COMPARISON OF MUSCLE FATIGUE BETWEEN WORKSTATIONS OF RETAILED STORE'S CASHIERS WHICH DESIGNED BY OSHA'S GUIDELINES AND NON-OSHA'S GUIDELINES

WORALUK SOMBOONNADEE

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…………………………………..
Miss Woraluk Somboonnadee
Candidate

………………………………….
Assoc. Prof. Chompusakdi Pulket,
Ph.D.
Major-Advisor

……...…………………………...
Asst. Prof. Preecha Loosereewanich,
Ph.D.
Co-Advisor

……...…………………………...
Assoc. Prof. Chalermchai Chaikittiporn,
Dr.P.H.
Co-Advisor

……...…………………………...
Assoc. Prof. Vajira Singhakajen,
M.A.
Co-Advisor

……...…………………………...
Assoc. Prof. Wantanee Phanprasit,
Dr.P.H.
Co-Advisor

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

……...…………………………...
Asst. Prof. Preecha Loosereewanich,
Ph.D.
Chair
Master of Science Programme in
Industrial Hygiene and Safety
Faculty of Public Health

Thesis

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on
January 4, 2008

…………………………………..
Miss Woraluk Somboonnadee
Candidate

…………………………………….
Assoc. Prof. Vajira Singhakajen,
M.A.
Member

…………………………………….
Assoc. Prof. Jitrapun Pusapukdepob,
Ph.D.
Chair

……..…………………………...
Asst. Prof. Preecha Loosereewanich,
Ph.D.
Member

…………………………………….
Assoc. Prof. Chompusakdi Pulket,
Ph.D.
Member

……..…………………………...
Assoc. Prof. Wantanee Phanprasit,
Dr.P.H.
Member

……..…………………………...
Assoc. Prof. Chalermchai Chaikittiporn,
Dr.P.H.
Member

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

……..…………………………...
Assoc. Prof. Phitaya Charupoonphol,
M.D., Dip. Thai Board of Epidemiology
Dean
Faculty of Public Health
Mahidol University

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Woraluk Somboonnadee

COMPARISON OF MUSCLE FATIGUE BETWEEN WORKSTATIONS OF RETAILED STORE'S CASHIERS WHICH DESIGNED BY OSHA'S GUIDELINES AND NON-OSHA'S GUIDELINES

WORALUK SOMBOONNADEE 4537324 PHIH/M

M.Sc. (INDUSTRIAL HYGIENE AND SAFETY)

THESIS ADVISORS: CHOMPUSAKDI PULKET, Ph.D., CHALERMCHAI CHAIKITTIPORN, Dr.P.H., WANTANEE PHANPRASIT, Dr.P.H., VAJIRA SINGHAKAJEN, M.A., PREECHA LOOSEREEWANICH, Ph.D.

ABSTRACT

The objectives of the study were to compare the muscular fatigue of retail store cashiers who worked at workstations designed according to OSHA guidelines with those working at other workstations. Ten female cashiers participated in this study. The average age, weight, height and body mass index were 26.0 ± (1.89) years, 48.6 ± (1.33) kilograms, 158.5 ± (1.57) centimeters and 19.32 ± (0.59), respectively. The median frequency of EMG was measured by electromyography every half an hour during working time. The evaluation of muscular fatigue was performed twice for each cashier at each workstation.

The results of this study revealed that the median frequencies of trapezius muscle, gastrocnemius muscle and tibialis anterior muscle for the cashiers who worked on OSHA designed workstations was significantly less than for cashiers working at non-OSHA designed workstations (p-value < 0.05). The results of questionnaires also showed that there were no differences in work satisfaction between the workstations. Work performance in terms of total scan quantity per half hour at the OSHA designed workstations was highes.

This experimental study shows that the OSHA guidelines can be successfully used to reduce muscular fatigue as well as to increase work performance.

KEY WORDS: OSHA'S GUIDELINE DESIGNED WORKSTATION / NON-OSHA'S GUIDELINE DESIGNED WORKSTATION / MUSCULARS FATIGUE / CASHIER / ELECTROMYOGRAPHY

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การเปรียบเทียบความเมื่อยล้ากล้ามเนื้อของพนักงานรับเงินที่ทำงานในสถานีงานที่ออกแบบตามข้อเสนอแนะของ OSHA และไม่เป็นไปตามข้อเสนอแนะของ OSHA (COMPARISON OF MUSCLE FATIGUE BETWEEN WORKSTATIONS OF RETAILED STORE'S CASHIERS WHICH DESIGNED BY OSHA'S GUIDELINES AND NON-OSHA'S GUIDELINES)

วรลักษณ์ สมบูรณ์นาดี 4537324 PHIH/M

วท.ม. (สุขศาสตร์อุตสาหกรรมและความปลอดภัย)

คณะกรรมการควบคุมวิทยานิพนธ์ : ชมภูศักดิ์ พูลเกษ, Ph.D., เฉลิมชัย ชัยกิตติภรณ์, Dr. P.H., วันทนี พันธุ์ประสิทธิ์, Dr. P.H., วชิระ สิงหะคเชนทร์, M.A., ปรีชา ลอเสรีวานิช, Ph.D.

บทคัดย่อ

การวิจัยนี้มีวัตถุประสงค์เพื่อเปรียบเทียบความเมื่อยล้ากล้ามเนื้อของพนักงานรับเงินที่ทำงานในสถานีงานที่ออกแบบตามข้อเสนอแนะของ OSHA และไม่ได้ออกแบบตามข้อเสนอแนะของ OSHA โดยมีพนักงานรับเงินเพศหญิงเข้าร่วมในการศึกษาจำนวน 10 คน ซึ่งมีอายุเฉลี่ย 26.0 ± (1.89) ปี น้ำหนัก ส่วนสูง และดัชนีมวลกายโดยเฉลี่ย 48.6 ± (1.33) กิโลกรัม 158.5 ± (1.57) เซนติเมตร และ 19.32 ± (0.59) ตามลำดับ ทำการวัดความเมื่อยล้ากล้ามเนื้อด้วยค่าความถี่กลางของคลื่นไฟฟ้ากล้ามเนื้อของพนักงานรับเงินในขณะทำงานทุกๆ ครึ่งชั่วโมง โดยทำการวัดซ้ำ 2 ครั้งในพนักงานรับเงินแต่ละคน และแต่ละสถานีงาน

จากการศึกษาพบว่า ขณะที่พนักงานรับเงินทำงานในสถานีงานที่ออกแบบตามข้อเสนอแนะของ OSHA นั้น ผลการประเมินความเมื่อยล้ากล้ามเนื้อด้วยค่าความถี่กลางของคลื่นไฟฟ้ากล้ามเนื้อ trapezius กล้ามเนื้อ gastrocnemius และกล้ามเนื้อ tibialis anterior น้อยกว่าทำงานในสถานีงานไม่ได้ออกแบบตามข้อเสนอแนะของ OSHA อย่างมีนัยสำคัญทางสถิติ ($p<0.05$) นอกจากนี้ ผลการตอบแบบสอบถามยังพบว่าพนักงานรับเงินมีความพึงพอใจในสถานีงานทั้ง 2 แบบไม่แตกต่างกัน และยังพบว่าประสิทธิภาพการทำงานของพนักงานรับเงินเพิ่มขึ้นเมื่อทำงานในสถานีงานที่ออกแบบตามข้อเสนอแนะของ OSHA

จากผลการศึกษาสรุปได้ว่า สถานีงานที่ออกแบบตามข้อเสนอแนะของ OSHA สามารถลดความเมื่อยล้ากล้ามเนื้อของพนักงานรับเงินขณะปฏิบัติงานได้ และยังเพิ่มประสิทธิภาพในการทำงาน

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CHAPTER I
INTRODUCTION

1.1 Background and Rationale

Thailand is the developing country that was rapidly developed many industries. There was a number of occupational injuries. According to the report of Compensation Fund, Ministry of Labour, the number of cases resulting in compensation increasing was the work-related disorders such as the work-related musculoskeletal disorders. For many workers in developing countries, ergonomic problems may not be high on the list of priority health and safety problems they face. However, the large and increasing numbers of workers affected by poor work design make ergonomic issues important. As a result of the importance and prevalence of health problems related to a lack of ergonomics at work, these issues have become points of negotiation for many unions. The work-related musculoskeletal disorders were not clearly to diagnosis. The symptoms of musculoskeletal disorders may not occur during work but may occur after work and often develop slowly over a period of months or years (1).

The muscular fatigue was an indicator of ergonomics problems. Besides fatigue is one of the causes of the work mistake, that had occurred accident. Cumulative muscular fatigue has worker health effect such as back pain, headache that organization has decrease productivity, absenteeism and associated costs. Peter W. Buckle, J. Jason devereux, (2) was studied the nature of work-related musculoskeletal disorders (WMSDs) of neck and upper limb. They are reviewed by using scientific data and the consensus view of experts, union bodies and government agencies across the European Union. Work-related musculoskeletal disorders describe a wide range of inflammatory and degenerative diseases and disorders. These disorders are a significant problem within European Union with respect to ill health, productivity and associated costs. Estimating the prevalence of WMSDs in the European Union is difficult because of the lack of standardized measures. Data collected from surveys across the European member states using self-report methods. The average 12-month prevalence of worker self-reported symptoms is approximately 28% for the neck (the highest) and 7.5% for the elbows (the lowest the four regions). In the Netherlands and Belgium approximately 30% and 40% of workers reported neck and upper limb musculoskeletal disorders, respectively. A relationship between the performance of work and the occurrence of neck and upper limb musculoskeletal disorders is evident. Intervention strategies in the workplace for the reduction of both exposure and effect should focus upon factors within the work organization as well as actively involving the individual worker. Suwanna et al, (3) studied the prevalence of pain symptom in 15 to 30 years of age female prolonged standing workers who stand during working for period of 5 to 12 hours per day. Data was collected from a total of 300 questionnaires. The results showed that prolonged standing workers experienced a greatest degree of pain in the calf muscle (76.9%) followed by the ankle joint (50%), back muscle (39.3%) and the knee joint (29.6%), respectively. Moreover, factor of age and standing time did not influence the prevalence of pain symptom in many areas.

The prevention and reduction work-related musculoskeletal disorders, the organization should be evaluated ergonomic problems in the workplace in order to investigated workplace problems. The organization has developed checklists to assess ergonomics concern. The employers can also identify ergonomic issues by talking with employees, and walkthrough workplace to observe employees performing their jobs (such as work practices and procedure, work posture and duration). When reviewing the various jobs in workplace, pay particular attention to the risk factors listed. The results are intended to address factors that are believed to be associated with WMSDs in employees that are appropriate to their workplace. At that time, redesigning existing workstation or designing new ones or equipment or job tasks are easier to implement. These changes can make significant improvements in worker comfort, health, safety, worker productivity and efficiency (4).

The Department of Ergonomics of Occupational Safety and Health Thailand Organization (5) conducted health problem evaluations to investigate the musculoskeletal disorders of 94 prolong standing workers that worked at 6 department stores by using questionnaire. All of subjects participated in the survey, of whom 67 were female and 27 were male. The result showed that had a muscular fatigue and pain at leg muscle, back muscle, neck and feet, respectively. It found that over time working had effect to increase the muscular fatigue at calf, low back, ankle and foot. Long periods of standing work can cause back pain, leg swelling problems with blood circulation, sore feet and tired muscles.

In recently, a number of retail store branches have been opened in many provinces and a number of cashiers were employed. Performing cashier work for an extended period of time without a break has been associated with increased hand and wrist problems and could contribute to back and lower limb problems. The typical supermarket cashier can handle up to 500-1000 items per hour, the equivalent of filling over 80 bags with wrist flexion/extension reaching up to 600 times per hour. Workstation design can lead to serious injury to the hands, wrists, joints, back or other parts of the body. In particular, workstation design can have an impact on worker health and well-being. Good technique can make a job easy and safe. OSHA recommends employers use engineering and administrative techniques, where feasible, as the preferred method of dealing with ergonomic issues in retail stores. The section on ergonomic solutions for retail stores describes changes to equipment, work practices, and procedures that can address ergonomic risk factors, help control costs, and reduce employee turnover. The changes included using a powered in-feed conveyor to help cashiers bring the items to their best work zone and a footrest to help reduce the strain on the back and to allow the worker to change positions and a anti-fatigue mat on the floor so the worker does not have to stand on a hard. Katharyn A.Grant et al, 1994 (6) was studied an ergonomics evaluation of cashier work activities at checker-unload workstations. The study was conducted to determine whether supermarket cashiers are exposed to increased biomechanical stress due to the use of checker-unload workstations for standing work. The work activities of 12 grocery cashiers from three supermarkets were recorded on videotape. Postures and movements associated with the scanning task were visually evaluated and compared with those of 10 grocery cashiers using a front-facing, customer-unload workstation examined in a previous study. The results indicate that use of the checker-unload workstation places additional stresses on the cashier beyond those imposed by customer-unload checkstands. Specifically, the task of removing groceries directly from the cart for scanning increases the frequency of long reaches, awkward shoulder postures, and lifts. These stresses can be mitigated by eliminating checker-unload operations and providing checkstands with conveyor belts for delivering groceries to the cashier.

From the primary survey by used 57 questionnaires in Saraburi branch retail store, where the cashiers stand for service the customers all time work. The result showed that 94.64% of the answers had the symptom of muscular fatigue. Feet muscular fatigue (73.58%), Calf (62.26%), shoulder (60.38%), back (47.17%). Muscular pain which occurrences on the job (100%).

The overall objective of the study was to compare the muscular fatigue of retailed store cashiers that worked at the OSHA's guidelines workstation and the non-OSHA's guidelines workstation.

1.2 Objectives

1.2.1 To study the muscular fatigue of retail store cashiers who work in workstation which designed by OSHA's guidelines and non-OSHA's guidelines.

1.2.2 To study total scan quantity per half hour affecting in terms of work performance which could be related the muscular fatigue.

1.2.3 To compare the muscular fatigue of retail store's cashiers who work in workstation which designed by the OSHA's guidelines and the non-OSHA's guidelines.

1.3 Hypotheses of this study

The muscular fatigue of retail store cashiers who work in workstation which designed by OSHA's guidelines is less than those who work in the workstation which designed by non-OSHA's guidelines.

1.4 Variables

1.4.1 Independent variables

1.4.1.1 Total scan quantity per half hour

1.4.1.2 Average scan quantity per time

1.4.2 Dependent variables

1.4.2.1 The muscular fatigue by using the median frequency (MF) of electromyography (EMG) while work on OSHA's guidelines workstation.

- Shoulder muscle (trapezius muscle)
- Leg muscle (gastrocnemius muscle)
- Feet muscle (tibialis anterior muscle)

1.4.2.2 The muscular fatigue by using the median frequency (MF) of electromyography (EMG) while working on the non-OSHA's guidelines workstation.

1.4.3 Control variables

1. The selected subjects in this study are female.
2. The subjects must be healthy, strong and have no personal disorders such as heart disease, liver disease etc., and have no history of muscular and bone diseases or accidents.
3. The subjects must not have menstruation during the experimental day.
4. The subjects must rest at least 7 hours before the study.
5. The subjects must have work experiences at least 6 months.

1.5 Scope and Limitation of this study

The scope and limitation of this study are as the following:

1.5.1 This study focused on the muscular fatigue and factors affecting the muscular fatigue of Saraburi branch retail store's cashiers who work on the OSHA's guidelines and the non-OSHA's guidelines workstations.

1.5.2 The samples of this study were 10 female retail store cashiers who have at least six months of experience in cashier. They are healthy and strong, no personal disease, or illness and no history of muscular and bone disease and no menstruation during the period of experiment. They rested before the study starting at least 7 hours.

1.5.3 The cashiers performed the task for four hours (on different day) at each of the workstations. The starting time of the experiment was set at the same time during 2.00 p.m. up to 6.00 p.m., for the rush hour which causes the cashiers got the muscular fatigue.

1.5.4 The electromyography was used to record the muscular fatigue of the subjects. Also display median frequency (MF) throughout experiment. Duplicate sampling that the measurement of electromyography and evaluate of muscular fatigue were performing twice for each cashier.

1.6 The expecting benefits from this study

1.6.1 The OSHA's guidelines designed workstation could be useful to reduce the muscular fatigue and cashiers can increase work efficiency.

1.6.2 As a result of the importance and prevalence of health problems related to a lack of ergonomics at work, these issues have become the standing points of negotiation for many stores.

1.6.3 This study could allow the workers to involve in workstation design so he or she can vary the work activities according to personal needs, work habits and the workplace environment.

1.7 Operational definitions

Retail store cashier	:	The worker who service customer and stands all of timework (8 hours).
The workstation	:	Workstation is the place a worker occupies when performing a job and It may be occupied all the time or it may be one of several places where work is done.
EMG	:	Refers to electromyography
Muscular fatigue	:	The evaluation the muscular fatigue of cashiers by median frequency (MF) of electromyography (EMG) such as trapezius muscle, gastrocnemius muscle and tibialis anterior muscle.
Median Frequency (MF)	:	The center frequency division under power spectrum into two parts equally which indicated the muscular fatigue. When the muscle had increase fatigue median frequency would be decrease.
Shoulder muscle	:	Left and right trapezius muscle
Leg muscle	:	Left and right gastrocnemius muscle
Feet muscle	:	Left and right tibialis anterior muscle
SD	:	Standard Deviation

Body mass index (BMI) : Body mass index is measure of body fat based on height and weight that applies to both adult men and women

BMI categories:

- Normal weight = 18.5-24.9
- Over weight = 25-29.9
- Obesity = 30 or greater

1.8 Conceptual framework

Independent variables

1. Total scan quantity per half hour
2. Average scan quantity per time

Dependent variables

1. The muscular fatigue by using the median frequency (MF) of electromyography (EMG) while working the on OSHA's guidelines workstation.
   - Shoulder muscle (trapezius muscle)
   - Leg muscle (gastrocnemius muscle)
   - Feet muscle (tibialis anterior muscle)
2. The muscular fatigue by using the median frequency (MF) of electromyography (EMG) while working on the non-OSHA's guidelines workstation.

Control variables

1. Sex
2. Status of health and medical history
3. Menstruation period
4. Resting state before the experiment
5. Work experiences

CHAPTER II
LITERATURE REVIEW

2.1 Introduction (6, 7, 8, 9)

The term "ergonomics" is derived from two Greek words: "ergon", meaning work and "nomoi", meaning natural laws. Ergonomists study human capabilities in relationship to work demands. International Labour Organization (ILO) state that ergonomics is the study of work in relation to the environment in which it is performed (the workplace) and those who perform it (workers). It is used to determine how the workplace can be designed or adapted to the worker in order to prevent a variety of health problems and to increase efficiency; in other words, to make the job fit the worker, instead of forcing the worker to conform to the job.

Ergonomics is a broad science encompassing the wide variety of working conditions can affect worker comfort and health, including factors such as lighting, noise, temperature, vibration, workstation design, tool design, machine design, chair design and footwear, and job design, including factors such as shift work, breaks, and meal schedules. The information will be limited to basic ergonomic principles for sitting and standing work, tools, heavy physical work and job design.

Ergonomics applies principles of biology, psychology, anatomy and physiology to remove from the work environment the conditions that may cause workers to experience discomfort, fatigue or poor health. The ergonomics implementation could be used to prevent injuries rather than to treat them. Ergonomics also focused on workstation design. First, a physical demands analysis is completed to determine how best to arrange the components an employee needs to perform regular tasks in safe and comfortable. Efforts are made to eliminate stressful activities like twisting and to provide proper support for activities like working at a keyboard. Ergonomics can be used to prevent bad design from being built into a job if applied when a job, tools or workstations are being set up. For example, a worker's risk of developing musculoskeletal injuries can be greatly reduced, or even eliminated completely, if he or she is provided with properly designed hand tools from the time he or she begins a job requiring the use of hand tools. A well designed workstation is important for preventing diseases related to poor working conditions, as well as for ensuring that work is productive. Every workstation should be designed with both the worker and the task in mind so that work can be performed comfortably, smoothly and efficiently. If the workstation is properly designed, the worker should be able to maintain a correct and comfortable body posture. This is important because an uncomfortable work posture can cause a variety of problems, such as back injury, development or aggravation of repetitive strain injuries (RSIs) and circulatory problems in the legs. The main causes of these problems are poorly designed seating, standing for long periods, reaching too far, inadequate lighting forcing the worker to get too close to the work. The following are some basic ergonomic principles for workstation design. Some companies now provide ergonomics assessments for employee to help them setup their workstations to prevent RSIs. A general rule of thumb is to consider body size information, such as height, when choosing and adjusting workstations. Above all, workstations must be adjusted so that the worker is comfortable.

The NIOSH (7) had reviewed the epidemiological evidences for work-related musculoskeletal disorders. It concluded disorders affecting the neck/shoulder, shoulder, elbow and hand/wrist region. Work-related physical risk factors were identified for tendon, nerve, muscle and circulatory/vascular disorders in these region by and combination of symptom reporting and physical examination. They summaries the strength of evidence supporting a relationship between work and neck and upper limb musculoskeletal disorders. The work risk factors shown to have a positive relationship with neck and upper limb musculoskeletal disorders were combinations of repetition, force and postural work factors for elbow musculoskeletal disorders and hand wrist tendonitis. A causal relationship is very likely between intense and long exposure to work risk factor and the development of disorders in these regions. There was evidence to suggest that a reduction in exposure to biomechanical load resulted in the subsequent reduction of the prevalence of musculoskeletal disorders in the workplace.

In recent years, ergonomists have attempted to define postures which minimize unnecessary static work and reduce the forces acting on the body. All of us could significantly reduce our risk of injury if we could adhere to the following ergonomic principles:

a) All work activities should permit the worker to adopt several different, but equally healthy and safe postures.
b) Where muscular force has to be exerted it should be done by the largest appropriate muscle groups available.
c) Work activities should be performed with the joints at about mid-point of their range of movement. This applies particularly to the head, trunk, and upper limbs.

