related musculoskeletal disorder among office workers is a very important health problem. If the strategy of prevention or treatment is not appropriate, the problem may be more severe and could affect more workers. The reimbursement for treatment and sick – leave could increase and cause economic and social impact. Therefore, any study for better understanding of the cause, prevention and treatment of work – related musculoskeletal disorder will benefit the workers, society and economy of the country.

The aims of this study were to investigate and compare the effect of 4 - week short break neck stretching exercise and relaxation breathing exercise in female office workers with prolong use of computer in term of neck pain (VAS), neck muscle fatigability by surface EMG median frequency (MF), and the neck disability index (NDI).

The study has been approved the by the Institutional Review Board of Faculty of Medicine, Chulalongkorn University. Written informed consent was obtained from each subject before the experiment started. On attendance, subjects were given the details of

the research procedure and risk involved, and reminded of their right to withdraw at any stage of the study.

Research Questions

Primary research question: Will the computer user office workers who do the neck stretching exercise have less pain level than the ones who do the breathing exercise for relaxation when the result was measured by the visual analog scale (VAS)?

Secondary research question: Will the computer user office workers who do the neck stretching exercise have less pain level than the ones who do the breathing exercise for relaxation when the result was measured by Surface EMG median frequency and the neck disability index (NDI)?

Objective

1. To investigate the changes of pain level, surface EMG median frequency (MF), and the neck disability index (NDI) of the neck stretching exercise and the breathing exercise for relaxation in computer users.

2. To compare the changes of pain level, surface EMG median frequency (MF), and the neck disability index (NDI) between the neck stretching exercise and the breathing exercise for relaxation.

Hypothesis

Computer user office workers in the neck stretching exercise group would have pain level, Surface EMG median frequency level changes, and the neck disability index level less than the ones in the breathing exercise for relaxation group.

Conceptual framework

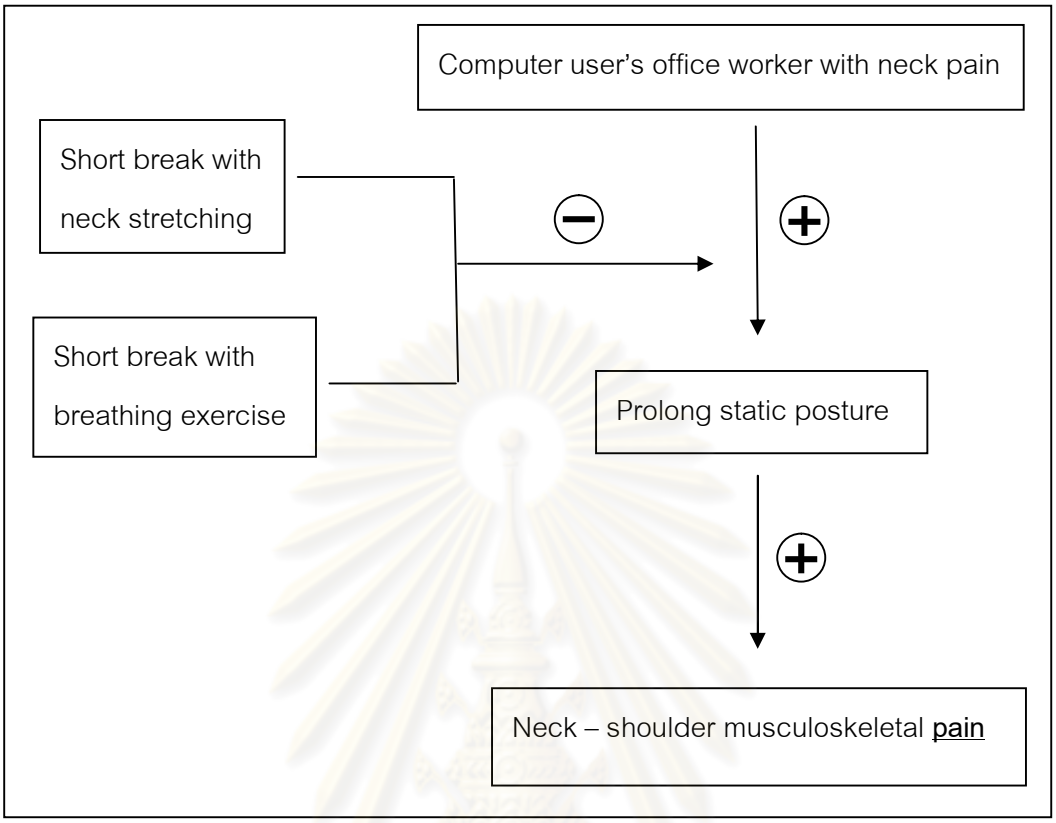

Figure 1 Conceptual framework.

Scope of study

This study is a human experimental research in which computer user office workers with neck pain as the subjects.

Workplace exercise programs were divided into two groups consists of neck stretching group and breathing exercise for relaxation group. Each group followed the protocol 2 sessions every working day for 4 weeks.

Assumption

1. The samples are volunteer and get the information paper with explanation of research methodology. All participants have to fill in the sign consent form.

2. The participants must not do any heavy activity or exercise, not being physiotherapy or medical program.

3. To collect data is before and after 4 – week of exercise program.

4. The Visual Analog Scale (VAS), surface EMG median frequency, and the Neck Disability Index (NDI) is protocol in this recent study.

Limitation of study

1. This study must be associated with computer user office worker include in inclusion criterion.

2. Some participants are possible to withdraw due to scare EMG provide painful.

3. During collecting data, the participants would be bored due to 2 – hour computer use session. Therefore, the participants must be motivated for control speed typing through the session.

4. This study is unable to compare the effects of stretching across different occupational groups with distinct demands.

Keywords

Stretching, Neck pain, Visual Analog Scale, Neck Disability Index, Surface Electromyography, Median frequency, Office worker

Operational Definition

1. Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage that result of a sustained spasm of skeletal muscle.

2. Chronic pain is a sensation of hyperalgia to skin palpation, ligaments, and muscles during both active and passive movement, with more than 3 months.

3. Muscle fatigue is failure to maintain the required force.

4. Stretching is elongation of the muscle that is one part of prevention or treatment for musculoskeletal disorders.

5. Breathing exercise for relaxation is one of breathing exercise technique by diaphragmatic breathing pattern

6. Neck disability index is the questionnaire has been designed to give the information as to how the neck pain has affected the ability to manage everyday life. Score is 0 – 50 range that “50” as worst disability.

7. Visual analog scale is a psychometric response scale which can be used in questionnaire. It is linear scale respondents specify their level of agreement to a statement by indicating a position along a 100 millimeters horizontal continuous line between two end – point that left – end “0” as no pain and right – end “100” as worst possible pain.

8. EMG median frequency is the frequency that divides the power spectrum into two parts with equal area.

Expected benefits and applications

1. To investigate physiology of pain and surface electromyography from stretching exercise in computer use.
2. To determine the appropriate stretching exercise program in computer use.
3. To apply in working hour.
4. Able to protect neck and shoulder musculoskeletal disorders in computer use.
5. To extent in future study.

CHAPTER II
LITERATURE REVIEW

Chronic neck musculoskeletal pain in office workers.

Neck musculoskeletal pain is common in the general population in many industry countries, especially among the prolonged computer users. The visual display terminal (VDT) or the computer desktop is standard equipment for many office workers. The VDT is able to increase risk of poor conditions related to the mental health and the musculoskeletal system. The pathology computer – related neck musculoskeletal disorder remains unclear, so to relief pain is the major demand (19, 20).

The selective and sustained activation of the muscles is the possible pathophysiological mechanisms hypothesis for the development of soft tissue damage (21). The prolong computer user office workers have been static posture with low – load muscle contraction because the computer task needs only low – load physical demand, but it is enough to give opportunity of muscle morphological changes, fatigue, and pain (11, 14, 22).

Upper trapezius (UT) and cervical erector spinea (CES) often pain among computer office workers (4, 14, 16, 23) due to they play an important role during computer task to provide stability and motion for neck and arms (19, 24, 25). This is mechanical neck pain that poor posture is one of multiple risk factors of neck musculoskeletal disorders. Self – poor posture, such as head forward or bad ergonomic of work station was associated with upper quarter musculoskeletal symptoms in computer users. Additional, inadequate postural changes promote musculoskeletal problems (6, 26).

Musculoskeletal pain is

Mention in Ana Cláudia “Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage that is why patients tend to stop working or exercise. In chronic pain, the sensorial process becomes abnormal, leading to detectable changes in central nervous system data processing, motor

control, and the experience of pain itself. Chronic neck pain is a sensation of hyperalgia to skin palpation, ligaments, and muscles during both active and passive movement. Mechanical neck pain has been described as having no detectable or specific etiology (such as inflammation or infection), and it may be reproduced by provocative stimuli" (27). Pain is the same meaning of myalgia (22). There is many term of work – related pain have been described differently in various include repetitive strain injury, cumulative trauma disorders, and occupational overuse syndrome. These disorders demonstrate little by little progression that is a chronic course and often disregard (28).

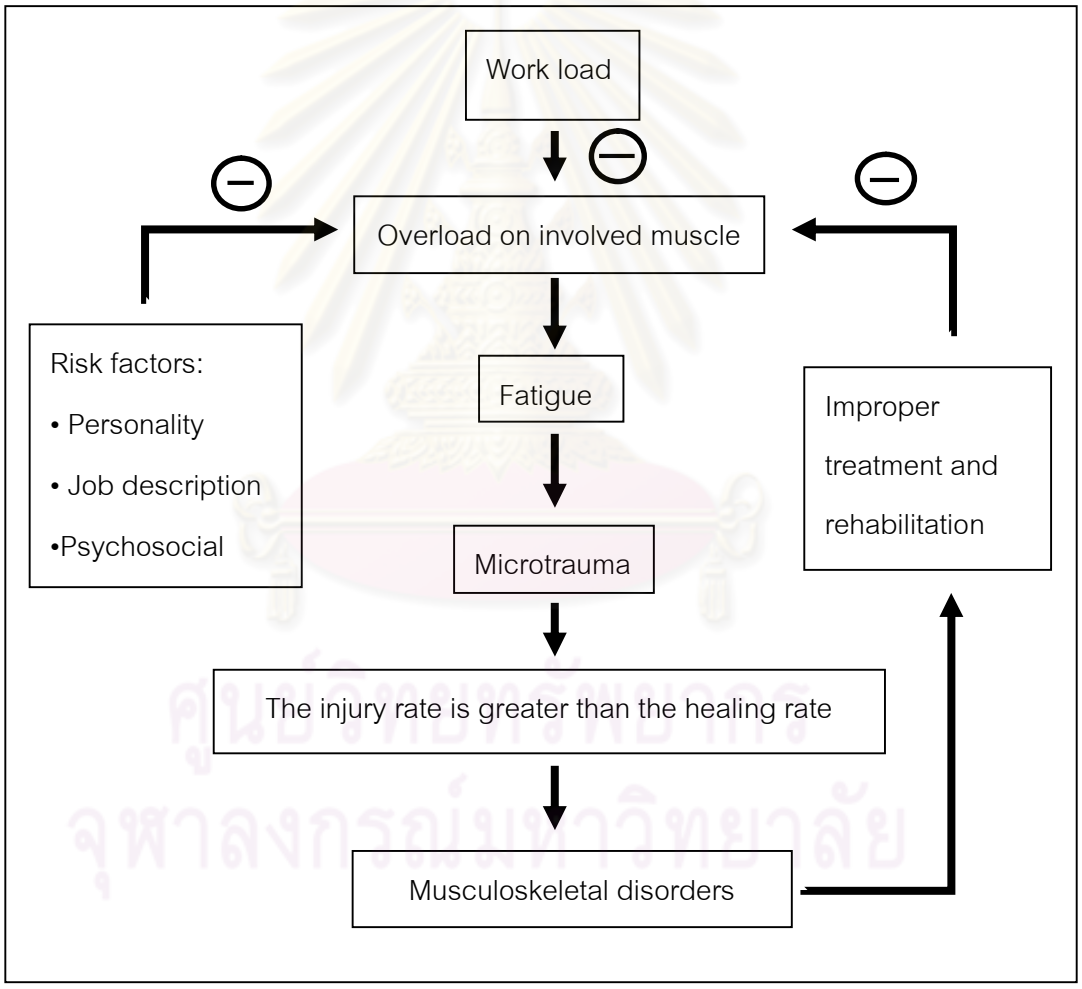

Figure 2 Process of Musculoskeletal disorders from working.

Risk factors of work – related musculoskeletal disorders.

The etiology of WRMSDs is originated by multi – factorial that is a combination of physiology, biomechanical, psychological, and social factors. They are possible to offset or modify the influence of other factors (16).

Following the biopsychosocial model of musculoskeletal disorders development combine 3 elements include physical, psychosocial, and biomechanical – environment that was divided into

1. Physical factors consists of personal factors, occupational factors
2. Psychosocial factors

Personal factors

Sex: Prevalence of female computer users with myalgia is greater than male. The potential reason is

• Normally, female's physical is weaker than males'.

• The most office equipment is paired with male's composition that provide inappropriate ergonomic in female, for example in computer task, females are more often elevate shoulder than males.

• The most women have to involve housework and look after the family duty that result muscle accumulation phenomenal.

• The prolonged monotonous work, such as, secretary or assistant, the most is women.

• Women are sensitive to stress than men. In some local, men cannot present bad attitude to stress and pain. This demonstrates the pain in females is greater than males (22, 25).

Age: Many physiological changes among elder peoples that contribute the risk of musculoskeletal disorder, example, tissues are decreased strength, endurance, and flexibility, delayed tissue healing, delayed new job skill. The most musculoskeletal disorders population is 45 – 64 years old. In the other hand, a long time skilled experience is able to prevent and protect musculoskeletal disorders through compensation and technique knowledge (6).

Body shape: Unsuitable equipment for body shape contributes inappropriate posture and movement is potential cause musculoskeletal disorders (6).

Physical fitness: Such as body composition, cardiovascular fitness, flexibility, muscle endurance, and muscle strength. An exercise group is less risk of musculoskeletal disorders than sedatives. Due to exercise provides physical fitness improvement and decrease mental stress. Computer office worker is one of sedative occupational style that is poor physical fitness and common development of musculoskeletal disorder (6, 29).

Illness history and congenital disability: For example, general health, hospital report, accident history, disease involved musculoskeletal system, mineral insufficiency, vitamin insufficiency, scoliosis, head forward, round shoulder, etc. People with illness is easier develop and recurrent the injury than normal one (6).

Characteristic: Work habits, such as, stressful, nonstop working, high responsibility, personality class A. Individual habits, such as, sedative, not enough resting, drunkard, and smoker. They are potential harmful physical condition (20).

Hobby: Avocation can decrease work – related muscle pain because posture and movement will be changed. Sport avocation improves physical fitness. However, some hobbies are harmful physical condition, such as, computer game (6, 24).

Family member: a number of children and state, a number of elderly people and capacity. High workload makes more risk (6).

Locality: Long duration of traffic contributes stress, static posture, reduce resting period, be exhausted that affect accumulated injury (6).

Smoking: This is secondary cause of musculoskeletal injury, particularly intervertebral disc, because of reduces oxygen transportation capacity and delayed tissue healing (6, 24).

Alcohol, Tea, Coffee: non – study shows relationship between them and development of muscle injury. However, drunkards are strong potential to make mistake or incident during working (6, 24).

Occupational factors

High force demands: Excess force effort in some activities or tasks is able to contribute musculoskeletal pain, such as, pushing, pulling, and carrying. Injury is a

consequence of incorrect ergonomic, improper biomechanics, overload, and over repetitive movement. In case of computer duty, is static effort which is sustained contraction of low – threshold motor unit or repetitive muscle tension in trapezius. Sedentary work is always impaired flexibility and local muscular circulation (19).

Posture in working: Posture is one of the key factors for neck pain, associate with duration of constrained postures, awkward, and improper device (26, 30).

Duration of working: Excess repetition or excess prolong posture provide overuse injury. There is not clarity about duration of computer working; however, average is between 3 – 5 hours/day. Sitting longer strongly relate to development of muscle pain, thus, the restriction of working duration can reduce risk to development. Break during working includes active break – change task pattern, walking, restroom, stretching muscle, etc – that be able to reduce risk factors and passive break – stop and freeze – that is not enough to prevent the pain (6, 26).

Environment: Include light, noise, temperature, space, ventilation. For example, inadequate brightness provides more gazing to focus with face close up, in the other hand, excess brightness can harm the eyes. Noise makes mental stress and distraction. Room temperature which is too cold provides muscle contraction to generate body temperature; this is tensional to soft tissue (24).

Work schedule: Involve regular work hour a day and a week, over – time per week. These indicate total work hour that relate duration of working (6).

Skill of specific work: High skill and experience level can reduce occupational relate injury because they know the best ergonomic and physical estimation, they know how to manage workload and stress. High experience is parallel to increased age that involve to principle of aging (20).

Psychosocial factors

Due to psychological, social, and environment are relate closely. Social and environment factors tend to effect temperament, as follow

Psychological risk factors (6) include

Anxiety

Fear of job loss or job insecurity

Low job satisfaction

Feel exhaust and overload

Low attitude of health care

Unsolved mission or problem

Social and environment risk factors (31) include

High quantitative demands

Lack of support from colleagues and/or boss

Low job control

Low influence

Intensive concentration demands

Monotonous or dynamic task

Urgent or routine task

An unsettled problem

Frequently equipment broken

Epidemic

Inadequate medical support

Outside of work problem (family and others)

Frustration causes stress which increase injury occasion. Moreover, stress makes overload to muscle, hormone, digestion, blood pressure increase, heart rate increase. These conditions effected tissue healing process. By the way, there was not enough amount of evidence to evaluate the relationship between disorders and psychosocial factors and how the biomechanics and individual factors interacts the workers.

Muscle fatigue definition

Fatigue is failure to maintain the required force, contraction do not produce smooth or steady force. While muscles are being fatigued, the force fluctuation demonstrates increase both during and after sustained contraction (32).

Physiology of fatigue

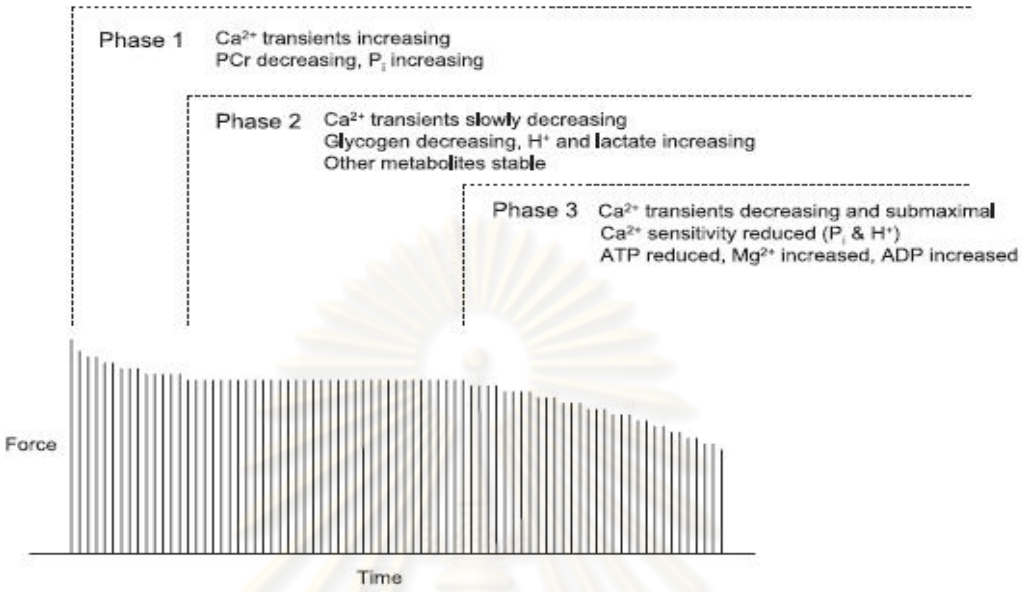

Figure 3 Schematic of the 3 phases of force decline are identified fatigue in an isolated single fiber at room temperature and relevant intercellular changes noted (33).

The studies in isolated single muscle cells at room temperature which measurement of ionic levels and metabolism. The fatigue mechanism combines with metabolites in contractile proteins and Ca^{2+} release from the sarcoplasmic reticulum (SR). There is force failure after maximal repeated isometric tetanus that includes 3 phases (figure 3), as following

Phase 1 A force reduction demonstrates 80 – 90 % of base line because the inhibitory effect of inorganic phosphate (Pi) on the transition of the cross bridge to its high – force state. Involve increasing of Ca^{2+} temporary, increasing of Pi, and decreasing of phosphocreatine (PCr).

Phase 2 Force of muscle demonstrates constant force. This phase manufacture ATP from aerobic and anaerobic break down of glycogen matches the rate of ATP consumption. Involve Ca^{2+} transients slowly decreasing, glycogen decreasing, H^+ and lactate increasing, other metabolism stable.

Phase 3 force starts to decline again caused principally by the reduction in SR $Ca2^+$ release (reduced Ca^{2+} transients) coupled to reduced sensitivity of the contractile

proteins to Ca^{2+}. The mechanism of the decline in Ca^{2+} release is still debated. Additional, involve Ca^{2+} sensitive reduced to Pi and H^{+}, ATP decreasing, Mg^{2+} increasing, and ADP increasing (21, 33).

Metabolic changes of fatigue

As definition of musculoskeletal fatigue, is failure to produce required force, is able to interpret that because of energy crisis. The essential energy source of muscle contraction is adenosine triphosphate (ATP) which originates from 2 major metabolic processes include glycolysis and the tricarboxylic acid (TAC) cycle or Kreb cycle.

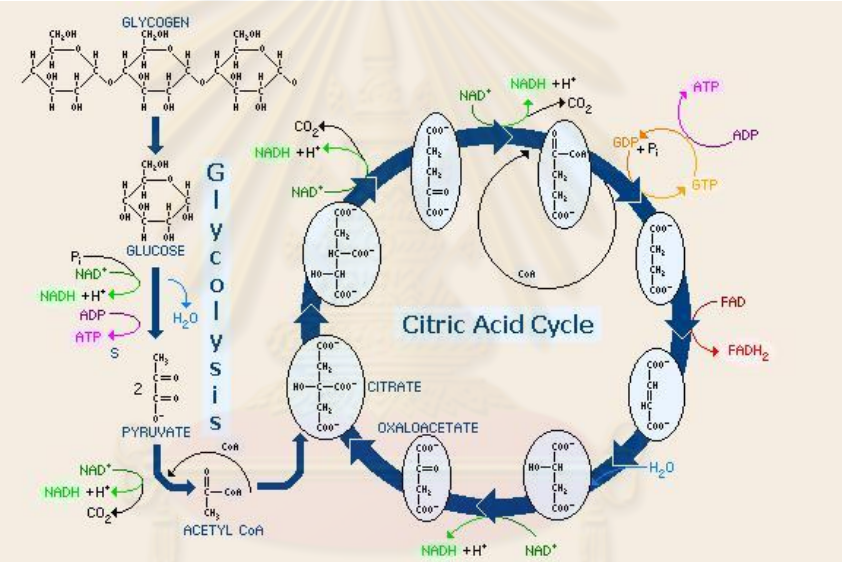

Figure 4 Glycolysis and Citric Acid Cycle (Kreb cycle) (http://student.biology.arizona.edu/honors99/group7/background.html)

The Kreb cycle is separated into 2 processes as the Glycolysis pathway (figure 5) and the Citric Acid Cycle (figure 6) are able to demonstrate the product in end of process.

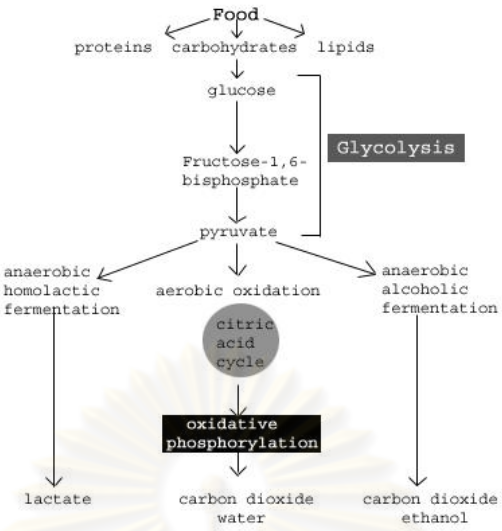

Figure 5 Analysis of Glycolysis pathway.
(http://www.sparknotes.com/biology/cellrespiration/glycolysis/summary.html)

Glycolysis is the metabolic pathway that converts glucose into pyrovate. This process contributes a few ATP. When oxygen is present, pyruvate can be completely oxidized by the TCA cycle to produce large number of ATP.

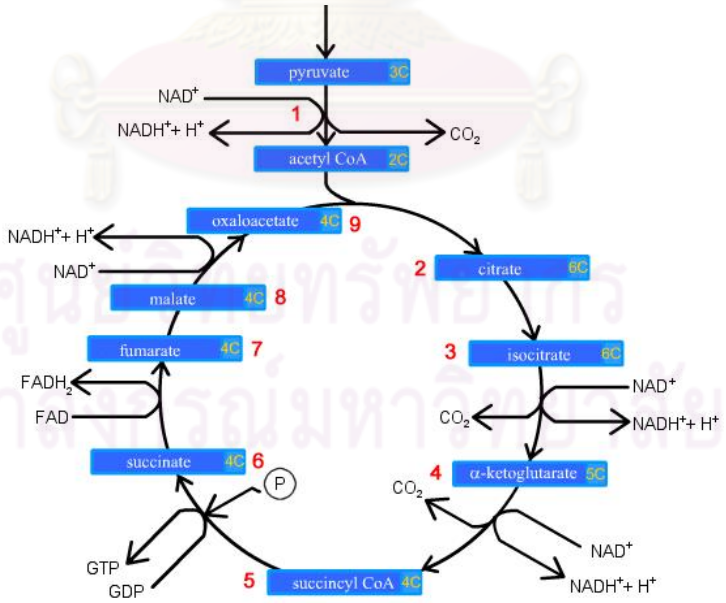

Figure 6 Analysis of Citric Acid Cycle pathway (http://swu141km.swu.ac.th)

In case of the rate of pyruvate from glycolysis exceeds the rate of pyruvate oxidation in the tricarboxylic cycle and/or oxygen insufficiency, it will be converted into lactic acid. Then, lactic acid dissociates into lacate and proton (H^+), which provide lower muscle pH. Proton in muscle may provide fatigue due to

1. Decreasing Ca^{2+} release from sarcoplasmic recticulum (SR). The lowering of pH is possible to inhibit the Ca^{2+} release from SR.

2. Decreasing the sensitivity of troponin C to Ca^{2+}. The lowering of pH is potential to provide Ca^{2+} sensitivity of troponin C impairment. Since muscle is activated, Ca^{2+} will be release from the SR and binds to troponin C. then, the binding troponin C exposes the myosin – binding sites on the actin filaments to allow cross – bridge formation and cycling. Muscle force production is indicated by Ca^{2+} release concentration and functional troponin C binding sites. The mechanism behind this decreased sensitivity is not known, but evidence suggests that a low pH ($\approx$ 6.8) may cause inhibition of Ca^{2+} binding to troponin C because of competition between H^+ and Ca^{2+}.