Ergonomics study

The NIOSH (7) had reviewed the epidemiological evidences for work-related musculoskeletal disorders. It concluded disorders affecting the neck/shoulder, shoulder, elbow and hand/wrist region. Work-related physical risk factors were identified for tendon, nerve, muscle and circulatory/vascular disorders in these region by and combination of symptom reporting and physical examination. They summaries the strength of evidence supporting a relationship between work and neck and upper limb musculoskeletal disorders. The work risk factors shown to have a positive relationship with neck and upper limb musculoskeletal disorders were combinations of repetition, force and postural work factors for elbow musculoskeletal disorders and hand wrist tendonitis. A causal relationship is very likely between intense and long exposure to work risk factor and the development of disorders in these regions. There was evidence to suggest that a reduction in exposure to biomechanical load resulted in the subsequent reduction of the prevalence of musculoskeletal disorders in the workplace.

Liz Ashby et al, 2002 (10) was evaluated the draft New Zealand Code of Practice for Manual Handling. The Code was studied in a sample of eight companies from four sectors of industry: service, retail, primary processing and manufacturing. The researcher used subjective and objective measures to evaluate the effectiveness of upper limb disorder checklist (Health and Safety Executive checklist). The results indicated that the Code was useful, applicable and informative. A number of limitations may have had a bearing on the validity of findings. A small sample size was used, and the representativeness of the participating companies was not established. Participating companies were not compensated directly for their time, and their motivations for talking part were not formally investigated as part the study.

Suebsak Nanthavanij and Howard Gage (11) were studied the normalization of inter-individual difference in the muscular fatigue test. The subjects participated in this study were 12 healthy male. This study addresses a comparison between three normalizing factors with respect to their effectiveness in reducing individual differences. The experiment involving sustained knee extension activities was design to study the fatigue characteristics of the quadriceps muscle group. A new factor, muscle mass, was included in this comparison, along with conventional MVC force and body weight. The experiment was divided into two parts. In the first part, the subject's MVC forces were measured. The second part investigated the fatigue characteristics of the quadriceps muscle group at four difference work loads: 25%, 40%, 55% and 70% MVC forces. The results showed that when the subject's body weight was used as a normalizing factor, (although the individual differences still existed), their effect was smaller and the measurement of body weight is easier to obtain, more objective, and more reliable than that of MVC force. Muscle mass is also found to be better normalizing factor than MVC, it still is less than that of body weight.

The National Institute of Occupational Health (NIOH) Viet Nam (12), reported physical workload is extremely heavy in many industries without automation: rice transport by shoulders, cement bag carrying, soil digging, coal shoveling and wagon pushing. The energy expenditure rises up to above 6 Kcal/min. In many occupations, people had to work in uncomfortable positions like erect, lying or kneeling positions. Some jobs with low energy expenditures result in muscle strain due to neuro-psychological stress of fast repetitive motion such as in telegraphists. Monotony occurs among machine-tool operators, weavers and printers. The NIOH will organize courses on the performance of occupational health techniques that applied to psycho – physiology of work and ergonomic:

(a) assessment of workload in high and low temperature, heavy physical workload and neuro-psychological stress in different occupations;
(b) ergonomic monitoring at factories, workshops and workplaces;
(c) ergonomic monitoring at factory design with respect to public health and sanitation;

(d) designing a scientific work organization applied to factory and a workshop.
(e) measurement of lung function and energy expenditure; and
(f) finding out factors and risks in each occupation on the basis of data collected from periodic medical examinations.

Takatoshi Murakami, Masaharu Kumshiro (13) investigated work loads of the two-shift workers in day shifts and night shifts of 13 workers in an assembly line of air-conditioning units. The degree of work load in day shift and night shift was investigated multilaterally by measurement of psychophysiological functions, feeling of subjective fatigue, such as stress and arousal, a survey of working aspects (performance, working postures, etc) and daily activities outside the workplace, blood pressure, sublingual temperature, Critical Fusion Frequency (CFF) and heart rate. The investigation was conducted for six days. The results showed that there were no substantial differences in working aspects of the two-shift workers between the day shift and night shift weeks. Also, there were no noticeable difference in arousal score, noted in stress score, the appearance rate of fatigued body parts and CFF between the day shift and night shift workers.

Larry J. Chapman et al., (15) conducted an intervention to convince small, fresh market vegetable operations to adopt mesh bags and standard containers, two production practices that aid in crop handling and that are known to improve labor efficiency and reduce exposures to musculoskeletal injury hazards. The intervention disseminated information about the practices to growers through trade publications public events, university Extension, and growers already using the practices. A mail questionnaire was administered to vegetable growers before and after the intervention. Strawberry growers were used as a comparison group and also received questionnaires. After the intervention, more vegetable growers reported seeing information about mesh bags in trade publications (37% vs. 59%) and about standard containers at public events (33% vs. 49%). Levels of self-reported adoption increased for containers (38% vs. 54%) and approached significance for bags (8% vs. 17%).

I. Balogh et al., (16) investigated the possible influence of musculoskeletal complaints, primarily from the neck and shoulders, gender and age on the self-reported as well as the directly measured exposures. The subjects were cleaners at four hospitals and office workers at one private company and two municipal officers. This study compares questionnaire assessed physical activity with direct technical measurements among cleaners and office workers, stratified regarding age, gender and self-reported neck and shoulder complaints. During two full working days number of steps was recorded by pedometer, sitting/standing positions by a posimeter and heart rate by a Sport-Tester. The subjects kept a work task diary for 10 days. There were high intra-individual variations in exposure, because of difference tasks between the days, difference tasks duration and/or "exceptional" days for the measurements. Subjects with complaints rated their exposure higher than those without, although in fact showed lower direct measured exposure. Rate of perceived exertion showed low correlation with heart rate ratio within the two occupational groups, but high, when the two groups were combined.

Annelise M. de Jong, Peter Vink, (17) was evaluated a step-by-step participatory approach to better work, applied in reducing the musculoskeletal workload in installation work. To arrive at a reduction in workload, a steering group led the project through the following steps:

1. Defining the goal and informing all 7,000 employees.
2. Analysis of work and health. There were 3 major types of activities appeared to cause problems: (1) manual transport; (2) kneeling and squatting; (3) work in static posture (bending over, reaching far, above head).
3. Creating solutions in group sessions and prioritized problems.
4. Promising solutions were tested during real operations.
5. Implementation. The PR department gathered the solution into 'product sheets' and bundled these in the 'ideas book'. Spreading the knowledge through the whole company and asking for additional solutions.
6. To evaluation the effect and the process by health and safety specialists of the company asked their employees.

In the results, each company bought or made one or more products and tested these in practice. From the tests it appeared that nine solutions were good enough to describe in the ideas book. Good enough means: proven to work in practice, the physical workload is perceived lower by the employee, the ergonomists evaluated the improvement positively and the work is at least as efficient as before.

Pranee Chavalitsaklchai et al., (19) were to investigate physical and psychosocial problems of the female work-forces in four difference workplace in Japan, and to examine the ergonomics intervention practice in the Japanese workplace. The subjects were 80 female workers from four difference workplace: Department store, Computer Company, cosmetic plant and concrete plant. All subjects were interviewed by using questionnaire at their workplace. A questionnaire was designed and divided into 2 parts; the first part was developed from the standardized Nordic Questionnaire for the analysis of the prevalence of musculoskeletal troubles in the difference body regions. The second part was developed from Kiba-Manual for the psychosocial study. Clinical examinations were observed and measured the musculoskeletal system. The observation technique was used during working time for analyzed working postures, and work tasks. They collected information regarding intervention practice at workplaces from the workers, the managements and the responsible government organization. The results showed that female workers had physical problems such as musculoskeletal disorder and psychosocial problems such as stress at work. Ergonomics intervention programs can help to solve of the problems in these workplaces and the principle for ergonomics intervention should start by training course in ergonomics for workers and managers to develop ergonomics awareness.

2.2 Muscular system and Fatigue

2.2.1 The muscle (20, 21)

The muscle is the combine tissue in the body. The human body is able to move because it has widely distributed system of muscles, which together comprise approximately 40% of the body weight. There are three types of muscle; skeletal muscle, cardiac muscle and smooth muscle.

2.2.1.1 The shoulder muscle

The shoulder muscle that position the humerus to vertebrae such as trapezius muscle, deltoid muscle, levator scapulae muscle and serratus anterior.

(1) Trapezius muscle Action (see figure 2.1)

Depends on active region and state of other muscle; may elevate, retract, depress or rotate scapula upward and/or elevate clavicle or extend neck; upper part elevates shoulders; middle part makes scapulars adducted and lower part depressed and rotated scapulars.

Origin: external occipital protuberance, along the medial sides of the superior nuchal line, ligamentum nuchae (surrounding the cervical spinous processes) and spinous processes of C1-T12.

Insertion: posterior, lateral 1/3 of clavicle; medial border of acromion and superior spine of scapula.

Action: elevates scapula, upward rotation of the scapula (upper fibers), downward rotation of the scapula (lower fibers) and retracts scapula.

Blood: transverse cervical artery.

Nerve: spinal Accessory (XI) (efferent or motor fibers) and ventral ramii of C3 & C4 (afferent or sensory fibers).

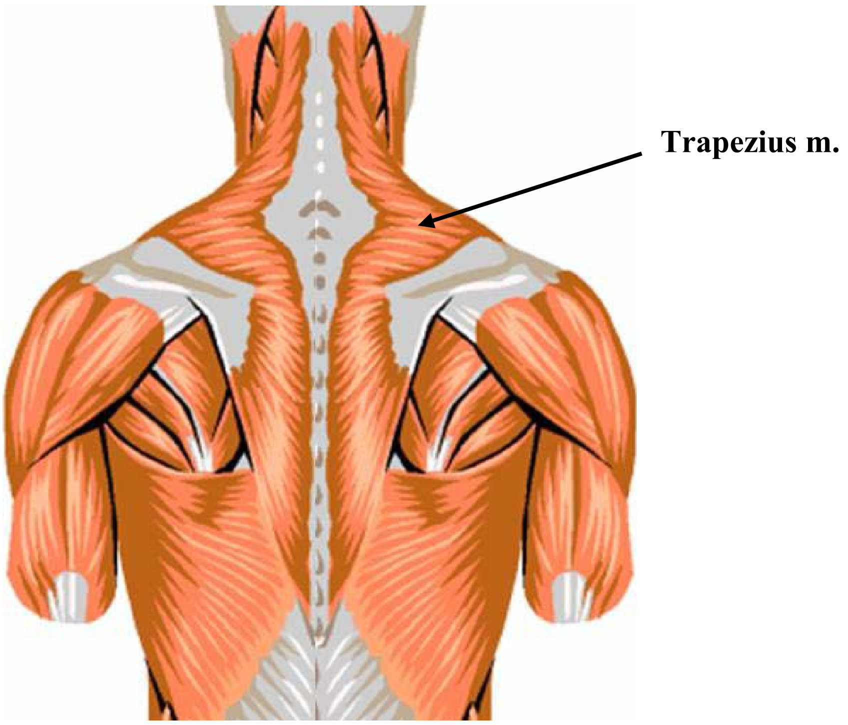


Figure 2.1 The shoulder muscles

2.2.1.2 The leg muscle (see figure 2.2)

The leg muscles consist of 4 parts: gluteal region, thigh, leg and foot. Leg muscles are divided into 3 groups: anterior, lateral and posterior. The anterior groups are tibialis anterior, the peronesus tertius, the extensor digitorum longus, the extensor hallucis longus and the extensor digitorum brevis. The posterior groups are the gastrocnemius, the soleus, the popliteua, the plantaris, the flexor hallucis longus, the flexor digitorum longus and tibialis posterior.

(1) Tibialis anterior muscle

Origin: lateral tibial condyle; proximal 2/3 of anteriolateral surface of tibia; interosseous membrane; and anterior intermuscular septum & crural fascia.

Insertion: medial & plantar surface of base of 1st metatarsal and medial & plantar surface of the cuneiform.

Action: dorsiflex the foot at ankle joint, inverts & adducts the foot and extend the toes.

Blood: anterior tibial artery.

Nerve: deep peroneal nerve, L4, L5, S1.

(2) Gastrocnemius muscle

Origin: medial head: just above medial condyle of femur, and lateral head: just above lateral condyle of femur.

Insertion: calcaneus via lateral portion of calcaneal tendon.

Action: plantar flexion of the foot at ankle joint, knee flexion (when not weight bearing), stabilizes ankle & knee when standing, invert the foot and flex the toes.

Blood: sural branches of popliteal artery, muscular branches of peroneal artery and posterior tibial artery.

Nerve: tibial nerve, S1, S2.

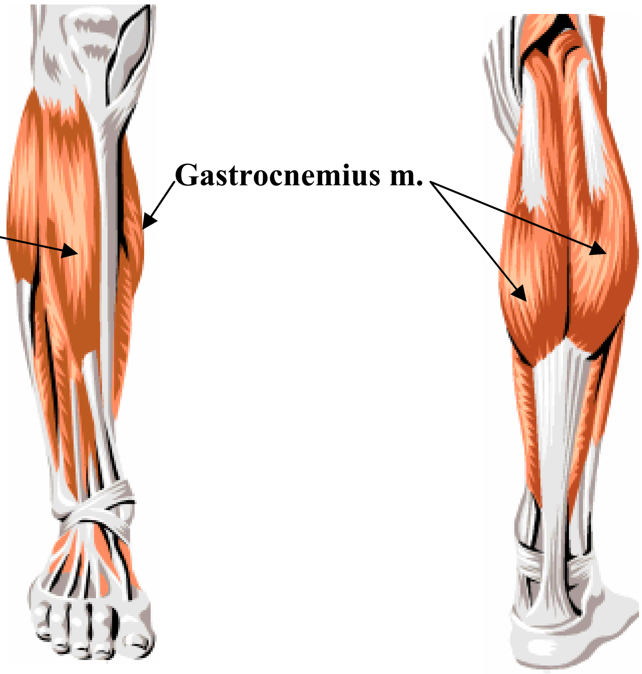


Figure 2.2 Leg and foot muscles

2.2.2 Fatigue

2.2.2.1 Definition of fatigue (31, 32, 33, 34)

Chompusakdi definition of Fatigue is the way define the unusual state or feeling of discomfort. However, the definition of fatigue is still controversial among scientists. Some scientists use the term "Monotony" and other use "Boredom". "Fatigue" is a state that is familiar to all of us in everyday life. The term usually denotes a loss of efficiency a disinclination for any kind of effort, but it is not a single, definite state. Nor does it become clearer if we define it more closely as physical fatigue, mental fatigue, and so on.

Kroemer (1994) mentioned that the term "Fatigue" is operationally defined as a "reduced muscular ability to continue an existing effort,"

Nevertheless, scientific definition of fatigue is the feeling that can be described or expressed of feeling. The feeling may be sometime included the feeling of discomfort or work efficiency decreased and loss more energy.

The physiologist given the meaning of fatigue is the feeling occurred in difference aspects depending on the "stimuli" which there will be resisted all time or sometime. The various researchers try to search the cause of fatigue of work, in the various type of work and try to fine out the scientific evidence confirming the major fatigue. The major causes are the sitting position, work duration, repetitive work which these factors will be the fatigue and the accidents.

2.2.2.2 Type of fatigue

(1) Muscular fatigue

Muscular fatigue is an acutely painful phenomenon, which arises in the overstressed muscles, and is localized there. The muscle is stimulated electrically, causing it to contract and perform physical work by lifting a weight. After several second it is found 3 topics, as follow:

a) The height of lift decrease.
b) Both contraction and relaxation became slower.
c) The latency (interval between stimulation and beginning of the contraction) becomes longer.

The muscular fatigue characteristic is not only reduced the muscular power, but also by slower movement. It can affect to increase error and accident when doing work.

(2) General fatigue

General fatigue is a diffused sensation, which is accompanied by feeling of indolence and disinclination for any kind of activities. And is a feeling of wholly body weariness, feeling like the whole body is inhibited or can not do any activity due to low motivation to attempt or accomplish that activity. General fatigue causes drowsiness, a major fatigue symptom is general sensation of weariness that is not unpleasant, like thirst, hunger and similar sensations, is one of nature's protective devices. Therefore the feeling of fatigue is a sign indicates that the body should stop doing activity and needs to take a rest for recovering. If there is a resting time when after feeling of fatigue, the body will better recover to the normal state.

2.2.2.3 Factors cause to fatigue in workers there were 3 factors, as follow:

(1) Worker factor is the most critical factor causing fatigue. If the worker is unhealthy, it is easy for that unhealthy worker to feel "fatigue". Moreover physiological impacts can also cause fatigue such as a feeling of discouragement, drug

abuse, heavy smoker, gambling and alcoholism. All of these mentioned before are the basic problems for workers.

(2) Family and community factor, such as poor families, having to many children, insufficient to resting time, non-sanitation of housing and environment can also cause fatigue.

(3) Work factor or work conditions consists of job description, working hour, workplace, regulations, security of work and income.

2.2.2.4 Symptoms of fatigue

Fatigue in workers need to be controlled. Since fatigue take a great effect on worker while working. The most important of fatigue symptoms as follow:

(1) Subjective feeling of weariness, somnolence, faintness and distaste of work
(2) Sluggish thinking
(3) Reduced alertness
(4) Poor and slow perception
(5) Unwillingness to work
(6) Decline in both bodily and mental performance

2.2.2.5 Fatigue measurement

There has been no specific method available for measuring of fatigue directly. Mostly are to evaluate the indicators of fatigue. There are 6 critical evaluations to determine fatigue.

(1) Quality and quantity of work performed
(2) Subjective fatigue feeling
(3) Electroencephalography (EEG)
(4) Critical flicker (fusion) frequency (CFF)
(5) Psychomotor test
(6) Mental test

2.2.3 Electromyography (EMG)

2.2.3.1 Introduction

Electromyography (EMG) is an electrical recording of muscle activity that aids in the diagnosis of neuromuscular disease.

Electromyography tests the integrity of the entire motor system, which consists of upper and lower motor neuron, neuromuscular junction and muscle. Further subdivision in each category reveals seven possible sites of involvement that may cause muscle weakness. One must first learn physiologic mechanism underlying normal muscle contraction to understand various abnormalities that characterize disorders of the motor system in each step. Electromyographers must also consider multiple factors that can significantly affect the outcome of recordings. These include the age of patients and the particular properties of the muscle under study, in addition to the electrical specifications of the electrode and recording apparatus, as discussed earlier.

Electromyography serves best if performed as an extension of the physical examination, rather than a laboratory procedure. The clinical symptoms and signs guide the optimal selection of specific muscle groups. An adequate study calls for multiple sampling of each muscle at rest and during different degrees of voluntary contraction. The findings in the initially tested muscles dictate the cause of subsequent exploration. Thus no rigid protocol suffices for routine electromyographic examination. Certain basic principles apply, but a flexible approach best fulfills the needs of individual patients.

Electromyography (EMG) has two types of electrode, surface and indwelling electrodes. The myoelectric signal detected at each electrode site. Both electrodes are usually placed over the muscle and each electrode will detect signals from the active motor units underlying each electrode; this is called a bipolar recording.

In this study EMG measuring used surface electrodes of the ME6000 Biomonitor System, which functions as a collection and recording unit with independent storage capability.

2.2.3.2 Muscle Tester series BIOMONITOR ME6000 (34)

The ME6000 Biomonitor System is intended to be used in field or laboratory environment. By means of electrodes applied directly to the skin, it measures electrical activity (EMG) from three muscles simultaneously. Because impulses produced by muscle fibers are extremely small, accurate amplification is required. Measured data is registered using state-of-the art amplification technology, in which the amplifier is connected directly to the grounding electrode. This very effectively eliminates disturbances, such as those caused by movements.

Measured data is transferred online to a PC for analysis with the aid of specially designed software. MegaWin PC software expands system feature or creating specific protocols for muscular assessment, performing various calculations, obtaining results and producing reports.

The ME6000 Biomonitor System consists of the following: ME6000 8 channel Complete System – measurement device, 4 EMG Preamplifier Cables, Package of surface electrodes, Interface Cable; Device Manual (on CD-ROM), System Case, Memory card (standard 256 MB), 4 batteries 1.5V, AA and MegaWin PC software.

(1) **MegaWin software 700046 version 2.2**

MegaWin is a Window application, which offers comprehensive tool for conducting measurements and analyzing the body muscle activity.

MegaWin is designed to support Mega Electronics' accurate biosignal measuring devices, such as Muscle Tester**.** Using MegaWin the treatment of an individual can be guided, starting from evaluating his condition, going through setting the measuring protocol and performing measurements; and finally – analyzing the data and producing reports. In order to use the ME6000 Biomonitor in PC, the user must be installed MegaWin software on your computer.

2.2.3.3 Electromyography measurement (34)

EMG Measurement is performed by placing electrodes on skin's surface and recording the electrical activity of the muscles underneath. Accurate measuring of muscular electricity requires proper positioning of electrodes for each individual muscle being measured. It is essential to know the main functions of the muscles to be measured as well as their location in the anatomy. The electrodes are fixed in bipolar fashion, with both active electrodes – measuring and ground (reference) – above the muscle. The ground electrode is attached to the snap connector located below the amplifier. To ensure repeatable results, always place the electrodes in the same locations above the muscle.

The ME6000 System is delivered with a package of disposable 'Medicotest Blue Sensor type M-00-S' electrodes, which comply with ANSI / AAMI

EC 12-1991 standard. These electrodes are equipped with snap connectors and are designed to be used in long measurements.

To ensure both dependable measurements and hygiene, it is recommended to use disposable, pre-filled Ag / AgCl electrodes, compatible with ANSI / AAMI EC 12-1991 standard. If you are using non- disposable electrodes, apply suitable gel (the kind that is use for ECG or ultrasound diagnostics) between electrodes and the skin.

If disposable electrodes are in use, make sure that the gel hasn't dried out before you attach them.

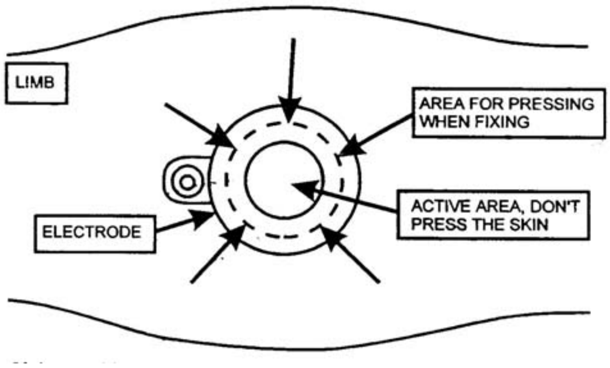


Figure 2.3 Position of electrodes on the surface of the skin above a muscle.

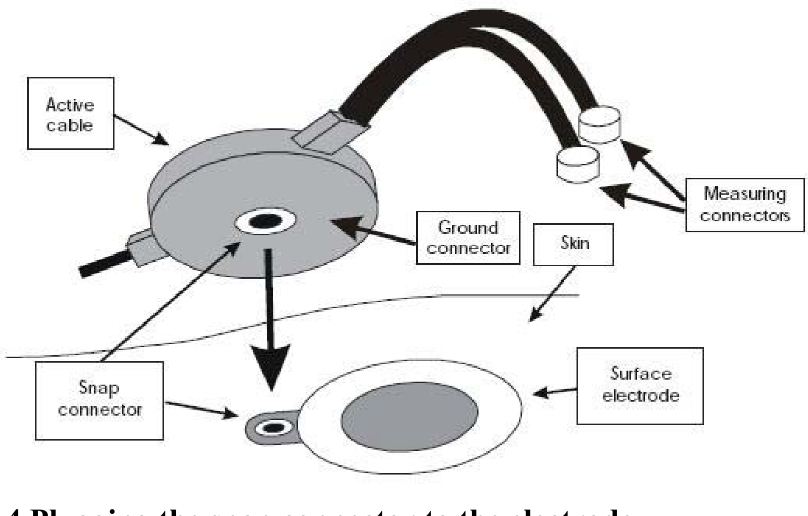


Figure 2.4 Plugging the snap connector to the electrode.

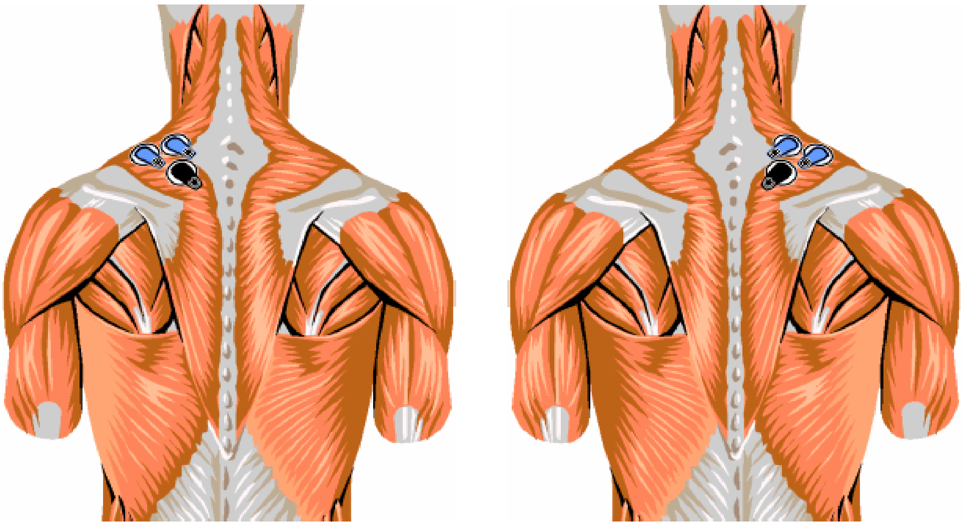


Figure 2.5 Positioning of electrodes on the trapezius muscle

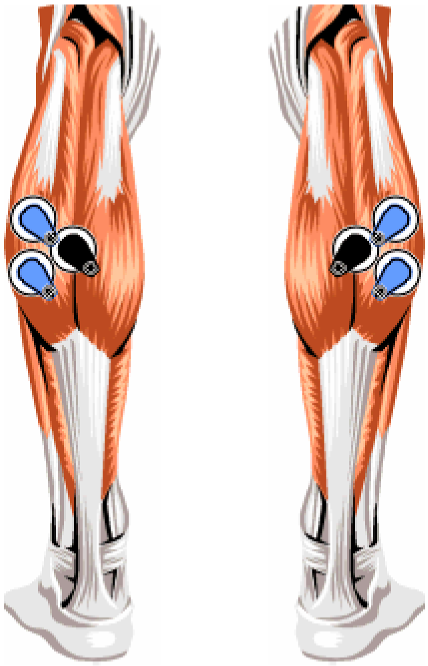


Figure 2.6 Positioning of electrodes on the gastrocnemius muscle

Figure 2.7 Positioning of electrodes on the tibialis anterior muscle

(1) Raw EMG measurement

The raw EMG is measured by using sufficient sampling frequency in bipolar electrodes without integration or full wave rectification. Using FFT (Fast Fourier Transform) analysis, the reduction in the EMG signal frequency composition, can be calculated therefore they also can be applied to neurophysiological investigation.

In the measurement, select component for the protocol as Raw Free component without timings. The measurement monitor displays the raw online measurement data. Raw online measurements values are displayed as continuous graph.

(2) Fatigue analysis

Analysis of the frequency composition of the EMG signal has been found to be useful in neurophysiological studies in evaluation of nervous system diseases. The phenomenon of muscular fatigue and its physiological background makes possible the objective evaluation of muscular fitness and rate of fatigue by using EMG frequency analysis. During muscular exertion, intracellular acidification occurs as result of the production of energy and as a consequence of deficient oxygen. As a result of the acidification conductivity of the muscle cell membrane decreases, generation of the action potential slows and arrival of the nerve impulse the muscle cell is inhibited. Fatigue test is used in raw measurement for analyzing the muscle duration and fatigue.

EMG study

Yves Roquelaure et al., (18) were studied to assess the musculoskeletal load on the hand-wrist system during pruning with the new model of hand-powered pruning shears in the comparison with standard pruning shears. The subjects were 4 healthy, right hand and experienced male winegrowers. Surface electromyography of the finger flexor and wrist postures were analyzed in 4 vineyard workers during actual work with the new and reference hand-powered pruning shears. The results demonstrated the mean cutting rate did not differ between pruning shears for all subjects. The mean sEMG activity was not statistically significant differ between the two types of pruning shears.

Hakan Sporrng and other (36) was carried out to map the muscular engagement and postures of construction workers undertaking ceiling fitting, and to compare the results to those of laboratory studies. Two ambulatory devices were used, one allowing recording of electromyographic (EMG) signal bilaterally from the trapezius muscle, and the other to record the position of both arms and back by means of measuring the angle between the vertical line and the back and both upper arms. The subjects were 16 construction workers. These recording were performed during 1.5-2 h work sequences. It was conducted that the exposure of construction workers undertaking ceiling fitting meets the criteria formulated on the basis laboratory experiments with respect to a high risk of acquiring chronic shoulder pain, due to rotator cuff tendonitis.

Monica Mortimer and other (35) was to validate interview data concerning the duration of four work postures (1) sitting, (2) standing/walking with hands above shoulder level, (3) standing/walking with hands between shoulder and knuckle level, and (4) standing/walking with hands below knuckle level. The most common methods used for quantifying exposure in epidemiological studies are (1) questionnaires (2) observation methods and (3) direct measurements. The self-reported time spent in each posture was tested in relation to observations and technical measurement in 20 subjects during two full working days. The linear relationships between self-reports and observations were strong for the three postures; sitting, standing/walking with hands above shoulder level and standing/walking with hands below knuckle level. Thus, using this interview technique, self-reports concerning time spent may be accurate enough for studying these work postures in epidemiological studies.

Tony Brace (37) was found that pushing and pulling activities can place hazardous levels of compressive force on the discs of the low back when exertions are performed between the hips and the knees. The amount of exertion and subsequent musculoskeletal risk faced by employees engaged in push and pull activities related to physical factors such as friction wheel properties, load weight, and postural considerations, such as handle height, torso position, foot position, and the distance and frequency load is moved. The researcher using the Liberty Mutual Manual materials Handling Tables as guidelines for pushing and pulling can help identify when tasks may put individuals at greater risk for musculoskeletal disorders.

Ryan G.A. (38) studied the incidence of muscle discomfort and pain in supermarket departments, that the checkout area had a high incidence of lower extremity discomfort and pain. Symptom had occurred neck, upper back, shoulder and hand. The causation of muscular fatigue was standing posture.

2.3 Workstation design of Grocery cashiers (14, 22, 34)

2.3.1 Workstation design

Workstation refers to the establishment, office, warehouse, motorcar or various area. So, the place need design the character of worker, equipment and related machines, including the job description and their environments. All components will effect the work efficiency both the physical and mental components. The design should focus on the workers which work in good position, convenience and efficiency.

The key to comfort is maintaining the body in relaxed, neutral position. The ideal work position is to have the arms hanging relaxed from the shoulders. The workstation environment and the way task is performed can influence the risk of injury and general work productivity.

Workstation study

Viren M. Victor, Saswati Nath, Ajay Verma (23) was to surveyed the anthropometric of male agricultural farm workers of Chhattisgarh region as a reference for the ergonomic considerations, while going for design and developing tools, implements and machinery. This survey has also been compare with available data of other regions. Nine measurements included body weight, stature, chest circumference, bideltoid breadth, arm length, sitting height, popliteal height (sitting), buttock popliteal length, hip breadth (standing) were selected from a farm machinery design point of view. The results showed that the Indians (Chhattisgarh region) are smaller than western people. The other body dimensions were also found lower than the western people except popliteal height (sitting) and buttock popliteal length in which Indians have the higher value of body dimensions. Thus, for designing of a farm equipments and tools for Indians, the western anthropometric data will not be appropriate and also the imported farm equipments and tools which were designed considering the anthropometric data of western people would not be suitable. This survey set out to assist the development of more appropriately designed equipments, tools and agricultural machinery.

Karin Garmer, Lena Sperling, Anette Forsberg (24) was studied deals with the design, use and evaluation of a hand-ergonomics training kit for use in ergonomics training programs. The effect on awareness of hand ergonomics among training course participants have been evaluated by means of questionnaire and interviews at a car production plant in Sweden. The evaluation was carried out about one and a half years after training with the hand-ergonomics training kit consist of a guide to practical exercises, equipment for measuring hand size and strength, examples of hand tools for use in practical exercises, equipment for testing and valuating the hand tools and checklists and judgement forms for qualitative evaluation. In addition, the kit contains relevant scientifically based reference reports and hand-ergonomics. The evaluation showed that the practical exercises with hand-ergonomics training kit had to remarkable extent increased individuals awareness of anthropometric differences and of the importance of ergonomically well-designed hand tools. After the practical exercises with training kit communication within the plant when choosing hand tools seem to be based on objective criteria to higher degree.

2.3.2 Grocery cashiers (28)

Pain, numbness, burning, or tingling in the hands, wrists, elbows, shoulders, back or legs, affect many grocery cashiers. These symptoms may be related to your job. Symptoms may be start gradually. Many people try to ignore them at first. However, if you ignore them, symptoms can get worse and became harder to treat.

Symptoms may occur at night, but still be work-related. Even if the symptoms go away during vacation, or on your days off, it doesn't necessarily mean the condition is gone. Inform your employer and get medical care right away if you have symptoms. These symptoms may indicate serious injuries and interfere with your work and personal activities. They can even lead to permanent disability.

2.3.2.1 Injuries prevention

(1) Provide workstations designed to prevent injury. Consider these recommended features:

a) Front-facing checkstands that balance the workload between both hands. Other designs can be converted easily to front-facing.
b) In-feed and take-away conveyor belts places as close as possible to the cashier to keep reaches to 18 inches or less.
c) Scanner close to cashiers with surfaces that promote "scan and slide" motions instead of lifting items over the scanner. Keep scanner windows clean and replace glass when excessively scratched.
d) Scanner-scale combinations or scales next to scanners flush with scanner tops.
e) Adjustable keyboard mounting.
f) Visual displays that cashiers can see without twisting.
g) Printers located in front of cashiers or within easy reach.
h) Cash drawers within an 18-inch reach distance.
i) Adjustable-height bag stands.
j) Foot rests or foot rails.
k) Anti-fatigue mats with beveled edges (for safety). Replace mats as needed.

l) Adjustable sit/stands or lumbar supports for cashiers to lean against.

(2) Inspect workstations regularly and provide maintenance as needed.

(3) Provide training that includes demonstrations on safe work procedures.

(4) Rest your body. Take tiny breaks during lag times. Take scheduled breaks.

(5) Provide training on the causes of injuries and early symptoms.

2.4 OSHA's Ergonomics for the Prevention of Musculoskeletal Disorders: Guidelines for Retail Grocery Stores; OSHA 3192-06N, 2004 (29)

OSHA's Guidelines provide practical recommendation to help grocery store employers and employees reduce the number and severity of injures in their workplaces. Many of the work related injuries and illnesses experienced by grocery store workers and musculoskeletal disorders (MSDs), such as back injuries and sprains or strains that may develop from various factors, including lifting, repetitive motion disorders such as carpal tunnel syndrome, or injuries resulting from overexertion.

These guidelines are intended only for retail grocery stores and combined full-line supermarket and discount merchandisers including warehouse retail establishments. The discussion is intended primarily for grocery store managers and store employees, but may also be useful for corporate managers or corporate safety professionals. OSHA did not develop these guidelines to address warehouses, convenience stores, or business operations that may be located within grocery stores, such as banks, post offices, or coffee shops. However, operations in retail or distribution that involve similar tasks or operations as those addressed in these guidelines may find the information useful.

The information in these guidelines provides grocery stores with effective approaches, as well as useful references to be used when determining the need for ergonomic solutions. The recommendations and information presented here are intended as a general guideline and flexible framework to be adapted to the needs and resources of each individual store.

Many grocery store workers handle thousands of items each day to stock shelves, check groceries, decorate bakery items, and prepare meat products. These tasks involve several ergonomic risk factors. The most important of these include force, repetition, awkward posture, and static postures

In the grocery store industry, the presence of these risk factors increases the potential for injuries and illnesses. In these guidelines, OSHA uses the term musculoskeletal disorders (MSDs) to refer to a variety of injuries and illnesses, including: muscle strains and back injuries that occur from repeated use or overexertion; tendinitis; carpal tunnel syndrome; rotator cuff injuries (a shoulder problem); epicondylitis (an elbow problem); and trigger finger that occurs from repeated use of a single finger.

These guidelines present recommendations for changing equipment, workstation design, or work methods with the goal of reducing work-related MSDs. Many ergonomic changes result in increased efficiency by reducing the time needed to perform a task. Many grocery stores that have already instituted programs have reported reduced MSDs, reduced workers' compensation costs, and improved efficiency.

2.4.1 A Process for Protecting Workers

Store and company management personnel should consider the general steps discussed below when establishing and implementing an ergonomics program. It should be noted, however, that each store will have different needs and limitations that should be considered when identifying and correcting workplace problems. Different stores may implement different types of programs and activities and may assign different staff to accomplish the goals of the ergonomics program.

2.4.1.1 Provide Management Support

Management support for reducing MSDs and communicating support to employees is very important. You have already demonstrated your interest in reducing MSDs by reading these voluntary guidelines. Management support improves the grocery store's ability to maintain a sustained effort, allocate needed resources, and follow up on program implementation. OSHA recommends that employers:

a) Develop clear goals,
b) Express the company's commitment to achieving them,

c) Assign responsibilities (training, job analysis, etc.) to designated staff members to achieve those goals,

d) Ensure that assigned responsibilities are fulfilled, and

e) Provide appropriate resources.

Meaningful efforts by management also improve employee participation, which is another essential element for achieving success.

2.4.1.2 Involve Employees

Employees are a vital source of information about hazards in their workplace. Employees help identify hazards and solve problems. Their involvement can enhance job satisfaction, motivation, and acceptance of workplace changes. There are many different ways employers can involve employees in their ergonomics efforts, including the following:

a) Submit suggestions and concerns;

b) Identify and report tasks that are difficult to perform;

c) Discuss work methods;

d) Provide input in the design of workstations, equipment, procedures and training;

e) Help evaluate equipment;

f) Respond to surveys and questionnaires;

g) Report injuries as soon as they occur;

h) Participate fully in MSD case investigations; and

i) Participate in task groups with responsibility for ergonomics.

2.4.1.3 Identify Problems

It is important to periodically review your job site and the activities of employees to identify possible ergonomic issues. This could include a review of OSHA 300 and 301 injury and illness information, workers' compensation records and employee reports of problems.

You can also identify ergonomic issues by talking with employees and walking through the grocery store to observe employees performing their jobs. When reviewing the various jobs in the grocery store, pay particular attention to the risk factors listed below.

Force --	the amount of physical effort required to perform a task (such as Heavy lifting, pushing or pulling), handle merchandise, or maintain control of equipment or tools;
Repetition --	performing the same motion or series of motions continually or frequently for an extended period of time;
Awkward and static postures --	assuming positions that place stress on the body, such as prolonged or repetitive reaching above shoulder height, kneeling, squatting, leaning over a counter, using a knife with wrists bent, or twisting the torso while lifting; and
Contact stress --	pressing the body or part of the body (such as the hand) against hard or sharp edges, or using the hand as a hammer.

However, the presence of risk factors in a job does not necessarily mean that employees will develop an MSD. Whether certain work activities put an employee at risk of injury depends on the duration (how long), frequency (how often), and magnitude (how intense) of the employee's exposure to the risk factors in the activity. For example, performing cashier work for an extended period of time without a break has been associated with increased hand and wrist problems and could contribute to back and lower limb problems.

2.4.1.4 Implement Solutions

Examples of potential solutions for various concerns are located in the Implementing Solutions section of these guidelines. Store managers or other designated individuals should establish a procedure for receiving reports of injuries and responding to them appropriately. Early intervention is an effective method of handling potential injuries. Employees should report injuries early so that action can be taken to address any potential job-related issues. These reports can help the retail grocery store identify problem areas and evaluate ergonomic efforts.

2.4.1.5 Checklist for Identifying Potential Ergonomics Risk Factors by Workplace Activity

If the answer to any of the following questions is **yes**, the activity should be further reviewed.

(1) Force in Lifting

- Does the lift involve pinching to hold the object?
- Is heavy lifting done with one hand?
- Are very heavy items lifted without the assistance of a mechanical device?
- Are heavy items lifted while bending over, reaching above shoulder height, or twisting?
- Are most items lifted rather than slid over the scanner?

(2) Repetitive Tasks

- Are multiple scans needed?
- Is a quick wrist motion used while scanning?
- Do repetitive motions last for several hours without a break (e.g., slicing deli meats, scanning groceries)?
- Does the job require repeated finger force (e.g., kneading bread, squeezing frosting, using pricing gun)?

(3) Awkward and Static Postures?

- Is the back bent or twisted while lifting or holding heavy items?
- Are objects lifted out of or put into cramped spaces?
- Do routine tasks involve leaning, bending forward, kneeling or squatting?
- Do routine tasks involve working with the wrists in a bent or twisted position?
- Are routine tasks done with the hands below the waist or above the shoulders?
- Are routine tasks done behind (e.g., pushing items to bagging) or to the sides of the body?
- Does the job require standing for most of the shift without anti-fatigue mats?

- Do employees work with their arms or hands in the same position for long periods of time without changing positions or resting?

(4) Contact Stress

- Are there sharp or hard edges with which the worker may come into contact?

2.4.1.6 Checklist for Identifying Potential Job-Specific Ergonomics Concerns

If the answer to any of the following questions is no, the activity may be a potential source of ergonomic concern, depending on the duration, frequency, and magnitude of the activity.

Cashiering

- Are items within easy reach?
- Are keyboard supports adjustable?
- Can the cashier work with items at about elbow height?
- Can the display be read without twisting?
- Are all edges smoothed or rounded so the cashier does not come into contact with sharp or hard edges?
- Are objects easily scanned the first time?
- Are objects scanned without twisting hand motions?
- Can cashiers scan heavy/bulky/awkward items without lifting them?
- Are the scale, conveyor, and horizontal scanner plates all the same height?
- Is the scanner plate clean and unscratched?
- Does the cashier have an anti-fatigue mat and/or footrest?

2.4.2 STOREWIDE ERGONOMIC SOLUTIONS

This section describes storewide ergonomic principles on safe work practices employees can follow to reduce their risk of injury. Employers should train employees to use these techniques and design stores to make it easy to do so.

2.4.2.1 Power Grips

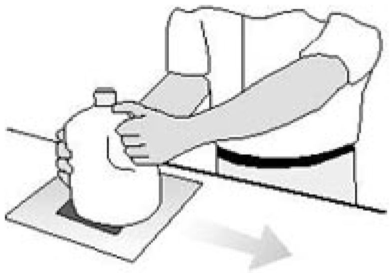
A power grip uses the muscles of the hand and forearm effectively, and is less stressful than a pinch grasp. Consequently, a one- or two-handed power grip should be used whenever possible.

A power grip can be described as wrapping all the fingers and the thumb around the object that is being gripped. It is sometimes described as making a fist around the object being gripped.

The power grip can be used for many items, including bags, cans and small boxes.

2.4.2.2 Power Lifts

When the item to be grasped is too heavy or bulky to lift with a one-hand power grip, use the two-hand power grip.



2.4.2.3 Pinch Grasps

A pinch grasp should never be used when a power grip can be used instead. However, a pinch grasp is acceptable for small, light items (e.g., a pack of gum, etc.)

2.4.2.4 Recommended Working Postures

Recommended Working Postures describe body positions that are neutral and comfortable to use. Using postures other than those recommended will generally waste energy and motion as well as potentially raise the risk of injury. It's also important to change position frequently and stretch between tasks. This improves circulation and lessens fatigue.

(1) Head and Neck

- Avoid situations that require twisting the neck or bending it forward, backward or to the side.

(2) Shoulders and Arms

- Keep the shoulder relaxed-not "shrugged-up" or "slumped-down."
- Keep your elbows close to your body.
- Keep work at about elbows height.

(3) Hands and Wrists

- Keep the hands straight and in line with the forearms - avoid twisting hands.
- Avoid working with wrists pressed against sharp or hard edges.

(4) Back

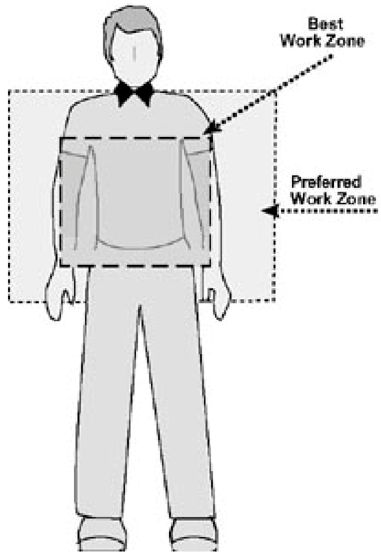
- Stand straight - avoid situations that require bending (forward or backward), leaning to the side or twisting.
- A sit/stand stool will allow for changes in posture.
- For work performed while sitting, a back rest will help maintain proper posture.