3. Interference cross – bridge cycling. The investigation of metabolic factors related muscle fatigue. The muscle fatigue role was determined by analysis of the different metabolic components concentration, for example, adenosine diphosphate [ADP], inorganic phosphate [Pi], and hydrogen ion [H^+], in single muscle fiber. In muscle membrane, intracellular calcium concentration of Ca^{2+} release manipulation is one of direct problem in cross – bridge cycling. An increased Pi concentration is not only interfere cross – bridge formation, but also decreases Ca^{2+} release from SR. It is one of major causative factor in skeletal muscle fatigue at the cross – bridge level (34, 35).

Pathophysiology of muscle nociceptor and painful muscle spasm

Nociceptor is a sensory receptor that responds to potentially damaging stimuli. Nociceptor includes external and internal nociceptor that muscle nociceptor is one of internal norciceptor. Nociception starts at pain stimuli assault free nerve ending C – fiber and Aδ that locate in muscle or skin over muscle. Then one part of pain signal will be send to the spinal cord via dorsal horn and brain via spinothalamic tract for percept of

pain. Another one contributes spinal reflex by stimulate γ motor neurons and $\acute{\alpha}$ motor neurons at ventral horn result in increase muscle tone, painful muscle spasm, and spasm – pain – spasm cycle, respectively (36).

Several receptor molecules on the nociceptor membrane are responsive to pain – producing agents. They are seem to be directly to muscle pain and tenderness, as following

Bradykinin (BKN) receptors (B1 and B2) is released from blood plasma protein when blood vessel break. It is not be able to considered a specific excitant of nociceptors because BKN excite is not only nociceptors but also low – threshold mechnosensitive endings.

Serotonin receptors (particularly 5 – HT_3), Serotonin (5 – hydroxytryptamin, 5 – HT) is released from blood platelets when blood clotting. The serotonin concentrations released in the tissue are usually not enough to excite nociceptors directly but they are more sensitive than BKN.

Prostaglandins (particularly prostaglandin E2) is as sensitive as serotonin.

Acid – sensing ion channels (ASICs) are sensitive to a lowering pH and non – specific pH level and response to small pH changes. This receptor, for example, ASIC1 and ASIC3 is very important for muscle pain. Exhausting exercise, ischemia, and inflammation is cause lower tissue pH that is pathogenic changes in muscle.

P2X3 receptors are a subtype of the purinergic receptors that are activated by ATP. It is released from all trauma tissue and other pathologic changes that are related cell death. That's why; ATP is considered a general signal substance for tissue trauma and pain.

Transient receptor potential receptor subtype (TRPV1) is one of the most important molecules to produce pain. It is activated by capsaicin, increased H+ concentration, and heat (approximately 39 C) (37).

Pathophysiological model of chronic muscle pain

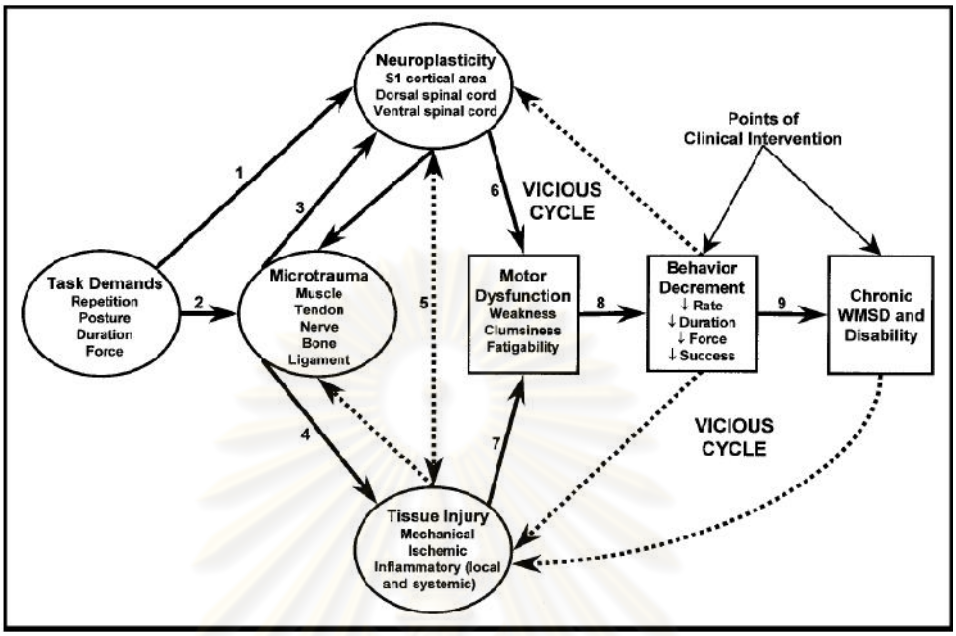

Figure 7 Schematic of the development of musculoskeletal disorders. Solid arrows represented the pathway from recent research. Dotted arrows represented the pathway of elucidation (36).

A conceptual schematic for the mechanisms of WRMSD illustration starts from repetitive, posture, duration, and force. These factors affects to tissue that include muscle, tendon, nerve, ligament, and bone. In computer – related neck pain involves muscle system and nerve system. The effects of prolonged static posture on muscles is ischemic and inflammation, both local and systemic. And neuroplasticity affects about chronic pain. Both of two phenomenons provide motor dysfunction and decrease functional efficiency, finally, progress to be chronic WRMSDs and disability (36).

Energy crisis theory explains relationship between ATP and Ca^{2+} pump, which demonstrates ATP insufficiency is cause of decreased sarcoplasmic reticulum Ca^{2+} pump for release muscle contraction. Prolonged muscle overload causes macrotrauma or microtrauma, that microtrauma is the most common injury in computer task. Cell trauma contributes Ca^{2+} leakage from disruption of sarcoplasmic reticulum (SR) or extracellular fluid. They go to sarcolemma, and then accompany with ATP to activate

actin bind myosin, and then become pathophysiological muscle contraction. This contraction is not voluntary contraction due to normal physiologic contraction will release contraction after ran out of nerve impulse and it just takes place some part of the whole muscle. These areas named relative ischemic that are insufficient of oxygen and collecting of metabolic waste, for example, prostaglandins, bradykinins, serotonin, histamine, kinins, and potassium. These substances promote local edema and muscle fiber segmental degeneration. According to muscle fatigue and lactate, lactate is acid that be able to inhibit ATP production.

Motor endplate (Dysfunction endplate) hypothesis, additional, associated with energy crisis through disorder of endplate or neuromuscular junction increases acetylcholine secretion from motor nerve terminal over than normal 100 – 1,000 time. This process makes sustained depolarization at post – junction membrane of muscle fiber and energy crisis, after (36, 37).

Figure 8 illustrated the pathophysiologic mechanism of local muscle pain. Then pathophysiological mechanism of chronic muscle pain is from peripheral mechanism which is chronic sensitization of nociceptor and from central mechanism which is neuroplasticity.

Chronic sensitization of nociceptor that consists of 2 major causes, as following;

1. Energy crisis theory

2. Local edema. Injured muscle secretes vasoneuroactive substances that can be vasodilatation and increase vascular permeability. The key substance is bradykinin, prostaglandins, and histamine, so, make local edema. Normally, muscle healing process will start healing state after edema. But in case of chronic muscle pain, local edema is not stopped by 2 reasons;

2.1 Local edema. The primary local edema disturbs pumping action of veins that is circulation obstruction, and then become local ischemic. The local ischemic is the key activation to bradykinin which is vasoneuroactive substance and nociceptors stimulant. This process repeat again and again until be local edema cycle.

2.2 Axon reflex. Central sensitization phenomenon comes from vasoneuroactive substance, and then activates nociceptors that provide neuropeptides from that specific

nociceptor. Substance P SP) and calcitonin – gene related peptide (CGRP) is the key of axon reflex, especially SP affects to exaggerated local edema.

The continuous vasoneuroactive substances secretion and local edema develops to be chronic sensitization of nociceptor.

Neuroplasticity was definite as the ability of the human CNS to changes the synaptic functional area shortly as a result of one experience, especially, dorsal horn neurons at spinal cord and brain stem. Recently, this process is the most interesting to explain chronic muscle pain that talk about depleted nerve impulse but pain remain.

There are 2 procedures work at synaptic area, as following;

1. Secretion of excitatory transmitter substances from presynaptic membrane that are glutamate and aspartate. Both of them accompany with receptor at postsynaptic membrane, and allow positive charged molecules, then make depolarization. Moreover, it is easy to activate action potential.

2. Secretion of inhibitory transmitter that is glycine. It participates to receptor of postsynaptic potential membrane and allows negative charged molecules. That reason of difficult activation.

In normal, both of these procedures should be balance, on the other hand, pain shows increased excitatory input and/or decreased inhibitory input (18).

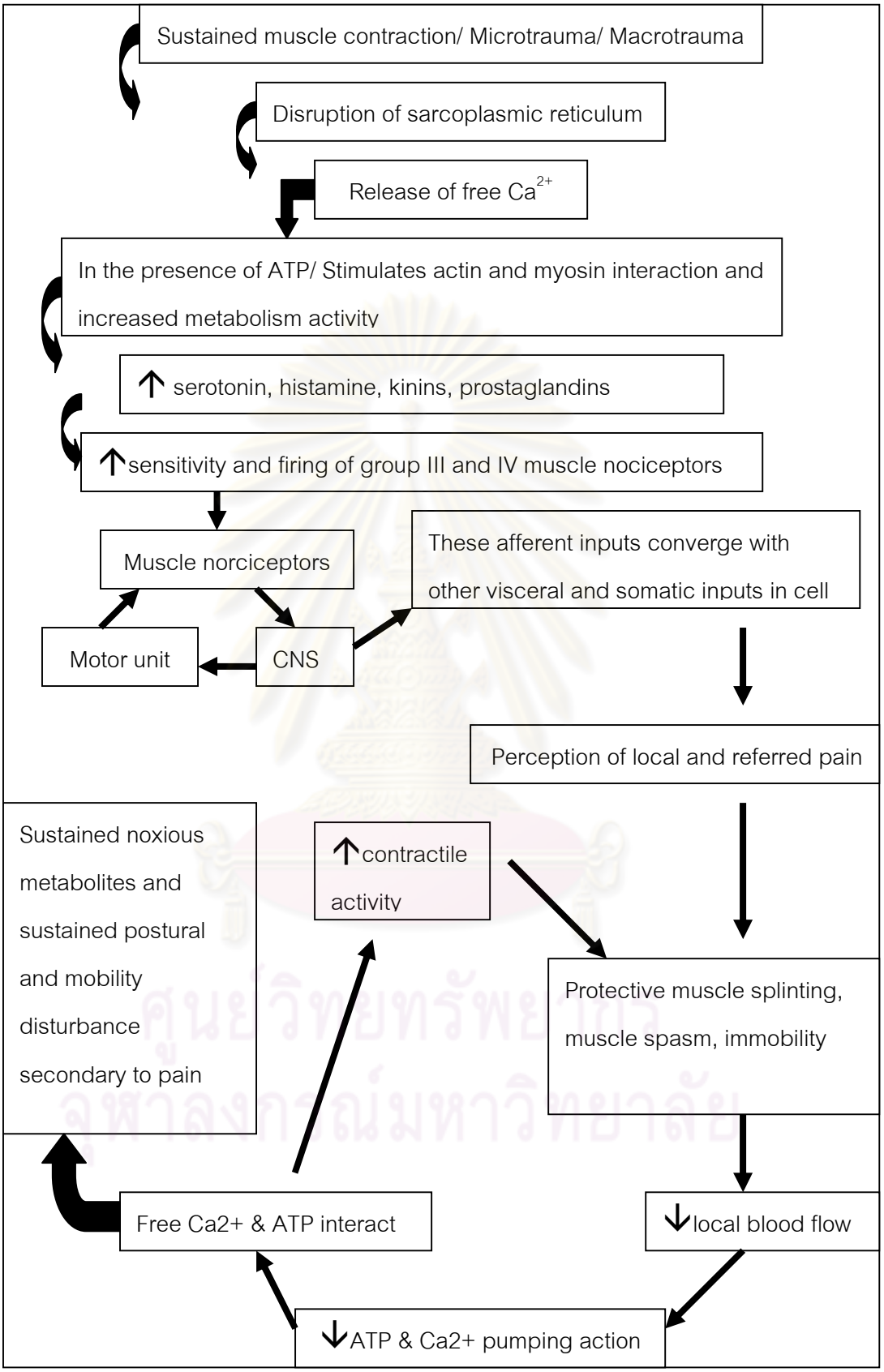

Figure 8 Physiological pathway of musculoskeletal disorders (18)

Pathophysiology of overuse progression of neck pain in computer usage (14, 37).

Chronic work – related muscle pain was described as chronic work – related muscle myalgia or repetitive strain injury that mentions to three typical manners, include, constant sitting, increase movement of the hand, and mind strain. This kind of muscle working makes incomplete recovery time or relaxation between contraction because of too little time, pain in the muscle, and psychology stress. Prolonged low force muscle contraction provides, as following;

1. Muscle ischemia. Low load approximately 10 – 20% of maximal voluntary contraction is potential to occlude the microcirculation in the muscle.

2. The sympathetic nervous system is increased. Muscle working contributes increased sympathetic nervous system activity and vasoconstriction respectively.

3. Depletion of energy resources. Normally, glycogen is stored in large fast fatigable muscle fiber more than the small one which does most of the work during prolonged low load contractions. So, the small one is easy to exhaust and if circulation is not enough, they cannot be refresh. The ATP insufficiency is likely to affect to painful contractures.

4. Motor unit recruitment changes. Normally, Type I muscle fiber are recruited before Type II muscle fiber and deactivated last. This was referred to The Cinderella hypothesis that postulate the continuous activity of motor units of type I (low – threshold) muscle fiber, and then prone to be overloaded. This kind of pain may be mediated by proton – sensitive membrane receptors because continuous contractions probably have a low pH.

5. Shear forces between active and inactive fibers. During high – force contraction of muscle, almost all muscle fibers are activated together, but not during low – force contraction. In low – force contractions have only the small fibers do contraction and shear forces is happen between active motor units and adjacent inactive ones. After that, they may release sensitizing substances from interstitial cells that sensitize muscle nociceptors. Sensitized nociceptors are easy to stimulate and excited by the relative movement between muscle fibers. The Cinderella phenomenon reflects an impaired muscle control because the motor units don not take turns. Not only nociceptors but also

muscle spindle and golgi tendon organs changes the afferent input that compromises motor coordination

Evaluation of musculoskeletal disorders

Visual Analog Scale (VAS)

VAS is a measurement instrument to measure a characteristic or attitude that convince to range across a gradual intensity and cannot easily be directly measured. Normally, VAS is a horizontal line with 100 mm. length with anchored by word descriptors at each end. 0 where is the left end as “no pain” and 100 where is the right end as “worst imaginable pain”. The rate of score is marked in the line that represents the perception condition at present. The VAS score is determined by measuring in millimeters from the left hand end of the line to the point that was marked (25, 38).

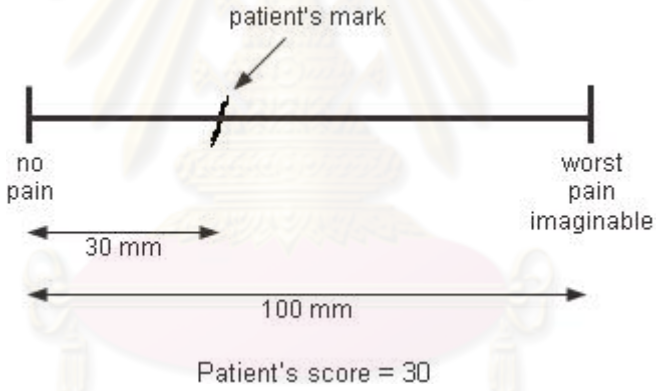

Figure 9 Visual Analog Scale (VAS) (25, 38)

VAS is one of the most popular to assess the pain intensity in occupational investigation. Vegard Strom reported the pain intensity VAS before started experimental session was higher than reference group, significantly. After 90 minute computer work task, both of these two groups reached the peak of pain intensity at the end of work task (4). According, Anna Sjors investigated different physiological reaction between women with chronic trapezius myalgia and pain – free from the low – load repetitive work. On completion of the repetitive task, the pain group rated VAS and stress intensity higher than base line (22). Grace Pui Yuk Szeto evaluated motor control differences between symptomatic and asymptomatic office workers in different resting postures, consisted of

resting hands on lab and resting hands on a keyboard. Additional compared the muscle activity response in pain related to typing. At the study of each study in the resting conditions, symptomatic group had a greater mean summed discomfort rating than asymptomatic group, significantly (23). During the typing trials, as well as, asymptomatic group also had greater discomfort rate. V. Johnston examined the impairments which have been documented in other neck disorders, include ROM, surface EMG, VAS, and NDI. Workers with neck pain had reduced neck rotation and increased muscle activity. At the end of the task, the neck muscles showed an inability to relax in the pain group. There was linear relationship between the worker's self – reported intensity of pain and disability and the movement and muscle changes (14). Lars L. Andersen investigated the effect of three contrasting interventions on muscle function and pain in women with trapezius myalgia due to monotonous work, repetitive work tasks, prolonged static muscle activity, and insufficient variation in movement. The measurements include pain intensity by VAS, surface EMG for EMG amplitude and spectrum median frequency, and muscle thickness by ultrasound scanner (25). Isabel A P Walsh evaluated musculoskeletal disorders among active industrial workers by physical assessment and fill in the questionnaires. The results indicated significant and good correlations were found between clinical finding and symptoms ($r = 0.73$), and between but moderate correlations were found between clinical findings and the pain scale ($r = 0.56$), and between clinical findings and ODQ ($r = 0.60$). But not significant association was identified between the results from clinical findings and sick leave (39).

The Neck Disability Index (NDI)

The Neck Disability Index is a ten – item questionnaire that assesses disability associated with neck pain and whiplash to determine how much the neck pain has affected patient ability for self activities daily management. It contains four items that relate to subjective symptomatology and six items that relate to activities of daily living. Subjects have to circle only one choice in each section which most closely describes the problem right now.

The summed of total score ranging from 0 (no disability) to 50 (maximum disability) that is divided into less than 4 indicates no disability, 5 – 14 mild disability, 15 – 24 moderate disability, 25 – 34 severe disability, and greater than 35 complete disability. This questionnaire shows to correlate with VAS of pain (correlation coefficient 0.6) (40).

Table 1 Score of VAS relate level of disability.

Score	Level of disability
Less than 4	No disability
5 – 14	Mild disability
15 – 24	Moderate disability
25 – 34	Severe disability
Greater than 35	Complete disability

NDI is one of many questionnaires in occupational medicine study, for example, David M. Kietry studied the effects of strength and flexibility exercise for 4 weeks in computer users. It was showed lowering NDI score from baseline, but VAS current pain was a bit higher (26). Julie M. Fritz used the NDI to describe a proposed classification system for patients with neck pain that received physical therapy interventions for one year (41). V. Johnston assessed neck ROM and muscle activity, moreover, the office workers fill in some questionnaire include NDI, VAS, and GHQ – 12 for stronger relationship between pain intensity and degree of physical changes. It was found that workers without pain demonstrated higher level of cervical activity in the coordination task than non – working control subjects which could infer risk if developing a work – related cervical disorder in computer users (14).

Calculation score of the neck disability index as this process (42).

1. Collect point together (total maximum = 50) in each of the 10 sections which is scored separately (0 – 5 points each)

Table 2 Demonstrate the representation between choice in NDI and point value.

Choice		Point value
A	Represents as	0
B	Represents as	1
C	Represents as	2
D	Represents as	3
E	Represents as	4
F	Represents as	5

2. In case of all 10 sections are completed, simply double the patients score.

3. In case of 10 sections are not completed due to it never be done. The total score will be divided by the number of sections completed times 5.

Following the formula;

$$\frac{\text{Patient's total score}}{\text{Number of sections completed} \times 5} \times 100 = \_\_\_\_\%\text{Disability}$$

Example: if 9 of 10 sections are completed, divide the patient's score by 9 × 5 = 45; if patient's score were 22.

$$\frac{22}{9 \times 5} \times 100 = 48\%\text{Disability}$$

Surface electromyography (SEMG)

Surface Electromyography (SEMG) is the study of muscle function through analysis of the electrical signals emanated during muscle contractions. The electric signal is the muscle electrical activity that from the skin over the evoked action potentials of all active motor units in a muscle (43).

Mechanism of SEMG signal

EMG is measuring the electrical signal associated with the activation of the muscle include voluntary and involuntary muscle contraction. The EMG signal capture from the depolarization of a motor unit which is named motor unit action potential. The functional unit of muscle contraction is a motor unit that was activated by the action potentials. While the nerve impulse of the motor nerve, which supplies one muscle, was transferred to the muscle. Then, the depolarization generates an electromagnetic field and spreads along the muscle membrane that is muscle action potential which can be measured as a voltage. In contraction of muscle, the motor unit action potential is the temporal summation of the individual muscle action potentials for all the fibers of a single motor unit within the pick – up area or size of electrode. So, the SEMG signal is the algebraic summation of motor unit action potentials within surface of electrode that perhaps include over than one motor unit because of different mergence of muscle fiber was entered by the motor unit; a single motor unit is able to contain 3 – 2,000 muscle fibers. EMG signal would be reduced at the skin surface, that why, decrease skin impedance and use amplifier is necessary (43, 44).

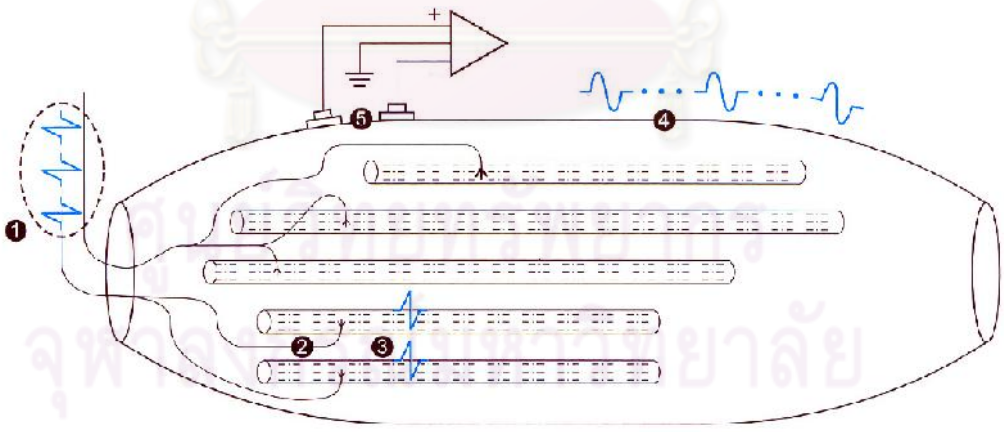

Figure 10 The motorneuron AP initiates the process of muscle fiber excitation (1) The AP arrives at all of the motor endplate innervated by the motorneuron (2) By electrochemical process, a muscle fiber AP is initiated and propagates along the length of the muscle fiber (3) The sum of all muscle fiber potentials activated by one motorneuron produces a motor unit AP (4) which can be recorded at the skin surface with amplifiers used specifically for biological signals (44).

The advantages and disadvantages of surface electromyography

The advantages of surface electromyography (44, 45)

1. Safe to patient
2. Easy to use than indwelling electrode
3. SEMG is noninvasive method that is not necessary to penetrate the skin

The disadvantages of surface electromyography (44, 45)

1. Surface electrodes can only be used for recording from superficial.
2. Be the best for large muscle.
3. Electromyography is often abused and misused by the most practitioners.
4. A cross talk phenomenon is easy to happen where the energy from one muscle group step is over into the capture site of another muscle group. This phenomenon is a problem to specific of SEMG recording.

Type of electromyography signal processing include

1. Time domain is the time analysis. This shows the ability to correlate EMG amplitude with muscle force output (44).

1.1 Rectification is any type of average of the EMG signal in the time domain will yield a value of close to zero, independent of the number of motor units contributing to the signal and their mean firing rates.

1.2 Smoothing is elimination of the high – frequency of the EMG raw signal. It is accomplished by any low – pass filter.

1.3 Integration The integration of the EMG signal is performed in the rectified form of the signal and refers to mathematical integration of the EMG – time records with respect to time. It has been related to muscle force more than any other forms

1.4 Root Mean Square (RMS) is representing the number of active motor units and the average firing rate of the active motor units. It is an excellent indicator of the magnitude of the signal and it is frequently used in muscle fatigue study.

2. Frequency domain or spectral analysis is received much attention because of the high – frequency content of the signal with increasing muscle fatigue or can be call

muscle fatigue indexes. The most important parameters for analysis of power density spectra of the EMG signal that be obtained by the Fast Fourier Transformation technique (FFT) include

2.1 Mean frequency or Mean power frequency (MPF) is defined as the sum of the first moments of frequency divided by the area under the power frequency curve. The mean is defined as mean in statistic. It is the most commonly used in the power spectral frequency (16, 23).

2.2 Median frequency (MF) is defined as the frequency that divides the power of the EMG spectrum into two equal areas. The median is defined as median in statistic (the 50^{th} percentile). It is also the most commonly used in the power spectral frequency but it is considered to be more sensitive to changes in the low – frequency band (20 – 40 Hz) of the power spectrum. The typical nature of the power spectrum is negative skew; therefore, MF may be a more appropriate parameter of central tendency (16, 23, 45).

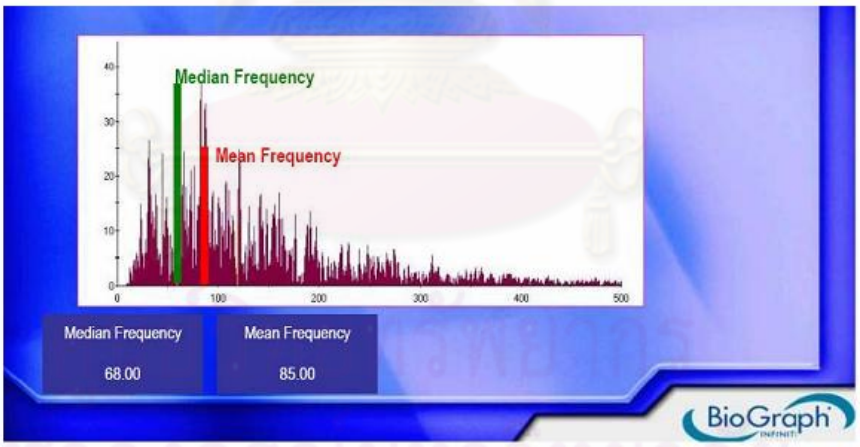

Figure 11 Median frequency and mean frequency in frequency domain or spectral analysis (70).

2.3 The Zero crossing rates is the less commonly parameter which donates the number of times that the surface EMG signals cross the “zero” polarity line per time unit (16, 23, 44).

Additional, this parameter in frequency domain can be called the surface EMG power spectrum, which represents a sum of all the spectrum contributions of active motor unit action potentials. The shift of the power spectrum demonstrates muscle fatigue (16, 23, 45).

Analysis of EMG in muscle fatigue (16, 23, 44, 45, 46)

The energy from muscles has a frequency spectrum like the rainbow that consists of its range of frequencies. The spectral is analyzed by the fast fourrie transformation (FFT) which is a mathematic technique. FFT decomposes the signal into its various frequency components. It provides the power spectral density curve that is plotted from the frequency components of the SEMG signal as a function of the probability of their occurrence.

The relationship of muscle energy represented by the two filters described above could shift under various conditions. During the muscle fatigue observed a downward shift in the shape of the power density such that the median frequency. In fatigued muscle, the shape of the frequency spectrum changes such that is a diminution of the higher frequencies and an augmentation of the slower frequency. This shift or fall in the median frequency could be attributed to the synchronization of motor unit recruitment patterns, a slowing of the conduction velocities of the muscle fibers, a shift in dominance from fast – stitch fiber to slow – twitch fiber as a result of the fatigability of the fast – twitch fibers, or a combination of all of the above. In order to quantify the spectral shift secondary to fatigue, however, one must ask the patient to exert a steady isometric contraction at approximately 80% of maximum voluntary (isometric) contraction (IMVC) for a period of 1 minute. Such an analysis can be quite powerful.

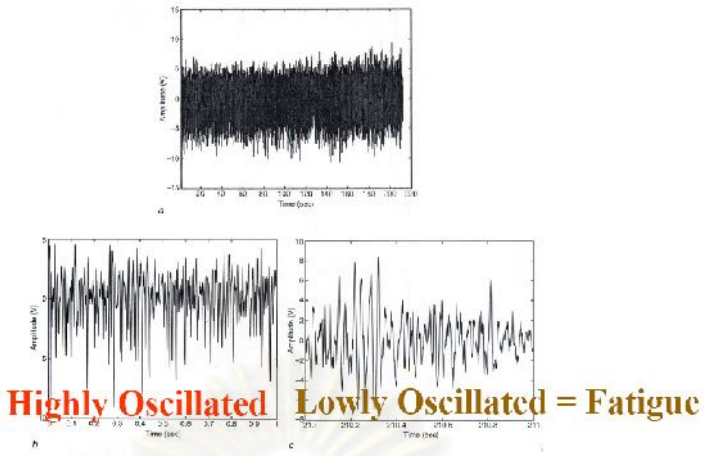

Figure 12 The oscillation of single muscle fiber that showed analysis of fatigue muscle EMG. Highly oscillated represents normal muscle contraction. Lowly oscillated represents muscle fatigue (44).

Qualitative assessments can be made by calculating the power spectral density for each segment of data and comparing them. Quantitative assessments can be made by calculating the mean frequency or the median frequency of the power spectral density sequentially for epochs of EMG data. The most important application of spectral analysis is the study of muscle with time during a task that the mean and median frequencies of the EMG signal decrease with time during a task that induces fatigue.

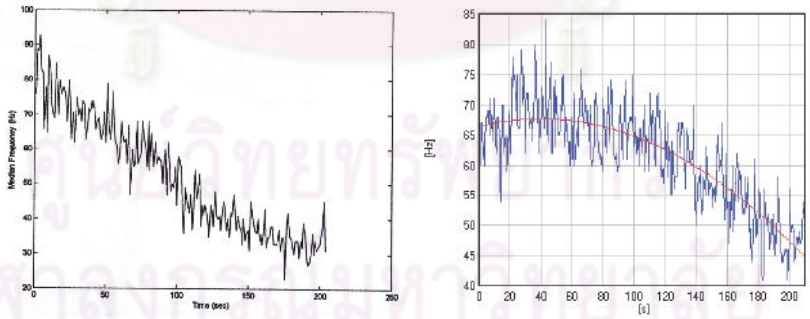

Figure 13 The development graph of a decreasing firing rate of the median frequency as the muscle demonstrates fatigued (44).

Diagnostic EMG of muscle pain assessment to presume pain relates fatigue has been difficult to establish. SEMG signals illustrates a spectral shift to lower frequencies, but not convincingly established to provide an index of muscle fatigue. It is not known whether there are other causes of similar spectral shift. Some spectral parameters such

as the mean and median frequency are known to decrease continuously after the onset of muscle contraction. So, it may be possible to monitor the fatigue process early in contraction before the point of mechanical failure has been reach (47).

Noise and artifact (46, 48)

The characteristics of the electrical noise that may spread from various sources include

1. Ambient noise is generated by electromagnetic devices such as computers, force plates, power lines, radio, television, electrical – power wires, light bulbs, fluorescent lamps, and anything that is plugged into the wall A/C (Alternating Current). This noise has a wide range of frequency components, however, the dominant frequency component is 50Hz or 60Hz, corresponding to the frequency of the A/C power supply (i.e. wall outlet).

2. Motion artifacts consist of two main sources of motion. First, originate from the interface between the detection surface of the electrode and the skin. Second, originate from movement of the cable connecting the electrode to the amplifier. Both of them have most of their energy in the frequency range between 0 – 20 Hz.

3. Inherent noise in the electronics components in the detection and recording equipment is generated from all electronics equipment. This noise cannot be eliminated but only can be reduced by high quality electronic components. It has frequency range from 0 Hz to several thousand Hz.

4. Inherent instability of the signal. The frequency components between 0 – 20 Hz that are unstable because they are affected by the quasi – random nature of the firing rate of the motor units and EMG amplitude.

Filter

To clarify the signal, it is needed filter for filtering the signal by the specific filter, as following

1. High – pass filter (16, 23, 44)

This mean the frequency that higher than then number is allowed to pass. Use for reducing the influence of movement artifact, cable, and electrode contact. High – pass filter at 20 Hz, that hold up 0 – 20 – Hz frequency range.

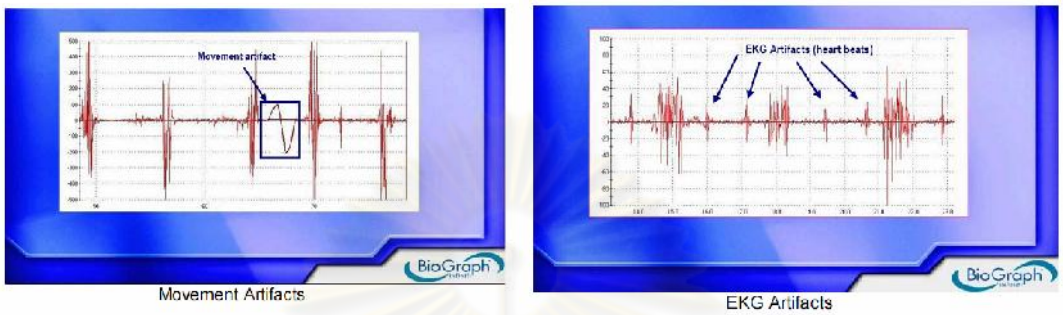

Figure 14 Movement artifacts (left) and EKG artifacts (right) that was eliminated by high – pass filter (70).

2. Low – pass filter (16, 44, 48)

This mean the frequency that lowers than the number will be allowed to pass. Use for reducing the influence of high frequency from electric equipment. The low – pass filter at 200 Hz, that hold up 0 – xxxx – Hz frequency ranges.

3. Notch filter (16, 44, 48)

Use to reduce the non – biological signal noise or electromagnetic radiation, such as, radio, TV, electrical – power wire, and fluorescent lamps. This filter cuts off 2 specific frequencies include 50 Hz from main power and 60 Hz from the transformer.

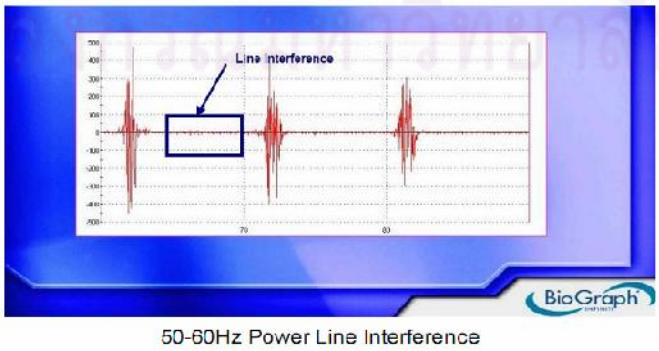

Figure 15 50 – 60 Hz power line interference that is seen in electronic equipments (70).

Impedance (16, 45)

The impedance of the skin at the electrode – skin interface is important in SEMG procedure. The impedance at the electrode skin interface is too high or too imbalanced is considered to be unclean signal. It is necessary to be as low as possible and balanced of the two recording electrodes. The high impedance at the electrode site includes dry skin, scaly skin, skin with oil, based makeup, scurf, and skin with a deep layer of hair.

No specific level of skin impedance that valid and meaningful clinical record due to this is upon the SEMG instrument. For research purposes, the impedance at the electrode site was suggested to be below 5,000 – 10,000 ohms. To decrease skin impedance, it is commonly accomplished by abrading and scrapes the skin vigorously with an alcohol pad and shaves the hair.

However, one should not be seduced into thinking that because the SEMG will allow resistance at the electrode – skin interface of 10 megohms, it is not necessary to abrade or otherwise prepare the skin for the electrode; dry, horny skin or oily skin can easily exceed an impedance of 10 megohms.

One should avoid placement on hairy areas whenever possible. In addition, imbalances may occur when one electrode loses good adhesion to the skin during a dynamic evaluation or treatment session. Two other elements can moderate the impedance of the signal. The first is the electrode itself. The second element is the cable that exists between the electrode and the amplifier itself.

Skin preparation (45, 48)

Site preparation is strongly recommended as part of all clinical protocols. It is a delicate matter and need to be as low and balanced as possible. This process must be done before put the electrodes on the skin.

As above, dry skin, scaly skin, skin with oil, based makeup, scurf, and skin with a deep layer of hair is a key material in high skin impedance. These should be eliminated by shave the hair, use an alcohol – soaked pad and rub the electrode site with approximately six vigorous strokes. The pad should contain some rag content so that it is a little rough. To abrade of skin, some electrode preparation pads contain a

small amount of pumice to facilitate abrasion. Avoid cotton balls and tissues for this purpose.

Skin temperature is another factor that may noticeably affect the impedance of the site of recordings. Vigorous exercise is more likely affect on skin temperature than room temperature. Skin temperature is fluctuate, for example, the skin temperature increase makes the impedance reduce that can alter the SEMG recording.

Electrode placement (46, 48)

Introduction of surface electromyography has mentioned to Fridlund and Cacioppo who have highlighted 6 elements of strategies for electrode placement that can improve the fidelity and the best outcome of SEMG recording;

1. Select the appropriated proximity of a proposed site to the underlying muscle mass, keeping the minimum amount of tissue between the electrodes and the muscle fibers themselves.

2. Select the appropriate position of the electrodes relative to the muscle fibers. Whenever possible, the electrodes should be placed parallel to the fibers to maximize sensitivity and selectivity. Perpendicular placements tend to lead to greater common mode rejection and less selectivity.

3. Avoid straddling the motor end plate region. If this is done, the amplitude observed typically lower due to differential amplification. Placing electrodes a little off the center of the muscle will accomplish this goal.

4. Choose sites that are easy to locate (sites that have good anatomical landmarks to facilitate reliable placement of electrodes during subsequent recording sessions)

5. Choose sites that do not unduly obstruct vision or movement. Avoid areas that present problems from skin folds, bony obstruction, etc.

6. Minimize cross – talk from proximal deep or superficial muscles by selecting the best electrode size and inter – electrode spacing.

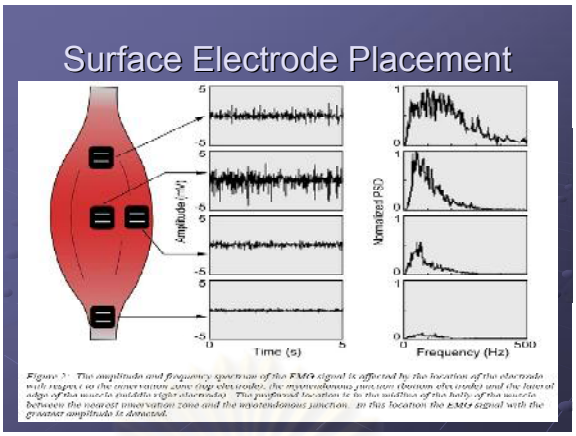

Figure 16 The amplitude and frequency sprectrum of the EMG signal is determined by the location of the electrode. The greatest amplitude is in the midline of the belly of the muscle (http://www.delsys.com/Attachments_pdf/WP_Biomechanics.pdf).

Upper trapezius (UT)

Location: place two active electrodes (2 cm apart) so that they run parallel to the muscle fibers (origin and insertion) of upper trapezius, along the ridge of the shoulder, slightly lateral to and one half the distances between the cervical spine at C7 and the acromion. Palpate the muscle mass and place over the muscle belly (45).

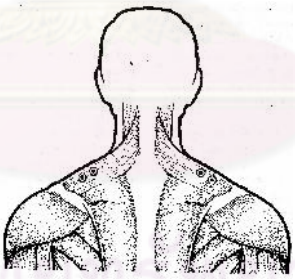

Figure 17 Active electrode location of upper trapezius (45)

Cervical erector spinea (CES)

Mid cervical paraspinal location: palpate for the spinous processes of the cervical spine and the two muscle bellies that lie just lateral to it. Two active electrodes (approximately 2 cm apart) are placed so that they run parallel to the spine, approximately 2 cm from the midline, over the muscle belly at approximately C4. Avoid the hairline (45).

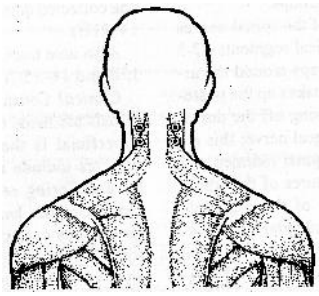

Figure 18 Active electrode location of cervical erector spinae (45).

There are some studies have reported lowering or downward shifting of the EMG power spectrum. Yuichi Umezu investigated the difference in back muscle endurance between normal adult women and men with power spectral analysis that include median frequency, mean power frequency, and zero crossing rate. The finding showed the negative slopes of these muscle fatigued parameters in both groups (49). As well as, M. Lowery (2002) observed the EMG frequency spectrum during sustained fatigue contractions of brachioradialis. The result was lower median frequency and muscle fiber conduction velocity, but not in root mean square amplitude (50). Static contraction is more fatigue than dynamic contraction that was demonstrated by Kazumi Masuda. This study, compared between static and dynamic contraction of Quadriceps muscle, was investigated by median frequency and muscle fiber conduction velocity. The outcome showed both of them decrease from initial value, but the static contraction showed significantly lower values of dynamic contraction at the completion. According to, this effect of the result, an accumulation of metabolic produces such as lactic acid, which reduces intracellular pH and decreases the excitability of the muscle fiber membrane (51). Because typewriting is static contraction task, Mitsutochi Kimura investigated the development and recovery of muscle fatigue in the upper trapezius muscle by analyzing electromyographic signals. During office workers are typing, decreased median frequency with increased root mean square (11).

As above, pain has related with muscle fatigue. There are some study have investigated muscle pain by surface EMG. Joseph K – F Ng used trunk holding test to fine evidence that the endurance capacity of the back extensors is a predictor of the first onset of back pain. The result showed negatively slope of median frequency in

iliocostalis lumborum muscle and multifidus muscle with greater amplitude of both muscles. This finding may be explained by the differential of both measurements used to quantify the fatigue (52). Trunk muscle holding test, similarly, Serge H. Roy used the EMG median frequency to assess a series of fatiguing isometric tasks. The results were compared with chronic low back pain subjects. There is a normal characteristic pattern of fatigue. The relative change in median frequency slope was significantly greater among low back pain subjects compared to the control subjects (53). Some studies have reported lowering or downward shifting of the EMG power spectrum during performance of prolong computer tasks in a work situation. Grace Pui Yuk Szeto studied the EMG frequency changes during standardized typing tasks in a series of two conditions include to observe the effects of prolonged static posture and increasing typing speed versus typing force. These results from two laboratory conditions showed trends for higher median frequency in symptomatic subjects compared to asymptomatic subjects. This finding did not show any apparent decline of median frequency with time (16). And in 2008, Grace Pui Yuk Szeto et al, compared muscle activity when female office workers with chronic neck pain and asymptomatic adopted two resting posture between hands on laps versus hands on a keyboard. The outcome demonstrated similar muscle activity levels in symptomatic and asymptomatic with hands resting on laps. In case of resting hands on the keyboard, there was greater muscle activity of the case, especially in the high discomfort group (23). V. Johnston wanted to explore aspects of cervical muscle function in women office workers with neck pain. It was found that during the coordination task, workers with pain showed greater EMG amplitude in the cervical extensor muscle than asymptomatic group and perceived greater tension and discomfort than those asymptomatic (14). Anna Sjörs assessed whether women with chronic trapezius myalgia show different physiological reaction, compared with pain – free controls, during experimental repetitive low – force work, and a standardized psychosocial stress test. The result showed graph of the root mean square value and pain intensity were higher in both group during typing task. And all values of myalgia group were greater than pain – free group (22). Annick Champagne indicated about one of the physical characteristics of chronic low back pain subjects is higher fatigability of

the back extensor muscle, as demonstrated by lower back endurance test duration (54). L. Andersen investigated the effect of three different interventions on muscle function and pain in women with trapezius myalgia for 10 weeks. The exercise program consisted of specific strength training of neck – shoulder muscle, general fitness training. The result demonstrated VAS level in the strength training group was lower after training, contrast in the general fitness training (25). According to increased EMG amplitude with small decreased EMG median frequency.

Stretching Exercise

Stretching is the popular method to increase flexibility and ROM. Stretching is not only effect on muscle and tendon but also ligament, capsule, and nerve.

Flexibility is ability in movement without pain. Range of motion (ROM) occurs at a single joint or series of joint that is used as one of physical index. Good flexibility is important not only athletic performance but also in everyday activities (56, 57).

Principle of increased tissue flexibility

Flexibility is a key element in normal movement of the joint. Impaired flexibility provides decreased ROM, pain at rest and/or motion, and changes of movement pattern, be easy to injury or re – injury, reduced function or activities of daily living, and impaired flexibility in adjacent tissue. In case of rehabilitation, the flexibility is the first few things to select after recovery.

The factor in development of flexibility or ROM (3, 58) include

1. Intrinsic factor such as joint alignment, joint capsule, ligament, tendon, muscle fiber, skin, and nerve.

2. Extrinsic factor such as age, adipose tissue, degenerative disease, and trauma.

The way to increase range of motion that is used in rehabilitation (55 – 58)

1. Passive physiological movement is the method that someone gives joint movement to patient. The movement must be slow rhythmic and as far as without pain.

Advantages of passive movement

- Diffusion to cartilage. In full joint movement makes pressure which push the essential substance into joint and cartilage.
- Increase local blood circulation.
- Decrease pain because joint movement affects joint mechanoreceptors to activate impulse that is able to inhibit pain impulse. This mechanism is gate control theory.
- Promote tissue healing and collagen re – alignment for appropriate functional.

2. Active physiological movement or active exercise or ROM exercise is patient own movement with muscle contraction. This method need muscle strength. If muscle is strong enough, ROM would be increase easier. In the other hand, if muscle is not strong enough, patient will need assistant that is active assisted ROM. The most advantages are not only as same as the passive physiological movement but also involve muscle strength, prevent varicose vein, improve motor control, joint degenerative, improve co – ordination, and decrease stress.

This technique is suitable for musculotendinous spasm, muscle strain, ligament sprain, contusion, and early recovery. The principle of active physiological movement is similar to the passive physiological movement that is slow rhythmic, move without pain.

Types of stretching. There are 3 different types of stretching, as following

1. Static stretching

Static stretching is the most effective and safest for flexibility joint movement that is population in rehabilitation. There are two sub – types of this technique, include, passive static stretching is given stretch from someone, and active or auto static stretching is self stretching.

First, subject must be relax and then do stretching slowly to the point of tension or mild discomfort. In each muscle, hold 15 – 30 seconds, repeat 2 – 4 times and 5 – 7 days/week (at least 2 days/week) (55 – 58).

2. Ballistic stretching

The ballistic stretching is dynamic stretching actively with bouncing movement slowly and repetitively. This technique is useful in sport specific rehabilitation because

the pattern resemble to sport functional relevance. However, there is disadvantage due to exceeded ROM or too aggressive. Excess ROM or overstretching is able to harm the connective tissue. Moreover, sudden forceful activates reflex muscle contraction (deep tendon reflex) may provide actually shorten the muscle and inhibit the stretching. This technique is not suitable for severe injury state, elder, and sedentary people. Thus, it is the less commonly type of stretching for increasing flexibility (55, 57, 58).

3. Proprioceptive Neuromuscular Facilitation (PNF) stretching

This technique is high safety and greater effect but it is not popular. It is referring to certain reflex principle that involves contraction and relaxing in agonist and antagonist muscle group include autogenic inhibit reflex, and reciprocal inhibition reflex. The PNF stretching can produce great improvements of flexibility but it can result in muscle soreness. PNF is like static stretching, hold for 15 – 30 seconds, perform 2 – 4 times, and at least 2 days/week (55, 57).

Table 3 ACSM exercise prescription principles (57)

Cardiovascular	Frequency	Intensity	Time	Type
Cardiovascular	3 – 5 days/week	40/50 – 85% of HRR or VO_2R	20 – 60 min	Large muscle mass, continuous, rhythmic
Muscle strength	2 – 3 days/week	3 – to 20RM range, typically 8 – to 12 RM	1 set each of 8 – 10 exercises ($\leq$ 1hr)	Major muscle groups, full ROM, controlled speed (~ 3s concentric, ~3s eccentric)
Flexibility	2 or 3 days/week, ideally 5 – 7	To point of tightness	15 – 30 for each of 2 – 4 reps	Static

Guidelines for proper stretching (55 – 57)

- Determine posture or position to be used. Ensure proper position and alignment prior to the stretch.
- Emphasize proper breathing. Inhale through the nose and exhale through pursed lips during the stretch. One may stretch with the eyes closed to increase concentration and awareness.
- Hold end points progressively for 15 – 60 seconds and take another deep breath.
- Exhale and feel the muscle being stretched, relaxed, and softened so that further ROM is achieved.
- Discomfort may increase slightly, but continue to focus on breathing.
- Repeat the inhale – exhale – stretch cycle until the end of the available ROM for the day.
- Do not bounce or spring while stretching.
- Do not force a stretch while holding the breath.
- Increased stretching range during exhale encourages full body relaxation.
- Slowly reposition from the stretching posture and allow muscle to recover at natural resting length.

Precautions for flexibility training (55, 56)

- Stretch a joint through limits of normal ROM only.
- Do not stretching at healed fracture sires for about 8 – 12 weeks post fracture, after which gentle stretching may be start.
- In individual with known or suspected osteoporosis, stretch with particular caution, for example, men over than 80 years old, women over than 65 years old, elder with spinal cord injury.

- Avoid aggressive stretching of tissues that have been immobilized such as cast or splint. Tissues become dehydrated and lose tensile strength during immobilization.
- Mild soreness should take no longer than 24 hours to resolve after stretching. If more recovery time is necessary, the stretching force was excessive.
- Use active comfortable ROM to stretch edematous joints or soft tissue.

Contraindications for flexibility training/testing (55, 56)

- Motion limited by bony clock at a joint interface.
- Recent unhealed fracture.
- Infection and acute inflammation affecting the joint or surrounding tissues.
- Sharp pain associated with stretch or uncontrolled muscle cramping when attempting to stretch.
- Local hematoma as a result of an overstretch injury.
- Contracture (desired functional shortening) requiring stability to a joint capsule or ligament contracture that is intentional to improve function, particularly in clients with paralysis or severe muscle weakness such as tenodesis of finger flexor to allow grasp in an individual with quadriplegia.

Physiological of flexibility

There are many outcomes that were affected by stretching, as following;

Fiber realignment

The stretching of a muscle fiber begins with the sarcomere which is the basic unit of contraction in the muscle fiber. In the contraction of sarcomere, the areas of overlap between the thick and thin myofilaments are increased. On the other hand,

stretching decreases this overlap areas, then allow the muscle fiber to elongate. Once the muscle fiber is at its maximum resting length (all the sarcomeres are fully stretched) and add the force of stretching on the surrounding connective tissue. While the tension is increasing, the collagen fibers in the connective tissue align themselves along the same line of force as the tension. To stretch, thus, the muscle fiber is pulled out to its full length sarcomere by sarcomere, and then the connective tissue takes up the remaining slack. This process helps to realign any disorganized fibers in the direction of the tension. This realignment helps to rehabilitate scarred tissue back to health.

Stretching cannot elongate every fiver all together that mean some of them were lengthen, but others may remain at rest. The current length of the entire muscle depends upon the number of stretched fibers (similar to the way that the total strength of a contracting muscle depends on the number of recruited fibers contracting) (58).

Proprioceptors

Proprioceptor is the nerve ending which transfer the information about the musculoskeletal system to the central nervous system. Proprioceptors or Mechanoreceptors are the source of all proprioception.

Proprioception is functional of proprioceptor that uses to detect any changes in physical displacement (movement or position) and any changes in tension, or force, within the body. So, this process tells the body about one's own body position and movement that they are found in all nerve endings of the joints, muscles, and tendons.

The proprioceptors related to stretching are located in the tendons and in the muscle fibers. There are two kinds of muscle fibers, include, intrafusal muscle fibers and extrafusal muscle fibers. Extrafusil fibers are the ones that contain myofibrils and imply the muscle fibers. Intrafusal fibers are also called muscle spindles and lie parallel to the extrafusal fibers. Muscle spindles or stretch receptors are the primary proprioceptors in the muscle. Another proprioceptor that comes into play during stretching is located in the tendon near the end of the muscle fiber and is called the golgi tendon organ. A third type of proprioceptor, called a pacinian corpuscle, is located close to the golgi tendon

organ and is responsible for detecting changes in movement and pressure within the body.

To stretch, the extrafusal fiber and the intrafusal fiber (muscle spindles) is lengthen together. The muscle spindle contains two different types of fibers (or stretch receptors) which are sensitive to the change in muscle length and the rate of change in muscle length. As muscles contract that it gives tension on the tendons where the golgi tendon organ is located. The golgi tendon organ is sensitive to the change in tension and the rate of change of the tension (58).

The Stretch Reflex

In stretching of muscle that is stretch of muscle spindle. It records the change in length (and speed) and sends signals to the spine which convey this information. Then, it triggers the stretch reflex (also called the myotatic reflex) which attempts to resist the change in muscle length by causing the stretched muscle to contract. This basic function of the muscle spindle use to maintain muscle tone and to protect the body from injury.

Mechanism of holding a stretch for a prolonged period of time in a stretched position, the muscle spindle habituates (becomes accustomed to the new length) and reduces its signaling. Gradually, the stretch receptor can be trained to allow greater lengthening of the muscles (58).

Components of the Stretch Reflex

The stretch reflex contains a dynamic component and a static component. A dynamic component of the stretch reflex involves speed domain that response the initial sudden increase in muscle length. A static component of the stretch reflex involves time domain that persists as long as the stretched duration. Due to intrasusal muscle fiber consists of two kinds, include, nuclear chain fibers, which are responsible for the static component; and nuclear bag fibers, which are responsible for the dynamic component.