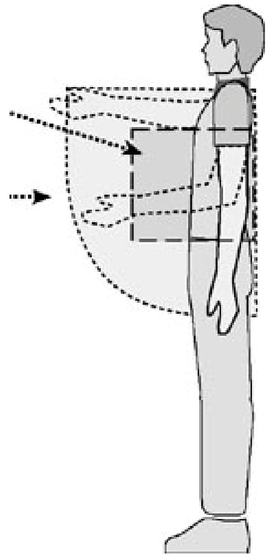
(5) Feet and Legs

- Placing a foot on a foot rest or other support twisting will promote comfort.
- Provide toe space to changes in posture. Allow workers to stand closer to counters. This can reduce reaching.
- Good quality anti-fatigue mats reduce back and leg fatigue.

2.4.2.5 Best and Preferred Work Zones

Performing work within the best and preferred work zones shown below facilitates productivity and comfort. Work is safest when lifting and reaching is performed in these zones. Working outside these work zones results in non-neutral postures that may increase the risk of injury. It is particularly important to perform heavy lifting tasks within the best work zone.





Best Work Zone

- As far forward as your wrist when you hold your arm slightly bent.
- As wide as the shoulders.
- Upper level at about heart height.
- Lower level at about waist height.

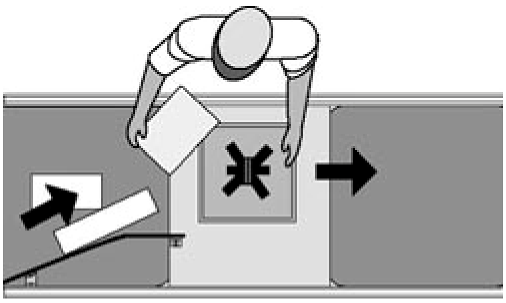
Preferred Work Zone

- As far forward as your hand when you your arm out straight.
- A foot on either side of the shoulders.
- Upper level at shoulder height.
- Lower level at tip of fingers with hands at the side.

2.4.3 Front End (Checkout, Bagging and Carry Out)

2.4.3.1 Use a powered in-feed conveyor to help cashiers bring the items to their best work zone, rather than leaning and reaching to get items further up the conveyor.

2.4.3.2 Use a "sweeper" to move items on the conveyor within the checker's reach.



2.4.3.3 Locate commonly used items such as the cash drawer and printer within easy horizontal reach.

2.4.3.4 Place in-feed and take-away conveyor belts as close as possible to the cashier to minimize reaching.

2.4.3.5 Consider using check stands designed with an adjustable sit/stand Or lumbar support against which cashiers can lean.

2.4.3.6 Remove, round-off, or pad sharp or hard edges with which the cashier may come into contact.

2.4.3.7 Provide adequate toe space (at least 4 inches) at the bottom of the workstation. Toe space allows cashiers to move closer to the check stand, decreasing reaching requirements.

2.4.3.8 Use footrests and anti-fatigue mats in areas where workers stand for prolonged periods. Standing on anti-fatigue mats, as compared to bare floors, provides a noticeable improvement in comfort.

2.4.3.9 Place the conveyor belt electronic eye close to the scanner, but allow sufficient area between the eye and the scanner to orient items and to ensure the belt does not push items into the scanning field.

2.4.3.10 Perform work within the preferred work zone.

2.4.3.11 Consider using keyboards to enter the quantity of identical products rather than scanning each individual item.

2.4.3.12 Use keyboard to enter code if item fails to scan after second attempt.

2.4.3.13 Place keyboards on supports that adjust in height, horizontal distance and tilt to keep work within the preferred work zone.

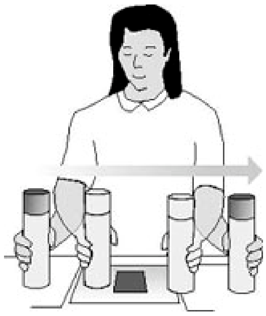
2.4.3.14 Use front facing check stands to reduce twisting motions and extended reaches to the side.

2.4.3.15 Adjust the check stand height to match the cashier's waist height, or use a platform.

2.4.3.16 Place cash register displays at or slightly below eye level.

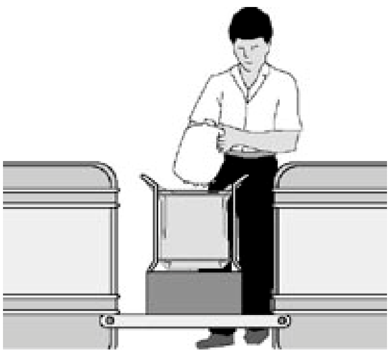
2.4.3.17 Use scan cards or scan guns for large or bulky items to eliminate the need to handle them.

2.4.3.18 Set scanners and conveyors at the same height so that cashiers can slide items across rather than lift them.



2.4.3.19 Establish a regular maintenance schedule for scanners; clean dirty plates and replace scratched ones.

2.4.3.20 Use combined scales/scanners.



2.4.3.21 Provide an adjustable-height bag stand. In bagging areas, the tops of plastic bags should be just below conveyor height.

2.4.3.22 To avoid extended reaches when loading bags into carts, move carts closer to the employee.

2.4.3.23 Use bags with handles. Handles make the bags easier and less stressful to carry.

2.4.3.24 Use carts to carry bags and groceries outside the store.

2.4.3.25 Consider using powered-tugs when retrieving carts from the parking area. Powered tugs facilitate moving more carts with more efficiency and less effort.

2.5 Work study of the retailed cashiers (39)

2.5.1 Definition of work study

Work study is a term used to refer inclusively to all the techniques of method study and work measurements which are employed to ensure the best possible use of human and material resources in performing a specific activity or job. International Labour Organization state that work study is the systematic examination of the methods of carrying on activities so as to improve the effective used of resources and to set up standards of performance for the activities being carried out.

2.5.2 Types and procedures of work study techniques

Work study comprises three techniques according to nature and the purpose of the studied work. Three techniques are method study or motion study, work measurement and job evaluation.

2.5.2.1 Method study or motion study

Method study or motion study is a systematic study of work system to find out how work should be done or it is systematic recording, analysis and critical examination of existing and proposed way of doing work, and also it is a systematic way for the development and application of easier and more effective method.

2.5.2.2 Work measurement

Work measurement is also a systematic study of work system involving finding out for how long and how hard people have to do a job. In other words, it is the application of techniques designed to establish the work content of a specific task by determining the time require for carrying it out at a predefined standard of performance by a qualified worker; or it is the application of techniques designed to establish the time for qualified worker to carry out a specific job at a predefined level of performance. The work measurement is one of the best ways in determining the actual manufacturing costs, improving planning, and determining machinery and labor requirements.

2.5.2.3 Job evaluation

Job evaluation is the method of finding out how much work is worth when it is done at its lowest acceptable standard of quantity and quality, in terms of the mental and physical demands of work. In addition, it is a systematic appraisal of the work of a particular job related to all other jobs in the agency or it is a prerequisite for fair salary structure and effective career ladders.

2.5.3 Retail

The varying characteristics of cashier workstations are concern in the retail trades. The appropriate workstations design to accommodate physical and visual requirements when using conveyers, scanners, registers, bag units and cash drawers. Other factor being evaluated include the force requirements when moving trolleys and bagged products, floor surface requirements to minimize friction and fatigue, and the relationships between shiftwork and fatigue, and processing speeds and cognitive consequences, including mental workload and error.

Work study

Ashraf A. Shikdar, Biman Das (40) was to determine the manner by which production standards or goals, performance or production feedback and monetary or wage incentive affected or moderated the relationship between worker satisfaction and productivity in a repetitive industrial task in a fishing industry. The industrial study was conducted to measure worker satisfaction and productivity under various experimental conditions involving production standards, performance feedback and monetary incentive. Forty-eight industrial operators from among the regular employees, were selected on voluntary basis as subjects for experimental research. The positive correlation coefficient (0.87) for this condition was found to be highly significant. The incorporation of production standards, performance feedback and monetary incentive affected worker satisfaction and productivity differently and this had an effect on the worker satisfaction-productivity relationship. In an earlier laboratory study, no significant worker satisfaction-productivity relationship was found when subjects (college students) were provided with similar experimental conditions.

2.6 The Nordic Questionnaire (32)

Nordic Questionnaire is well structured and requires forced, binary or multiple-choice answers. It consist of two parts, one asking for general information, the other specifically focusing on low back, neck, and shoulder regions. The general section uses a sketch of the human body, seen from behind, divided into nine regions. The interviewee indicates if there are any musculoskeletal symptoms in these areas.

A specific section of the Nordic Questionnaire concentrates on body areas in which musculoskeletal symptoms are most common, such as the neck and the low back areas. The questions probe deeply with respect to the nature of complaints, their duration, and their prevalence. A modification of the test for use in United States has been develop by Chaffin and Andersson (1991); further change may be advantageous to check on particular conditions. Yet, adherence to the "Nordic Questionnaire" provides internationally standardized information.

CHAPTR III
MATERIALS AND METHOD

3.1 Study design

This study was quasi-experiment study. The design was applied to the same subjects group as design and non-design workstation. The purpose of this study is to comparison of muscular fatigue, total scan item quantity and the average pieces per time from working at OSHA's guidelines designed workstation and non-OSHA's guidelines designed workstation. The subjects group was twice measured while working at both workstations. The muscular fatigue was evaluated by questionnaire and electromyography. The different of muscular fatigue while the subjects were working on both workstations was determined by t-test, statistical significant with 95% of confidence interval (P-value < 0.05).

3.2 Population and Samples

3.2.1 Population

The populations were the fifty-seven cashiers which work the payment point of retail store at Saraburi Branch. Population characteristic was evaluated general information by using the questionnaire.

3.2.2 Samples

The samples were ten female retail store cashiers who have at least six months of experience in cashier. They are healthy and strong, no personal disease, or illness and no history of muscular and bone disease and no menstruation. They were required to be well rested before the study (at least 7 hours). All subjects are voluntary participated in this study.

3.3 Material and Equipments

Subjective evaluation, total scan items, and median frequency of EMG were test, respectively, during working.

3.3.1 Muscular Fatigue Questionnaire

The Muscular Fatigue questionnaire was used to evaluate fatigue feeling of the cashiers. Muscular Fatigue questionnaire was a modification of the standardized Nordic questionnaire. This questionnaire is divided into 3 parts.

Part I: The general questionnaire used for asking the general information such as age, weight, height and health statue.

Part II: Working questionnaire used for asking working information such as working experience, workstation and work environmental.

Part III: Muscular fatigue questionnaire used for evaluating prevalence of muscular fatigue in the part six months.

The cashiers at Saraburi Branch were made prior to field-testing of questionnaire. This questionnaire used to screen the subjects. (See appendix A)

3.3.2 Body mass index (BMI)

3.3.2.1 Weighting measured (kilogram)

3.3.2.2 Heightens measures (meter)

BMI = Weight (kilogram) /Height (m^2)

3.3.3 Study of work characteristic and time motion study.

3.3.1.1 A video camera use for record the cashiers while working at both workstations and used take photos of the equipment and working postures.

3.3.1.2 A stop clock use for record working time. (See appendix B)

3.3.4 Workstation

The cashier's position is shifted to the right to improve reach on the product conveyor. Additionally, a deflector is provided to reduce the extreme reach conditions. The width of laser scanner is adjusted to make sure that the bag handling area is within the reach of cashier. The depth of deflector, the distance of cashier should be moved, and the width of the scanner depend on the reach capability of cashier. The work area for the hands at elbow height is about 20-30 centimeters in front of the body at forearm distance.

3.3.4.1 OSHA's guidelines designed workstation is the front–end checkstand that are being used regularly in cashier work. (See appendix C)

(1) Working surface: 58 x 298 x 86 centimeters.

(2) Use a powered in-feed conveyor to help cashier bring the items to their best work zone.

(3) Conveyor is appropriate for the input surface to make large enough for the next customer to put the goods into position on the conveyor while the first customer's goods are being registered, without any risk of confusion between the two batches. Goods are located outside the cashier's work zone, electrical control from within the work zone is appropriate.

(4) Use a "sweeper" to move items on the conveyor.

(5) Set scanners and conveyors at the same height so that cashiers can slide items across rather than lift them.

(6) Provide an adjustable-height bag stand. In bagging areas, the tops of plastic bags should be just below conveyor height.

3.4.2.2 Non-OSHA's guidelines designed workstation is the front-end checkstand that are being used regularly in cashier work. (See appendix C)

(1) Dimension of table: 58 x 150 x 86 centimeters.

(2) Not use a powered in-feed conveyor. Working surface is appropriate for one customer to put the goods.

(3) Provide a height bag stand. In bagging areas, the tops of plastic bags should be just below table height.

3.3.5 Electromyography

The electromyography was used to record the muscular fatigue of the body such as shoulder muscle (Trapezius muscle), leg muscle (Gastrocnemius muscle) and feet muscle (Tibialis anterior muscle). The myoelectric activity was obtained by surface electrodes. Electromyography (Muscle Tester series BIOMONITOR ME 6000, Mega Electronic Ltd., Finland) has measurement device (ME 6000 Menus), eight channels electrodes (4 EMG preamplifier cables), disposable Ag/AgCl surface electrodes (Medicotest Blue Sensor type M-00-S") and 256 MB Memory card. (See appendix C)

3.4 Data Collection

This study was divided into two steps, as follows:

3.4.1 Preparation step

3.4.1.1 Studied the details of OSHA's guideline design workstation.

3.4.1.2 Studied the Muscle Tester series BIOMONITOR ME 6000 manual for measurement surface EMG signals intended for assessment and evaluation of muscle fatigue.

3.4.1.3 Collected population data such as the number of retail store cashiers which work at the front-end checkstand in Saraburi Branch, age, gender, weight, height, body mass index, health status, work experiences, prevalence of muscular fatigue by using the questionnaires.

3.4.1.4 Observed and recorded working data, as follows:

(1) Working procedure, working posture, working time an quantity scan items.

(2) Time motion study by counting the time, to calculated time standard in each workstation.

(3) Working environmental such as temperature, light, humidity and ventilation.

3.4.1.5 The subject selection criteria were female, worked experience, and health status. They were 10 female retail store cashiers who were voluntarily participated in this study. They have at least six months of experience in cashier. They are healthy and strong, no personal disease, or illness and no history of muscular and bone disease and no menstruation. They took rest before starting experimental at least 7 hours.

3.4.1.6 Prepared subject before measurement. All of the subjects were clearly informed about the study objective and methodology of experiment in order to prepare themselves before measurement and willing to participate in this study. The requirements are that the subjects take rest before starting experimental at least 7 hours, did not have fatigue and menstruation period during experimental day. If these requirements were not met, the measurement would be postponed until when they are ready.

3.4.2 Process step

3.4.2.1 The subjects have been interviewed by using questionnaire, while working at both the OSHA's guidelines workstation and the non-OSHA's guidelines workstation.

3.4.2.2 Surface electrodes at the left and right trapezius muscle, left and right gastrocnemius muscle, left and right tibialis anterior muscle of cashier that worked at the OSHA's guidelines workstation and the non-OSHA's guidelines workstation, measurement process were being described as follows:

(1) Skin was cleaned with 70% alcohol.

(2) Surface electrodes were attached on the subject's skin above the muscle. (See appendix C)

(3) The electrodes are fixed in bipolar with active electrodes measuring and ground electrodes was attached about 10 centimeters away from measuring electrodes.

(4) Surface electrode of left and right trapezius muscle, left and right gastrocnemius muscle and left and right tibialis anterior muscle were connected to channel 1, 2, 3, 4, 5 and 6 respectively of electromyography.

3.4.2.3 The measurement unit, ME6000 Menus was used to record muscle activity left and right trapezius muscle, left and right gastrocnemius muscle and left and right tibialis anterior muscle in Raw EMG signal by continuous measurement throughout 30 seconds

3.4.2.4 The subjects were measured muscular fatigue by using median frequency (MF) of EMG, repeatedly while working at OSHA's guidelines workstation and the non-OSHA's guidelines workstation by using the Muscle Tester series BIOMONITOR ME6000.

3.4.2.5 The data was collected during 4 working hours by every half hour. That data is analyzed by using FFT-individual spectrum analysis program. Raw data is analyzed as median frequency (MF) by Mega Win software 700046 version 2.2.

3.4.2.6 Recorded working posture, working hour, equipment by camera while cashiers working at both workstations.

3.4.2.7 Recorded the frequency of cashiers scanned and bagged per half hour while cashiers working at both workstation. (See appendix B)

3.4.2.8 Calibration

The ME6000 calibration protocol must be a raw measurement. On-line measurement is recommended. The purpose of calibration is to produce new Factor and Raw offset values into channel's Devices- signal-channel window in the system setup.

(1) Open the calibration measurement data to Veiw window.
(2) Select Cursor and move it using Previous marker or Next marker buttons to the known MINIMUM level on the channel to be calibrated. If there is not a marker at that site then press the space key to lock the cursor.
(3) Click the Freeze Cursor button, in the Freeze channels pop-up select the channels you wish to calibrate and click OK.
(4) The Statistics window appears. Unlock the differential cursor using the space key and move it to the known MAXIMUM level of the channel. If there is not a marker at that site, then press the space key again to lock the cursor.
(5) Double-click the box of the Y-dif value for the channel to be calibrated to open the Calibration window.
(6) The Y-min and Y-max fields are displaying the minimum and maximum levels. Types the actual signal values in Actual Y-min and Y-max field. Check set zero.
(7) Set zero must be checked.
(8) Click calibrate to make the calibration. The new values are set in the channel's Devices- signal- channel window in the system setup. The new value will be set in all configurations for similar device-in the calibrated channel which has the same signal attached.
(9) By using cursor you can check, if the Actual Y-min and Y-max data points have got new, correct values.
(10) Close Cursor.

(11) Repeat steps 2-10 until all needed signals are calibrated.

(12) Check the new values in the channel's Devices- signal- channel window in the system setup. If the Factor and Raw offset values has been changed it indicates that calibration has been successful.

3.4.2.9 Analysis and compare of result among the muscular fatigue, satisfaction level of workstation, work satisfaction, average working time scanned items both OSHA's guidelines and non-OSHA's guidelines workstation.

3.5 Statistical analysis (41, 42)

The "SPSS 9.0 for Windows" software program was used for the statistical analysis.

3.5.1 Descriptive statistics

3.5.1.1 Percentage

(1) Physical health status

(2) Working data

(3) Muscular fatigue data

3.5.1.2 Mean and standard deviation.

(1) General information

(2) Muscular fatigue data.

3.5.2 Inferential statistics

The level of significance was set at 5% for all analyses.

3.5.2.1 Student t-test

(1) To compare the median frequency (MF) of left and right trapezius muscle, left and right gastrocnemius muscle and left and right tibialis anterior muscle by EMG between service in OSHA's guidelines and non-OSHA's guidelines workstations every half hour.

(2) To compare the total scan item quantity per half hour both OSHA's guidelines and non-OSHA's guidelines workstation.

(3) To compare average working time scanned items both OSHA's guidelines workstation and non-OSHA's guidelines workstation.

3.5.2.2 One-way analysis of variance (One-way ANOVA)

ANOVA was used to analyze the interaction of group: OSHA and non-OSHA and time of test (every 30 seconds).

(1) To compare the median frequency(MF) of left and right trapezius muscle, left and right gastrocnemius muscle and left and right tibialis anterior muscle between service in OSHA's guidelines workstation and non-OSHA's guidelines workstation throughout 4 working hours.

CHAPTER IV
RESULTS

The results of this study were divided into 4 parts as the followings:

4.1 The characteristics of population and muscular fatigue

4.1.1 General Information

4.1.2 The Working Data

4.1.3 The fatigue feeling by using questionnaire

4.2 The characteristics of samples

4.2.1 General Information

4.2.2 The Working Data

4.2.3 The fatigue feeling by using questionnaire

4.3 Result of the experimental studies

4.3.1 The designing and construction of workstation

4.3.2 Result of work satisfaction of workstation by using questionnaire

4.3.3 The variation median frequency (MF) of muscular between the OSHA's guidelines and the non-OSHA's guidelines workstation by using electromyography (EMG)

4.3.4 The changing median frequency (MF) throughout 4 hours of working

4.3.5 The result of total scan quantity per half hour (pieces/half hour) of samples

4.3.6 The result of the average scan per working time (pieces/minute) of samples

4.3.7 The cashier productivity

4.1 The characteristics of population and muscular fatigue

4.1.1 General Information

The result of the population characteristics was evaluated general information by using questionnaire from the fifty-seven related stored cashiers which work at Saraburi Branch. The average age of 57 cashiers was 28.18 $\pm$ (0.79) years old. The average weight and height were 53.11 $\pm$ (1.35) kilograms and 160.14 $\pm$ (0.81) centimeters, respectively. The physical health status showed that they had no illness history such as heart disease, diabetic and hypertension. The average sleeping per day was 7 hours. The results are presented in Table 4.1.

Table 4.1 The characteristics of population (n=57)

Item	Min	Max	Mean	SD	SE
Age (years)	19	46	28.18	5.94	0.79
Weight (kilograms)	42	105	53.11	10.18	1.35
Height (centimeters)	145	175	160.14	6.10	0.81
BMI	16.92	37.20	20.66	3.37	0.45

4.1.2 The Working Data

The results are presented in Table 4.2. Fifty-seven retailed stored cashiers were interviewed about the working data by using questionnaire. They had worked as cashier for 3.8 year.

Table 4.2 The working performances of population (n=57)

Item	Percents (%)
Working Posture	
- Prolong standing	85.71
- Bending, reaching and twisting body	50.00
- Bending and lifting items	39.29
Heavy work load during the month	
- Beginning of month (Date 1-10)	58.93
- Middle of month (Date 11-20)	5.36
- Ending of month (Date 21-30)	32.14
- Weekend (Saturday)	73.21
Heavy work load during the day	
- 10.00 a.m. - 13.00 p.m.	23.21
- 13.01 p.m. - 16.00 p.m.	16.08
- 16.01 p.m. - 19.00 p.m.	25.71
- 19.01 p.m. - 22.00 p.m.	53.51

Table 4.2 The working performances of population (Continued)

Item	Percents (%)
Subject shoes	
- Sneaker shoes	26.79
- High heel shoes	21.43
- Loafer shoes	60.71

4.1.3 The fatigue feeling by using questionnaire

All of 57 cashiers were interviewed about fatigue feeling by using questionnaire interval the past six months, they had muscular pain or fatigue. (94.64%) Part of body subjects have usually pain or fatigue were feet (73.58%), Calf (62.26%), shoulder (60.38%), back (47.17%). Muscular pain which occurrences on the job (100%).