Nuclear chain fibers are long and thin, and lengthen steadily when stretched. When these fibers are stretched, the stretch reflex nerves increase their firing rates

(signaling) as their length steadily increases. This is the static component of the stretch reflex. Nuclear bag fibers bulge out at the middle, where they are the most elastic. The stretch-sensing nerve ending for these fibers is wrapped around this middle area, which lengthens rapidly when the fiber is stretched. The outer-middle areas, in contrast, act like they are filled with viscous fluid; they resist fast stretching, and then gradually extend under prolonged tension. Thus, when a fast stretch is demanded of these fibers, the middle takes most of the stretch at first; then, as the outer-middle parts extend, the middle can shorten somewhat. So the nerve that senses stretching in these fibers fires rapidly with the onset of a fast stretch, then slows as the middle section of the fiber is allowed to shorten again. This is the dynamic component of the stretch reflex: a strong signal to contract at the onset of a rapid increase in muscle length, followed by slightly "higher than normal" signaling which gradually decreases as the rate of change of the muscle length decreases (58).

The Lengthening Reaction

Any muscle contraction, it produces tension at the point where the muscle is connected to the tendon, where the golgi tendon organ is located. The golgi tendon organ records the change in tension, and the rate of change of the tension, and sends signals to the spine to convey this information. As this tension reaches over threshold, it triggers the lengthening reaction which inhibits the muscles from contracting and causes them to relax. This basic function helps to protect the muscles, tendons, and ligaments from injury. Another reason for holding a stretch for a prolonged period of time is to allow this lengthening reaction to occur, thus helping the stretched muscles to relax. It is easier to stretch, or lengthen, a muscle when it is not trying to contract (58).

Reciprocal Inhibition

In one motion is combined with contraction of agonists and relaxation of antagonists. This phenomenon is called reciprocal inhibition because the antagonists are inhibited from contracting. Stretching of calf muscle, for example, tibialis anterior contraction inhibits the contraction of calf muscle (58).

Viscoelastic changes in the muscle-tendon unit and range of motion.

Elastic property is one of the musculoskeletal properties which are able to return to original length after release stretching immediately. But not in viscous properties that muscles were stretched slowly when placed under stress and release to the starting length slowly when the stress is removed. By sustained stretching at least 30 seconds that is sustained for prolong time with continue stretch in the same load (creep), the muscle compliance would be increased. Finally, ROM is gained by viscoelastic properties of the musculotendinous unit (3).

Analgesic effect and ROM.

Muscle stretching provides increasing the pain threshold that is able to explain by the analgesic effect of stretching. It is related between increasing of ROM and increasing of pain threshold that the first stretching moves until reach the pain threshold, then, the second stretching needs more force for reaching the pain threshold and there is increase pain – free ROM. This state is related the gain in ROM to an increased pain threshold rather than changes in the viscoelastic properties which was argued because of unclear mechanism (3).

Anti-inflammatory effect.

Delayed muscle soreness (DOMES) is micro – injuries of muscle fibers, resulting from unfamiliar and mainly eccentric exercises. Micro – injuries lead to inflammation, swelling and free radical proliferation, causing pain that peaks 24 – 48 hours after exercise and stops within 96 hours. Stretching is commonly used after physical activity to prevent delayed muscle soreness. However, stretching is difficult to prevent intense activity induced DOMS (3).

Neurophysiological changes and ROM.

Neuromuscular is effected by neurophysiological that were considered as a possible for stretching induced ROM increasing. Proprioceptive neuromuscular

facilitation (PNF) stretches are based on the belief that a muscle contraction would cause a reciprocal inhibition allowing a larger stretch (3).

Muscle contraction changes.

There is not enough and clear between stretching and muscle strength. So, stretching may be improve strength and prevent injury or may be not.

In case of myofascial pain syndrome that are involved to decrease blood flow in the muscles due to sustained contraction for prolonged periods of time. Stretching results in more efficient muscle contraction requiring less oxygen. However, it is no specific duration of sustain the posture and no long – term evidence. Anyway, this stretching may be suggested for workers performing jobs who do continuous sustained contraction (i.e. isometric contraction) is typical of the activities performed (e.g. precision work such as computer panel assembly and data entry), unless the forces required are high (e.g. wire welding) given the decreases in force generation capabilities (3).

Interaction between the physiological effects of stretching.

Neurophysiology and viscoelastic properties have changes together that decreased sensitivity of muscle spindles, and inhibition of α motoneuron due to activation of nocioceptors, type III and IV joint receptors, and Golgi tendon organs may be responsible for inhibition of the muscle fibers following stretching. But there are augment in some studies that reported an increased or unaltered electromyographic activity following stretching attributed to the increased ROM due to analgesia.

When muscle contraction gives tendon loading that tendon will be stretched 1% - 2%. After the contraction, the tendon returns to the original length. Normally, tendons elongate approximately 1% (residual strain) after contractions to reduced stress tolerance capacity due to residual strain (decreased cross-sectional area).

The increased muscle compliance due to stretching decreases area of crossbridge that may result in decreasing force production capabilities. Muscle and tendon alterations modify mechanical efficiency requiring increased contraction to

generate the same force. Similar changes may be observed in other musculoskeletal tissues due to their viscoelastic characteristics (3).

There are studies that suggest using stretching in patients with muscle pain. David M. Kietrys said resisted exercises is acceptable to enhance muscle performance and perhaps advocated for postural alignment that could be efficacious for chronic neck musculoskeletal disorder, additional, stretching exercises has also been advocated for prevention of injuries associated with worker or athletic performance. In this study, subjects were assigned into experimental groups consist of isometric, and elastic exercise and stretching groups consist of stretching 5 second hold, 5 repetitions. Both of these programs provided better feeling (26). William P. Hanten studied to determine the effective of a home program of ischemic pressure followed by sustained stretching for the treatment of myofascial pain trigger point. Participants were divided into stretching group consisted of holding each muscle 30 – 60 seconds and control group consisted of active ROM 10 times each for 5 days. The outcome was greater lowering pain intensity in stretching group (59). This holding duration is similar to Ana Cláudia Violino Cunha compared the effect of conventional static stretching and muscle chain stretching by the global posture reeducation method for 6 weeks during working hour. The static stretching group performed 30 second hold each muscle, and the chain stretching performed 15 minute training. The result showed the static stretching and the chain stretching were equally effective in reduce pain and improve ROM, nor quality of life (27). Additional, Jorgen R. Jepsen investigated effects of stretching on prevention of upper limb pain in computer users for 6 months. One group performed stretching 4 directions which hold 20 – 30 seconds approximately, 2 times, 3 times per day in office hour. The other was control group. The result was not different on pain intensity in both groups but may prevent the computer – related upper limb disorders (60).

Relaxation exercise

Anxiety and stress is one of the psychological risk factors to develop WRMSDs, relaxation technique is one of therapeutic exercise to treat these disorders.

Pawilai concluded “the definition of relaxation is defensive reaction and the opposite mechanism of stress or anxiety. It is a moment of freedom from stress, anxiety, and muscle tension that demonstrates both physical and psychological comfort.” (61).

Muscle relaxation is referred to “methods or techniques that are used to control muscles for the purpose of relaxing muscle tension, reducing stress and anxiety with the principle of mind – body connection.”

The relaxation includes many techniques to achieve the relaxation response, as following;

1. Progressive muscle relaxation (tense and relax)
2. Visual imagery
3. Deep breathing
4. Meditation
5. Hypnosis
6. Yoga
7. Biofeedback

Benefit of muscle relaxation exercise

1. To reduce anxiety, autonomic hyperactivity, and muscle tension that all seen in chronic pain state.
2. This technique is easy to learn and practice.
3. Be easy to use in daily lifestyles.
4. Decrease medicine administration, reduce risk of side effect.
5. To crease peace of mind and diminishes negative attitude and frustration.
6. Increase energy and decrease fatigue.
7. Increase motivation, productivity, and improve decision – making.
8. Improve sleep disorder, high – blood pressure, and drowsiness.

Physiology effects of relaxation exercise

Muscle relaxation reduces functions of two excited nervous systems.

1. The autonomic nervous system

Particularly, the sympathetic nerve that is in spinal cord level. The threaten autonomic nervous system alters subject and prepares physical to be offensive and defensive. An offensive physical responses increase heart rates, blood pressure, and others including muscle tension. So, the indicator of stress and anxiety was autonomic nervous system hyperactivity and muscle tightness that possible to show increasing of stress and anxiety. Muscle relaxation training helps to inhibit the feedback mechanical to the central nervous system temporary that provide lower stress, more comfort, fineness, and relaxation (61, 62).

2. The hypothalamus

The direct effect on the hypothalamus is the sympathetic nervous system inhabitation which is the major role in stress and anxiety. It increase muscle tension and physical functions, include, oxygenation, carbon – dioxide production, metabolism, respiratory rate, heart rate, blood pressure, and lactate level. Any diseases or disorders from stress and anxiety can be reduced by relaxation techniques that decrease emotional tension, anxiety, hyperthermia at the end – limbed, higher epithelial resistance, carbon – dioxide excretion, negative attitude, and increase the alpha and beta electroencephalogram that related to happiness and relaxation (61, 62).

Breathing exercise (63)

Deep breathing or abdominal breathing or diaphragmatic breathing is able to reduce myalgia that makes muscle tension decreases. Breathing exercise effects directly on the autonomic nervous system that is able to increase relaxation. The breathing relaxation therapy is the simplest to relaxation that possible to practice anywhere and anytime.

Typical pattern of diaphragmatic breathing exercise includes rhythm, slow, and aware muscle tension. Lower chest wall must be expanding with upper abdominal inflation while inhaling. The practice guideline of this exercise sequence being with sit on the chair with full support, rest both arm on armrest with both feet on the floor, close the eyes, awareness of breathing pattern, inhalation, and slow exhalation, respectively. This exercise needs a least a few minutes everyday.

A few studies related between relaxation breathing exercise and release pain, for example, Matti Viljanen studied the effectiveness of dynamic muscle training and relaxation training for chronic neck pain. All participants were trained by physiotherapist three times a week for 30 minutes each over 12 weeks and followed up after 12 months. The dynamic muscle training group exercised resisted training 1 – 3 kg. and stretching after session. The relaxation training group comprised various techniques based on the progressive relaxation method in 15 different techniques. The ordinary activity or control group got instruction participant not to change the physical activity. They found that at month 12th, all of them decreased pain intensity from initiate (64). Afshin Samani investigated effects of active and passive pause on spatial electromyographic activity of pain in trapezius muscle during computer work. Active pause was 30% maximum voluntary contraction of shoulder elevation. Passive pause was relaxation. Both groups performed four sessions of computer work for two minutes in one day. The results displayed a more trapezius activity pattern and increased activity with active compared with passive pauses. Pain intensity in active group was greater than passive group (65).

Chapter III

MATERIALS AND METHODOLOGY

Research Design

This study was an experimental research which is randomized controlled trial research. The aim of this study was to study the effects of neck stretching at work on neck pain intensity and surface EMG median frequency changes in office worker.

Population and Sampling

The population of this study was a female office worker with neck pain who is computer users. The sampling was a volunteer that is 25 – 35 years old – female office workers with neck pain who are computer user over than 4 hours/day.

Inclusion Criteria

1. Female office workers aged 25 – 35 years old.
2. All participants have to perform a minimum 4 hours of computer daily with mainly typing task.
3. All participants have been experienced neck pain or discomfort during working or after finite computer task.
4. History of chronic neck pain or discomfort at least 3 months.
5. All participants are not in medical program or physical therapy program.
6. To be willing to do experiment and sign in experimental sign consent form.

Exclusion Criteria

1. A past history of neck surgery.
2. A past history of neck trauma.
3. Show sign and symptom of Cervical radiculopathy or Myelopathy.
4. Show sign and symptom of Systemic illness or connective tissue disorder.
5. Present illness or forbidden stretch musculoskeletal problem or obstructed testing, example, Rheumatoid arthritis, Spondyloarthropathy .
6. Show deformity consists of round back, round shoulder, and head forward.

7. Being in forbidden stretching exercise.

8. Over experimental period, get any severe pain or be musculoskeletal injury provide needs medical treatment or physical therapy program.

Sampling procedures

The computer general randomization technique was used to random participants into 2 groups.

Sample size calculation

To compute the target population was calculated from David M. Kietrys et al which studied effects of at work exercise in computer user 72 office workers. To be divided into various exercise types. The result showed stretching group is better 63% (15/24) and control group 21% (5/24) (26) that calculate in the proportion difference equation with two – sample population

$$n/group = \frac{\{Z_{\alpha}\sqrt{(r+1)P(1-P)} + Z_{\beta}\sqrt{rP_1(1-P1) + P_2(1-P2)}\}^2}{r(P_1 - P_2)^2}$$

but "n" in each group was equal that provided r = 1, therefore, the final is

$$n/group = \frac{\{Z_{\alpha}\sqrt{2P(1-P)} + Z_{\beta}\sqrt{P_1(1-P_1) + P_2(1-P_2)}\}^2}{(P_1 - P_2)^2}$$

Determination P_1 = ratio of stretching group is 0.63

P_2 = ratio of control group is 0.21

$$P = \frac{P_1 + P_2}{2} = \frac{0.625 + 0.21}{2} = 0.42$$

$d = P_1 - P_2 = 0.63 - 0.42 = 0.42$

α = 0.05 (two-sided), $Z_{\alpha} = 1.96$

β = 0.10 (one-sided), $Z_{\beta} = 1.28$

$$n/group = \frac{\{1.96\sqrt{2(0.42)(1-0.42)} + 1.28\sqrt{0.63(1-0.63) + 0.21(1-0.21)}\}^2}{(0.42)^2}$$

n/group = 26.85 ≈ 27

To prevent participants loss, additional, should add more participants 10% approximately. Finally, this is 27 + 3 = 30 participants for each group.

Equipments

1. The Visual Analog Scale form (VAS)
2. The Neck Disability Index form (NDI)
3. Collective data instrument “Surface Electromyography” BIOPAC MP 100 (BIOPAC Systems Inc., USA) with self – adhesive Ag/AgCl electrode
4. Personal data form
5. Workstation (computer table and office chair)
6. Computer desktop
7. Typing practice software
8. Collective data computer
9. Stop watch
10. Ruler
11. Tape measure
12. Alcohol
13. Gauze
14. Cotton
15. Towel
16. Experimental shirt
17. Cap
18. Stretching exercise information sheet
19. Breathing exercise information sheet

Methodology process

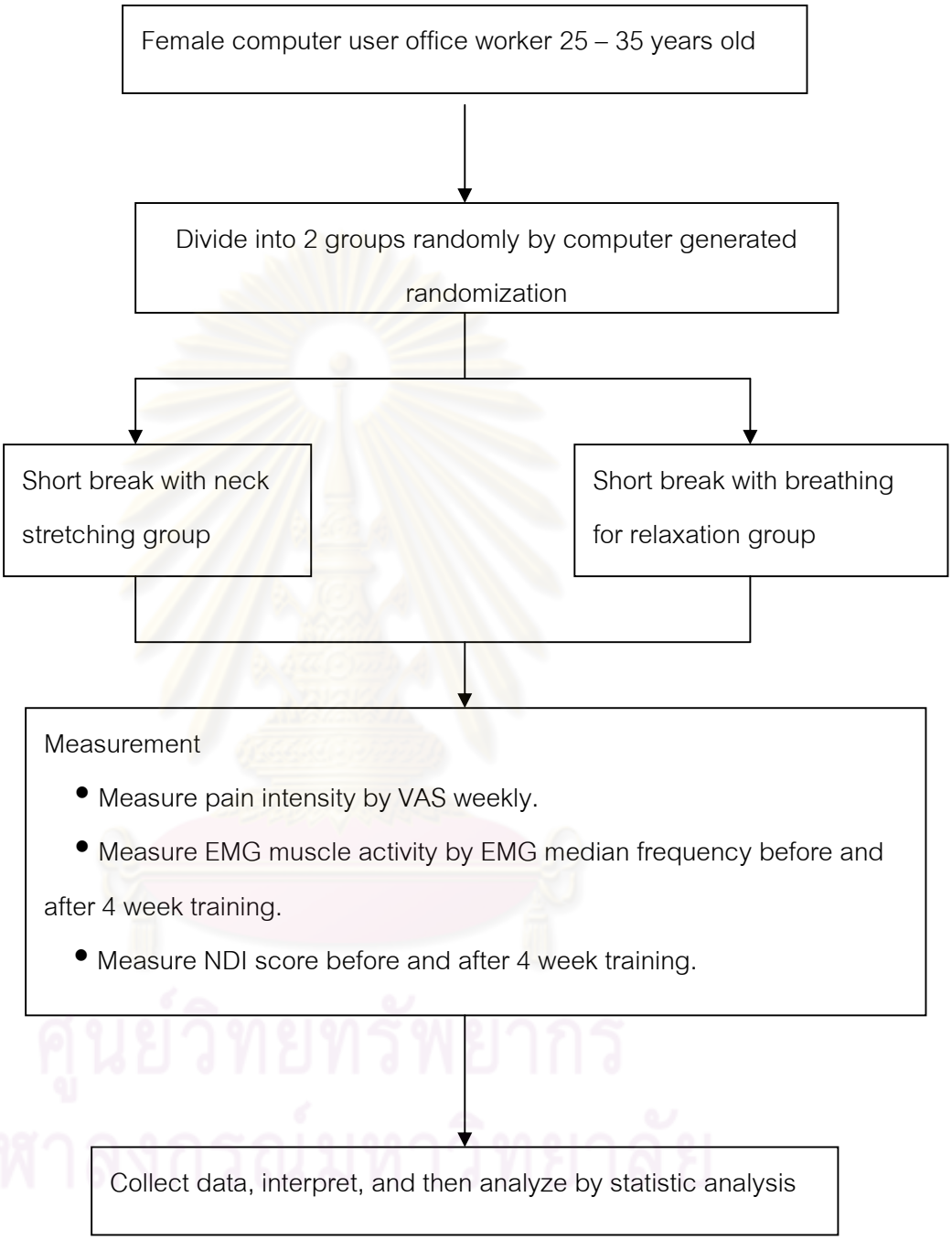

Figure 19 Methodology process

Methodology protocol

1. Explain research objective and protocol to participant.

2. Volunteer will be screened by criteria.

3. Participant has to fill in the consent form.

4. Fill the personal data in the personal data form.

5. Participant was divided into two groups by a simple random sampling technique that includes stretching group (experimental) and breathing exercise for relaxation (control), 30 participants each.

6. Participant has to change cloth into the experimental shirt to explore upper trapzius and take a cap to hide hair.

7. To scrub the skin by gauze with alcohol over involved area for decreasing skin impedance.

8. Attach surface electrode at both upper trapezius and cervical erector spinea.

9. Normalization to upper trapezius and cervical erector spinea.

10. Typing for testing and capture the SEMG median frequency.

11. Collecting pain data in VAS and NDI.

12. Explain exercise guideline and give exercise information sheet to participant, follow the random group.

13. Make appointment for post – test in 4 weeks.

14. In the case of participant get any injury or trauma and being in medication or physiotherapy program will be exclusion criteria.

15. Everyone will receive SMS to remind the exercise every Monday to Friday, twice a day, at 10:00 am and 3:00 pm for 4 weeks.

16. Repeat 6^{th} – 11^{th} protocol again in post – test.

Data collecting

1. The Visual Analog Scale

Intensity of neck muscle pain was rated by individual participants on a 100 – mm visual analog scale, where at 0 mm is “not pain at all” and 100 “the worst imaginable pain”. The score was recorded at rest as pain at rest after 120 – minute computer typing

task. Moreover, all participants received VAS as record form to rate the pain intensity every Friday evening for 4 weeks. VAS was separated to 4 papers for 4 weeks. That is total 5 – VAS graphs for pre – test and 4 – week program. Each paper would be marked | on the 100 – mm line and conserve in envelop for prevention comparison. The score was demonstrated by ruler to measure length from the left end of the horizontal graph. Unit is millimeters.

2. The SEMG median frequency

Skin preparation

The method, first, change shirt that open neck extensor and upper trapezius both sides. Second, skin was abraded for cleaning and minimizing skin impedance with 75% alcohol and gauze on both cervical erector spinae muscles (CES) and upper trapezius muscles (UT). Third, two active electrodes of both upper trapezius locate stable along the ridge of the shoulder, a halfway between the cervical spine at C7 and the acromion. Similarly, cervical erector spinae were placed about 1 cm. distance lateral to the C4 spinous process bilaterally.

Normalization

EMG normalization procedures were carried out by having the participant perform three trials of resisted isometric maximum voluntary contractions (IMVC) for each muscle before the typing trial. Each repetitive hold 10 seconds and rest 30 seconds. Repeated 3 times each pose, and then calculated by sum of IMVC divided by 3. Upper trapezius, sit on the chair properly, against manual resistance on both shoulders abduction 90 degree and extension with pronation of elbow. Cervical erector spinae, sit on the chair, against manual resistance on neck extension.

Muscle electrical activity

The instrument were used for EMG capture in this study include BIOPAC MP 100 (BIOPAC Systems Inc., USA) and self – adhesive Ag/AgCl electrode. Bipolar surface electrodes 18 min diameter were placed on the four muscles, include, both upper

trapezius and both cervical erector spinae. With a 36 mm inter – electrode distance (center to center). The BIOPAC MP 100 was used to capture the EMG signals as a sampling frequency of 1,000 Hz and a band – width 10 – 500 Hz. EMG data were captured from the four muscles for a 60 – second period. A high pass filter at 20 Hz, a low pass filter at 500 Hz, and notch filters at 50 and 60 Hz to reduce the noise levels. The 20 – Hz high pass filter was used to reduce the influence of movement artifact and of EKG signals. The 500 – Hz low pass filter reduced the influence of high frequency aliases. Whilst there was a small amount of EMG power over 200 Hz lost, this counteracted the loss associated with the two notch filters. In some of the testing session, there were still some non – biological interfering frequencies recorded which presented as second – wave harmonics in the power spectrum were discarded and these were replaced with data from adjacent recording trials. The 50 and 60 Hz notch filters were inserted in order to attenuate the non – biological signal noise at 50 Hz (from the mains power) and at 60 Hz (from the transformer).

To collect the EMG signal data was capture 5 times over the 120 – minute typing trials. First, participant has to adjust the posture, workstation, chair, and computer set into proper ergonomics. To capture the signal was 1 – minute period for 5 times, include, at 0, 30th, 60th, 90th, and 120th minute. Each capture will be transform to the median frequency value by AcqKnowlegde Software® (BIOPAC Systems Inc., USA).

Figure 20 Demonstrate surface EMG electrode locations of UT and CES (http://www.delsys.com/Attachments_pdf/WP_Biomechanics.pdf)

3. The Neck Disability Index

To score the NDI by choosing the most closely answer in each section, and then calculate the score follow as the formula. This questionnaire needs to collect in pre – test and post – test after typing test only. Unit is percentage.

Patient preparation before test

1. Sleep at least 6 – 8 hours the night before the test.

2. Do not take any food and beverage that was mixed with alcohol and/or caffeine at least 12 hours.

3. Avoid vigorous activities and/or exercises before the test 24 hours.

Participant instruction protocol

Neck stretching instruction for experimental group

1. Correct sitting posture

2. Stretch upper trapezius muscle side by side. To start being to do right neck lateral with right hand compression until feel tightness hold 30 seconds, repeat 3 times. Then, repeat again in other direction.

3. Stretch cervical erector spinae muscle by put both hands behind the head with bend head over until feel tightness. Hold 30 seconds, repeat 3 times.

4. Follow number 2 and 3 daily in office at 10:00 am. and 3:00 pm. All participants will receive the remind SMS before both practice sessions.

5. All participants receive self – report form.

Diaphragmatic breathing exercise instruction for control group

1. Correct posture and feel relax with the work chair.

2. Put both hands over diaphragm or inferior to xyxphoid.

3. Inhale via nose until abdominal inflate and do not elevate shoulder. Then exhale with purse lip technique.

4. Do breathing exercise during 5 minutes period daily in workplace at 10:00 am. and 15:00 pm. All participants will receive remind SMS before both practice sessions.

5. All participants receive self – report form.

This experiment gathered data in the Padthayapatana building, Chulalongkorn University, and 4th floor. To collect data in 2 days that is before and after 4 weeks.

Data Analysis

It is very important to verify all data after collect data completely. All demographic data were analyzed by static methodology as following;

1. Demographic data of age, height, body weight, working hour, keyboard working period, and mouse working period were analyzed by descriptive statistic that demonstrate as Mean ± SD.

2. Comparing the difference of pain intensity (VAS and NDI) of neck muscle and SEMG median frequency value between before and after stretching program by pair t – test.

3. Comparing the difference of pain intensity (VAS and NDI) of neck muscle and SEMG median frequency value between before and after stretching program with between the experimental group and the control group by ANCOVA.

Statistic significance at 0.05 ($p < 0.05$).

Chapter IV
RESULTS

Characteristics of subjects

Sixty office eligible female volunteers were selected according to the criterion and divided into 2 groups of 30, include, stretching exercise group and breathing exercise group. No one dropped out during experimental period.

Table 4.1 Baseline characteristics of subjects (n=60)

Features	Stretching group n=30	Breathing group n=30	*p* values
	Mean(SD)	Mean(SD)	
Age (years old)	29.83(2.98)	28.40(2.86)	0.709
Weight (kg.)	52.37(7.03)	54.18(10.52)	0.198
Height (cm.)	159.67(5.94)	158.37(7.22)	0.360
BMI (kg/m^2)	20.52(2.32)	21.74(3.92)	0.182
Work hour (hr)	8.70(2.26)	7.67(2.09)	0.071
Keyboard (hr)	5.20(1.06)	5.27(1.33)	0.832
Mouse hour (hr)	3.47(1.57)	2.40(1.10)	0.003*

*p< 0.05 represents statistic significant

Baseline characteristics of all of 60 subjects were shown in table 4.1. All female participants were 25 – 35 years old range. The mean age was 29.12 ± 2.99 years old. Range of body weight was 38 – 90 kilogram (53.28 ± 8.92 kg.). They are tall between 144 – 172 cm. (159.02 ± 6.59 cm.). Range of BMI between 16.89 – 36.98 kg/m^2 (21.13 ± 3.25 kg/m^2). These data were separated into 2 group in table 4.1 that is not significant different of anthropometric.

All of them have worked 5 – 13 hours (8.18 ± 2.22 hours), consisted of, keyboard use hour 4 – 8 hours (5.23 ± 1.20 hours) and mouse use hour 1 – 6 hours (2.93 ± 1.45

hours). However, mouse use hour in stretching group is greater than breathing group (3.47 ± 1.57 vs. 2.40 ± 1.10) ($p< 0.05$). The most baseline characteristics of both groups were very similar.

Table 4.2 Practice hour percentage (n=60)

	Stretching group Mean (SD)	Breathing group Mean(SD)	*p* values
Practice hour (%)	86.83(11.82)	88.42(12.70)	0.619

Table 4.2 showed percentage of practice hour in each group. Stretching group had practiced less than breathing group; however, it is not difference significantly.

Table 4.3 Visual Analog Scale (VAS) (n=60)

	VAS 0 (mm.)	VAS 4th (mm.)	*p* values
	Mean(SD)	Mean(SD)	
Stretching group	48.80(18.41)	26.30(22.22)	0.000*
Breathing group	42.83(22.20)	19.33(20.37)	0.000*

*$p< 0.001$ represents statistic significant

Table 4.3 showed pre – test, post – test, difference means, and standard deviations of the VAS score of pain intensity. Mean different of VAS value in stretching group was decreased 22.50 ± 22.10 mm. (48.80 ± 18.41 vs. 26.30 ± 22.22) ($p<0.001$). In breathing group changes was decreased 23.50 ± 23.41 mm. (42.83 ± 22.20 vs. 19.33 ± 20.37) ($p<0.001$).

Table 4.4 Surface EMG median frequency (MF) (n=60)

Group	Muscle	Pre – test Mean(SD)		p values	Post – test Mean(SD)		p values
		Min0th	Min120th		Min0th	Min120th	
Stretching	Lt.CES	181.25(24.33)	165.73(19.53)	0.000*	173.86(23.07)	171.04(23.07)	0.648
	Lt.UT	183.10(33.92)	157.03(27.44)	0.001*	171.41(28.40)	161.07(30.82)	0.120
	Rt.CES	186.68(21.04)	171.49(24.05)	0.002*	185.39(21.50)	175.62(27.27)	0.014*
	Rt.UT	193.10(30.34)	141.00(27.02)	0.000*	194.99(41.02)	150.70(31.23)	0.000*
Breathing	Lt.CES	174.42(21.32)	165.37(20.66)	0.017*	180.39(26.91)	167.99(18.39)	0.018*
	Lt.UT	180.19(42.37)	158.33(31.42)	0.002*	169.11(29.17)	151.97(25.06)	0.003*
	Rt.CES	181.34(27.24)	168.32(21.55)	0.009*	183.83(25.66)	173.04(28.95)	0.009*
	Rt.UT	186.43(39.60)	147.64(30.84)	0.000*	179.61(41.29)	135.41(23.87)	0.000*

*p< 0.05 represents statistic significant

Table 4.4 demonstrated the surface EMG median frequency value of both groups that consists of pre – test and post – test in 4 invloved muscles. Significance in decreasing of MF imply muscle fatigue. The pre – test values of both group are on left side that every muscle shows decreasing of MF for both group significantly ($p<0.05$). The post – test values of both group are on right side that breathing group showed muscle fatigue for all involved muscles. In stretching group has showed fatigueing on Rt. CES and Rt. UT, however, Lt. CES and Lt. UT did not show fatigueing.

Table 4.5 The neck disability index (NDI)

Group	Pre - test Mean(SD)	Post – test Mean(SD)	*p* values
Stretching (%)	13.26(8.81)	7.44(4.86)	0.000*
Breathing (%)	12.78(10.59)	9.16(10.33)	0.000*

*p< 0.001 represents statistic significant

Table 4.5 demonstrated the neck disability index score that was calculated into percentage. Both groups have showed decreased percentage of NDI significantly ($p<0.001$) that indicated the better quality of life and functional. The stretching group changed 5.81 ± 6.29% (13.26 ± 8.81 vs. 7.44 ± 4.86) ($p<0.001$), additional, the breathing group changed 3.61 ± 0.79% (12.78 ± 10.59 vs. 9.16 ± 10.33) ($p<0.001$).

Table 4.6 Intergroup comparison of VAS between stretching group and breathing group.

	Stretching group	Breathing group	p values
	Mean (SD)	Mean (SD)	
Pre – test (VAS0)	48.80 (23.99)	42.83 (22.20)	0.001*
Post – test (VAS4)	25.40 (22.91)	19.33 (20.37)	0.390

*$p<0.05$ represents statistic significant

This table was analyzed by ANCOVA. The pain intensity score in pre – test between intergroup was significant difference ($p<0.05$). But the pain intensity score in post – test between intergroup was no significant difference ($p>0.05$).

Table 4.7 Intergroup comparison of mean difference of MF on Lt. UT between stretching group and breathing group (Pre - test).

	Stretching group	Breathing group	p values
	Mean (SD)	Mean (SD)	
Min 0^{th}	183.10(33.92)	157.03(27.44)	0.000*
Min 120^{th}	171.41(28.40)	158.33(31.42)	0.740

*$p<0.05$ represents statistic significant

This table was analyzed by ANCOVA. At the pre – test, the mean difference of MF on Lt. UT at the min 0^{th} was significant difference between groups ($p<0.001$). And

the mean difference of MF on Lt. UT at the min 120th was no significant difference between groups (p>0.05).

Table 4.8 Intergroup comparison of mean difference of MF on Lt. UT between stretching group and breathing group (Post - test).

	Stretching group	Breathing group	p values
	Mean (SD)	Mean (SD)	
Min 0th	171.41(28.40)	169.11(29.17)	0.006*
Min 120th	161.07(30.82)	151.97(25.06)	0.230

*p< 0.05 represents statistic significant

This table was analyzed by ANCOVA. At the post – test, the mean difference of MF on Lt. UT at the min 0th was significant difference between groups (p<0.05). And the mean difference of MF on Lt. UT at the min 120th was no significant difference between groups (p>0.05).

Table 4.9 Intergroup comparison of mean difference of MF on Lt. CES between stretching group and breathing group (pre – test).

	Stretching group	Breathing group	p values
	Mean (SD)	Mean (SD)	
Min 0th	181.25(24.33)	174.42(21.32)	0.000*
Min 120th	165.73(19.53)	165.37(20.66)	0.482

*p< 0.05 represents statistic significant

This table was analyzed by ANCOVA. At the pre – test, the mean difference of MF on Lt. CES at the min 0th was significant difference between groups (p<0.05). And the mean difference of MF on Lt. UT at the min 120th was no significant difference between groups (p>0.05).

Table 4.10 Intergroup comparison of mean difference of MF on Lt. CES between stretching group and breathing group (post – test).

	Stretching group	Breathing group	p values
	Mean (SD)	Mean (SD)	
Min 0th	173.86(23.07)	180.39(26.91)	0.037*
Min 120th	171.04(23.07)	167.99(18.39)	0.453

*p< 0.05 represents statistic significant

This table was analyzed by ANCOVA. At the post – test, the mean difference of MF on Lt. CES at the min 0th was significant difference between groups ($p<0.05$). And the mean difference of MF on Lt. UT at the min 120th was no significant difference between groups ($p>0.05$).

Table 4.11 Intergroup comparison of mean difference of MF on Rt. UT between stretching group and breathing group (pre – test).

	Stretching group	Breathing group	p values
	Mean (SD)	Mean (SD)	
Min 0th	193.10(30.34)	186.43(39.60)	0.758
Min 120th	141.00(27.02)	147.64(30.84)	0.401

*p< 0.05 represents statistic significant

This table was analyzed by ANCOVA. At the pre – test, the mean difference of MF on Rt. UT at the min 0th was no significant difference between groups ($p>0.05$). And the mean difference of MF on Rt. UT at the min 120th was no significant difference between groups ($p>0.05$).

Table 4.12 Intergroup comparison of mean difference of MF on Rt. UT between stretching group and breathing group (post – test).

	Stretching group	Breathing group	p values
	Mean (SD)	Mean (SD)	
Min 0^{th}	194.99(41.02)	179.61(41.29)	0.044*
Min 120^{th}	150.70(31.23)	135.41(23.87)	0.083

*p< 0.05 represents statistic significant

This table was analyzed by ANCOVA. At the post – test, the mean difference of MF on Rt. UT at the min 0^{th} was significant difference between groups ($p<0.05$). And the mean difference of MF on Rt. UT at the min 120^{th} was no significant difference between groups ($p>0.05$).

Table 4.13 Intergroup comparison of mean difference of MF on Rt. CES between stretching group and breathing group (pre – test).

	Stretching group	Breathing group	p values
	Mean (SD)	Mean (SD)	
Min 0^{th}	186.68(21.04)	181.34(27.24)	0.000*
Min 120^{th}	171.49(24.05)	168.32(21.55)	0.862

*p< 0.05 represents statistic significant

This table was analyzed by ANCOVA. At the pre – test, the mean difference of MF on Rt. CES at the min 0^{th} was significant difference between groups ($p<0.05$). And the mean difference of MF on Rt. CES at the min 120^{th} was no significant difference between groups ($p>0.05$).

Table 4.14 Intergroup comparison of mean difference of MF on Rt. CES between stretching group and breathing group (post – test).

	Stretching group	Breathing group	p values
	Mean (SD)	Mean (SD)	
Min 0^{th}	194.99(41.02)	150.70(31.23)	0.758
Min 120^{th}	179.61(41.29)	135.41(23.87)	0.401

*p< 0.05 represents statistic significant

This table was analyzed by ANCOVA. At the pre – test, the mean difference of MF on Rt. CES at the min 0^{th} was no significant difference between groups (p>0.05). And the mean difference of MF on Rt. CES at the min 120^{th} was significant difference between groups (p>0.05).

Table 4.15 Intergroup comparison of NDI between stretching group and breathing group.

	Stretching group	Breathing group	p values
	Mean (SD)	Mean (SD)	
Pre – test	13.26(8.81)	12.78(10.59)	0.000*
Post – test	7.44(4.86)	9.16(10.33)	0.086

*p< 0.001 represents statistic significant

This table was analyzed by ANCOVA. The mean difference of NDI score in pre – test between intergroup was significant (p<0.001). But the NDI score in post – test between intergroup was no significant difference (p>0.05).

Table 4.16 Comparison of difference between VAS0 and VAS4 from both groups by ANCOVA.

Mean(SD)	Stretching group	Breathing group	p values
VAS 0^{th} – VAS 4^{th}	22.50(22.10)	23.50(23.41)	0.866

$p < 0.05$ represents statistic significant

Table 4.16 showed the average between VAS0 and VAS4 which are average of VAS 0^{th} minutes VAS 4^{th} from each group. At the end of program, ST decreased 22.50 ± 22.10 and BE decreased 23.50 ± 23.41 that demonstrated the BE was greater lowering than ST but this was no significant ($p>0.05$). This could imply the effects of stretching did not provide the better effect than control.

Table 4.17 Comparison of difference between pre – test and post – test of Lt. UT from each group.

Mean(SD)	Pre – test	Post – test	p values
Stretching group	26.06±38.07	21.85±35.10	0.858
Breathing group	21.85±28.95	17.15±28.95	

$p < 0.05$ represents statistic significant

Table 4.17 showed average of min 0^{th} minutes min 120^{th} in each group with divided into pre – test and post – test. The comparison of these average between pre – test and post – test was no significant ($p>0.05$). This could imply the effects of stretching did not provide the better effect than control.

Table 4.18 Comparison of difference between pre – test and post – test of Lt. CES from each group.

Mean(SD)	Pre – test	Post – test	p values
Stretching group	15.52±20.57	20.57±19.50	0.600
Breathing group	90.48±19.50	12.40±27.16	

$p < 0.05$ represents statistic significant

Table 4.18 showed average of min 0^{th} minutes min 120^{th} in each group with divided into pre – test and post – test. The comparison of these average between pre – test and post – test was no significant ($p>0.05$). This could be possible to imply the effects of stretching did not provide the better effect than control.

Table 4.19 Comparison of difference between pre – test and post – test of Rt. UT from each group.

Mean(SD)	Pre – test	Post – test	p values
Stretching group	15.52±20.57	2.81±19.50	
Breathing group	90.48±19.50	12.40±17.16	

$p < 0.05$ represents statistic significant

Table 4.19 showed average of min 0^{th} minutes min 120^{th} in each group with divided into pre – test and post – test. The comparison of these average between pre – test and post – test was unable to be computed by ANCOVA.

Table 4.20 Comparison of difference between pre – test and post – test of Rt. CES from each group.

Mean(SD)	Pre – test	Post – test	p values
Stretching group	15.18±24.33	44.29±48.14	0.016*
Breathing group	13.02±25.35	44.20±37.60	

p< 0.05 represents statistic significant

Table 4.19 showed average of min 0^{th} minutes min 120^{th} in each group with divided into pre – test and post – test. The comparison of these average between pre – test and post – test was significant ($p<0.05$). This could imply the effects of stretching provide the better effect than control.

Table 4.21 Comparison of difference NDI between pre – test and post – test from both groups by ANCOVA.

Mean(SD)%	Stretching group	Breathing group	p values
Pre – Post test	5.81 ± 6.29	3.61 ± 0.79	0.122

p< 0.05 represents statistic significant

Table 4.21 demonstrated the average difference of pre –test minutes post – test in each group. At the end of program, ST decreased 5.81 ± 6.29 and BE decreased 3.61 ± 0.79 that demonstrated the ST was greater lowering than BE but this was no significant ($p>0.05$). This could imply the effects of stretching did not provide the better effect than control.

CHAPTER V

DISCUSSION AND CONCLUSION

Computer users use both hands for keyboard task and they use right hand for mouse task, which may be the reason why their right hands work greater than their left hands. As shown in table 4.1, average computer usage duration and keyboard hours were very similar in both groups but neck stretching exercise group used mouse longer than breathing exercise for relaxation group significantly. It might be potentially more painful on the right side than on left side if right hands were used more than the left one. Mean age of all samples in this study was below 30 years old which should eliminate degenerative cervical spondylosis that might cause neck pain rather than work related chronic neck pain from computer task fatigue.

The Visual Analog Scale (VAS)

Both neck stretching exercise and breathing exercise for relaxation could reduce VAS pain score at neck significantly ($p<0.001$) after 4 weeks of exercise (Table 4.3). Neck stretching exercise is a popular and widely prescribed treatment for neck pain. The effects of stretching contribute in reducing discomfort and pain around the neck effectively. Thus, there is a growing utilization of stretching exercise for reducing the risk of work – related musculoskeletal disorder in the workplace, especially, in computer users. A systemic review showed a positive outcome on the productivity and release fewer neck symptoms using programs of “stop and stretch” or “stretch break” program among computer users during working hour. There were various protocols of stretching intervention in office workers that provided positive effects. In this study, stretching exercise in the office twice a day while at work for a period of 4 week was able to help in reducing neck discomfort and neck pain significantly (3). One stretching was sustained 5 seconds and repeated 5 times. Other studies showed not only neck pain but also upper extremities pain and discomfort could be improved by sustained stretching (26, 60). The program set a sustained stretch 20 – 30 seconds at least 3 times daily during working hours and after working over a 6 – month period (60). A home program stretching twice a day for one week followed by sustained stretch for 30 seconds for 10 times also showed the effectiveness of pain reducing in individuals with

neck and upper back pain from myofascial pain syndrome (59). Sustained stretching was always prescribed to chronic neck pain patients. Any sustained stretching, as well as, conventional static stretching and muscle chain stretching, in accompany with manual therapy provided significant pain relief, ROM improvement, and quality of life improvement (27). Working break stretching, whether rest break 5 minutes in every 35 minutes or 7 seconds micro break in every 5 minutes at computer work station showed the efficacy of neck pain reduction during computer work (66). Yoga is an exercise that combines stretching with diaphragmatic breathing exercise. Yoga during working and rest could reduce pain score, increase pain threshold and improve quality of life in housewife with chronic neck and upper back pain (18).

The VAS in breathing exercise group also reduced significantly, it indicated that deep breathing exercise for relaxation could help to reduce pain intensity. The mixed intervention included massage, stretching, mobilization, correct posture, and relaxation techniques provided reduction of pain intensity during stress increasing were used to eliminate pain and muscle tone that be induced by stress (67). In the USA, commonly, use the deep breathing technique as mind – body therapy for patient with medical condition associated with anxiety/depression and musculoskeletal pain syndrome among adults that provided positive outcomes. These patients took varied technique of mild – body therapy as self – care program over 12 months, then, the breathing exercise was the most common exercise (68).

As table 4.16, the mean difference between pre – test and post – test in stretching exercise was as in similar as breathing exercise for relaxation. From table 4.3 and 4.16 it could be implied that the protocols in this present study which was set daily rest break with stretching or with breathing exercise for relaxation approximately 5 minutes each session, twice a day that was 10 minutes for one single working day over 4 weeks would be enough to reduce the pain intensity by VAS.

The Neck Disability Index (NDI)

The NDI is also self – reported levels of pain that associated between pain and disability. Both groups have got lower score of disability that imply they are able to do more activities and easier (table 4.5). At the beginning of experiment, the stretching

group had greater disability than the breathing exercise for relaxation group had – but – at the end of experiment, the stretching group had no less significant less disability than the breathing group had (table 4.21). Exercise effects at office during work hour twice a day for 4 – week period included strengthening, stretching, and breathing exercise group that resulted all of them to rate lower NDI score from baseline. An 8 – week effects of software programs stimulating regular breaks and exercises on work – related neck and upper – limb disorders that were 5 – minute natural rest break and 5 – minute break with stretching for every 35 minutes. There are no significant different changes among all of them but they showed decrease pain and discomfort score, decrease sick leave, and increase productivity that were similar to this recent study (66). Ylinen used exercise to treat female office worker with chronic neck pain consists of strength, endurance, and aerobic group. Exercise prescription was 45 minutes with 20 – minute stretching exercise for the neck, shoulder, and upper limb muscles for regularly 3 times a week, then, the NDI had decreased in strength and endurance group compared with the aerobic group significantly but the VAS was not (1). Deep breathing exercises potential help to release stress and reduce discomfort of trapzius and cervical extensor spinae muscles (26).

There were increasing use of mixed intervention model included massage, stretching, mobilization, correct posture, and relaxation techniques which provided reduction of pain intensity and muscle tone that induced by stress (67). Deep breathing exercise for relaxation also showed positive outcome in patient with medical condition associated with anxiety/depression and musculoskeletal pain syndrome (68). The total workout in this study was 10 minutes per day for 4 weeks, this amount of exercise showed efficacy in the reduction of neck pain and improved neck disability index scores (table 4.5). Deep breathing exercises for relaxation release stress and reduce discomfort of trapzius and cervical extensor spinae muscles (26). This study compared the effect of stretching exercise, strengthening exercise and breathing exercise for relaxation in the office twice a day for 4 week and found that all exercises could reduce neck disability index score. This study showed that breathing exercise for relaxation provided improvement of function outcome as same as stretching exercise did. The

breathing exercise for relaxation protocol in this study could reduce the pain score and improve the quality of life significantly.

Thus, this suggested that breathing exercise for relaxation provided improvement of pain and function as same as stretching exercise did. The breathing exercise protocols in this study could be enough to reduce the pain score and improve the quality of life.

The surface MEG median frequency

In this study, median frequency was used as the indicator to measure pain and neck muscle fatigue phenomenon. The lowering of median frequency in the linear regression slope and increase EMG activities after prolonged muscle contraction indicated muscle fatigue around neck muscles (11). All participants in this study showed neck pain and muscle fatigue after 120 – minute computer typing trial when compared to the median frequency of neck muscle before and after the computer tasks. After 4 weeks of breathing exercise, surface EMG of neck muscles still showed the lowering of median frequency after 120 minutes computer typing trial while there was improvement of the fatigue pattern by surface EMG median frequency in left upper trapezius and left cervical erector spinae after 4 weeks of neck stretching exercise. The right upper trapezius and right cervical erector spinae still showed lowering of the median frequency after prolonged working (table 4.4). These findings were similar to Grace's study who found that EMG muscle activity of symptomatic office workers on the Rt. CES and Rt. UT was more than Lt. side (23). This finding may imply that right side worked more than the left side and 4 weeks stretching exercise still could not prevent muscle fatigue on the right side.

There was another study using surface EMG analysis to evaluate physiologic of muscle changes in female computer users during 120 – minute typing task (16). The results of this study showed downward shifting of the median frequency of Rt. CES, Lt. CES, and Lt. UT, but not Rt. UT. Mitsutochi et al assessed the development and recovery of muscle fatigue by analysis of surface electromyographic median frequency. This study showed that after 120 minutes typing with the perception of fatigue, there was downward shift of median frequency surface EMG and the frequency increased after

rest period (11). There were some studies explored relationships between EMG amplitude and functional tests and showed greater surface EMG activity of neck muscles during the test session (14). Another study tried to explain relationship between surface EMG analysis and psychosocial stress test in chronic myalgia females but there was still no conclusion (22). Most of the studies did not explore the effect of exercise intervention in the benefit of changing muscular fatigue pattern by surface EMG frequency domain test.

The outcomes could be implied that stretching exercise help to decrease pain, however, these interventions in this study may not enough to decrease pain on right side. As above, because the right hands must be used for keyboard task and mouse task throughout the duration of computer use but the left hands were used only for keyboard task. In the same intensity, duration, and frequency of stretching protocol provided decrease pain from the left side overload level only.

Our study tried to investigate the effect of neck stretching exercise and breathing exercise for relaxation to improve neck muscle fatigue pattern but we could observe that the stretching exercise could improve fatigue only for the left upper trapezius and the left cervical erector spinae which might be less used than the right side neck muscle during computer work.

Conclusion

The effects of stretching exercise from short break exercise at work twice a day in 4 – week program provided the improvement in pain level, quality of life, and muscle fatigability on the left side. The effects of breathing exercise for relaxation contributed to the improvement in pain level and quality of life but not for all muscle fatigability. Thus, stretching exercise had some potential in reducing chronic neck muscle pain in computer users.

Recommendation to future study

1. Try to add any psychometric questionnaire to strengthen outcome.

2. This is able to add other parameter or questionnaire to be evidence base for analysis of the results, such as, a number of children, housework duration, recreation, psychological stress level, etc.

3. This is able to add more physical examination such as pressure pain threshold.

4. Try to separate VAS for each side of muscle because some muscles maybe better, some muscles maybe worse.

5. Try to add other physical training protocol.

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APPENDICES

Appendix A

Patient Information Sheet

ชื่อโครงการ ผลของการยืดกล้ามเนื้อคอในขณะพักการทำงานต่ออาการปวดคอและการเปลี่ยนแปลงของ Surface EMG median frequency ในกลุ่มพนักงานสำนักงาน

Effects of short break neck stretching on neck pain and surface EMG median frequency changes in office workers

ผู้ทำการวิจัย นายอธิพล เมธาทิพย์
นิสิตหลักสูตรวิทยาศาสตรมหาบัณฑิต สาขาเวชศาสตร์การกีฬา

อาจารย์ที่ปรึกษาโครงการ รองศาสตร์จารย์ นายแพทย์ พงศ์ศักดิ์ ยุกตะนันทน์

ผู้ดูแลที่ติดต่อได้

1. รองศาสตร์จารย์ นายแพทย์ พงศ์ศักดิ์ ยุกตะนันทน์ ภาควิชาออร์โธปิดิกส์ คณะแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัยโทรศัพท์ 02-256-4230 (ที่ทำงาน)
2. นายอธิพล เมธาทิพย์ ห้องปฏิบัติการวิจัยทางเวชศาสตร์การกีฬา ชั้น 4 อาคารแพทยพัฒน์ คณะแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
โทรศัพท์ 02-256-4267, มือถือ 081-671-9203

สถานที่วิจัย

ห้องปฏิบัติการวิจัยทางเวชศาสตร์การกีฬา ชั้น 4 อาคารแพทยพัฒน์ คณะแพทยศาสตร์ โรงพยาบาลจุฬาลงกรณ์ โทรศัพท์ 02-252-7854 ต่อ 2431

ความเป็นมาของโครงการ

โรคทางระบบกระดูกและกล้ามเนื้อเป็นปัญหาสุขภาพที่พบได้อย่างกว้างขวางในประชาชนทั่วโลกรวมทั้งในประเทศไทย สาเหตุสำคัญอันหนึ่งของการเกิดโรคทางระบบกระดูกและกล้ามเนื้อในคนอายุระหว่าง 20-60 ปีก็คือการทำงาน (work-related musculoskeletal disorders) การเกิดโรคทางระบบกระดูกและกล้ามเนื้อในคนวัยทำงานมีผลเสียอย่างมากต่อระบบเศรษฐกิจและสังคมของประเทศ

การที่ผู้ทำงานในสำนักงานมีความเสี่ยงต่อการเป็นโรคทางระบบกระดูกและกล้ามเนื้อค่อนข้างมากเนื่องจากลักษณะของงานมักจำเป็นต้องอยู่ในท่าใดท่าหนึ่งเป็นเวลานานๆ หรือมีท่าทางการทำงานที่ไม่เหมาะสม หรือมีการเคลื่อนไหวที่ซ้ำซากเป็นประจำ ซึ่งสิ่งเหล่านี้ส่งผลเพิ่มความเครียดต่อระบบกระดูกและกล้ามเนื้อทำให้เกิดการบาดเจ็บได้ง่าย ในปัจจุบันพบว่าผู้ที่ทำงานในสำนักงานมีแนวโน้มในการเกิดปัญหาทางระบบกระดูกและกล้ามเนื้อเพิ่มขึ้นอย่างต่อเนื่อง ดังนั้น โรคทางระบบกระดูกและกล้ามเนื้อเนื่องจากการทำงานในสำนักงานจึงเป็นปัญหาสุขภาพที่มีแนวโน้มว่าจะมีความสำคัญมากขึ้นเรื่อยๆ ซึ่งจะส่งผลให้กองทุนเงินทดแทน สำนักงานประกันสังคมหรือนายจ้างต้องแบกรับภาระค่าใช้จ่ายมากขึ้นตามไปด้วย ลักษณะสำคัญของโรคทางระบบกระดูกและกล้ามเนื้อจากการทำงานโดยใช้เครื่องคอมพิวเตอร์ประกอบด้วยอาการปวด เมื่อย ตึง รู้สึกไม่สบายกล้ามเนื้อ ซึ่งเป็นอาการสำคัญที่สุด นอกจากนี้ยังทำให้มีความสามารถในการใช้งานลดลง มีมุมการเคลื่อนไหวลดลง มักจะพบในบริเวณคอ หลังส่วนบน ไหล่ และแขน ทั้ง 2 ข้าง และเกิดความเครียดต่อจิตใจเพิ่มขึ้น

หลักการรักษาอาการของโรคทางระบบกระดูกและกล้ามเนื้อประกอบไปด้วยหลายวิธีเช่น การกินยา การฉีดยา การฝังเข็ม การรักษาทางกายภาพบำบัดซึ่งมีเทคนิคและวิธีการต่างๆเช่น การใช้ความร้อนตื้นและลึก การใช้ความเย็น การใช้เครื่องกระตุ้นไฟฟ้า การนวด การกดจุด การออกกำลังกายเพื่อเพิ่มความแข็งแรง เพิ่มความทนทาน เพิ่มความยืดหยุ่นให้กับกล้ามเนื้อ การฝึกจัดท่าทางให้เหมาะสม เป็นต้น ซึ่งการออกกำลังกายเพื่อเพิ่มความยืดหยุ่นด้วยวิธีการยืดกล้ามเนื้อ (Stretching exercise) ถือเป็นวิธีการรักษาที่ช่วยลดอาการปวดได้นานและเป็นการรักษาที่ได้รับนิยมมาก สามารถแนะนำให้ผู้ป่วยทำเองได้

งานวิจัยนี้มีวัตถุประสงค์ในการศึกษาผลของการยืดกล้ามเนื้อต่ออาการปวดคอในกลุ่มผู้ที่ใช้คอมพิวเตอร์ในสำนักงานเป็นประจำ เพื่อที่จะนำไปประยุกต์ใช้ในชีวิตการทำงานได้อย่างเหมาะสมซึ่งน่าจะช่วยลดความเสี่ยงในการเกิดหรือบรรเทาอาการของโรคทางระบบกระดูกและกล้ามเนื้อเนื่องจากการทำงาน

เหตุผลที่เข้าร่วม

ข้อมูลที่ได้สามารถนำไปประยุกต์ใช้ในชีวิตการทำงานได้อย่างเหมาะสมซึ่งน่าจะช่วยลดความเสี่ยงในการเกิดหรือบรรเทาอาการของโรคทางระบบกระดูกและกล้ามเนื้อเนื่องจากการทำงาน