4.2 The characteristics of samples

4.2.1 General Information

Ten female retailed stored cashiers participated in this study. The average age was 26.00 ± (1.89) years old. The average weight and height were 48.60 ± (1.33) kilograms and 158.50 ± (1.57) centimeters, respectively. The average body mass index, BMI was 19.32 ± (0.59). The physical health status showed they had no illness history such as disease, diabetic and hypertension. The average sleeping per day was 7 hours. The result are presented in Table 4.3

Table 4.3 The characteristics of cashiers (n=10)

Item	Min	Max	Mean	SD	SE
Age (years)	20	37	26.00	5.96	1.89
Weight (kilograms)	45	59	48.60	4.20	1.33
Height (centimeters)	150	163	158.50	4.97	1.57
BMI	16.94	22.21	19.32	1.86	0.59

4.2.2 The Working Data

Ten cashiers were interviewed about working data by questionnaire. They had worked as cashier for 1 year. The result are presented in Table 4.4

Table 4.4 The working posture of the cashiers (n=10)

Item	Percents (%)
Working Posture	
- Prolong standing	90.00
- Bending, reaching and twisting body	70.00
- Bending and lifting items	70.00
Heavy work load during the month	
- Beginning of month (Date 1-10)	40.00
- End of month (Date 21-31)	70.00
- Weekend (Saturday-Sunday)	80.00
Heavy work load during the day	
- 10.00 a.m. - 13.00 p.m.	10.00
- 13.01 p.m. - 16.00 p.m.	10.00
- 16.01 p.m. - 19.00 p.m.	10.00
- 19.01 p.m. - 22.00 p.m.	90.00
Subject shoes	
- Sneaker shoes	30.00
- High heel shoes	20.00
- Loafer shoes	50.00
Size of table	
- Suitable	80.00
- Unsuitable	20.00
Height level of equipments	
- Suitable	80.00
- Unsuitable	20.00
Distance of reach out	
- Suitable	60.00
- Unsuitable	40.00
Height level of hand and feet support	
- Suitable	70.00
- Unsuitable	30.00

Table 4.4 The working posture of the cashiers (Continued)

Item	Percents (%)
Working area	
- Suitable	80.00
- Unsuitable	20.00
Light in working area	
- Suitable	90.00
- Unsuitable	10.00
Temperature working area	
- Suitable	30.00
- Unsuitable	70.00
Rest area	
- Suitable	50.00
- Unsuitable	50.00
Period time of rest	
- Adequate	80.00
- Not adequate	20.00
Degree of satisfaction on work	
- Excellent	-
- Good	100.00
- Poor	-
Level of competency	
- Too high	-
- Suitable	100.00
- Too low	-

4.2.3 The fatigue feeling by using questionnaire

All of samples were interviewed about fatigue feeling by using questionnaire interval the past six months; they had muscular pain or fatigue (100.00%). Parts of body subjects have usually pain or fatigues were feet (80.00%), shoulder (80.00%), back (80.00%), Calf (70.00%). Muscular pain which occurrences on the job (100.00%).

4.3 Result of the experimental studies

4.3.1 The designing and construction of workstation

Comparison of designing and construction between OSHA's guidelines and non-OSHA's guidelines workstations are presented in Table 4.5

Table 4.5 Comparisons of the OSHA's guidelines and the non-OSHA's guidelines workstations

OSHA's guidelines workstation	Non-OSHA's guidelines workstation
Table	Table
− Dimension 58 x 298 x 86 centimeters	Dimension 58 x 150 x 86 centimeters
− Use a powered in-feed conveyor to help cashier bring the items	− Not use a powered in-feed conveyor
− Conveyor is appropriate for the input surface to make large enough for the next customer to put the goods into position on the conveyor while the first customer's goods are being registered, without any risk of confusion between the two batch. Goods are located outside the cashier's work zone, electrical control from within the work zone is appropriate.	− Working surface is appropriate for one customer to put the goods that not over 10 pieces
− Use a "sweeper" to move items on the conveyor.	− Not use a "sweeper" to move items on table.
− Bag stand height can be adjustable	− Bag stand height can be fixed

4.3.2 Result of work satisfaction of workstation by using questionnaire

The results of work satisfaction were conducted by using the questionnaire. The subjects were interviewed about work satisfaction at the working time. The differences of height level and equipment satisfaction were determined by percentage. The result of work satisfaction between the OSHA's guidelines designed workstation and the non-OSHA's guidelines designed workstation was presented in Table 4.6. The result of work satisfaction on the OSHA's guidelines designed workstation showed that the size of table, of the subjects, 80 percents perceived suitable. For the height level of equipments, the work satisfaction of the subjects, 80 percents perceived suitable. The work satisfaction of the subjects, 60 percents perceived suitable for the reaching distance, 70 percents perceived suitable for the height level of hand and feet support, 80 percents perceived suitable the working area. For the light in working area, the work satisfaction of the subjects, 90 percents perceived suitable. For the temperature working area, the work satisfaction of the subjects, 30 percents perceived suitable. For the rest area, the work satisfaction of the subjects, 50 percents perceived suitable. For the period time of rest, work satisfaction of the subjects, 80 percents perceived adequate. For the degree of satisfaction on work, the work satisfaction of the subjects, 100 percents perceived good. And the satisfaction of the subjects, 100 percents perceived suitable for level of competency.

When the result of work satisfaction on the non-OSHA's guidelines designed workstation in Table 4.6 shown that the size of table, of the subjects, 80 percents perceived suitable. For the height level of equipments, the work satisfaction of the subjects, 80 percents perceived suitable. The work satisfaction of the subjects, 90 percents perceived suitable for the reaching distance, 70 percents perceived suitable for the height level of hand and feet support, 80 percents perceived suitable the working area. For the light in working area, the work satisfaction of the subjects, 90 percents perceived suitable. For the temperature working area, the work satisfaction of the subjects, 10 percents perceived suitable. For the rest area, the work satisfaction of the subjects, 50 percents perceived suitable. For the period time of rest, work satisfaction of the subjects, 80 percents perceived adequate. For the degree of satisfaction on work, the work satisfaction of the subjects, 100 percents perceived good. And the satisfaction of the subjects, 100 percents perceived suitable for level of competency.

Table 4.6 Work satisfaction between the OSHA's guidelines and non-OSHA's guidelines workstations

Item	OSHA's guidelines workstation (Percents of satisfaction)	Non-OSHA's guidelines workstation (Percents of satisfaction)
Size of table		
- Suitable	80.00	80.00
- Unsuitable	20.00	20.00
Height level of equipments		
- Suitable	80.00	80.00
- Unsuitable	20.00	20.00
Distance of reach out		
- Suitable	60.00	90.00
- Unsuitable	40.00	10.00
Height level of hand and feet support		
- Suitable	70.00	70.00
- Unsuitable	30.00	30.00
Working area		
- Suitable	80.00	80.00
- Unsuitable	20.00	20.00
Light in working area		
- Suitable	90.00	90.00
- Unsuitable	10.00	10.00
Temperature working area		
- Suitable	30.00	10.00
- Unsuitable	70.00	90.00
Rest area		
- Suitable	50.00	50.00
- Unsuitable	50.00	50.00

Table 4.6 Work satisfaction between the OSHA's guidelines and non-OSHA's guidelines workstations (Continued)

Item	OSHA's guidelines workstation (Percents of satisfaction)	Non-OSHA's guidelines workstation (Percents of satisfaction)
Period time of rest		
- Adequate	80.00	80.00
- Not adequate	20.00	20.00
Degree of satisfaction on work		
- Excellent	-	-
- Good	100.00	100.00
- Poor	-	-
Level of competency		
- Too high	-	-
- Suitable	100.00	100.00

4.3.3 The variation median frequency (MF) of muscular between the OSHA's guidelines and the non-OSHA's guidelines workstations by using electromyography (EMG)

4.3.3.1 Left trapezius muscle

The results of left trapezius muscular fatigue by using electromyography were collected every half an hour throughout the experimental time, i.e. 2.00 p.m. to 6.00 p.m. The EMG measurements were recorded every 30 minutes for 9 times. The student t-test was used to analyze for the difference of median frequency (MF) of left trapezius muscle of the subjects while they were working at the two stations. The results indicated that the median frequency (MF) between those two sets of the data were significantly different only at the time of before work and 150 minutes with 95% of confidence interval (p-value < 0.05). The results are presented in table 4.7. Median frequency (MF) of left trapezius muscle was showed in figure 4.1.

Table 4.7 The comparisons of mean of median frequency (MF) of left trapezius muscle between the OSHA's guidelines and the non-OSHA's guidelines workstations

Time (min)	OSHA workstation		Non-OSHA workstation		df	t-test	p-value
	$\bar{X}$	SD	$\bar{X}$	SD			
0	43.45	7.437	48.35	5.815	38	-2.321	0.026*
30	46.60	14.402	48.95	7.287	38	-0.651	0.519
60	45.10	8.528	48.80	5.899	38	-1.596	0.119
90	45.40	10.007	49.70	6.736	38	-1.594	0.119
120	48.90	8.435	47.75	6.414	38	0.485	0.630
150	44.15	6.869	48.95	7.373	38	-2.130	0.040*
180	45.90	8.366	48.45	4.989	38	-1.171	0.249
210	44.05	7.681	48.40	7.140	38	-1.855	0.071
240	43.90	8.747	48.50	5.434	38	-1.998	0.053
Total	45.27	6.699	48.65	5.455	38	-1.748	0.088

*Level of Significant at $\alpha = 0.05$

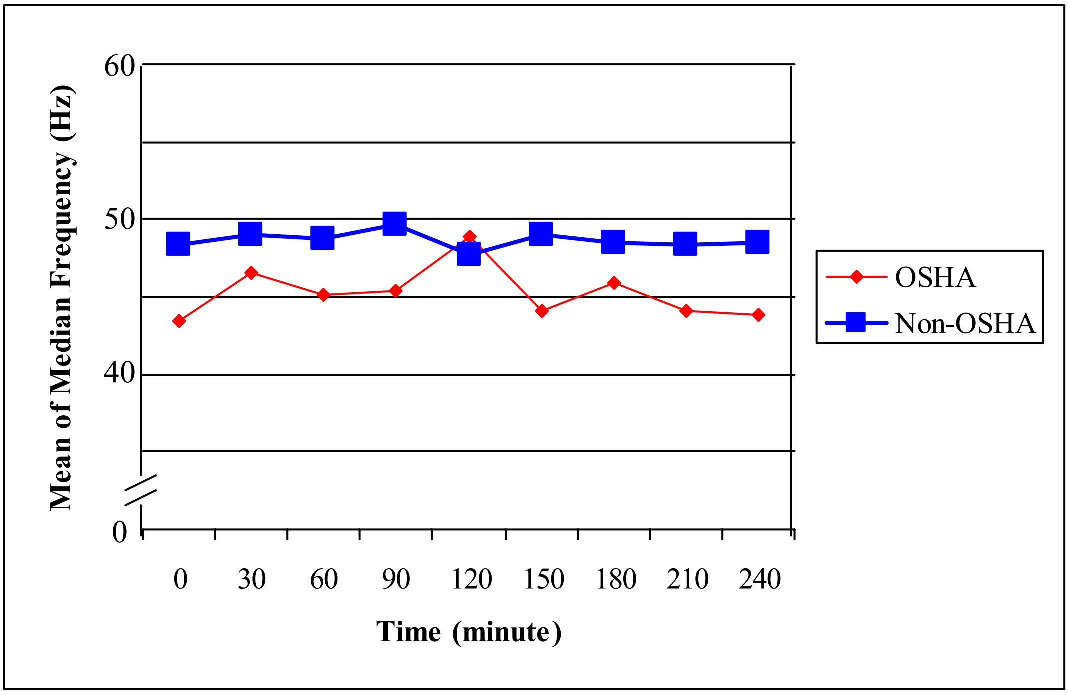


Figure 4.1 Median frequency (MF) of left trapezius muscle (for 240 minutes) of the same workers at the OSHA's guidelines and the non-OSHA's guidelines workstations

4.3.3.2 Right trapezius muscle

The results of right trapezius muscular fatigue by using electromyography were collected every half an hour throughout the experimental time, i.e. 2.00 p.m. to 6.00 p.m. The EMG measurements were recorded every 30 minutes for 9 times. The student t-test was used to analyze for the difference of median frequency (MF) of right trapezius muscle of the subjects while they were working at the two stations. The results indicated that the median frequency (MF) between those two sets of the data were significantly different only at the time of 60 minutes and 180 minutes with 95% of confidence interval (p-value < 0.05). The results are presented in table 4.8. Median frequency (MF) of right trapezius muscle was showed in figure 4.2.

Table 4.8 The comparisons of mean of median frequency (MF) of right trapezius muscle between the OSHA's guidelines and the non-OSHA's guidelines workstations

Time (min)	OSHA workstation		Non-OSHA workstation		df	t-test	p-value
	$\bar{X}$	SD	$\bar{X}$	SD			
0	42.85	15.829	43.95	6.100	25	-0.290	0.774
30	52.10	22.613	44.65	4.440	20	1.446	0.163
60	48.10	6.415	43.65	4.977	38	2.451	0.019*
90	48.00	14.371	45.80	5.493	38	0.640	0.526
120	45.35	4.043	43.05	3.605	38	1.899	0.065
150	46.55	5.643	44.40	2.624	27	1.545	0.134
180	45.55	3.605	42.85	4.295	38	2.153	0.038*
210	41.65	9.074	44.10	3.538	25	-1.125	0.271
240	43.30	4.900	45.75	8.996	38	-1.070	0.292
Total	45.94	3.779	44.24	2.754	38	1.621	0.113

* Level of Significant at $\alpha = 0.05$

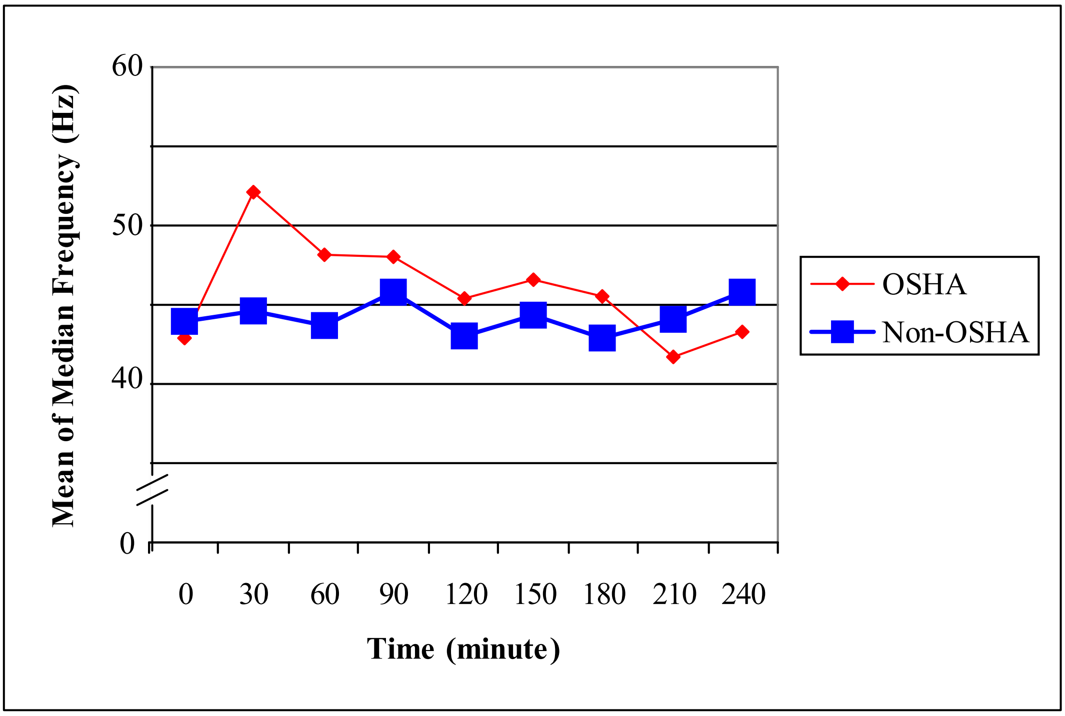


Figure 4.2 Median frequency (MF) of right trapezius muscle (for 240 minutes) of the same workers at the OSHA's guidelines and the non-OSHA's guidelines workstations

4.3.3.3 Left gastrocnemius muscle

The results of left gastrocnemius muscular fatigue by using electromyography were collected every half an hour throughout the experimental time, i.e. 2.00 p.m. to 6.00 p.m. The EMG measurements were recorded every 30 minutes for 9 times. The student t-test was used to analyze for the difference of median frequency (MF) of left gastrocnemius muscle of the subjects while they were working at the two stations. The results indicated that the median frequency (MF) between those two sets of the data were significantly different at during time 60 up to 240 minutes with 95% of confidence interval (p-value < 0.05). The results are presented in table 4.9. Median frequency (MF) of left gastrocnemius muscle was showed in figure 4.3.

Table 4.9 The comparisons of mean of median frequency (MF) of left gastrocnemius muscle between the OSHA's guidelines and the non-OSHA's guidelines workstations

Time (min)	OSHA workstation		Non-OSHA workstation		df	t-test	p-value
	$\bar{X}$	SD	$\bar{X}$	SD			
0	59.20	34.908	57.70	7.060	21	0.188	0.853
30	74.15	21.343	64.85	12.364	30	1.686	0.102
60	79.95	21.088	65.60	9.939	27	2.753	0.010*
90	76.50	20.867	63.40	16.869	38	2.183	0.035*
120	80.60	19.305	77.95	11.745	31	0.524	0.604
150	82.15	19.467	69.30	13.259	34	2.440	0.020*
180	81.15	18.919	67.75	9.716	28	2.818	0.009*
210	81.85	19.826	70.40	13.485	38	2.316	0.039*
240	82.05	17.512	71.65	11.847	33	2.200	0.035*
Total	77.51	15.966	67.62	5.758	24	2.606	0.016*

*Level of Significant at $\alpha = 0.05$

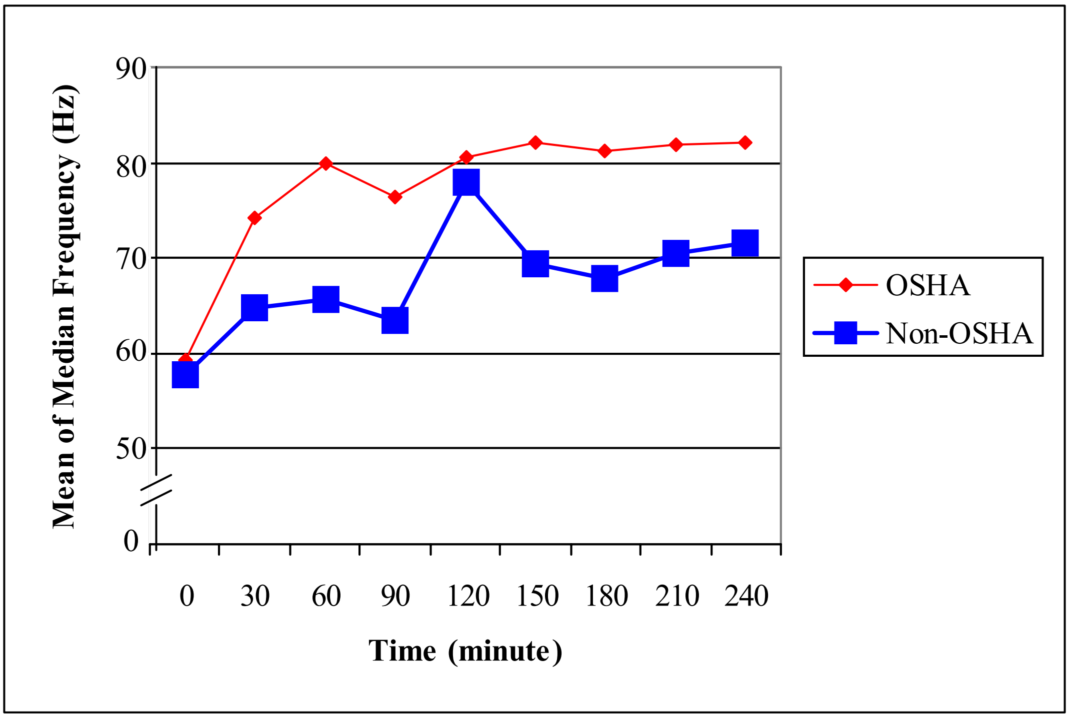


Figure 4.3 Median frequency (MF) of left gastrocnemius muscle (for 240 minutes) of the same workers at the OSHA's guidelines and the non-OSHA's guidelines workstations

4.3.3.4 Right gastrocnemius muscle

The results of right gastrocnemius muscular fatigue by using electromyography were collected every half an hour throughout the experimental time, i.e. 2.00 p.m. to 6.00 p.m. The EMG measurements were recorded every 30 minutes for 9 times. The student t-test was used to analyze for the difference of median frequency (MF) of right gastrocnemius muscle of the subjects while they were working at the two stations. The results indicated that the median frequency (MF) between those two sets of the data were no significantly different at working time with 95% of confidence interval (p-value > 0.05). The results are presented in table 4.10. Median frequency (MF) of right gastrocnemius muscle was showed in figure 4.4.