วัตถุประสงค์ของการวิจัย

1. เพื่อศึกษาการเปลี่ยนแปลงระดับของอาการปวดคอและการเปลี่ยนแปลงของคลื่นไฟฟ้ากล้ามเนื้อคอหลังจากการยืดกล้ามเนื้อของพนักงานที่ใช้คอมพิวเตอร์เป็นเวลา 4 สัปดาห์
2. เพื่อเปรียบเทียบการเปลี่ยนแปลงระดับของอาการปวดคอและการเปลี่ยนแปลงของคลื่นไฟฟ้ากล้ามเนื้อคอระหว่างกลุ่มที่ทำการยืดกล้ามเนื้อกับกลุ่มที่ฝึกหายใจลึกเพื่อผ่อนคลายเป็นเวลา 4 สัปดาห์

รายละเอียดที่จะปฏิบัติต่อผู้เข้าร่วมวิจัย

1. ผู้เข้าร่วมวิจัยจะได้รับการชี้แจงรายละเอียดเกี่ยวกับงานวิจัยโดยย่อ และได้รับการแจ้งให้ทราบว่าการเข้าร่วมโครงการศึกษาวิจัยในครั้งนี้ผู้เข้าร่วมวิจัยไม่ต้องเสียค่าใช้จ่ายใดๆทั้งสิ้น เมื่อผู้เข้าร่วมวิจัยตัดสินใจเข้าร่วมงานวิจัย ผู้เข้าร่วมวิจัยจะต้องลงนามยินยอมเข้าร่วมในการวิจัย

2. ผู้เข้าร่วมการวิจัยจะถูกแบ่งโดยวิธีการสุ่ม ออกเป็น 2 กลุ่ม คือ กลุ่มทดลองและกลุ่มควบคุม

กลุ่มที่ 1 คือ กลุ่มที่ทำการออกกำลังกายแบบยืดกล้ามเนื้อคอ

กลุ่มที่ 2 คือ กลุ่มที่ทำการออกกำลังกายแบบ diaphragmatic breathing exercise เพื่อการผ่อนคลาย

ซึ่งแต่ละกลุ่มจะได้รับการอธิบายวิธีการฝึกการยืดกล้ามเนื้อคอหรือการหายใจแบบ diaphragmatic breathing exercise เพื่อการผ่อนคลาย พร้อมกับเอกสารแนะนำการฝึก

3.ทั้ง 2 กลุ่มจะได้รับการขอร้องให้มาทำการทดสอบและประเมินผลทั้งหมด 2 ครั้ง คือ ครั้งแรกเป็นการทดสอบก่อนการฝึก ครั้งที่ 2 เป็นการทดสอบและประเมินผลหลังการฝึกเป็นระยะเวลา 4 สัปดาห์ ซึ่งการทดสอบและการประเมินผลประกอบไปด้วย

3.1 วัดระดับอาการปวดคอด้วย Visual Analog Scale

3.2 วัดระดับการเปลี่ยนแปลงของคลื่นไฟฟ้ากล้ามเนื้อคอด้วยเครื่อง surface EMG

4.ในการเก็บข้อมูลแต่ละครั้งจะขอให้ผู้เข้าร่วมนั่งพิมพ์งานด้วยท่าทางที่ถูกต้องและต้องพิมพ์ตามโปรแกรมที่กำหนดไว้เป็นเวลา 2 ชั่วโมง พร้อมกันนี้จะมีการถามระดับอาการปวดคอด้วย (VAS) และวัดระดับการเปลี่ยนแปลงของคลื่นไฟฟ้ากล้ามเนื้อคอ เป็นช่วงๆ ทั้งหมด 5 ช่วง การวัดระดับการเปลี่ยนแปลงของคลื่นไฟฟ้ากล้ามเนื้อคอ เป็นเพียงขั้วกาวติดที่ผิวหนังของผู้เข้าร่วม

เท่านั้น แต่จะต้องมีการทำความสะอาดผิวด้วยแอลกอฮอล์ก่อนการติดขั้ว ดังนั้นผู้ที่มีประวัติผิวหนังแพ้แอลกอฮอล์กรุณาแจ้งให้ผู้วิจัยทราบก่อนด้วย หลังการพิมพ์ 2 ชั่วโมงจะขอให้ผู้เข้าร่วมทำแบบสอบถาม the Neck Disability Index ด้วย

5.ทุกวันศุกร์หลังเลิกงานจะขอให้ผู้เข้าร่วมทำเครื่องหมายบนเส้นวัดอาการปวดคอด้วย (VAS) แล้วเก็บไว้ในซองที่แนบไปด้วย

ข้อตกลงเบื้องต้น

1. ท่านต้องไม่ออกกำลังกายหรือทำกิจกรรมอย่างหนักก่อนการทดลอง 24 ชั่วโมง
2. ท่านมีสิทธิที่จะบอกเลิกการเข้าร่วมในการวิจัยนี้เมื่อใดก็ได้

ผลหรือประโยชน์ที่จะได้รับจากการร่วมงานวิจัย

1. ผู้เข้าร่วมโครงการที่ทำงานเป็นเวลานานกับคอมพิวเตอร์จะได้รับการประเมินอาการปวดบริเวณคอและการตรวจการทำงานของกล้ามเนื้อคอ

2. ผู้เข้าร่วมโรงการจะได้รับคำแนะนำและการดูแลการยืดกล้ามเนื้อคอในระหว่างพักช่วงการทำงาน หรือได้รับคำแนะนำและดูแลการฝึกหายใจลึกเพื่อผ่อนคลายในระหว่างการพักช่วงการทำงานทำให้สามารถบรรเทาอาการปวดคอที่เกิดจากการทำงานนานกับคอมพิวเตอร์ และอาจทำให้ประสิทธิภาพการทำงานดีขึ้น 3. ผู้เข้าร่วมโครงการสามารถนำการฝึกการยืดกล้ามเนื้อคอไปใช้ได้ในชีวิตการทำงานประจำวันได้จริง

4. หากผลการวิจัยพบว่าการฝึกยืดกล้ามเนื้อคอสามารถลดอาการปวดได้ดี กลุ่มควบคุมจะได้รับคำแนะนำและการฝึกยืดกล้ามเนื้อคอทุกคน

5. ผลการวิจัยสามารถนำไปใช้ป้องกันโรคทางระบบกระดูกและกล้ามเนื้อคอและไหล่เนื่องจากการทำงานกับคอมพิวเตอร์ได้

6. เป็นข้อมูลในการพัฒนางานวิจัยในอนาคต

ค่าตอบแทนอาสาสมัครผู้เข้าร่วมงานวิจัย

ท่านจะได้รับค่าตอบแทนสำหรับการเข้าร่วมโครงการวิจัย 2 ครั้ง ครั้งละ 400 บาท

ผลข้างเคียงที่อาจเกิดขึ้นแก่ผู้ร่วมโครงการ

การฝึกการยืดกล้ามเนื้อคอรวมทั้งการฝึกการหายใจลึกเป็นการฝึกที่เป็นมาตราฐานและมีการปฏิบัติมานานจึงเป็นการฝึกที่มีความปลอดภัย นอกจากนี้ผู้เข้าร่วมการวิจัยจะได้รับการ

ประเมินจากแพทย์ก่อน หากมีความผิดปกติของกระดูกคอและอาจไม่ปลอดภัยจะถูกคัดออกก่อนการแบ่งกลุ่มวิจัย นอกจากนี้การฝึกยังอยู่ภายใต้การดูแลของนักกายภาพบำบัดที่มีใบอนุญาตใบประกอบวิชาชีพกายภาพบำบัด ผู้เข้าร่วมโครงการจะไม่ได้รับความเสี่ยงใดๆ อย่างไรก็ตามหากมีอาการปวดบริเวณกล้ามเนื้อคอ ไหล่หรือแขนมากจนทนไม่ได้ อาการล้าหรืออาการผิดปกติต่างๆ เช่น เวียนศีรษะ ปวดศีรษะ ปวดคอ ปวดแขน เป็นต้น สามารถแจ้งผู้วิจัยได้ทันทีหรือเมื่อนักกายภาพบำบัดเห็นว่าท่านมีอาการดังกล่าว จะหยุดทำการทดสอบทันทีพร้อมกับปฐมพยาบาล และถ้าท่านมีอาการไม่ดีขึ้นจะทำการส่งพบแพทย์โดยทันที

การประเมินอาการปวดใช้การประเมินแบบมาตราฐานซึ่งไม่มีอันตรายใดๆ การตรวจคลื่นไฟฟ้ากล้ามเนื้อใช้แผ่นติดผิวหนังภายนอกและใช้ไฟฟ้าระดับต่ำมาก รวมทั้งทำการตรวจโดยผู้เชี่ยวชาญจึงมีความปลอดภัยและเชื่อถือได้

การเก็บข้อมูลเป็นความลับ

ผู้ทำการวิจัยขอยืนยันว่า ข้อมูลเกี่ยวกับตัวผู้เข้าร่วมงานวิจัยจะถูกเก็บไว้เป็นความลับและจะใช้สำหรับงานวิจัยนี้เท่านั้น และชื่อของผู้เข้าร่วมงานวิจัยจะไม่ปรากฏในแบบฟอร์มการเก็บข้อมูล และในฐานข้อมูลทั่วไป โดยมีผู้ทำวิจัยเพียงคนเดียวเท่านั้นที่ทราบรายละเอียดของข้อมูลนี้ ผู้ทำวิจัยขอขอบพระคุณผู้เข้าร่วมงานวิจัยที่ให้ความร่วมมือในการทำวิจัยครั้งนี้

ท่านสามารถขอถอนตัวออกจากโครงการวิจัยได้ทุกเวลา

หากท่านมีข้อสงสัยใดๆ สามารถสอบถามได้ที่ นายอธิพล เมธาทิพย์ โทรศัพท์ 081-671-9203 ซึ่งยินดีตอบคำถามทุกเวลา

ทั้งนี้ หากท่านมีปัญหาทางด้านจริยธรรมการวิจัย ท่านสามารถร้องเรียนได้ต่อคณะกรรมการจริยธรรมการวิจัยที่เบอร์ (02) 256-4455 ต่อ 14, 15

Appendix B

Consent form

การวิจัยเรื่อง ผลของการยืดกล้ามเนื้อคอในขณะพักการทำงานต่ออาการปวดคอและการเปลี่ยนแปลงของ Surface EMG median frequency ในกลุ่มพนักงานสำนักงาน

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

ข้าพเจ้า นาย/นาง/นางสาว..... ได้อ่านรายละเอียดจากเอกสารข้อมูลสำหรับผู้เข้าร่วมโครงการวิจัยที่แนบมาฉบับวันที่..... และข้าพเจ้ายินยอมเข้าร่วมโครงการวิจัยโดยสมัครใจ

ข้าพเจ้าได้รับสำเนาเอกสารแสดงความยินยอมเข้าร่วมในโครงการวิจัยที่ข้าพเจ้าได้ลงนาม และ วันที่ พร้อมด้วยเอกสารข้อมูลสำหรับผู้เข้าร่วมโครงการวิจัย ทั้งนี้ก่อนที่จะลงนามในใบยินยอมให้ทำการวิจัยนี้ ข้าพเจ้าได้รับการอธิบายจากผู้วิจัยถึงวัตถุประสงค์ของการวิจัย ระยะเวลาของการทำวิจัย วิธีการวิจัย อันตราย หรืออาการที่อาจเกิดขึ้นจากการวิจัย หรือจากยาที่ใช้ รวมทั้งประโยชน์ที่จะเกิดขึ้นจากการวิจัย และแนวทางรักษาโดยวิธีอื่นอย่างละเอียด ข้าพเจ้ามีเวลาและโอกาสเพียงพอในการซักถามข้อสงสัยจนมีความเข้าใจอย่างดีแล้ว โดยผู้วิจัยได้ตอบคำถามต่าง ๆ ด้วยความเต็มใจไม่ปิดบังซ่อนเร้นจนข้าพเจ้าพอใจ

ข้าพเจ้ารับทราบจากผู้วิจัยว่าหากเกิดอันตรายหรือผลข้างเคียงใดๆ จากการวิจัยดังกล่าว ผู้วิจัยเข้าร่วมจะได้รับการรักษาพยาบาลโดยไม่เสียค่าใช้จ่าย และจะได้รับค่าชดเชยตามสมควรจากเงินทุนวิจัย รองศาสตราจารย์ นายแพทย์พงศ์ศักดิ์ ยุกตะนันทน์

ข้าพเจ้ามีสิทธิที่จะบอกเลิกเข้าร่วมในโครงการวิจัยเมื่อใดก็ได้ โดยไม่จำเป็นต้องแจ้งเหตุผล และการบอกเลิกการเข้าร่วมการวิจัยนี้ จะไม่มีผลต่อการรักษาโรคหรือสิทธิอื่น ๆ ที่ข้าพเจ้าจะพึงได้รับต่อไป

ผู้วิจัยรับรองว่าจะเก็บข้อมูลส่วนตัวของข้าพเจ้าเป็นความลับ และจะเปิดเผยได้เฉพาะเมื่อได้รับการยินยอมจากข้าพเจ้าเท่านั้น บุคคลอื่นในนามของบริษัทผู้สนับสนุนการวิจัย คณะกรรมการพิจารณาจริยธรรมการวิจัยหรือผู้ได้รับอำนาจมอบหมายให้เข้ามาตรวจและประมวลข้อมูลของผู้เข้าร่วมวิจัย ทั้งนี้จะต้องกระทำไปเพื่อวัตถุประสงค์เพื่อตรวจสอบความถูกต้องของข้อมูลเท่านั้น โดยการตกลงที่จะเข้าร่วมการศึกษานี้ข้าพเจ้าได้ให้คำยินยอมที่จะให้มีการตรวจสอบข้อมูลประวัติทางการแพทย์ของผู้เข้าร่วมวิจัยได้

ผู้วิจัยรับรองว่าจะไม่มีการเก็บข้อมูลใด ๆ ของผู้เข้าร่วมวิจัย เพิ่มเติม หลังจากที่ข้าพเจ้าขอยกเลิกการเข้าร่วมโครงการวิจัยและต้องการให้ทำลายเอกสารและ/หรือ ตัวอย่างที่ใช้ตรวจสอบทั้งหมดที่สามารถสืบค้นถึงตัวข้าพเจ้าได้

ข้าพเจ้าเข้าใจว่า ข้าพเจ้ามีสิทธิ์ที่จะตรวจสอบหรือแก้ไขข้อมูลส่วนตัวของข้าพเจ้าและสามารถเลิกการให้สิทธิในการใช้ข้อมูลส่วนตัวของข้าพเจ้าได้ โดยต้องแจ้งให้ผู้วิจัยรับทราบ

ข้าพเจ้าได้ตระหนักว่าข้อมูลในการวิจัยรวมถึงข้อมูลทางการแพทย์ที่ไม่มีการเปิดเผยชื่อจะผ่านกระบวนการต่าง ๆ เช่น การเก็บข้อมูล การบันทึกข้อมูลในคอมพิวเตอร์ การตรวจสอบ การวิเคราะห์ และการรายงานเพื่อวัตถุประสงค์ทางวิทยาศาสตร์ รวมทั้งการใช้ข้อมูลทางการแพทย์ในอนาคตหรือการวิจัยทางด้านเภสัชภัณฑ์ เท่านั้น

ข้าพเจ้ายินดีลงนามในเอกสารยินยอมนี้เพื่อเข้าร่วมการวิจัยด้วยความเต็มใจ

.....ลงนามผู้ยินยอม

(.....) ชื่อผู้ยินยอมตัวบรรจง

วันที่ .....เดือน.....พ.ศ.....

ข้าพเจ้าได้อธิบายถึงวัตถุประสงค์ของการวิจัย วิธีการวิจัย อันตราย หรืออาการที่อาจเกิดขึ้นจากการวิจัย หรือจากยาที่ใช้ รวมทั้งประโยชน์ที่จะเกิดขึ้นจากการวิจัยอย่างละเอียด ให้ผู้เข้าร่วมในโครงการวิจัยตามนามข้างต้นได้ทราบและมีความเข้าใจดีแล้ว พร้อมลงนามลงในเอกสารแสดงความยินยอมด้วยความเต็มใจ

.....ลงนามผู้ทำวิจัย

(.....)ชื่อผู้ทำวิจัย ตัวบรรจง

วันที่ .....เดือน.....พ.ศ.....

.....ลงนามพยาน

(.....) ชื่อพยาน ตัวบรรจง

วันที่ .....เดือน.....พ.ศ.....

Appendix C

Personal Data Sheet

การวิจัยเรื่อง ผลของการยืดกล้ามเนื้อคอในขณะพักการทำงานต่ออาการปวดคอและการเปลี่ยนแปลงของ Surface EMG median frequency ในกลุ่มพนักงานสำนักงาน

ข้อมูลพื้นฐาน

Subject number_____ Group_____

อายุ ..... ปี น้ำหนัก ..... กิโลกรัม ส่วนสูง ..... เซนติเมตร

BMI……

สถานภาพ ☐ โสด ☐ คู่ ☐ หย่า ☐ แยกกันอยู่

อาชีพ .....

ระดับการศึกษา ☐ ต่ำกว่าปริญญาตรี ☐ ปริญญาตรี

☐ ปริญญาโท ☐ ปริญญาเอก

ระยะเวลาการใช้คอมพิวเตอร์ต่อวัน.....ชั่วโมง/วัน

ระยะเวลาการใช้แป้นพิมพ์ต่อวัน.....ชั่วโมง/วัน

ระยะเวลาการใช้เมาส์ต่อวัน.....ชั่วโมง/วัน

.....

(……)

ผู้บันทึก

Appendix D

Screening visit

Date…….

Subject number……

เกณฑ์ในการคัดเลือกประชากร (ตอบใช่ทุกข้อ)	Yes	No
1. เป็นพนักงานที่ทำงานในสำนักงานและทำงานกับคอมพิวเตอร์ ที่มีอายุระหว่าง 25 – 50 ปี	☐	☐
2. ทำงานกับคอมพิวเตอร์ทุกวัน อย่างน้อยวันละ 4 ชั่วโมง ซึ่งเป็นงานพิมพ์เป็นส่วนใหญ่	☐	☐
3. มีอาการปวดคอหรือไม่สบายกล้ามเนื้อมานานกว่า 3 เดือน	☐	☐
4. เคยมีอาการปวดคอหรือไม่สบายกล้ามเนื้อในขณะที่ทำงาน หรือหลังการทำงานกับคอมพิวเตอร์	☐	☐
5. ไม่ได้อยู่ในช่วงที่ได้รับการรักษาด้วยยาหรือกายภาพบำบัด	☐	☐
6. สมัครใจยินยอมเข้าร่วมการวิจัย และลงลายมือชื่อในใบยินยอมเข้าร่วมการวิจัย	☐	☐

เกณฑ์ในการคัดเลือกออกจากการศึกษา (ตอบไม่ใช่ทุกข้อ)	Yes	No
1. มีประวัติเคยได้รับการผ่าตัดบริเวณคอหรือหลังส่วนบน (Neck surgery)	☐	☐
2. มีประวัติเคยประสบอุบัติเหตุที่คอ (Trauma)	☐	☐
3. เป็นผู้ที่ได้รับการวินิจฉัยว่าเป็น Cervical radiculopathy	☐	☐
4. เป็นผู้ที่ได้รับการวินิจฉัยว่าเป็น Myelopathy	☐	☐
5. เป็นผู้ที่ได้รับการวินิจฉัยว่าเป็น Systemic illness หรือ connective tissue disorder	☐	☐
6. เป็นผู้ที่ได้รับการวินิจฉัยว่าเป็นโรคข้ออื่นๆเช่น Rheumatoid arthritis, Spondyloarthropathy เป็นต้น	☐	☐
7. มีการผิดรูปลักษณะ round back, round shoulder, และ head forward	☐	☐
8. เป็นผู้ที่มีภาวะตั้งครรภ์	☐	☐
9. ไม่สมัครใจเข้าร่วมการฝึกหลังการทดสอบ	☐	☐

Appendix E

การวัดผล (Data measurement)

Date…….

Subject number…… Group……..

1. ค่า Normalization (100%MVC)UPPER TRAPEZIUS……

CES……

2. ค่า 30 %MVC UPPER TRAPEZIUS…….. CES……..

3. ตารางบันทึกค่า VAS และ EMG median frequency จากการทดสอบ

นาทีที่	**ค่า** VAS	**ค่า** EMG median frequency (Hz) **ของ** Upper trapezius	**ค่า** EMG median frequency (Hz) **ของ** CES
0			
30			
60			
90			
120			

Appendix F

Study summary

Group……..

Date……

Subject number……..

การนัดหมายครั้งนี้เป็นครั้งสุดท้ายเพราะ

☐ การเก็บข้อมูลครบถ้วนสมบูรณ์

☐ ไม่สามารถเก็บข้อมูลได้ครบถ้วนสมบูรณ์ เนื่องจาก

- ☐ อาสาสมัครมีความประสงค์จะออกจากการศึกษา
- ☐ อาสาสมัครไม่มาตามนัด และไม่สามารถติดต่อได้
- ☐ อาสาสมัครไม่สามารถมาตามนัดได้ เนื่องจาก

……
……
……
……
……

Appendix G

Short break neck stretching exercise diary

Group……. Subject number…….

<u>คำชี้แจง</u> กรุณาบันทึกตามความเป็นจริงเพื่อให้ทราบความก้าวหน้าของการฝึก

เริ่มการฝึกเมื่อวันที่..... สิ้นสุดการฝึกเมื่อวันที่

.....

สัปดาห์ที่ 1	จันทร์	อังคาร	พุธ	พฤหัสบดี	ศุกร์
เวลา 10:00					
เวลา 15:00					
หมายเหตุ					

สัปดาห์ที่ 2	จันทร์	อังคาร	พุธ	พฤหัสบดี	ศุกร์
เวลา 10:00					
เวลา 15:00					
หมายเหตุ					

สัปดาห์ที่ 3	จันทร์	อังคาร	พุธ	พฤหัสบดี	ศุกร์
เวลา 10:00					
เวลา 15:00					
หมายเหตุ					

สัปดาห์ที่ 4	จันทร์	อังคาร	พุธ	พฤหัสบดี	ศุกร์
เวลา 10:00					
เวลา 15:00					
หมายเหตุ					

Appendix H

Short break deep breathing exercise for relaxation diary

Group……. Subject's number…….

<u>คำชี้แจง</u> กรุณาบันทึกตามความเป็นจริงเพื่อให้ทราบความก้าวหน้าของการฝึก

เริ่มการฝึกเมื่อวันที่..... สิ้นสุดการฝึกเมื่อวันที่

.....

สัปดาห์ที่ 1	จันทร์	อังคาร	พุธ	พฤหัสบดี	ศุกร์
เวลา 10:00					
เวลา 15:00					
หมายเหตุ					

สัปดาห์ที่ 2	จันทร์	อังคาร	พุธ	พฤหัสบดี	ศุกร์
เวลา 10:00					
เวลา 15:00					
หมายเหตุ					

สัปดาห์ที่ 3	จันทร์	อังคาร	พุธ	พฤหัสบดี	ศุกร์
เวลา 10:00					
เวลา 15:00					
หมายเหตุ					

สัปดาห์ที่ 4	จันทร์	อังคาร	พุธ	พฤหัสบดี	ศุกร์
เวลา 10:00					
เวลา 15:00					
หมายเหตุ					

Appendix I

The visual Analog Scale

……..

สำหรับสัปดาห์ที่ 4 โปรดฉีกตามรอยปรุ เมื่อทำเครื่องหมายแล้วให้เก็บไว้ในซองที่เตรียมไว้ให้

……..

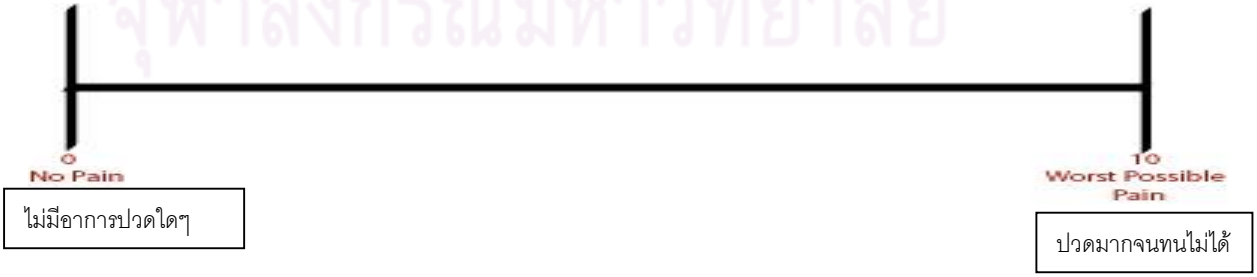
สำหรับสัปดาห์ที่ 3 โปรดฉีกตามรอยปรุ เมื่อทำเครื่องหมายแล้วให้เก็บไว้ในซองที่เตรียมไว้ให้

……..

สำหรับสัปดาห์ที่ 2 โปรดฉีกตามรอยปรุ เมื่อทำเครื่องหมายแล้วให้เก็บไว้ในซองที่เตรียมไว้ให้

……..

สำหรับสัปดาห์ที่ 1 โปรดฉีกตามรอยปรุ เมื่อทำเครื่องหมายแล้วให้เก็บไว้ในซองที่เตรียมไว้ให้



Appendix J

The Neck Disability Index

วันที่บันทึก..... Subject number…….

Group……..

NECK PAIN AND DISABILITY INDEX (Vernon-Mior)

PLEASE READ INSTRUCTIONS:
This questionnaire has been designed to give the doctor information as to how your neck pain has affected your ability to manage in everyday life. Please answer every section and mark in each section only ONE box which applies to you. We realize you may consider that two of the statements in any one section relate to you, but just mark the box which most closely describes your problem.

SECTION 1 - PAIN INTENSITY
- ☐ I have no pain at the moment.
- ☐ The pain is very mild at the moment.
- ☐ The pain is moderate at the moment.
- ☐ The pain is fairly severe at the moment.
- ☐ The pain is very severe at the moment.
- ☐ The pain is the worst imaginable at the moment.

SECTION 2 - PERSONAL CARE (Washing, Dressing, etc.)
- ☐ I can look after myself normally without causing extra pain.
- ☐ I can look after myself normally but it causes extra pain.
- ☐ It is painful to look after myself and I am slow and careful.
- ☐ I need some help but manage most of my personal care.
- ☐ I need help every day in most aspects of self care.
- ☐ I do not get dressed, I wash with difficulty and stay in bed.

SECTION 3 - LIFTING
- ☐ I can lift heavy weights without extra pain.
- ☐ I can lift heavy weights but it gives extra pain.
- ☐ Pain prevents me from lifting heavy weights off the floor, but I can manage if they are conveniently positioned, for example on a table.
- ☐ Pain prevents me from lifting heavy weights, but I can manage light to medium weights if they are conveniently positioned.
- ☐ I can lift very light weights.
- ☐ I cannot lift or carry anything at all.

SECTION 4 - READING
- ☐ I can read as much as I want to with no pain in my neck.
- ☐ I can read as much as I want to with slight pain in my neck.
- ☐ I can read as much as I want with moderate pain in my neck.
- ☐ I can't read as much as I want because of moderate pain in my neck.
- ☐ I can hardly read at all because of severe pain in my neck.
- ☐ I cannot read at all.