Table 4.10 The comparisons of mean of median frequency (MF) of right gastrocnemius muscle between the OSHA's guidelines the non-OSHA's guidelines workstations

Time (min)	OSHA workstation		Non-OSHA workstation		df	t-test	p-value
	$\bar{X}$	SD	$\bar{X}$	SD			
0	83.85	16.378	90.35	12.347	38	-1.417	0.165
30	92.30	20.599	95.95	10.385	28	-0.708	0.485
60	97.00	18.287	95.90	11.991	38	0.225	0.823
90	94.65	17.086	92.05	12.841	38	0.544	0.590
120	101.95	19.627	98.95	10.734	29	0.600	0.553
150	99.10	16.477	93.85	14.558	38	1.069	0.292
180	97.70	16.118	88.30	15.315	38	1.891	0.066
210	88.75	17.950	86.65	13.355	38	0.420	0.677
240	91.95	18.850	88.75	9.803	29	0.674	0.506
Total	94.14	11.783	92.31	7.629	38	0.584	0.563

*Level of Significant at $\alpha = 0.05$

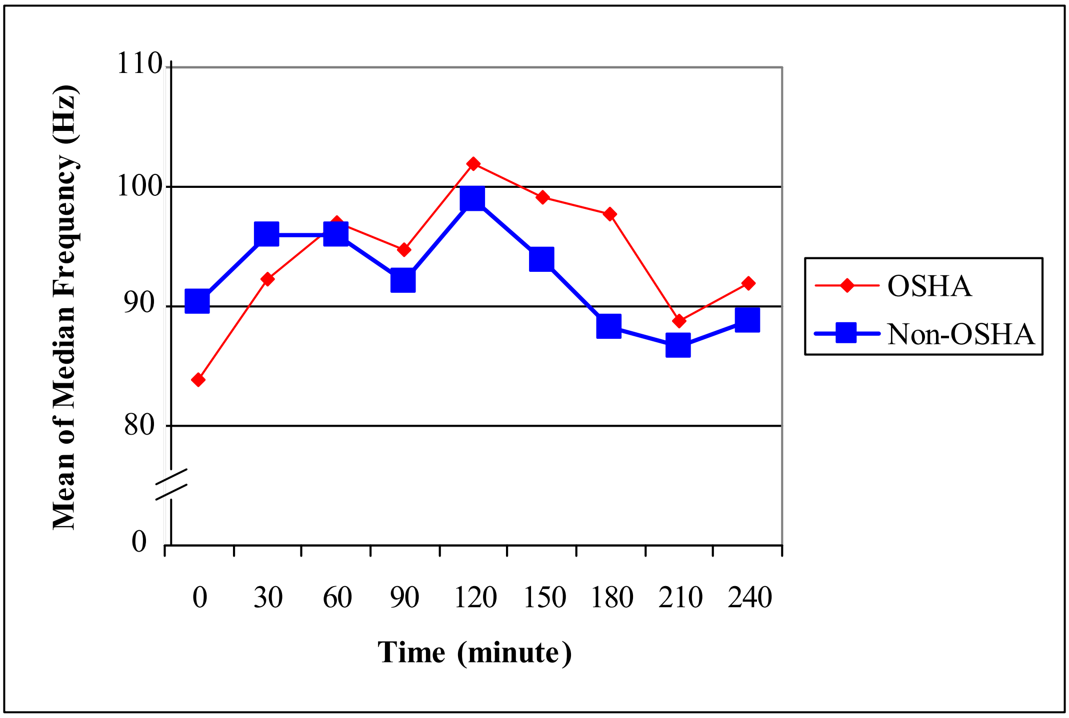


Figure 4.4 Median frequency (MF) of right gastrocnemius muscle (for 240 minutes) of the same workers at the OSHA's guidelines and the non-OSHA's guidelines workstations

4.3.3.5 Left tibialis anterior muscle

The results of left tibialis anterior muscular fatigue by using electromyography were collected every half an hour throughout the experimental time, i.e. 2.00 p.m. to 6.00 p.m. The EMG measurements were recorded every 30 minutes for 9 times. The student t-test was used to analyze for the difference of median frequency (MF) of left tibialis anterior muscle of the subjects while they were working at the two stations. The results indicated that the median frequency (MF) between those two sets of the data were significantly different only at the time of 90 minutes with 95% of confidence interval (p-value < 0.05). The results are presented in table 4.11. Median frequency (MF) of left tibialis anterior muscle was showed in figure 4.5.

Table 4.11 The comparisons of mean of median frequency (MF) of left tibialis anterior muscle between the OSHA's guidelines and the non-OSHA's guidelines workstations

Time (min)	OSHA workstation		Non-OSHA workstation		df	t-test	p-value
	$\bar{X}$	SD	$\bar{X}$	SD			
0	62.05	13.790	59.50	18.421	38	0.496	0.623
30	62.55	10.670	57.75	8.771	38	1.554	0.128
60	66.95	16.008	60.50	9.892	32	1.533	0.135
90	68.85	16.778	58.95	11.105	33	2.201	0.035*
120	65.95	20.917	60.50	13.919	38	0.970	0.338
150	63.25	15.127	59.00	14.675	38	0.902	0.373
180	63.60	12.947	58.90	11.355	38	1.221	0.230
210	59.05	13.065	61.65	16.589	38	-0.551	0.585
240	64.20	13.633	56.45	12.215	38	1.893	0.066
Total	64.05	11.338	59.24	10.597	38	1.385	0.174

*Level of Significant at $\alpha = 0.05$

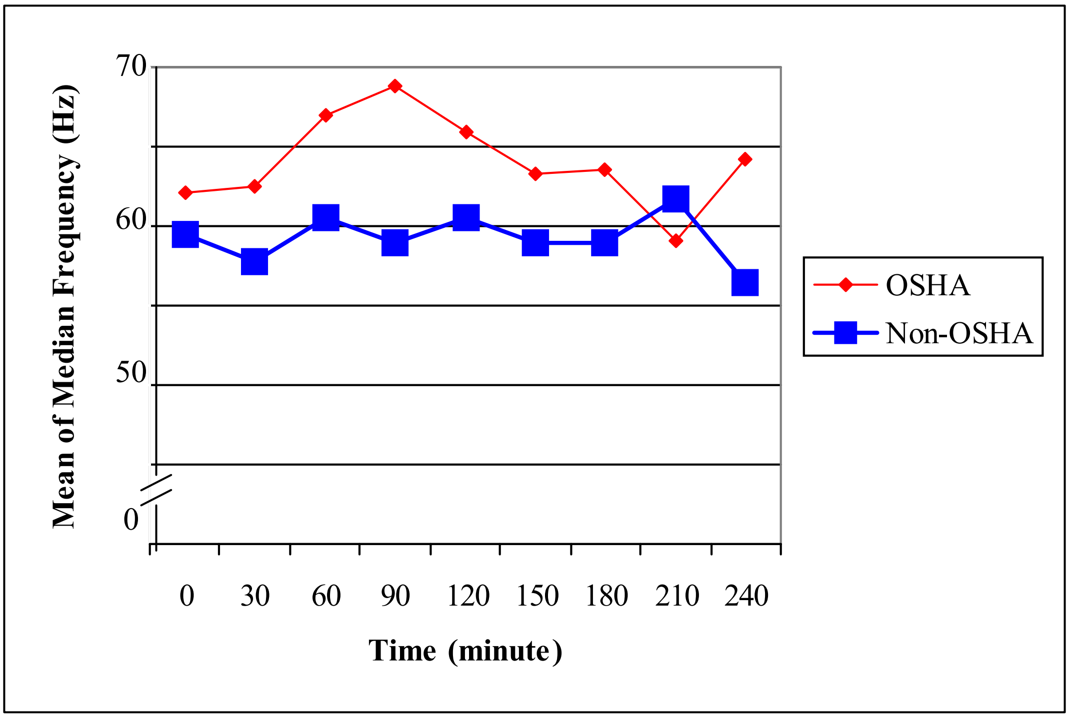


Figure 4.5 Median frequency (MF) of left tibialis anterior muscle (for 240 minutes) of the same workers at the OSHA's guidelines and the non-OSHA's guidelines workstations

4.3.3.6 Right tibialis anterior muscle

The results of right tibialis anterior muscular fatigue by using electromyography were collected every half an hour throughout the experimental time, i.e. 2.00 p.m. to 6.00 p.m. The EMG measurements were recorded every 30 minutes for 9 times. The student t-test was used to analyze for the difference of median frequency (MF) of right tibialis anterior muscle of the subjects while they were working at the two stations. The results indicated that the median frequency (MF) between those two sets of the data were no significantly different only at the time of 120 minutes with 95% of confidence interval (p-value < 0.05). The results are presented in table 4.12. Median frequency (MF) of right tibialis anterior muscle was showed in figure 4.6.

Table 4.12 The comparisons of mean of median frequency (MF) of right tibialis anterior muscle between the OSHA's guidelines and the non-OSHA's guidelines workstations

Time (min)	OSHA workstation		Non-OSHA workstation		df	t-test	p-value
	$\bar{X}$	SD	$\bar{X}$	SD			
0	71.75	17.060	70.45	11.825	38	0.280	0.781
30	77.00	16.594	76.00	12.674	38	0.214	0.832
60	82.10	20.013	76.35	11.094	30	1.124	0.270
90	80.40	21.989	78.05	14.802	33	0.396	0.694
120	84.35	20.051	71.85	9.675	27	2.511	0.018*
150	78.00	25.606	71.45	12.680	38	1.025	0.312
180	77.35	23.401	67.10	13.329	30	1.702	0.099
210	73.10	18.241	68.60	9.960	29	0.968	0.341
240	74.85	18.986	72.30	9.189	27	0.541	0.593
Total	77.66	18.137	72.46	8.038	26	1.171	0.252

*Level of Significant at $\alpha = 0.05$

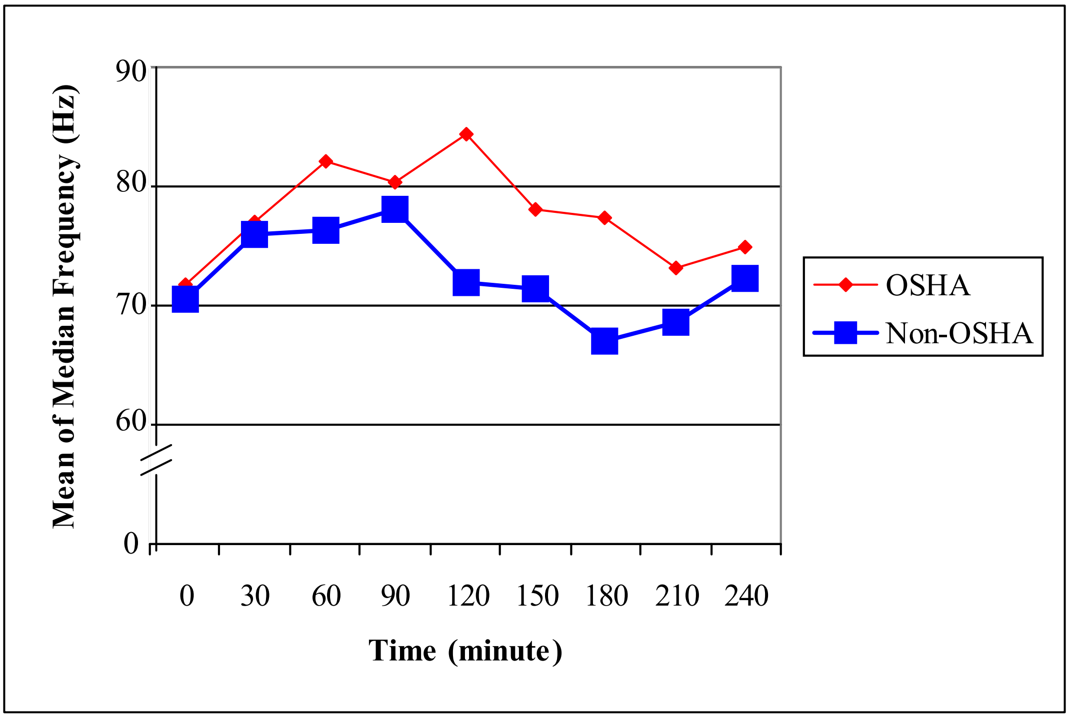


Figure 4.6 Median frequency (MF) of left tibialis anterior muscle (for 240 minutes) of the same workers at the OSHA's guidelines and the non-OSHA's guidelines workstations

4.3.4 The changing median frequency (MF) throughout 4 hours of working

Electrical activity of trapezius muscle, gastrocnemius muscle and tibialis anterior muscle were recorded by Raw EMG signal and the FFT-individual spectrum analysis program was used to analyze that data. The desired area of analysis throughout 30 seconds of raw data and all median frequency (MF) were calculated again of mean median frequency (MF) for each period of working-hours. One-way ANOVA was applied to compare mean median frequency (MF) of each muscle and time. The result of analysis was presented in table 4.13.

The results of analysis for median frequency (MF) that the most were statistically significant difference between OSHA's guidelines and non-OSHA's guidelines designed workstation with 95% of confidence interval (P-value > 0.05). In summary, the result was the muscle of subjects had decreased fatigue when worked on OSHA's guidelines designed workstation.

Table 4.13 The comparisons of median frequency (MF) between trapezius muscle, gastrocnemius muscle and tibialis anterior muscle between the OSHA's guidelines and the non-OSHA's guidelines workstations (throughout 4 working-hours)

Item		Mean	SD	df	F-ratio	p-value
Workstation						
• MF trapezuis	OSHA	45.61	10.42	1	1.742	0.187
	Non-OSHA	46.45	6.15			
• MF Gastrocnemius	OSHA	85.83	22.20	1	15.229	<0.001*
	Non-OSHA	79.96	17.87			
• MF Tibialis anterior	OSHA	70.85	19.07	1	15.905	<0.001*
	Non-OSHA	65.85	14.22			
Side						
• MF trapezuis	left	46.96	8	1	8.679	0.003*
	right	45.09	9			
• MF Gastrocnemius	left	72.57	19.09	1	249.601	<0.001*
	right	93.22	15.84			
• MF Tibialis anterior	left	61.65	14.24	1	132.623	<0.001*
	right	75.06	16.89			
Time						
• MF trapezuis	0 min	44.65	9.77	8	1.436	0.178
	30 min	48.08	14.08			
	60 min	46.41	6.80			
	90 min	47.23	9.75			
	120 min	46.26	6.26			
	150 min	46.01	6.13			
	180 min	45.69	5.86			
	210 min	44.55	7.43			
	240 min	45.36	7.41			

Table 4.13 The comparisons of median frequency (MF) between trapezius muscle, gastrocnemius muscle and tibialis anterior muscle between the OSHA's guidelines and the non-OSHA's guidelines workstations: throughout 4 working-hours (Continued)

Item		Mean	SD	df	F-ratio	p-value
Time						
• MF Gastrocnemius	0 min	72.78	24.93	8	4.230	<0.001*
	30 min	81.81	20.99			
	60 min	84.61	20.34	**0 ≠ 30, 0 ≠ 60,		
	90 min	81.65	21.08	0 ≠ 90, 0 ≠ 120,		
	120 min	89.86	18.94	0 ≠ 150, 0 ≠ 180,		
	150 min	86.10	19.57	0 ≠ 210, 0 ≠ 240,		
	180 min	83.73	18.67	30 ≠ 120, 90 ≠ 120,		
	210 min	81.91	17.60	120 ≠ 210,		
	240 min	83.60	16.65	120 ≠ 240		
• MF Tibialis anterior	0 min	65.94	16.09	8	1.517	0.148
	30 min	68.33	14.88			
	60 min	71.47	16.77			
	90 min	71.56	18.41			
	120 min	70.66	18.72			
	150 min	67.93	18.91			
	180 min	66.74	17.10			
	210 min	65.60	15.57			
	240 min	66.95	15.51			

**Level of Significant at $\alpha = 0.05$

**Multiple Comparisons by LSD

4.3.5 The result of total scan quantity per half hour (pieces / half hour) of samples

The result of total scan quantity per half hour was evaluated information by count the total scan quantity during 2 p.m. up 6 p.m. of working hour which each subject working on the OSHA's guidelines designed workstation and the non-OSHA's guidelines designed workstation**.**

The difference of total scan quantity per half hour was determined by t-test while the subjects were working on the OSHA's guidelines designed workstation and the non-OSHA's guidelines designed workstation. The result showed that total scan quantity per half hour of working on the OSHA's guidelines designed workstation was significant less than that of working on the non-OSHA's guidelines designed workstation with 95% of confidence interval (p-value < 0.05), as presented in table 4.14.

Table 4.14 The comparisons of mean of total scan quantity per half hour of working between the OSHA's guidelines and the non-OSHA's guidelines workstations

Items	Mean	SD	t-test	df	p-value
OSHA workstation	193.327	59.271	2.779	38	0.008*
Non- OSHA workstation	152.552	28.143			

*Level of Significant at $\alpha = 0.05$

4.3.6 The result of the average scan per working time (pieces / minute) of samples

The average scan per time was evaluated by stop clock and record scan for service time both working on the OSHA's guidelines designed workstation and the non-OSHA's guidelines designed workstation**.**

The difference of average scan per working time was determined by using t-test while the subjects were working on the OSHA's guidelines designed workstation and the non-OSHA's guidelines designed workstation. The result showed that average scan per time of working on the OSHA's guidelines designed workstation was not significant that of working on the non-OSHA's guidelines designed workstation with 95% of confidence interval (p-value > 0.05), as presented in table 4.15.

Table 4.15 The comparisons of average scan per of working time between the OSHA's guidelines and the non-OSHA's guidelines workstations

Items	Mean	SD	t-test	Df	P-value
OSHA workstation	6.829	2.123	0.879	38	0.385
Non- OSHA workstation	6.289	1.737			

*Level of Significant at $\alpha = 0.05$

4.3.7 The cashier productivity

The cashier productivity was measured in terms of quantity output (pieces/half hour). Productivity increased. Using the OSHA's guidelines workstation, cashiers were able to average scan 193 pieces/half hour compared to the non-OSHA's guidelines workstation average scan 153 pieces/half hour (Table 4.14). The results showed that total scan quantity per half hour of working on the OSHA's guidelines workstation was significant less than that of working on the non-OSHA's guidelines workstation with 95% of confidence interval (p-value < 0.05).

CHAPTER V
DISCUSSION

5.1 Discussion of study design

The error of data collection and analysis this study might occur from the listed below;

5.1.1 Systematic error

5.1.1.1 Personal error

This error could be occurred from the researcher. If the researcher lack of skill or insufficient training or lack of attention, this could also cause inaccurate recording. In this study the researcher had trained to increase skill in used electromyography, read value, analysis and interpretation by expert in order to prevent any errors that could be occurred, so techniques and method were applied carefully.

The researcher was controlled by face to face interview and described information of the questions meaning in order to the subjects understood questions and decreased the error from questionnaire.

5.1.1.2 Instrument error

In this study, muscular fatigue questionnaire was applied to evaluated subjective feeling of fatigue by interviewing subjects while working at the the OSHA's guidelines designed workstation and the non-OSHA's guidelines designed workstation.

The errors of fatigued feeling might be occurred by the questionnaire responder, the individual attitude of fatigue and intimately. Some subjects might be misunderstood the questionnaire clearly. To prevent an error before experiment the researcher described the meaning of each questionnaire and then asked them to answer the questionnaires about the current fatigue.

The muscular fatigue questionnaire was improved for cashiers there are lack of items to analyze association between work and lifestyle factors. It might be useful to assess fatigue symptoms specific to retail cashiers with modification to cover items related to work and lifestyle. However the researcher used only subjective feeling of fatigue questionnaire was not enough to represent the subjective overall fatigue. The objective measurement like electromyography (EMG) was applied in this study.

The muscular fatigue was evaluated with surface electromyography (Muscle Tester ME 6000), silver-silver chloride (Ag/AgCl) surface electrode. It is used in the research studies practically and qualified to the muscle specifically. It has both advantages and disadvantages. The weak points are the surface electrode is large electrode with can cause cross take from adjacent muscles. It can only be used for superficial muscles. Because of those disadvantages, before recording the researcher must be kept in mind and full consideration given to such as factors that influence process of record. Those factors are skin preparation, electrode placement, electrode wire, preamplifier cable and PC. These measurements could display the raw EMG that is measured by using sufficient sampling frequency in bipolar fashion without integration. Using FFT analysis, the reduction in the EMG signal frequency composition can calculated that can be applied to neurophysiological investigation. The raw EMG was used for muscular status assessment throughout the experiment. However, the recording data was limited by storage capacity of memory card. Therefore, recording data was 30 seconds of every half hour during working throughout four working hours which each subject working on the OSHA's guidelines designed workstation and the non-OSHA's guidelines designed workstation.

5.1.1.3 Method errors

The errors could be occurred during data collection and analytical method. The errors of subjective fatigue felling might be occurred from the person answering, attitude or familiarity about fatigue. The questionnaires of this study were modified from the worldwide application of ergonomics approaches to prevent the error from interview. Before experiment the researcher described meaning of each questions clearly to the subjects. The researcher conducted the electromyography measurement, which based on the recommendation from Mega Electronics Ltd.

The errors of data collection could be occurred from electrodes position. It was specific anatomical location for surface electrode and individual subject was recorded and marked position of electrode, continuously. This error might occur due to the site measurement study. In order to minimize the effect from the body movement, the researcher applied tape to fix an electrode to the subject's skin.

5.2 Discussion of study results

5.2.1 Preliminary survey of cashier

The results of primary survey about general information, physical health status of 10 female cashiers showed that average age of total samples was 26.0 years old, average weight and average height were 48.6 kilograms, 158.5 centimeters, respectively. They had worked as cashier for 1 year, on average. All of them had muscular fatigue while working: i.e. the feet (80%), shoulder (80%), back (80%) and calf (70%). The main cause of muscular fatigue was working posture such as standing for long periods, reaching item to scan so far and handle thousands of items into the bag.

This result was similar to Suwanna et al, (3) studied the prevalence of pain symptom in 15 to 30 years of age female prolonged standing workers by using questionnaire. The results showed that prolonged standing workers experienced a greatest degree of pain in the calf muscle (76.9%) followed by the ankle joint (50%), back muscle (39.3%) and the knee joint (29.6%), respectively. Moreover, factor of age and standing time did not influence the prevalence of pain symptom in many areas. OSHThai (5) conducted health problem evaluations to investigate the musculoskeletal disorders of 94 prolong standing workers that worked at 6 department stores by using questionnaire. The result showed that had a muscular fatigue and pain at leg muscle, back muscle, neck and feet, respectively. It found that over time working had effect to increase the muscular fatigue at calf, low back, ankle and foot. Ryan G.A. (38) studied the incidence of muscle discomfort and pain in supermarket departments, that the checkout area had a high incidence of lower extremity discomfort and pain. Symptom had occurred neck, upper back, shoulder and hand. The causation of muscular fatigue was standing posture especially for prolong standing posture.

5.2.2 Result of work satisfaction of workstation by using questionnaire

The result showed that there was no difference in work satisfaction between the OSHA's guidelines and the non-OSHA's guidelines workstations. All cashiers perceived suitable for the size of table, height level of equipments, height level of hand

and feet support, working area, light in working area, rest area, period time of rest, degree of satisfaction on work and level of competency both the OSHA's guidelines and the non-OSHA's guidelines workstations at the same percents of satisfaction**.**

5.2.3 Result of muscular fatigue by using electromyography (EMG)

The measurement of muscular fatigue was done by using electromyography (EMG) throughout 4 working hours. In this study, the subjects had adequately rest (at least 7 hours) before measurement and did not have menstruation during in experiment day in order to control variables. The results of median frequency (MF) were divided in three parts, as following;

5.2.3.1 Trapezius muscle:

The results showed that median frequency (MF) of left trapezius muscle before work (0 minute) on the OSHA's guidelines workstation was significant less than while working on the non-OSHA's guidelines workstation with 95% of confidence interval (p-value < 0.05). It was conducted the OSHA's guidelines designed workstation was 2 types: left side check stand and right side check stand. The non-OSHA's guidelines designed workstation was only left side check stand. The different of check stand had effected to cashiers' posture and movement. The subjects who worked on the OSHA's guidelines designed workstation had used their hand by both hands, but who worked at the non-OSHA's guidelines designed workstation had used their hand by left hand. In addition, the subjects had acclimatized the OSHA's guidelines designed workstation.

This result was similar to Phonnipha Boriboonsuksree (43) who studied to improve the workstation in order to reduce muscular fatigue in waterwork cashiers. Results showed that the median frequency (MF) of right upper trapezius muscle from measurement by EMG while cashiers worked on the existing workstation was significantly less than worked on the improved workstation.

5.2.3.2 Gastrocnemius muscle

The results showed that median frequency (MF) of left gastrocnemius muscle while working on the OSHA's guidelines designed workstation was significant less than while working on the non-OSHA's guidelines designed workstation with 95% of confidence interval (p-value < 0.05) at during time 60 minutes up 240 minutes.

This may be explained that during did not have customer, cashier who worked on the OSHA's guidelines designed workstation had sit rest on the bagging area.

5.2.3.3 Tibialis anterior muscle

The results showed that median frequency (MF) of left and right tibialis anterior muscle while working on the OSHA's guidelines designed workstation was no significant while working on the non-OSHA's guidelines designed workstation with 95% of confidence interval (p-value > 0.05).

The muscle fatigue increased due to working for along time affecting the median frequency (MF) of electromyography (EMG). Muscular fatigue indicated by increasing of amplitude and decreasing of frequency of the electrical activity is observed. Under the rest conditions, the median frequency (MF) of myoelectric signal was twice as high as that of fatigue of muscle. The variation of the EMG signal frequency composition to the lower frequency during muscular exertion when comparison EMG measurement between the subjects performed on the OSHA's guidelines designed workstation was no significant while working on the non-OSHA's guidelines designed workstation. Shift in median frequency (MF) of EMG power spectra were investigated.

The median frequency (MF) of muscle shifted to a lower frequency to a greater degree. In this study, the results of trapezius muscular fatigue, gastrocnemius muscular fatigue, tibialis anterior muscular fatigue was supported the hypotheses that the OSHA's guidelines designed workstation had effect in decreasing median frequency (MF) of shoulder muscle and legs muscle. Sometime such as the result of median frequency of tibialis anterior muscle showed no difference of average mean of median frequency (MF). The muscle might not occurred muscular fatigue because the subjects got rest at least seven hours before measurement or cause might occur from the attaching electrodes to surface of skin throughout measurement. Skin might be occurring sweats that interrupt between the myoelectric signal in the muscle and electrodes surface on the skin.

This result was similar to NIOSH (7) had reviewed the epidemiological evidences for work-related musculoskeletal disorders. The work risk factors showed to have a positive relationship with neck and upper limb musculoskeletal disorders were combinations of repetition, force and postural work factors for elbow musculoskeletal disorders and hand wrist tendonitis. A causal relationship is very likely between intense and long exposure to work risk factor and the development of disorders in these regions. There was evidence to suggest that a reduction in exposure to biomechanical load resulted in the subsequent reduction of the prevalence of musculoskeletal disorders in the workplace.

5.2.4 The changing median frequency (MF) throughout 4 hours of working

The results of this data analysis consist of 3 items as the following:

5.2.4.1 There was significant differences of median frequency (MF) of gastrocnemius muscle and tibialis anterior muscle between the OSHA's guidelines and the non-OSHA's guidelines workstations (p-value < 0.05).

5.2.4.2 There was significant differences of median frequency (MF) of trapezuis muscle, gastrocnemius muscle and tibialis anterior muscle between the left and the right (p-value < 0.05).

5.2.4.3 There was significant difference of median frequency (MF) gastrocnemius muscle among working-hours (p-value < 0.05).

5.2.5 Result of total scan quantity per half hour (pieces/half hour) of amples

The average total scan quantity per half hour while the subjects were working on the OSHA's guidelines workstation was significant less than that working on the non-OSHA's guidelines workstation with 95% of confidence interval (p-value < 0.05), as presented in table 4.14. The outcomes were similar to the study of Nipaporn Khomlom (44) who demonstrated that were increased productivity and reduce fatigue after improvement workstation.

5.2.6 Result of the average scan per time (pieces/minute) of samples

The average scan per time was evaluated by same time, same subjects, and record scan item use for customer service times both working on the OSHA's guidelines designed workstation was no significant while working on the non-OSHA's guidelines designed workstation. The results showed that the average scan item per time of working on the OSHA's guidelines designed workstation was no significantly while working on the non-OSHA's guidelines designed workstation with 95% of confidence interval (p-value > 0.05).

The result from the change workstation, especially the working equipments were adjusted for individual cashier base on the anthropometry and OSHA's guidelines data. Thus, while working on non-OSHA's guidelines designed workstation the average scan item per time was decreased.

5.2.7 The cashier productivity

The result showed that total scan quantity per half hour of working on the OSHA's guidelines workstation was significant less than that of working on the non-OSHA's guidelines workstation with 95% of confidence interval (p-value < 0.05).

Productivity increased. Using the OSHA's guidelines workstation, cashiers were able to average scan 193 pieces/half hour compared to the non-OSHA's guidelines workstation average scan 153 pieces/half hour.

CHAPTER VI
CONCLUSION AND RECOMMENDATION

6.1 Conclusion of study

The study is to compare the muscular fatigue of cashiers who work at front-end in retail store and workstation based on the designs of OSHA's guideline workstation. The type of research was a Quasi-Experiment Research. The objective was to compare the OSHA's guideline workstation to reduce muscular fatigue. First step was to survey the prevalence of the muscular fatigue, and then the sample was chosen by using the questionnaire and interview. Due to a limitation of the samples who engaged to perform the experimental. Therefore must duplicate sampling that the measurement of electromyography (EMG) was performing twice for each cashier. The subjects of this study were 10 female cashiers which work the payment point of retail store at Saraburi branch. The electromyography (EMG) was used to demonstrate their muscular fatigue. Also to demonstrate median frequency (MF) throughout experiment. The comparison of muscular fatigue of cashiers that work at the OSHA's guideline workstation and the non-OSHA's guideline workstation were analyzed by t-test. One-way analysis of variance (One-way ANOVA) was used to analyze the interaction of group: OSHA and non- OSHA; left and right of muscle and time of test (every 30 seconds). And counted total scan item quantity and recorded time of scan item in each subject. The results of study were conducted as follows:

6.1.1 Characteristics of subjects

The average age of cashiers were 26.0 years old, average weight were 48.6 kilograms and average height were 158.5 centimeters. The cashiers had work experience 1 year. They had healthy and strong, no personal disease, or illness and no history of muscular and bone disease or accident. They had no menstruation in experimental day and adequate resting period before the study start.

6.1.2 The feeling of muscular fatigue

The subjects group would be interviewed by using questionnaires to show theirs feeling of muscular fatigue**.** They had muscular pain or fatigue while working. Part of body subject have usually pain or fatigue were feet (80%), shoulder (80%), back (80%), Calf (70%). Muscular pain which occurrences from the job.

6.1.3 The EMG test results

The result of the variation median frequency (MF) of muscle between the OSHA's guideline workstation and the non-OSHA's guideline workstation by using electromyography showed that the difference of median frequency (MF) of trapezius muscle, of gastrocnemius muscle and of tibialis anterior while the subjects were working on the OSHA's guideline design workstation were significant less than while working on the non-OSHA's guideline design workstation with 95% of confidence interval (p-value < 0.05). Because of the conveyor of OSHA's guideline workstation is appropriate for the input surface to make large enough for the customer to put the goods. Goods are located outside the cashier's work zone, electrical control from within the work zone. The cashier could be sit rest on the bagging area of OSHA's guideline workstation.

6.1.4 The performance in terms of scan per half an hour

The average total scan quantity per half hour while the subjects were working on the OSHA's guideline design workstation was significant less than that working on the non-OSHA's guideline design workstation with 95% of confidence interval (p-value < 0.05). Cashier productivity increased.

The average scan per time was evaluated by same subject and recorded scan item use for customer service times both working on the OSHA's guideline design workstation and working on the non-OSHA's guideline design workstation showed that the difference of the average scan item per time when the 10 subjects were working on the OSHA's guideline workstation and working on the non-OSHA's guideline workstation were no significant with 95% of confidence interval (p-value > 0.05).

6.2 Recommendation for retail store cashiers

6.2.1 The result of this study showed that the OSHA's guideline design workstation can reduce muscular fatigue of trapezius muscle, of left gastrocnemius muscle and of tibialis anterior muscle. Therefore, retail store authority should design workstation base on OSHA's guideline in order to reduce the fatigue.

6.2.2 Concentrates on an ergonomics approach and includes the layout of the workstation, the work posture, the task undertaken and the seating provided. Arrangement equipments and item in best work zone in order to easy reach because of long reach can strain the body and work more difficult.

6.2.3 Training the cashiers before working on workstation such as work practices, using equipments, principles of ergonomics, improved work methods, self-reported symptoms and use of ergonomically improved equipments.

6.2.4 The employers could review effective ergonomics processes and programs in OSHA's guidelines and decide what types of processes or programs, if any, would work at their facilities.

6.2.5 The manufacturer should provide appropriate environment that affect not only the comfort, health and productivity such as temperature, noise and speed.

6.2.6 The cashier participation in setting his standard appears to be an important factor for improvement of workstation, satisfaction and productivity enchancement.

6.3 Recommendation for future studies

6.3.1 The study to assess the muscular fatigue on the shoulder, calf and feet during cashiers work. The number of participants and the number branch of retail stores were not representative of the real life work situation. In this study, the subjects were cashiers worked in a real life work situation.

6.3.2 The measurements of muscular fatigue should cover the normal working hour (8 working hours) at the same position of workstation because of a number of customer not difference.

6.3.3 In practical task, the cashiers have to perform varieties of standing posture such as reach out, push-pull, bend and handle heavy item, which require difference muscle groups. Therefore, the muscular fatigue should evaluate for all muscle groups used in those working posture.

6.3.4 Future research should be concentrated the muscular fatigue in many working conditions such as standing on good quality of anti-fatigue mats, as compared to bare floors, provides a noticeable improvement in comfort.

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APPENDIX

APPENDIX A
QUESTIONNAIRE

แบบสำรวจความเมื่อยล้าของกล้ามเนื้อพนักงานประจำจุดรับเงินชำระค่าสินค้า
ของห้างสรรพสินค้า

วันที่ .... เวลา ....น. หมายเลขแบบสอบถาม......

กรุณากรอกข้อความลงในช่องว่าง และเขียนเครื่องหมาย / ลงในช่อง ( ) หน้าข้อความที่ท่านต้องการตอบ

1. ข้อมูลทั่วไป

1.1 ชื่อ-สกุล..ปฏิบัติงานสาขา..

1.2 ตำแหน่ง/หน้าที่..ลักษณะงาน..

1.3 เพศ ( ) ชาย ( ) หญิง

1.4 อายุ...........ปี

1.5 น้ำหนัก.......................... กิโลกรัม ส่วนสูง.......................... เซนติเมตร

1.6 สถานภาพสมรส

( ) โสด ( ) แต่งงานแล้ว ( ) หม้าย ( ) หย่า/แยกกันอยู่

1.7 ระดับการศึกษา

( ) ต่ำกว่าปริญญาตรี ( ) ปริญญาตรี

( ) สูงกว่าปริญญาตรี ( ) อื่นๆระบุ).......................................

1.8 การออกกำลังกาย

( ) ออกกำลังกาย ( ) ไม่ออกกำลังกาย

1.9 การสูบบุหรี่

( ) สูบ ( ) ไม่สูบ

1.10 การดื่มสุรา หรือเครื่องดื่มที่มีแอลกอฮอล์ (เบียร์ ไวน์ฯ)

( ) ดื่ม ( ) ไม่ดื่ม

1.10.1 ถ้าดื่ม ท่านดื่มกี่ครั้งต่อสัปดาห์ ....ครั้ง

1.10.2 ในวันที่ดื่ม ท่านดื่มมากน้อยแค่ไหน

( ) ดื่มพอเป็นกระสาย ( ) ดื่มพอมึนๆ ( ) ดื่มเรื่อยๆ จนเมา

1.11 ประวัติสุขภาพ คุณเคยมีประวัติเป็นโรคเหล่านี้หรือไม่

( ) โรคเบาหวาน ( ) ความดันโลหิตสูง

( ) โรคหัวใจ ( ) โรคประจำตัวอื่นๆ

( ) เคยมีประวัติเข้ารับการรักษาด้วยการผ่าตัด

1.12 ปกติคุณเข้านอนเวลา................................น. ตื่นเวลา................................น.

2. ข้อมูลเกี่ยวกับการทำงาน

2.1 คุณทำงานในหน้าที่นี้มาทั้งสิ้น................................ ปี

2.2 ในรอบ 6 เดือนที่ผ่านมา คุณทำงานวันละ.................ชั่วโมง

โดยเริ่มงานตั้งแต่เวลา................น. ถึง เวลา.................น.

2.3 ในรอบ 6 เดือนที่ผ่านมา คุณทำงานล่วงเวลาวันละ..........................ชั่วโมง

2.4 ในรอบ 6 เดือนที่ผ่านมา ลักษณะการทำงานของคุณส่วนใหญ่

( ) นั่งทำงานปกติ ( ) ยืนทำงานตลอดเวลา

( ) ก้มๆ เงยๆ เอื้อมมือ และเอี้ยวตัว ( ) ก้มๆ เงยๆ ยกของอยู่ตลอดเวลา

( ) อื่นๆ (ระบุ)...

2.5 ในช่วงเวลาใดในแต่ละเดือนที่มีผู้มาใช้บริการชำระค่าสินค้ามากที่สุด

( ) ต้นเดือน(วันที่ 1-10) ( ) กลางเดือน (วันที่ 11-20)

( ) ปลายเดือน (วันที่ 21-31) ( ) วันหยุด (วันเสาร์-อาทิตย์)

2.6 ในช่วงเวลาใดในแต่ละวันที่มีผู้มาใช้บริการชำระค่าสินค้ามากที่สุด

( ) 10.00-13.00น. ( ) 13.01-16.00 น.

( ) 16.01-19.00 น. ( ) 19.01-22.00 น.

2.7 คุณสวมรองเท้าแบบใดในการทำงาน

( ) รองเท้าผ้าใบ ( ) รองเท้าส้นสูง

( ) รองเท้าหนังพื้นเสมอ

2.8 สถานที่ปฏิบัติงาน

2.8.1 ความเหมาะสมขนาดโต๊ะทำงาน	( ) เหมาะสม	( ) ไม่เหมาะสม
2.8.2 การปรับระดับความสูงของอุปกรณ์ต่างๆ	( ) เหมาะสม	( ) ไม่เหมาะสม
2.8.3 ระยะห่างของการเอื้อมหยิบ (จากลำตัวถึงวัสดุที่หยิบ)	( ) เหมาะสม	( ) ไม่เหมาะสม
2.8.4 การจัดที่วางพักแขน และขา	( ) เหมาะสม	( ) ไม่เหมาะสม
2.8.5 พื้นที่ว่างเพียงพอสำหรับการปฏิบัติงาน	( ) เหมาะสม	( ) ไม่เหมาะสม

2.9 สภาพแวดล้อมในการทำงาน

2.9.1 แสงสว่างในการทำงาน	( ) เหมาะสม	( ) ไม่เหมาะสม
2.9.2 อุณหภูมิในสถานที่ทำงาน	( ) เหมาะสม	( ) ไม่เหมาะสม
2.9.3 ในพื้นที่ทำงานมีเสียงดังรบกวน การสื่อสารของคุณ	( ) มี	( ) ไม่มี
2.9.4 ในพื้นที่ทำงานมีกลิ่นรบกวน การทำงานของคุณ	( ) มี	( ) ไม่มี

2.10 สถานที่พักผ่อนที่เหมาะสมหรือไม่	( ) เหมาะสม	( ) ไม่เหมาะสม
2.11 ระยะเวลาในการพักผ่อนเพียงพอหรือไม่	( ) เพียงพอ	( ) ไม่เพียงพอ

2.12 ในรอบ 6 เดือนที่ผ่านมา คุณมีความสุข/พึงพอใจในการทำงานในระดับใด

( ) ดีมาก ( ) ค่อนข้างดี

( ) มีความยุ่งยาก ( ) อื่นๆ(ระบุ)................................

2.13 ในรอบ 6 เดือนที่ผ่านมา คุณรู้สึกว่าได้ใช้ความสามารถในการทำงานอยู่ในระดับใด

( ) มากเกินไป ( ) พอดี

( ) น้อยเกินไป ( ) อื่นๆ (ระบุ)................................

2.14 ข้อเสนอแนะเพิ่มเติมในการปรับปรุงสถานที่ทำงาน

....

....

....

3. ความเมื่อยล้าจากการทำงาน

3.1 ท่านเคยมีความรู้สึกเมื่อยล้า หรือปวดบริเวณร่างกาย ขณะปฏิบัติงานหรือไม่

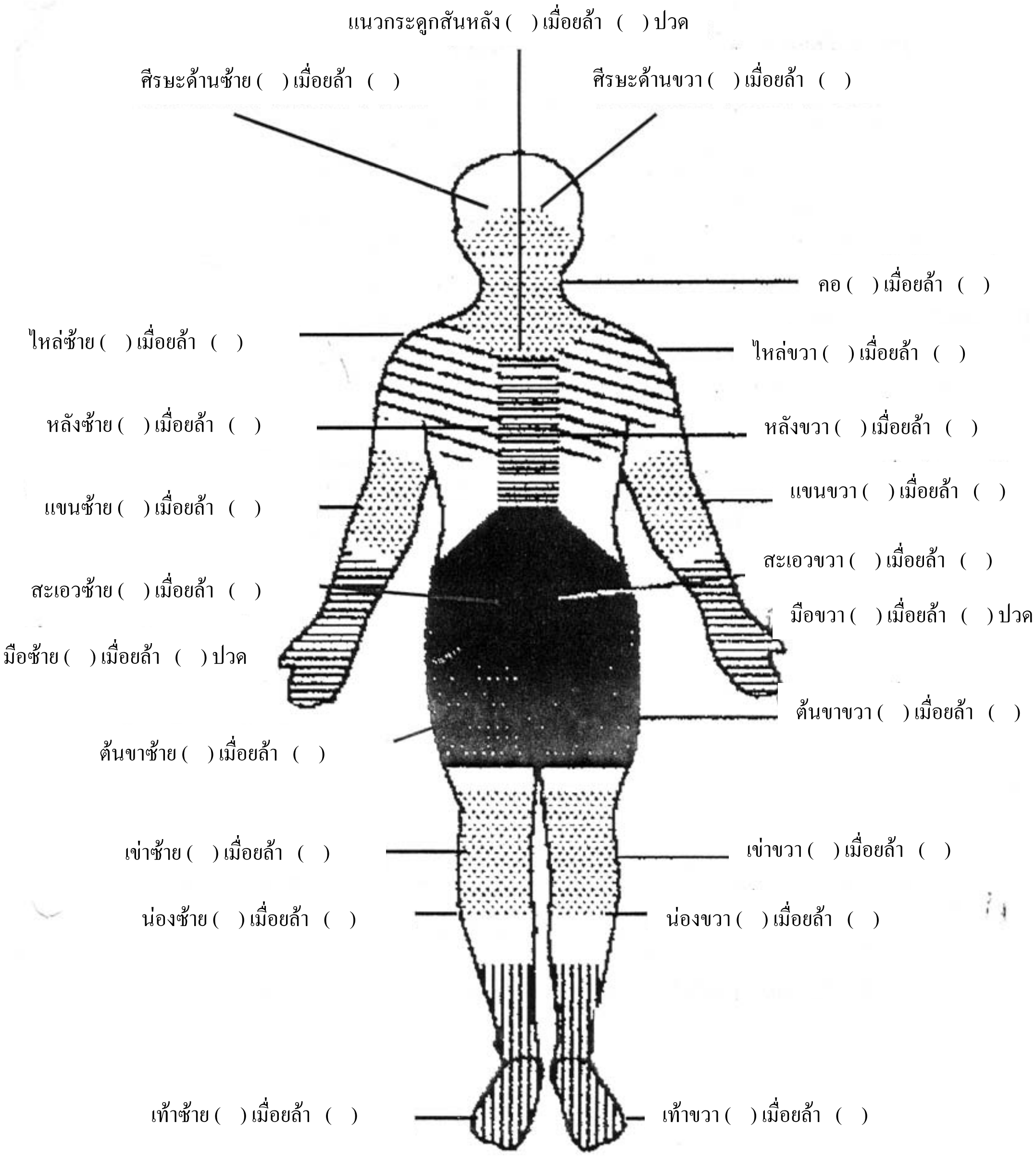
( ) เคย ( ) ไม่เคย

ถ้าท่านไม่เคยมีอาการเมื่อยล้า หรือปวดตามส่วนต่างๆ ของร่างกายไม่ต้องตอบข้อต่อไป

3.2 ในระหว่าง 6 เดือนที่ผ่านมา ขณะปฏิบัติงานท่านรู้สึกปวด หรือเมื่อยล้าบริเวณจุดใดของร่างกาย เป็นประจำโปรดชี้จุด (ตามรูปภาพ)

อาการปวด หมายถึง รู้สึกปวด หรือเจ็บจี๊ดๆ

อาการเมื่อยล้า หมายถึง รู้สึกระบม แต่ยังไม่เจ็บ


แนวกระดูกสันหลัง ( ) เมื่อยล้า ( ) ปวด
ศีรษะด้านซ้าย ( ) เมื่อยล้า ( )
ศีรษะด้านขวา ( ) เมื่อยล้า ( )
คอ ( ) เมื่อยล้า ( )
ไหล่ซ้าย ( ) เมื่อยล้า ( )
ไหล่ขวา ( ) เมื่อยล้า ( )
หลังซ้าย ( ) เมื่อยล้า ( )
หลังขวา ( ) เมื่อยล้า ( )
แขนซ้าย ( ) เมื่อยล้า ( )
แขนขวา ( ) เมื่อยล้า ( )
สะเอวขวา ( ) เมื่อยล้า ( )
สะเอวซ้าย ( ) เมื่อยล้า ( )
มือขวา ( ) เมื่อยล้า ( ) ปวด
มือซ้าย ( ) เมื่อยล้า ( ) ปวด
ต้นขาขวา ( ) เมื่อยล้า ( )
ต้นขาซ้าย ( ) เมื่อยล้า ( )
เข่าซ้าย ( ) เมื่อยล้า ( )
เข่าขวา ( ) เมื่อยล้า ( )
น่องซ้าย ( ) เมื่อยล้า ( )
น่องขวา ( ) เมื่อยล้า ( )
เท้าซ้าย ( ) เมื่อยล้า ( )
เท้าขวา ( ) เมื่อยล้า ( )

APPENDIX B
FORMATS

แบบบันทึกการปฏิบัติงานของพนักงานประจำจุดรับเงินชำระค่าสินค้า

1. ข้อมูลทั่วไป

ชื่อ-สกุล.. วันที่ .... เวลา ....น.