SECTION 5 - HEADACHES
- ☐ I have no headaches at all.
- ☐ I have slight headaches which come infrequently.
- ☐ I have moderate headaches which come infrequently.
- ☐ I have moderate headaches which come frequently.
- ☐ I have severe headaches which come frequently.
- ☐ I have headaches almost all the time.

SECTION 6 - CONCENTRATION
- ☐ I can concentrate fully when I want to with no difficulty.
- ☐ I can concentrate fully when I want to with slight difficulty.
- ☐ I have a fair degree of difficulty in concentrating when I want to.
- ☐ I have alot of difficulty in concentrating when I want to.
- ☐ I have a great deal of difficulty in concentrating when I want to.
- ☐ I cannot concentrate at all.

SECTION 7 - WORK
- ☐ I can do as much work as I want to.
- ☐ I can only do my usual work, but no more.
- ☐ I can do most of my usual work, but no more.
- ☐ I cannot do my usual work.
- ☐ I can hardly do any work at all.
- ☐ I can't do any work at all.

SECTION 8 - DRIVING
- ☐ I can drive my car without any neck pain.
- ☐ I can drive my car as long as I want with slight pain in my neck.
- ☐ I can drive my car as long as I want with moderate pain in my neck
- ☐ I can't drive my car as long as I want with because of moderate pain in my neck.
- ☐ I can hardly drive at all because of severe pain in my neck.
- ☐ I can't drive my car at all.

SECTION 9 - SLEEPING
- ☐ I have no trouble sleeping.
- ☐ My sleep is slightly disturbed (less than 1 hour sleepless).
- ☐ My sleep is mildly disturbed (1-2 hours sleepless).
- ☐ My sleep is moderately disturbed (2-3 hours sleepless).
- ☐ My sleep is greatly disturbed (3-5 hours sleepless).
- ☐ My sleep is completely disturbed (5-7 hours sleepless).

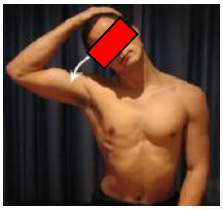
SECTION 10 - RECREATION
- ☐ I am able to engage in all my recreation activities with no neck pain at all.
- ☐ I am able to engage in all my recreation activities, with some pain in my neck.
- ☐ I am able to engage in most, but not all of my usual recreation activities because of pain in my neck.
- ☐ I am able to engage in few of my usual recreation activities because of pain in my neck.
- ☐ I can hardly do any recreation activities because of pain in my neck.
- ☐ I can't do any recreation activities at all.

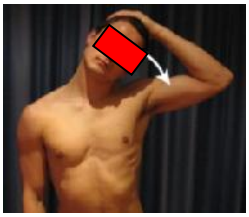
Appendix K

Instruction of short break neck stretching exercise

<u>การยืดกล้ามเนื้อคอ</u>

1.การยืดกล้ามเนื้อคอด้านข้าง : นั่งตัวตรง หลังพิงพนักเก้าอี้ ยืดกล้ามเนื้อดังภาพ แต่ละภาพให้ทำการยืดค้างไว้ 30 วินาที/ครั้ง จำนวน 3 ครั้ง โดยการยืดแต่ละครั้งจะต้องรู้สึกตึง ห้ามรู้สึกเจ็บ





2.การยืดกล้ามเนื้อคอด้านหลัง : นั่งตัวตรง หลังพิงพนักเก้าอี้ ยืดกล้ามเนื้อดังภาพ ทำการยืดค้างไว้ 30 วินาที/ครั้ง จำนวน 3 ครั้ง โดยการยืดแต่ละครั้งจะต้องรู้สึกตึง ห้ามรู้สึกเจ็บ

<u>การปรับสิ่งแวดล้อมในการทำงานให้เหมาะสม</u>

1.นั่งตัวตรง หลังพิงพนักเก้าอี้

2.ปรับความสูงของพนักเก้าอี้ให้ความสูงของแป้นพิมพ์เท่ากับข้อศอก และเท้าวางพื้นทั้ง 2 ข้าง

3.แสงสว่างบริเวณโต๊ะทำงานต้องเพียงพอเพื่อจะได้ไม่ต้องก้มหน้าไปใกล้จอภาพ

4.ปรับอุณหภูมิภายในห้องให้พอดี (ประมาณ 25 องศาเซลเซียส) เพราะอากาศที่เย็นเกินไปทำให้กล้ามเนื้อเกร็งตัวเพิ่มขึ้น

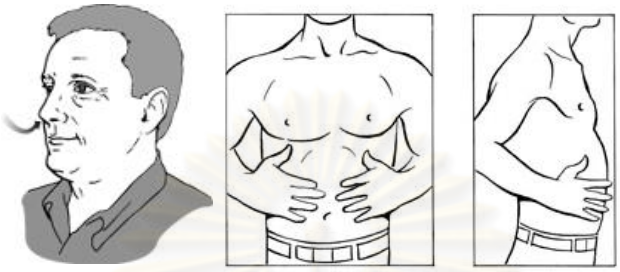
Appendix M

Instruction of short break deep breathing exercise for relaxation

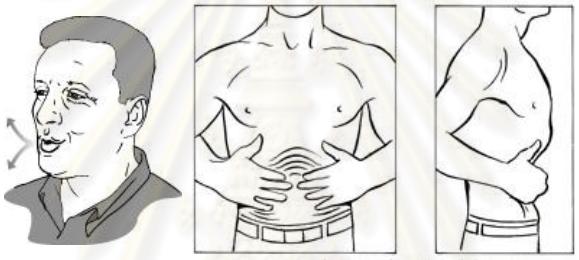
<u>การฝึกการหายใจเพื่อการผ่อนคลาย มีขั้นตอนดังนี้</u>

1.นั่งหลังพิงพนักเก้าอี้ มือทั้ง 2 ข้าง วางไว้ตรงกระบังลม (ใต้ลิ้นปี่)

2. หายใจเข้าทางจมูกช้าๆ ท้องจะป่องดังรูป



3.หายใจออกทางปากช้าๆ ท้องจะยุบดังรูป



<u>การปรับสิ่งแวดล้อมในการทำงานให้เหมาะสม</u>

1.นั่งตัวตรง หลังพิงพนักเก้าอี้

2.ปรับความสูงของพนักเก้าอี้ให้ความสูงของแป้นพิมพ์เท่ากับข้อศอก และเท้าวางพื้นทั้ง 2 ข้าง

3.แสงสว่างบริเวณโต๊ะทำงานต้องเพียงพอเพื่อจะได้ไม่ต้องก้มหน้าไปใกล้จอภาพ

4.ปรับอุณหภูมิภายในห้องให้พอดี (ประมาณ 25 องศาเซลเซียส) เพราะอากาศที่เย็นเกินไปทำให้กล้ามเนื้อเกร็งตัวเพิ่มขึ้น

Appendix N

Equipments

1. The Visual Analog Scale form (VAS) (ภาคผนวก ฌ)

2. The Neck Disability Index form (NDI) (ภาคผนวก ญ)

3. Collective data instrument “Surface Electromyography” BIOPAC MP 100 (BIOPAC Systems Inc., USA) with self – adhesive Ag/AgCl electrode

4. Personal data form

5. Workstation (computer table and office chair)

6. Computer desktop

7. Typing practice software (โปรแกรมฝึกพิมพ์สัมผัสไทย – อังกฤษ Smart typist)

8. Collective data computer

9. Stop watch

10. Ruler

11. Tape measure

12. Alcohol

13. Gauze

14. Cotton

15. Towel

16. Experimental shirt

17. Cap

18. Stretching exercise information sheet (ภาคผนวก ฎ)

19. Breathing exercise information sheet (ภาคผนวก ฐ)

20. Self – adhesive Ag/AgCl electrode

Appendix O

Methods

1. ผู้เข้าร่วมงานวิจัยเปลี่ยนเสื้อโดยการใส่กลับหลัง

2. ทำความสะอาดผิวหนังบริเวณที่จะติด surface EMG electrode

3. วัดระยะทางสำหรับติด surface EMG electrode สำหรับ UT

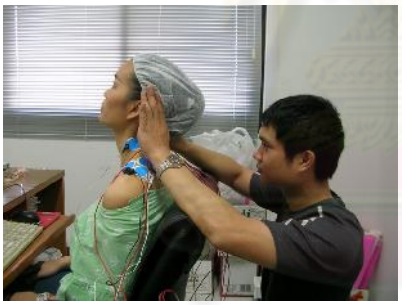


4. วัดระยะทางสำหรับติด surface EMG electrode สำหรับ CES


5. ติดสาย surface EMG electrode cable

6. EMG normalization สำหรับ UT

7. EMG normalization สำหรับ CES



8. เริ่มต้นการพิมพ์และ Capture EMG median frequency

Appendix P

Raw data

ตารางที่ 1 ข้อมูลพื้นฐานเชิงกลุ่ม

ลำดับที่	กลุ่ม	อายุ	น้ำหนัก	ส่วนสูง	BMI	ใช้คอม	ใช้แป้น	ใช้เม้าส์	วุฒิ
1	ST	28	55	158	22.03	10	4	6	ตรี
2	ST	33	70	166	25.4	8	4	4	ตรี
3	ST	30	51	156	20.96	11	6	5	ตรี
									ต่ำกว่า
4	ST	31	43	150	19.11	5	4	1	ตรี
5	ST	27	50	162	19.05	10	6	4	โท
6	ST	28	54	168	19.13	10	6	4	โท
7	ST	29	41	152	17.75	10	6	4	โท
8	ST	28	52	160	20.31	6	4	2	ตรี
9	ST	36	80	170	27.68	7	4	3	ตรี
10	ST	29	50	165	18.37	6	5	1	ตรี
11	ST	30	59	154	24.88	8	5	3	ตรี
12	ST	30	50	165	18.37	6	4	2	ตรี
13	ST	34	44	155	18.31	8	5	2	ตรี
14	ST	24	55	163	19.95	10	6	4	ตรี
15	ST	25	60	164	22.31	10	6	4	โท
16	ST	32	50	170	17.3	13	7	6	ตรี
									ต่ำกว่า
17	ST	27	56	162	21.34	6	4	2	ตรี
18	ST	31	58	155	24.14	6	4	2	ตรี
19	ST	27	57	153	24.35	5	4	1	ตรี
20	ST	27	50	165	18.37	8	6	2	ตรี
21	ST	28	51	159	20.17	7	5	2	ตรี
22	ST	25	42	150	18.67	8	4	4	ตรี
23	ST	34	56	163	21.08	11	7	4	ตรี
24	ST	34	58	165	21.3	12	6	6	ตรี
25	ST	34	58	165	21.3	12	6	6	ตรี

26	ST	28	49	155	20.4	10	6	4	ตรี
27	ST	33	44	156	18.08	10	7	3	ตรี
									ต่ำกว่า
28	ST	34	50	150	22.22	8	5	3	ตรี
29	ST	33	50	160	19.53	8	4	4	ตรี
30	ST	25	42	157	17.04	12	6	6	ตรี
31	BE	28	75	167	26.89	8	5	3	ตรี
32	BE	25	60	161	23.15	10	6	4	ตรี
33	BE	28	62	168	21.97	10	7	3	ตรี
34	BE	27	42	153	17.94	9	9	9	ตรี
35	BE	29	48	156	19.72	7	5	2	ตรี
36	BE	25	59	164	24.88	5	4	1	ตรี
37	BE	31	46	160	17.97	10	7	3	ตรี
38	BE	30	50	145	23.78	8	4	4	ตรี
39	BE	25	51	144	24.59	8	6	2	ตรี
40	BE	25	50	160	19.53	10	8	2	ตรี
41	BE	24	50	160	19.53	5	4	1	ตรี
42	BE	27	59	168	20.9	7	5	2	ตรี
43	BE	30	38	150	16.89	8	5	3	โท
44	BE	30	58	172	19.6	5	4	1	โท
45	BE	31	64	168	22.68	5	4	1	ตรี
46	BE	30	48	164	17.85	13	8	5	โท
47	BE	26	53	155	22.06	10	6	4	ตรี
48	BE	26	46	155	19.15	9	5	4	ตรี
49	BE	35	40	150	17.78	8	5	3	ตรี
									ต่ำกว่า
50	BE	27	56	158	22.43	8	5	3	ตรี
51	BE	29	41	154	17.29	6	4	2	โท
52	BE	34	95	156	39.04	9	6	3	ตรี
53	BE	26	53.5	163	20.14	6	4	2	โท
54	BE	26	58	161	22.38	10	8	2	ตรี

55	BE	26	55	160	21.48	8	5	3	ตรี
56	BE	33	52	147	24.06	7	5	2	ตรี
57	BE	32	65	156	26.71	5	4	1	ตรี
58	BE	31	53	158	21.23	5	4	1	ตรี
59	BE	26	48	150	21.33	5	4	1	ต่ำกว่าตรี
60	BE	25	55	160	21.48	6	4	2	ตรี

ตารางที่ 2 ข้อมูลร้อยละของจำนวนชั่วโมงในการออกกำลังกายระหว่างทำงาน

ลำดับที่	กลุ่ม	%practiceHr
1	ST	80
2	ST	90
3	ST	70
4	ST	90
5	ST	100
6	ST	67.5
7	ST	85
8	ST	90
9	ST	100
10	ST	75
11	ST	70
12	ST	80
13	ST	92.5
14	ST	82.5
15	ST	100
16	ST	82.5
17	ST	95
18	ST	77.5
19	ST	100
20	ST	85
21	ST	92.5

22	ST	100
23	ST	52.5
24	ST	85
25	ST	100
26	ST	80
27	ST	95
28	ST	97.5
29	ST	95
30	ST	95
31	BE	60
32	BE	85
33	BE	100
34	BE	82.5
35	BE	85
36	BE	100
37	BE	100
38	BE	100
39	BE	100
40	BE	100
41	BE	77.5
42	BE	70
43	BE	100
44	BE	100
45	BE	100
46	BE	100
47	BE	75
48	BE	92.5
49	BE	82.5
50	BE	100
51	BE	62.5
52	BE	72.5

53	BE	92.5
54	BE	95
55	BE	90
56	BE	72.5
57	BE	97.5
58	BE	85
59	BE	100
60	BE	75

ตารางที่ 3 ระดับความเจ็บปวด Visual Analog Scale ของสัปดาห์ที่ 0 – 4

ลำดับที่	กลุ่ม	VAS 0	VAS 1	VAS 2	VAS 3	VAS 4
1	ST	80	70	70	63	51
2	ST	40	55	50	49	44
3	ST	13	65	55	36	10
4	ST	68	74	64	50	29
5	ST	29	25	28	16	16
6	ST	54	12	13	8	1
7	ST	68	47	35	31	0
8	ST	45	29	42	35	29
9	ST	50	56	50	49	36
10	ST	55	55	48	47	35
11	ST	67	66	61	73	67
12	ST	41	20	19	17	17
13	ST	68	56	32	21	20
14	ST	38	60	60	52	52
15	ST	70	77	58	53	41
16	ST	42	39	50	36	27
17	ST	69	4	2	0	0
18	ST	23	11	6	3	1
19	ST	65	80	77	68	65
20	ST	42	26	25	12	8

21	ST	27	17	7	9	12
22	ST	23	13	4	0	0
23	ST	48	49	52	53	27
24	ST	60	67	61	62	53
25	ST	37	44	52	47	57
26	ST	56	81	80	57	18
27	ST	13	11	9	5	5
28	ST	60	12	8	8	4
29	ST	40	1	2	2	0
30	ST	73	54	50	63	64
31	BE	63	58	65	57	62
32	BE	71	67	51	52	42
33	BE	55	67	48	48	35
34	BE	20	0	0	5	3
35	BE	11	9	9	7	8
36	BE	21	18	31	5	5
37	BE	70	10	19	42	13
38	BE	44	46	47	39	30
39	BE	80	32	49	40	27
40	BE	31	6	7	6	6
41	BE	28	81	61	51	35
42	BE	81	54	49	44	40
43	BE	29	5	2	3	4
44	BE	19	6	12	3	4
45	BE	90	15	0	0	0
46	BE	61	59	54	35	17
47	BE	33	21	16	16	9
48	BE	33	10	11	12	10
49	BE	59	50	51	39	40
50	BE	28	22	17	18	17
51	BE	15	5	5	29	4

52	BE	45	34	28	18	88
53	BE	40	0	0	0	0
54	BE	23	10	11	5	5
55	BE	31	3	4	4	6
56	BE	57	8	13	6	28
57	BE	36	22	15	1	8
58	BE	65	47	33	25	8
59	BE	14	11	12	6	3
60	BE	32	24	26	23	23

ตารางที่ 4 Surface EMG median frequency

ตารางที่ 4.1 Surface EMG median frequency of left UT (pre – test)

ลำดับที่	กลุ่ม	นาทีที่0	นาทีที่30	นาทีที่60	นาทีที่90	นาทีที่120
1	ST	157.1655	159.8053	169.32678	149.74976	151.87073
2	ST	184.1431	183.09021	203.72009	148.16284	160.85815
3	ST	158.7524	151.33667	150.80261	138.1073	157.16553
4	ST	157.6843	170.76111	184.67712	166.15295	169.86084
5	ST	163.5132	167.73987	17356873	138.64136	144.98901
6	ST	167.7399	132.8125	131.75964	141.81519	143.93616
7	ST	116.4093	139.69421	153.9917	146.04187	149.74976
8	ST	260.8795	126.46484	134.93347	129.11987	151.87073
9	ST	193.6646	136.52039	130.17273	143.93616	136.52039
10	ST	150.2838	169.86084	174.16382	123.29102	194.19861
11	ST	200.0275	150.80261	169.86084	192.07764	191.02478
12	ST	150.2838	150.80261	126.46484	213.77563	126.9989
13	ST	193.1458	131.75964	122.23816	128.05176	126.46484
14	ST	202.6672	164.03198	149.74976	160.85815	138.64136
15	ST	215.3626	151.33667	173.03467	161.39221	176.74255
16	ST	172.5006	126.9989	151.33667	150.80261	119.58313

17	ST	150.8026	150.80261	142.86804	135.98633	150.80261
18	ST	165.1001	169.32678	166.68701	180.43518	216.43066
19	ST	179.9164	128.58582	137.57324	131.75964	142.86804
20	ST	194.7327	176.74255	150.80261	179.91638	176.74255
21	ST	130.1727	104.76685	149.74976	109.00879	106.35376
22	ST	183.6243	147.10999	144.98901	142.34924	138.64136
23	ST	247.1161	159.8053	190.49072	166.68701	207.42798
24	ST	230.1788	249.75586	161.39221	193.66455	193.14575
25	ST	230.1789	160.33936	125.94604	143.93616	130.70679
26	ST	215.8966	140.76233	129.63867	126.9989	123.82507
27	ST	195.2515	191.02478	173.56873	170.3949	176.2085
28	ST	153.4576	150.28381	130.17273	174.08752	148.6969
29	ST	210.6018	205.84106	195.78552	209.01489	188.90381
30	ST	161.9263	114.82239	171.44775	218.01758	169.86084
31	BE	145.5231	144.45496	148.16284	150.80261	153.9917
32	BE	146.0419	192.61169	191.55884	158.75244	164.56604
33	BE	209.0149	176.20859	167.73987	167.22107	165.1001
34	BE	147.6288	169.86084	150.28381	236.52649	150.80261
35	BE	249.2371	153.45764	150.28381	153.45764	231.24695
36	BE	221.1914	160.85815	216.43066	147.10999	211.13586
37	BE	225.9522	125.41199	116.94336	192.07764	179.38232
38	BE	174.6216	135.46753	120.11719	120.65125	122.23816
39	BE	169.8608	155.57861	164.03198	158.75244	150.80261
40	BE	167.7399	172.50061	149.74976	165.1001	192.07764
41	BE	116.9434	149.2157	126.46484	122.75696	119.58313
42	BE	249.7559	208.48083	237.06055	212.18872	188.90381
43	BE	243.4082	163.51318	161.39221	165.6189	165.6189
44	BE	123.8251	117.47742	120.65125	120.65125	123.29102
45	BE	212.7228	146.57593	137.57324	168.80798	219.07043
46	BE	255.5847	186.7981	168.27393	209.54895	165.1001
47	BE	133.3166	165.1001	134.93347	165.1001	150.80261

48	BE	113.2355	119.58313	123.82507	122.75696	122.75696
49	BE	178.8483	124.87793	129.11987	135.98633	179.38232
50	BE	159.2712	154.5105	151.87073	150.80261	146.04187
51	BE	123.8251	120.11719	159.27124	117.99622	129.63867
52	BE	177.7954	155.57861	150.28381	150.80261	165.1001
53	BE	192.0776	147.62878	122.75696	125.94604	125.94604
54	BE	182.5562	123.82507	165.1001	165.1001	125.41199
55	BE	125.946	132.8125	138.1073	149.2157	124.35913
56	BE	227.005	131.22559	134.93347	129.11987	131.22559
57	BE	177.2614	115.8905	115.8905	112.71667	116.94336
58	BE	195.7855	170.3949	179.38232	185.21118	170.9137
59	BE	193.6646	176.74255	192.61169	187.31689	165.1001
60	BE	166.153	161.92627	156.63147	150.28381	193.66455

ตารางที่ 4.2 Surface EMG median frequency of left CES (pre – test)

ลำดับที่	กลุ่ม	นาทีที่0	นาทีที่30	นาทีที่60	นาทีที่90	นาทีที่120
1	ST	201.61438	169.32678	173.56873	151.33667	165.1001
2	ST	173.56873	160.85815	164.03198	162.97913	156.09741
3	ST	164.03198	163.51318	177.26135	161.39221	176.74255
4	ST	172.50061	167.57202	184.14307	163.51318	173.03467
5	ST	155.57861	156.63147	154.5105	141.28113	161.92627
6	ST	161.92627	162.44507	147.62878	156.63147	138.1073
7	ST	123.82507	133.34656	147.62878	133.34656	141.81519
8	ST	187.31689	165.6189	157.16553	159.27127	162.97913
9	ST	167.22107	156.63147	159.27124	164.56604	168.27393
10	ST	197.37244	197.37244	194.39697	176.74255	170.9137
11	ST	215.89661	149.2157	198.44055	185.21118	198.44055
12	ST	149.74976	150.80261	150.80261	150.28381	150.80261
13	ST	177.79541	156.09741	152.38953	153.45764	169.86084
14	ST	202.66724	157.68433	148.16284	152.92358	147.10999
15	ST	213.25684	144.98901	168.80798	173.56873	168.80798

16	ST	164.03198	163.51318	150.28381	156.63147	144.98901
17	ST	219.07043	171.98181	174.62158	171.98181	176.2085
18	ST	173.56873	182.03735	165.1001	184.14307	175.67444
19	ST	186.7981	156.09741	157.16553	143.93616	125.41199
20	ST	166.68701	165.6189	153.9917	178.32947	162.97913
21	ST	211.66992	1701.3949	188.90381	162.44507	178.32947
22	ST	170.3949	138.1073	132.2937	134.39941	158.75244
23	ST	224.36523	201.61438	185.72998	238.1134	222.77832
24	ST	157.68433	173.03467	178.84827	167.73987	163.51318
25	ST	166.15295	177.79541	169.32678	177.26135	179.38232
26	ST	192.07764	170.9137	165.1001	165.6189	184.14307
27	ST	219.07043	198.44055	199.49341	200.54626	195.25146
28	ST	160.85815	137.05444	148.6969	231.76575	152.92358
29	ST	171.98181	143.4021	149.74976	161.39221	150.80261
30	ST	188.90381	153.45764	170.9137	182.03735	150.80261
31	BE	205.30701	162.97913	175.15564	167.22107	159.8053
32	BE	155.57861	151.87073	157.16553	152.38953	158.75244
33	BE	175.155564	148.6969	146.04187	147.10999	141.81519
34	BE	150.28381	142.86804	138.1073	145.52307	154.5105
35	BE	197.90649	188.38501	178.32947	191.02478	205.30701
36	BE	174.62158	165.6189	173.56873	163.51318	186.26404
37	BE	223.83118	170.3949	162.97913	207.42798	198.44055
38	BE	165.1001	149.74976	141.28113	148.16284	145.52307
39	BE	179.91638	167.73987	175.15564	148.6969	162.44507
40	BE	139.69421	148.16284	166.15295	150.80261	150.28381
41	BE	142.34924	139.69421	134.39941	137.57324	140.22827
42	BE	175.67444	174.62158	169.32678	169.86084	147.10999
43	BE	187.85095	166.15295	155.57861	169.86084	175.155564
44	BE	167.73987	165.6189	164.56604	196.31958	174.08752
45	BE	168.27393	158.21838	141.28113	144.45496	157.68433
46	BE	184.67712	195.78552	180.96924	171.98181	164.03198

47	BE	144.45496	153.45764	150.28381	150.28381	151.33667
48	BE	189.43787	174.08752	175.67444	146.04187	187.31689
49	BE	148.16284	167.22107	165.1001	174.62158	170.3949
50	BE	160.33936	171.44775	160.33936	169.32678	198.95935
51	BE	152.92358	177.26135	178.84827	165.1001	132.2937
52	BE	183.09021	165.1001	158.75244	162.97913	163.51318
53	BE	160.85815	147.62878	141.81519	142.34924	144.45496
54	BE	188.90381	189.43787	190.49072	195.25146	180.96924
55	BE	180.96924	200.54626	200.02747	147.62878	155.57861
56	BE	216.94946	165.1001	182.55615	154.5105	167.73987
57	BE	155.57861	126.46484	126.46484	126.46484	128.58582
58	BE	179.91638	178.32947	176.74255	174.62158	171.98181
59	BE	187.31689	179.91638	184.67712	186.7981	193.14575
60	BE	189.97192	190.49072	195.78552	189.43787	193.66455

ตารางที่ 4.3 Surface EMG median frequency of right CES (pre – test)

ลำดับที่	กลุ่ม	นาทีที่0	นาทีที่30	นาทีที่60	นาทีที่90	นาทีที่120
1	ST	249.23706	173.56873	167.22107	190.49072	182.03735
2	ST	182.55615	157.68433	166.15295	162.44507	160.85815
3	ST	163.51318	161.39221	169.32678	184.14307	173.56873
4	ST	179.77905	178.32947	183.09021	170.9137	181.5033
5	ST	161.92627	153.45764	152.38953	153.45764	161.92627
6	ST	175.67444	179.38232	153.45764	165.6189	151.87073
7	ST	172.50061	132.8125	144.98901	130.17273	141.28113
8	ST	194.19861	149.2157	142.86804	143.93616	144.45496
9	ST	188.38501	157.16553	166.15295	171.98181	174.62158
10	ST	193.14575	197.90649	198.44055	196.85364	185.72998
11	ST	218.01758	159.8053	203.20129	184.67712	242.35535

12	ST	150.28381	155.57861	190.49072	167.22107	162.97913
13	ST	179.91638	154.5101	161.62627	158.75244	161.92627
14	ST	168.80798	165.6189	143.4021	167.73987	164.56604
15	ST	219.07043	169.32678	188.38501	167.22107	198.44055
16	ST	162.44057	149.2157	138.1073	148.6969	152.92358
17	ST	218.53638	173.56873	171.44775	173.56873	192.07764
18	ST	196.31958	195.25146	186.7981	177.79541	190.49072
19	ST	184.67712	140.76233	164.03198	152.92358	126.46484
20	ST	172.50061	161.39221	158.75244	165.6189	159.27124
21	ST	205.84106	176.2085	205.84106	166.15295	183.62427
22	ST	175.67444	131.22559	128.05176	126.9989	136.52039
23	ST	202.13318	178.32947	181.5033	207.96204	195.25146
24	ST	169.32678	196.85364	147.10999	168.27393	174.08752
25	ST	179.91638	173.56873	169.32678	178.32947	183.09021
26	ST	182.55615	172.50061	168.80798	170.9137	185.72998
27	ST	176.74255	201.08032	195.78552	181.5033	207.78821
28	ST	180.96924	150.28381	149.74976	237.5946	167.73987
29	ST	207.96204	135.46753	133.88062	142.34924	137.05444
30	ST	187.85095	161.39221	185.21118	183.09021	164.56604
31	BE	213.77563	169.32678	152.38953	163.51318	175.15564
32	BE	159.8053	148.6969	143.4021	142.34924	155.04456
33	BE	162.44507	137.05444	140.22827	138.1073	135.98633
34	BE	165.6189	158.75244	185.75244	159.27124	182.03735
35	BE	274.10889	228.07312	228.59192	200.54626	233.88672
36	BE	171.44775	154.5105	153.9917	158.75244	162.44507
37	BE	150.80261	171.98181	168.27393	214.30969	202.13318
38	BE	168.80035	181.5033	161.39221	162.97913	161.39221
39	BE	182.55651	166.15295	170.3949	160.88515	171.44775
40	BE	162.97913	151.33667	167.22107	149.2157	154.5105
41	BE	143.93616	162.97913	137.05444	141.28113	143.93616
42	BE	163.51318	157.16553	164.56604	177.79541	161.92627

43	BE	201.61438	161.92627	165.6189	156.63147	169.86084
44	BE	185.72998	172.50061	161.39211	204.78821	173.56873
45	BE	164.56604	159.27124	170.9137	159.27124	165.6189
46	BE	180.43518	182.55615	180.96924	174.08752	166.15295
47	BE	155.57861	152.38953	159.27124	156.63147	162.97913
48	BE	209.54895	152.38953	150.28381	165.1001	154.5105
49	BE	200.54626	176.74255	174.08752	173.56873	174.08752
50	BE	161.92627	17039490	173.03467	164.56604	197.90649
51	BE	164.56604	168.27393	168.80798	164.56604	138.1073
52	BE	196.31958	154.5105	150.28381	158.21838	156.09741
53	BE	165.1001	146.57593	147.62878	149.74976	147.62878
54	BE	194.73267	195.25146	188.903814	193.66455	184.67712
55	BE	179.91638	206.37512	188.38501	192.07764	197.37244
56	BE	236.00769	178.32947	218.53638	247.65015	163.51318
57	BE	175.67444	140.76233	142.34924	139.17542	145.52307
58	BE	165.1001	156.09741	160.33936	155.04456	162.44507
59	BE	201.08032	101.07422	199.49341	200.02747	199.49341
60	BE	182.03735	178.84827	187.31689	169.86084	150.28381

ตารางที่ 4.4 Surface EMG median frequency of right UT (pre – test)

ลำดับที่	กลุ่ม	นาทีที่0	นาทีที่30	นาทีที่60	นาทีที่90	นาทีที่120
1	ST	146.57593	118.53027	117.47742	123.29102	124.35913
2	ST	246.06323	155.57861	168.27393	162.44507	150.28381
3	ST	166.15295	146.57593	141.28113	152.92358	162.44507
4	ST	190.38391	152.38953	173.56873	150.80261	149.2157
5	ST	174.62158	172.50061	157.16553	160.33936	166.15295
6	ST	206.37512	128.58582	116.94336	124.87793	147.62878
7	ST	180.43518	121.7041	144.98901	120.65125	145.52307
8	ST	234.42078	115.8905	119.58313	116.4093	120.11719
9	ST	249.75586	113.23547	118.53027	130.70679	115.8905

10	ST	169.32678	176.2085	146.57593	137.05444	171.44775
11	ST	165.1001	155.04456	150.80261	153.45764	153.45764
12	ST	150.80261	149.74976	150.28381	150.28381	150.28381
13	ST	205.84106	115.35645	113.23547	111.64856	111.12976
14	ST	205.84106	125.41199	123.29102	119.58313	124.35913
15	ST	229.12598	111.64856	153.9917	115.8905	156.63147
16	ST	198.95935	128.58582	120.11719	119.58313	109.00879
17	ST	164.56604	125.41199	122.75696	119.06433	112.71667
18	ST	153.45764	149.2157	145.52307	149.74976	145.52307
19	ST	191.02478	155.8905	149.2157	150.80261	113.76953
20	ST	171.44775	108.47473	194.73267	143.4021	117.47742
21	ST	200.54626	107.94067	137.57324	105.83496	100.06165
22	ST	215.36255	120.65125	124.35913	126.9989	142.34924
23	ST	237.5946	136.52039	150.80261	139.69421	147.62878
24	ST	234.93958	219.07043	150.28381	214.84375	226.48621
25	ST	184.14307	159.8053	174.62158	161.39221	141.28113
26	ST	212.18872	143.4021	110.5957	121.7041	131.75964
27	ST	176.2085	164.56604	141.81519	153.45764	157.68433
28	ST	188.38501	131.75964	150.80261	189.43787	182.03735
29	ST	201.61438	102.66113	103.17993	102.12708	101.07422
30	ST	141.81519	121.7041	155.57861	206.89392	152.38953
31	BE	249.75586	120.11719	136.52039	149.2157	107.42188
32	BE	124.35913	183.09021	165.1001	165.1001	180.43518
33	BE	249.75586	152.92358	150.80261	143.93616	132.2937
34	BE	144.45496	133.88062	130.17273	127.53296	220.65735
35	BE	188.38501	131.75964	128.58582	134.93347	133.34656
36	BE	182.03735	153.9917	141.28113	139.17542	137.05444
37	BE	168.27393	127.53296	126.46484	134.93347	147.62878
38	BE	225.41809	107.94067	120.11719	111.12976	113.23547
39	BE	164.56604	131.75964	137.05444	130.70679	132.2937
40	BE	167.22107	138.64136	162.97913	143.4021	142.34924

41	BE	115.35645	131.75964	113.76953	114.82239	111.64856
42	BE	154.5105	123.82507	126.9989	166.68701	157.16553
43	BE	227.005	148.16284	147.10999	146.04187	150.28381
44	BE	160.85815	135.98633	128.05176	146.04187	141.28113
45	BE	211.66992	141.28113	157.16553	113.23547	229.6603
46	BE	264.57214	184.67712	225.41809	191.55884	170.9137
47	BE	160.85815	131.22559	144.98901	140.76233	139.54163
48	BE	189.43787	131.75964	130.70679	156.63147	129.11987
49	BE	177.79541	169.32678	166.15295	167.22107	165.1001
50	BE	159.27124	135.98633	141.81519	139.17542	186.2604
51	BE	146.57593	202.13318	211.13586	211.13586	116.94336
52	BE	214.30969	150.28381	149.2157	157.68433	151.33667
53	BE	212.18872	140.22827	134.93347	126.46484	131.22559
54	BE	168.27393	119.58313	117.47742	120.65125	109.54285
55	BE	233.35266	136.52039	131.75964	220.65735	188.38501
56	BE	250.28992	117.99622	122.23816	155.8905	115.35645
57	BE	184.67712	137.57324	135.98633	140.76233	134.39941
58	BE	139.69421	133.88062	130.70679	133.34656	124.87793
59	BE	196.31958	117.99622	175.15564	123.82507	163.51318
60	BE	161.92627	119.58313	148.6969	149.74976	166.15295

ตารางที่ 4.5 Surface EMG median frequency of left UT (post – test)

ลำดับที่	กลุ่ม	นาทีที่0	นาทีที่30	นาทีที่60	นาทีที่90	นาทีที่120
1	ST	141.81519	155.04456	130.70679	122.23816	119.58313
2	ST	150.28381	149.74976	152.92358	149.74976	151.33667
3	ST	133.88062	127.53296	124.35913	150.80261	189.43787
4	ST	176.74255	192.07764	179.91638	196.31958	185.722998
5	ST	117.47742	123.82507	173.56873	164.03198	127.53296
6	ST	212.18872	188.90381	194.73267	155.04456	176.74255
7	ST	126.9989	136.52039	136.52039	149.74976	138.1073

8	ST	187.97192	105.3009	108.47473	105.3009	194.19861
9	ST	150.28381	116.94336	119.58313	119.58313	174.62158
10	ST	172.50061	198.95935	187.31689	170.3949	150.28381
11	ST	150.28381	152.92358	151.33667	160.85815	151.92627
12	ST	180.43518	152.92358	191.02478	157.68433	147.62878
13	ST	209.01489	118.53027	143.4021	117.47742	124.87793
14	ST	192.07764	131.22559	111.64856	114.30359	117.99622
15	ST	182.55615	132.8125	124.87793	120.11719	161.92627
16	ST	201.61438	192.61169	151.33667	195.78552	162.44507
17	ST	159.8053	150.28381	134.39941	145.52307	140.76233
18	ST	154.5105	152.92358	150.80261	157.16553	154.5105
19	ST	193.14575	131.75964	122.23816	128.05176	126.46484
20	ST	226.48621	150.80261	177.26135	178.32947	205.30701
21	ST	149.2157	152.92358	152.38953	171.98181	150.80261
22	ST	134.93347	119.58313	117.99622	122.23816	116.4093
23	ST	200.02747	198.44055	189.43787	192.61169	241.30969
24	ST	207.96204	150.28381	135.46753	252.92969	122.23816
25	ST	178.84827	124.87793	129.11987	135.98633	179.38232
26	ST	152.38953	175.67444	201.08032	165.6189	187.31689
27	ST	194.19861	165.6189	186.26404	176.2085	198.44055
28	ST	144.98901	162.44507	127.53296	155.57861	165.6189
29	ST	168.27393	160.33936	188.90381	173.03467	198.44055
30	ST	191.55884	150.80261	146.57593	134.93347	170.9137
31	BE	198.44055	151.33667	121.7041	115.35645	149.74976
32	BE	205.84106	192.61169	151.87073	172.50061	160.85815
33	BE	208.48083	157.68433	162.44507	142.34924	161.39221
34	BE	143.93616	143.93616	127.53296	144.98901	149.2157
35	BE	183.09021	164.03198	150.80261	224.36523	211.66992
36	BE	175.67444	185.21118	200.54626	183.62427	196.85364
37	BE	130.17273	135.46753	129.11987	154.5105	126.9989
38	BE	102.66113	98.95325	98.95325	98.95325	100.0061

39	BE	159.8053	150.80261	157.16553	171.44775	169.86084
40	BE	188.38501	153.9917	169.86084	132.2937	193.14575
41	BE	148.16284	144.98901	147310999	138.64136	150.80261
42	BE	130.70679	158.21838	115.35645	150.80261	157.16553
43	BE	137.05444	150.28381	158.21838	152.92358	148.6969
44	BE	181.5033	170.9137	156.63147	143.93616	142.86804
45	BE	170.3949	144.45496	158.75244	160.85815	151.33667
46	BE	180.43518	157.16553	168.27393	161.92627	175.67444
47	BE	166.15295	110.5957	144.45496	122.75696	158.75244
48	BE	192.07764	131.22559	111.64856	114.30359	117.99622
49	BE	153.9917	109.00879	138.64136	157.16553	151.33667
50	BE	155.57861	150.80261	148.6969	151.33667	151.87073
51	BE	149.74976	236.00769	118.53027	166.68701	138.64136
52	BE	184.67712	128.05176	129.11987	122.23816	123.29102
53	BE	137.05444	125.41199	122.75696	117.47742	115.8905
54	BE	176.74255	115.8905	137.57324	153.45764	133.88062
55	BE	166.15295	197.90649	173.03467	189.97192	173.03467
56	BE	241.82129	133.34656	170.9137	132.8125	187.31689
57	BE	158.75244	150.80261	127.53296	150.80261	131.75964
58	BE	211.66992	177.26135	147.62878	143.4021	149.2157
59	BE	184.14307	143.4021	138.64136	151.87073	129.63867
60	BE	150.28381	142.86804	175.67444	151.33667	150.28381

ตารางที่ 4.6 Surface EMG median frequency of left CES (post – test)

ลำดับที่	กลุ่ม	นาทีที่0	นาทีที่30	นาทีที่60	นาทีที่90	นาทีที่120
1	ST	153.45764	152.92358	149.74976	148.48328	143.93616
2	ST	189.43787	164.03198	176.2085	164.56604	165.6189
3	ST	150.80261	172.50061	175.67444	222.77832	210.06775
4	ST	151.87073	165.6189	158.21838	158.75244	158.75244
5	ST	145.52307	151.33667	162.44507	150.28381	144.98901
6	ST	169.86084	147.10999	135.98633	153.45764	149.74976

7	ST	138.64136	144.45496	136.52039	137.57324	128.05176
8	ST	183.62427	158.21838	152.92358	155.04456	209.01489
9	ST	176.74255	148.16284	150.28381	153.9917	163.51318
10	ST	175.67444	173.56873	150.80261	148.16284	203.72009
11	ST	207.96204	200.02747	200.02747	200.54626	198.95935
12	ST	158.21838	149.2157	151.33667	150.28381	151.33667
13	ST	168.80798	159.27124	160.33936	153.45764	163.51318
14	ST	186.7981	167.22107	160.85815	147.10999	150.28381
15	ST	221.71021	101.07422	100.54016	100.0061	100.54061
16	ST	148.16284	141.81519	139.17542	148.16284	137.57324
17	ST	200.54626	166.15295	172.50061	158.75244	170.3949
18	ST	169.32678	167.22107	151.33667	150.80261	157.16553
19	ST	177.79541	156.09741	152.38953	153.45764	169.86084
20	ST	175.15564	169.32678	173.56873	178.84827	185.21118
21	ST	179.91638	191.55884	195.78552	184.67712	213.77563
22	ST	150.80261	145.52307	146.04187	141.81519	144.98901
23	ST	216.94946	223.29712	195.25146	224.88403	245.52917
24	ST	169.86084	178.84827	181.5033	206.37512	147.10999
25	ST	148.16284	167.22107	165.1001	174.62158	170.3949
26	ST	173.03467	182.55615	175.67444	174.08752	178.32947
27	ST	216.43066	203.72009	228.59192	221.19141	201.61438
28	ST	153.45764	150.80261	173.03467	161.92627	206.89392
29	ST	157.16553	160.85815	149.2157	179.38232	195.78552
30	ST	200.02747	169.86084	162.97913	158.75244	164.68811
31	BE	186.26404	168.80798	158.75244	164.44507	169.86084
32	BE	168.27393	166.15295	160.85815	158.75244	151.87073
33	BE	171.44775	151.87073	156.09741	147.10999	160.85815
34	BE	141.28113	142.34924	139.17542	141.81519	149.74976
35	BE	226.48621	195.78552	190.49072	192.07764	180.43518
36	BE	161.39221	160.85815	172.50061	166.15295	163.51318
37	BE	151.87073	174.62158	156.63147	151.87073	155.04456

38	BE	157.16553	148.6969	149.2157	151.87073	153.99107
39	BE	171.98181	160.85815	186.7981	198.95935	191.55884
40	BE	160.33936	154.5105	166.68701	161.92627	160.85815
41	BE	165.6189	141.81519	151.33667	175.15564	166.15295
42	BE	178.32947	138.64136	132.2937	180.96924	167.73987
43	BE	152.92358	167.73987	171.44775	164.03198	168.27393
44	BE	262.46643	195.25146	162.97913	173.03467	160.33936
45	BE	183.62427	157.16553	168.27393	157.16553	160.33939
46	BE	161.39221	142.34924	137.57324	145.52307	158.21838
47	BE	163.51318	147.10999	153.45764	157.5105	184.14307
48	BE	186.7981	167.22107	160.85815	147.10999	150.28381
49	BE	158.75244	155.57861	166.15295	146.04187	155.57861
50	BE	157.15564	158.21838	161.92627	161.39221	158.21838
51	BE	234.42078	229.12598	210.60181	193.66455	178.84827
52	BE	197.90649	169.86084	170.9137	164.56604	165.6189
53	BE	181.5033	146.57593	144.98901	142.34924	144.98901
54	BE	198.44055	182.55615	182.03735	191.02478	187.85095
55	BE	205.30701	218.53638	238.1134	212.72278	229.12598
56	BE	211.19141	164.56604	167.73987	165.1001	175.15564
57	BE	164.03198	164.56604	153.45764	158.21838	150.28381
58	BE	189.97192	166.68701	150.28381	156.09741	150.28381
59	BE	180.96924	180.96924	184.14307	193.14575	199.49341
60	BE	180.96924	174.62158	191.55884	199.49341	191.02478

ตารางที่ 4.7 Surface EMG median frequency of right CES (post – test)

ลำดับที่	กลุ่ม	นาทีที่0	นาทีที่30	นาทีที่60	นาทีที่90	นาทีที่120
1	ST	167.73987	155.04456	144.45496	152.92358	157.68433
2	ST	179.91638	166.15295	164.56604	166.15295	163.51318

3	ST	165.6189	185.72998	191.02478	228.59192	181.5033
4	ST	200.54626	178.84827	174.08752	171.98181	174.62158
5	ST	149.74976	155.04456	165.1001	148.6969	145.52307
6	ST	177.79541	161.92627	158.75244	150.80261	148.6969
7	ST	147.10999	139.69421	140.22827	135.98633	138.1073
8	ST	180.43518	155.04456	150.80261	149.74976	194.19861
9	ST	209.01489	177.26135	154.5105	202.13318	189.97192
10	ST	164.03198	194.19861	185.21118	157.5105	175.67444
11	ST	214.30969	193.66455	175.67444	189.43787	179.38232
12	ST	164.56604	149.2157	150.28381	154.5105	141.81519
13	ST	177.26135	150.80261	159.27124	153.9917	148.6969
14	ST	189.97192	198.95935	239.18152	177.79541	171.98181
15	ST	221.19141	191.02478	169.00635	176.2085	192.61169
16	ST	159.27124	148.6969	147.62878	149.74976	129.63867
17	ST	204.78821	165.6189	164.56604	156.63147	168.27393
18	ST	201.61438	187.85095	181.5033	185.21118	187.85095
19	ST	179.91638	154.5105	161.92627	158.75244	161.92627
20	ST	175.15564	168.80798	168.80798	175.67444	173.56873
21	ST	189.97192	199.49341	203.72009	200.02747	247.65015
22	ST	155.57861	137.05444	138.1073	131.75964	142.34924
23	ST	234.42078	215.89661	194.19861	236.00769	244.99512
24	ST	213.25684	151.87073	188.90381	204.78821	192.61169
25	ST	200.54626	176.74255	174.08752	173.56873	174.08752
26	ST	194.73267	178.32947	168.80798	171.98181	178.84827
27	ST	193.14575	184.14307	218.53638	211.66992	195.25146
28	ST	178.32947	172.50061	205.30701	159.8053	201.08032
29	ST	187.85095	157.68433	160.33936	153.45764	193.61457
30	ST	184.14307	171.44775	155.04456	150.80261	173.03467
31	BE	155.57861	169.86084	163.51318	152.38953	139.17542
32	BE	171.98181	165.6189	167.73987	159.27124	151.87073
33	BE	170.3949	142.86804	146.57593	130.17273	143.4021

34	BE	161.39221	160.85815	158.75244	156.09741	156.63147
35	BE	249.75586	253.46375	257.70569	253.9978	260.54546
36	BE	155.57861	160.85815	162.44507	160.85815	164.56604
37	BE	191.55884	167.22107	150.28381	149.74976	150.80261
38	BE	171.44775	154.5105	162.44507	161.92627	165.6189
39	BE	173.56873	148.6969	147.10999	185.72998	181.5033
40	BE	169.89084	154.5105	169.32678	167.73987	170.9137
41	BE	172.50061	131.22559	149.74976	147.62878	182.03735
42	BE	175.15564	155.04456	144.98901	154.5105	155.04456
43	BE	153.9917	171.44775	173.56873	159.27124	166.3896
44	BE	250.28992	255.05066	257.17163	240.23438	243.4082
45	BE	150.80261	152.38953	168.27393	152.38953	152.92358
46	BE	168.90798	155.57861	152.92358	165.6189	173.56873
47	BE	170.3949	150.28981	158.21838	158.21838	178.32947
48	BE	189.97192	198.95935	239.18152	177.79541	171.98181
49	BE	161.39221	149.2157	175.67444	149.74976	152.38953
50	BE	186.7981	171.44775	185.72998	175.67444	180.43518
51	BE	210.60181	230.17883	223.29712	223.83118	191.02478
52	BE	183.62427	159.8053	163.51318	150.283814	152.38953
53	BE	204.25415	149.2157	150.28381	148.6969	148.16284
54	BE	208.48033	197.37244	189.97192	200.54626	198.44055
55	BE	209.01489	212.72278	299.12598	234.93958	225.41809
56	BE	221.19141	138.64136	149.74976	151.33667	143.4021
57	BE	163.51318	167.22107	150.80261	156.09741	158.21838
58	BE	183.09021	144.45496	149.74976	150.80261	152.92358
59	BE	191.02478	171.98181	161.92627	178.84827	184.14307
60	BE	188.90381	167.73987	188.38501	181.5033	195.78552

ตารางที่ 4.8 Surface EMG median frequency of right UT (post – test)

ลำดับที่	กลุ่ม	นาทีที่0	นาทีที่30	นาทีที่60	นาทีที่90	นาทีที่120

1	ST	249.23706	159.8053	106.88782	106.35376	163.51318
2	ST	249.75586	138.64136	165.1001	142.86804	141.81519
3	ST	200.02747	159.27124	191.55884	240.23438	230.71289
4	ST	213.77563	146.04187	129.11987	148.6969	147.10999
5	ST	168.80798	135.46753	152.38953	125.41199	156.09741
6	ST	166.68701	157.16553	155.04456	155.04456	155.04456
7	ST	121.7041	127.53296	123.82507	122.23816	127.53296
8	ST	225.95215	127.53296	110.5957	97.90039	95.77942
9	ST	233.88672	123.82507	115.35645	123.29102	171.44775
10	ST	105.83496	120.65125	207.42798	124.35913	150.80261
11	ST	159.27124	136.52039	126.9989	139.17542	137.05444
12	ST	239.71558	128.58582	139.69421	138.1073	120.11719
13	ST	200.54626	138.64136	149.2157	141.28113	139.69421
14	ST	100.0061	100.54016	139.69421	100.54016	100.54016
15	ST	185.21118	145.52307	128.05176	135.98633	167.22107
16	ST	216.43066	150.28381	130.70679	134.93347	150.80261
17	ST	160.85815	135.98633	133.88062	136.52039	132.8125
18	ST	161.39221	148.6969	142.34924	140.76233	142.34924
19	ST	205.84106	115.35645	113.23547	111.64856	111.12976
20	ST	213.25684	175.15564	150.28381	187.31689	195.25146
21	ST	158.75244	160.33936	160.33936	169.86084	162.44507
22	ST	211.66992	100.54016	100.54016	102.66113	102.12708
23	ST	213.77563	186.26404	194.19861	194.73267	210.06775
24	ST	250.28992	249.23706	178.32947	164.56604	139.69421
25	ST	177.79541	169.32678	166.15295	167.22107	165.1001
26	ST	218.01758	156.63147	187.85095	129.11987	135.46753
27	ST	249.23706	137.57324	171.44775	178.84827	175.67444
28	ST	176.2085	150.80261	191.55884	164.03198	198.44055
29	ST	200.02747	109.54285	104.24805	107.94067	155.57861
30	ST	215.89661	123.82507	131.75964	121.17004	139.69421
31	BE	138.1073	135.98633	128.58582	123.82507	123.82507

32	BE	228.59192	150.28381	121.7041	144.98901	126.9989
33	BE	221.71021	157.16553	156.63147	111.12976	156.63147
34	BE	156.63147	145.52307	146.04187	133.88062	127.53296
35	BE	249.23706	132.2937	138.64136	141.81519	107.94067
36	BE	133.34656	126.46484	143.4021	141.28113	150.80261
37	BE	110.5957	111.12976	107.94067	110.5957	109.00879
38	BE	98.95325	98.41919	95.77942	95.24536	97.36633
39	BE	144.98901	107.94064	116.4093	178.84827	119.06433
40	BE	176.74255	153.9917	151.87073	150.80261	161.92627
41	BE	155.57861	103.71399	107.42188	107.94064	183.62427
42	BE	216.94946	143.4021	127.53296	148.6969	150.80261
43	BE	146.54593	145.52307	143.93616	141.81519	133.88062
44	BE	246.58203	179.91638	158.75244	191.55884	168.27393
45	BE	228.59192	147.10999	152.38953	151.33667	152.38953
46	BE	200.54626	146.57593	149.2157	125.41199	184.67712
47	BE	191.55884	149.2157	140.22827	131.75964	132.8125
48	BE	100.0061	100.54016	139.69421	100.54016	100.54016
49	BE	140.76233	104.24805	111.64856	107.94067	110.06165
50	BE	193.14575	130.70679	133.34656	129.63867	134.93347
51	BE	169.86084	249.23706	117.47742	139.17542	117.99622
52	BE	198.95935	154.5105	140.76233	139.69421	129.11987
53	BE	180.96924	121.17004	130.17273	116.4093	107.42188
54	BE	171.98181	140.22827	135.46753	134.93347	126.46484
55	BE	187.31689	141.28113	128.05176	198.95935	117.47742
56	BE	221.71021	150.28381	149.2157	150.80261	176.74255
57	BE	166.15295	159.27124	127.53296	129.11987	149.2157
58	BE	223.29712	137.57324	131.22559	119.06433	133.34656
59	BE	186.7981	131.75964	146.57593	122.23816	140.76233
60	BE	202.13318	115.35645	149.74976	158.75244	130.70679

ตารางที่ 5 The Neck Disability Index (NDI)

ลำดับที่	กลุ่ม	Pre – test	Post – test
1	ST	20	6.67
2	ST	15	10
3	ST	14	3
4	ST	8	4
5	ST	6	4
6	ST	2	4
7	ST	0	0
8	ST	28.89	15.55
9	ST	15	8
10	ST	12	3
11	ST	18	15
12	ST	17.77	8.89
13	ST	9	4
14	ST	40	11.11
15	ST	14	4
16	ST	24.44	11.11
17	ST	7	4
18	ST	13.33	6.67
19	ST	29	22
20	ST	13	3
21	ST	8	5
22	ST	4	4
23	ST	13.33	13.33
24	ST	15	13
25	ST	9	7
26	ST	7	5
27	ST	3	5
28	ST	8	4
29	ST	6	7
30	ST	18	12

31	BE	55.55	53.33
32	BE	20	6.67
33	BE	18	8
34	BE	6	7
35	BE	8.89	2.23
36	BE	6	3
37	BE	3	4
38	BE	11	7
39	BE	24.45	26.27
40	BE	2	3
41	BE	8.89	15.55
42	BE	18	12
43	BE	3	1
44	BE	9	4
45	BE	4.45	4.45
46	BE	11	11
47	BE	8.88	2.22
48	BE	18	6.67
49	BE	26.67	22.22
50	BE	22.22	17.77
51	BE	11	7
52	BE	5	2
53	BE	23	13
54	BE	7	1
55	BE	6	4
56	BE	10	6
57	BE	8	8
58	BE	13.33	4.44
59	BE	6	6
60	BE	9	6

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