หมายเลขจุดชำระค่าบริการสินค้า...

ประเภทของสถานีงาน ( ) สถานีงานที่ออกแบบตามข้อเสนอแนะของ OSHA

( ) สถานีงานที่ไม่ได้ออกแบบตามข้อเสนอแนะของ OSHA

2. จำนวนสินค้าที่สแกนได้

เวลาในการสแกนสินค้าต่อใบเสร็จ		ระยะเวลาที่ใช้ ต่อหนึ่งใบเสร็จ(นาที)	จำนวนชิ้นสินค้าที่สแกนได้ต่อใบเสร็จ
เริ่มต้น	สิ้นสุด		

APPENDIX C
MUACULAR FATIGUE

Figure C-1 Biomonitor ME6000

Figure C-2 Electrodes (Medicotest Blue Sensor type M-00-S)

A)

B)

C)

D)

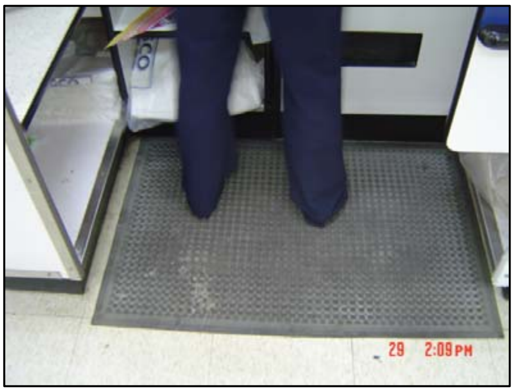


Figure C-3 OSHA’s guidelines workstation

A) Check stand

B) Conveyor belt

C) Cash register display, keyboards, scanner and scan gun

D) Footrest and anti fatigue mat

A)

B)

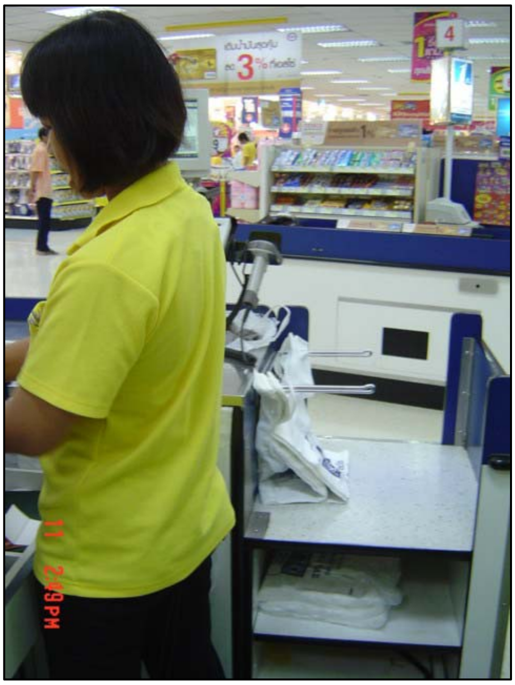


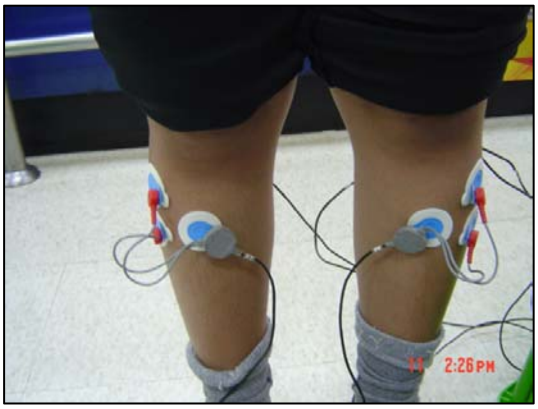
Figure C-4 Non-OSHA's guidelines workstation

A) Check stand

B) Bag stand

A)

B)



C)

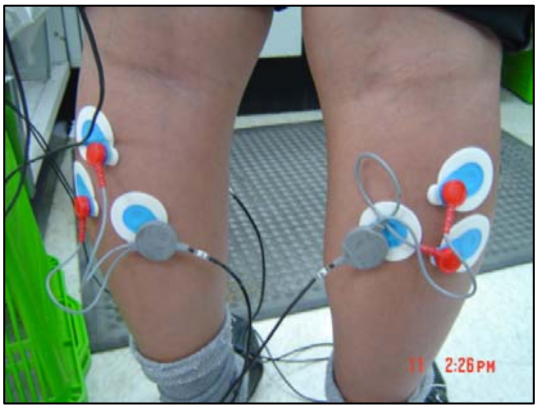


Figure C-5 Positioning of electrodes on the muscles

A) Positioning of electrodes on trapezius muscle

B) Positioning of electrodes on gastrocnemius muscle

C) Positioning of electrodes on tibialis anterior muscle

Table C-1 Median frequency (Hz) of left trapezius muscle of each interval

Measurement	OSHA's guidelines workstation									Non-OSHA's guidelines workstation								
	0	30	60	90	120	150	180	210	240	0	30	60	90	120	150	180	210	240
1	47	54	54	51	55	53	51	48	45	55	56	52	54	48	50	52	61	48
2	45	33	46	44	44	52	48	41	47	53	62	57	45	52	64	59	60	56
3	31	37	34	33	38	37	32	35	25	45	44	47	45	39	40	43	44	46
4	36	41	40	29	39	39	40	26	36	41	44	41	45	42	46	45	36	50
5	53	62	54	66	63	55	62	55	60	56	54	48	55	57	47	55	48	58
6	38	43	59	62	68	49	55	53	61	51	60	57	57	58	58	53	57	57
7	44	38	49	48	54	44	45	40	49	43	50	45	46	46	46	44	45	45
8	49	40	49	46	49	49	51	48	47	42	42	45	43	42	41	43	41	42
9	44	41	40	38	38	36	39	33	33	41	37	39	42	35	37	40	39	43
10	37	36	33	40	53	44	40	43	39	44	45	45	40	42	37	48	47	44
11	46	51	51	36	51	40	39	44	41	48	47	45	45	51	55	49	44	45
12	43	51	43	50	51	49	46	53	49	51	51	49	55	55	49	48	61	54
13	46	51	51	36	51	40	39	43	39	57	60	59	59	55	55	51	50	55
14	43	51	43	50	51	49	46	53	49	54	55	57	54	47	49	54	55	51
15	62	43	38	53	51	50	66	39	44	43	43	45	47	45	44	45	46	45
16	42	99	60	57	52	34	52	47	52	45	45	51	55	45	47	45	47	44
17	44	47	46	54	35	47	39	51	49	55	45	47	48	51	55	49	45	43
18	49	40	46	42	52	46	44	49	38	44	45	47	48	45	46	46	44	44
19	42	38	29	36	40	30	41	44	38	56	55	57	66	56	59	55	51	55
20	28	36	37	37	43	40	43	36	37	43	39	43	45	44	54	45	47	45

Table C-2 Median frequency (Hz) of right trapezius muscle of each interval

Measurement	OSHA's guidelines workstation									Non-OSHA's guidelines workstation								
	0	30	60	90	120	150	180	210	240	0	30	60	90	120	150	180	210	240
1	43	43	49	42	44	44	43	44	45	54	48	31	58	37	46	28	39	48
2	33	34	41	42	38	44	46	39	38	47	49	49	43	40	50	43	51	37
3	50	46	46	48	47	55	45	47	45	40	43	40	41	44	45	44	43	44
4	78	42	43	42	40	41	47	45	46	44	41	43	41	38	39	40	36	42
5	25	28	50	101	49	44	45	36	38	35	45	47	50	43	46	44	46	82
6	87	81	53	53	51	40	55	41	31	44	48	44	42	47	48	42	41	46
7	29	69	46	48	50	48	50	52	46	41	43	41	42	41	43	42	43	41
8	46	47	49	45	43	45	47	49	47	41	41	44	40	35	40	38	44	39
9	42	49	45	49	39	40	44	48	35	33	34	35	44	45	44	45	43	43
10	33	41	43	44	45	43	41	48	42	44	44	45	56	45	43	42	43	44
11	41	76	68	20	55	60	48	42	48	55	51	48	55	47	45	45	48	47
12	55	130	46	48	46	55	40	10	42	44	45	45	47	44	45	46	47	44
13	29	45	48	53	44	48	46	47	49	41	41	41	45	44	43	43	43	44
14	45	48	47	43	45	50	49	45	47	44	43	43	38	41	44	43	44	45
15	43	46	47	48	45	44	44	48	43	38	45	54	44	47	45	45	43	45
16	30	42	40	40	43	42	47	35	49	51	54	45	47	48	48	49	48	45
17	33	45	44	50	48	40	48	39	44	37	39	40	41	40	41	43	42	43
18	41	40	50	54	44	48	43	32	44	53	45	45	47	45	44	42	42	41
19	29	36	47	45	45	53	43	45	39	48	47	48	48	45	44	48	48	47
20	45	54	60	45	46	47	40	41	48	45	47	45	47	45	45	45	48	48

Table C-3 Median frequency (Hz) of left gastrocnemius muscle of each interval

Measurement	OSHA's guidelines workstation									Non-OSHA's guidelines workstation								
	0	30	60	90	120	150	180	210	240	0	30	60	90	120	150	180	210	240
1	30	42	77	89	66	67	70	71	75	62	66	79	81	83	43	60	79	67
2	9	54	60	58	57	61	54	58	71	49	50	69	47	77	65	88	86	85
3	24	71	68	72	47	76	70	66	76	59	70	58	51	64	81	76	65	74
4	90	82	89	94	99	82	65	68	74	66	85	75	81	60	93	77	91	65
5	118	124	96	64	72	110	98	93	115	52	98	75	82	90	51	77	86	85
6	136	110	120	108	110	115	104	109	107	59	51	76	21	80	99	63	60	97
7	46	82	92	63	61	66	59	56	60	63	65	55	63	66	69	78	82	87
8	66	82	46	43	69	60	96	118	71	69	68	85	77	88	75	62	86	78
9	30	48	85	77	69	63	66	55	54	67	67	68	76	98	65	67	89	87
10	14	57	59	59	59	60	54	74	89	61	63	67	89	87	56	65	65	55
11	112	79	55	85	92	105	101	113	102	59	61	57	58	87	64	65	67	68
12	92	72	116	118	110	103	99	85	93	65	65	67	87	91	78	77	65	54
13	46	72	67	65	77	98	70	60	59	56	59	80	65	64	78	56	61	54
14	67	82	75	41	78	77	104	96	103	54	78	57	56	69	65	55	69	76
15	56	58	78	80	89	93	97	81	99	45	45	56	53	89	65	55	51	65
16	53	106	120	109	117	48	94	107	92	67	73	54	56	66	69	77	75	69
17	45	71	88	78	80	96	67	80	76	56	65	58	59	63	67	76	65	67
18	35	55	65	60	75	77	60	72	69	48	54	55	56	89	76	65	54	68
19	67	83	76	78	98	88	90	76	66	54	60	65	65	78	66	56	43	65
20	48	53	67	89	87	98	105	99	90	43	54	56	45	70	71	60	69	67

Table C-4 Median frequency (Hz) of right gastrocnemius muscle of each interval

Measurement	OSHA's guidelines workstation									Non-OSHA's guidelines workstation								
	0	**30**	**60**	**90**	**120**	**150**	**180**	**210**	**240**	**0**	**30**	**60**	**90**	**120**	**150**	**180**	**210**	**240**
1	70	72	101	97	90	88	90	92	98	87	82	76	101	81	60	63	67	89
2	90	105	90	91	90	94	110	70	99	97	105	97	89	114	107	118	108	95
3	79	81	72	70	72	80	76	84	69	100	116	91	97	109	112	99	90	83
4	83	8	85	73	83	80	84	79	86	110	89	86	94	96	107	92	101	84
5	110	106	94	122	135	110	101	59	118	79	95	83	90	100	109	89	78	91
6	66	137	136	137	133	130	132	125	118	104	83	105	57	112	90	75	91	105
7	85	124	74	104	132	125	112	95	69	85	93	110	93	99	103	105	99	101
8	85	108	108	90	87	85	86	116	75	107	115	101	104	107	93	82	103	97
9	73	82	101	98	113	107	87	79	110	99	101	89	95	102	110	124	112	96
10	92	81	115	90	96	106	85	94	121	79	99	85	93	109	102	76	89	98
11	129	100	89	83	109	109	120	113	124	65	76	81	90	99	85	89	78	75
12	88	66	128	125	130	112	120	114	83	102	107	98	78	89	65	70	75	78
13	85	86	104	91	110	115	107	73	106	76	90	98	102	98	88	76	78	95
14	87	112	100	78	88	88	87	92	89	77	98	95	86	76	99	76	85	75
15	79	61	61	87	88	110	73	83	80	89	98	105	112	109	108	97	98	99
16	55	60	86	78	88	87	85	64	91	83	99	124	110	103	89	93	75	88
17	78	102	110	99	124	88	98	70	69	99	97	86	75	89	90	78	87	70
18	65	86	88	93	85	100	109	90	75	89	85	95	99	89	78	84	75	89
19	77	89	88	99	96	65	87	96	70	79	91	98	78	88	85	93	67	78
20	101	107	110	88	90	103	105	87	89	101	99	115	98	110	97	87	77	89

Table C-5 Median frequency (Hz) of left tibialis anterior muscle of each interval

Measurement	OSHA's guidelines workstation									Non-OSHA's guidelines workstation								
	0	30	60	90	120	150	180	210	240	0	30	60	90	120	150	180	210	240
1	59	58	85	73	75	69	70	75	77	49	54	49	72	67	55	50	66	59
2	77	66	71	84	70	67	74	60	79	98	68	79	68	83	88	83	89	82
3	51	53	51	51	49	50	53	59	46	50	50	51	51	50	52	52	51	53
4	44	60	46	51	24	34	48	47	46	55	54	58	56	50	54	51	86	52
5	83	87	82	56	66	61	76	53	76	44	52	57	75	80	58	67	76	56
6	67	77	98	85	91	98	66	63	75	92	63	75	48	81	96	73	103	95
7	68	55	61	83	77	73	62	56	73	50	50	50	50	53	55	55	55	53
8	51	56	54	52	57	56	64	59	60	56	56	69	53	50	54	50	52	55
9	57	68	81	70	70	72	66	72	63	45	55	56	57	48	50	53	53	55
10	71	68	81	74	70	72	72	71	82	45	56	48	45	45	51	51	47	47
11	96	80	53	82	76	77	80	84	78	90	67	75	88	85	78	82	79	65
12	67	52	97	87	86	58	69	59	67	51	56	57	65	56	54	53	55	51
13	68	75	64	87	59	67	88	72	76	53	51	62	56	76	66	56	51	55
14	51	55	55	54	58	63	56	55	59	53	65	67	56	45	54	53	55	53
15	50	49	56	49	49	56	54	30	35	49	50	52	55	54	67	56	45	44
16	48	50	54	37	10	28	27	42	60	48	56	55	51	56	43	56	67	54
17	63	56	50	76	80	66	58	45	47	89	78	75	68	69	56	64	53	57
18	44	65	56	51	87	76	64	69	75	79	75	54	65	61	63	76	54	45
19	53	56	77	87	76	66	66	65	55	43	45	54	44	43	31	43	41	45
20	73	65	67	88	89	56	59	45	55	51	54	67	56	58	55	54	55	53

Table C-6 Median frequency (Hz) of right tibialis anterior muscle of each interval

Measurement	OSHA's guidelines workstation									Non-OSHA's guidelines workstation								
	0	**30**	**60**	**90**	**120**	**150**	**180**	**210**	**240**	**0**	**30**	**60**	**90**	**120**	**150**	**180**	**210**	**240**
1	61	79	81	66	72	75	80	84	64	75	71	67	96	69	59	57	67	76
2	65	75	72	64	75	85	83	71	90	66	86	75	72	79	80	94	79	75
3	53	58	50	50	70	52	55	53	53	59	55	67	51	51	52	55	60	60
4	60	73	64	50	56	31	49	78	57	83	62	79	82	69	76	69	56	71
5	99	103	96	103	119	94	109	98	107	66	85	75	77	80	99	72	88	91
6	89	114	123	125	132	124	120	112	102	77	72	82	42	87	71	58	67	72
7	76	92	83	96	91	95	88	66	71	50	51	51	51	61	55	52	51	51
8	78	78	94	89	89	75	83	90	71	80	79	83	79	69	75	58	81	84
9	59	75	80	60	78	86	60	60	85	65	89	78	85	76	88	87	78	75
10	70	69	69	85	79	82	81	75	71	45	84	79	75	60	69	55	67	60
11	114	96	89	83	99	109	112	93	109	78	71	60	98	69	58	55	65	78
12	83	81	122	120	114	124	99	93	99	87	67	79	85	65	78	61	53	73
13	76	80	87	89	84	79	80	69	87	73	78	95	86	75	89	71	65	76
14	80	80	95	71	81	80	88	85	71	55	57	78	75	67	61	59	65	67
15	50	50	53	55	52	56	60	53	56	69	78	83	90	87	65	56	59	61
16	48	50	55	54	62	28	34	54	57	67	89	81	91	89	67	98	75	76
17	55	58	67	77	76	55	45	59	62	81	78	71	77	67	83	74	67	78
18	65	67	88	90	89	78	54	43	45	78	89	93	82	75	77	73	79	77
19	87	90	98	101	89	85	92	70	77	67	81	76	78	66	56	71	75	78
20	67	72	76	80	80	67	75	56	63	88	98	91	89	76	71	67	75	67

APPENDIX D
TOTAL QUANTITY

Table D-1 Total scan quantity per half hour of working on the OSHA's guidelines workstation

Measurement	Total items quantity of each interval								Average
	30	**60**	**90**	**120**	**150**	**180**	**210**	**240**	**Pcs./0.5 hr.**
1	271	346	226	289	223	308	315	201	272.38
2	144	233	237	175	130	153	128	172	171.5
3	120	74	211	203	185	155	258	175	172.63
4	375	103	41	86	66	152	133	100	132
5	100	114	159	185	214	185	107	149	151.63
6	97	174	245	205	302	233	294	112	207.75
7	181	138	146	135	188	208	155	169	165
8	147	153	244	181	245	171	239	187	195.88
9	110	99	123	159	200	153	112	178	141.75
10	115	260	259	234	270	256	292	264	243.75
11	110	206	268	236	76	165	105	164	166.25
12	370	368	334	280	250	228	320	258	301
13	216	224	203	200	232	189	343	324	241.38
14	245	300	256	250	218	168	235	246	239.75
15	170	213	220	180	187	180	192	200	192.75
16	46	41	48	78	57	63	55	63	56.38
17	94	84	110	115	101	137	118	124	110.38
18	258	218	223	214	263	232	245	267	240
19	258	287	208	231	251	263	228	221	243.38
20	119	183	228	276	264	222	211	265	221

Table D-2 Total scan quantity per half hour of working on the non-OSHA's guidelines workstation

Measurement	Total items quantity of each interval								Average
	30	60	90	120	150	180	210	240	Pcs./0.5 hr.
1	85	119	137	144	112	133	105	145	122.5
2	30	36	169	137	209	154	87	119	117.63
3	91	201	197	216	141	245	205	246	192.75
4	113	208	208	141	237	200	193	206	188.25
5	84	136	119	147	112	133	103	135	121.13
6	159	159	160	140	153	143	174	157	155.63
7	178	220	108	118	128	185	156	135	153.5
8	211	223	229	144	133	150	134	156	172.5
9	110	138	137	100	123	118	103	132	120.13
10	121	125	110	120	123	139	136	164	129.75
11	162	131	159	144	162	98	134	155	143.13
12	86	100	144	141	111	120	110	114	115.75
13	150	174	226	159	230	189	221	178	190.88
14	146	176	151	163	157	181	184	196	169.25
15	120	114	142	165	172	154	115	141	140.38
16	120	122	123	139	168	155	113	144	135.5
17	152	150	143	166	158	164	134	155	152.75
18	134	151	166	160	159	153	161	162	155.75
19	167	186	165	169	179	174	106	165	163.88
20	170	222	194	238	205	212	197	242	210

APPENDIX E
AVERAGE PIECES PER TIME

Table E-1 Total scan quantity per minute of working on the OSHA's guidelines workstation

Measurement	Total scan quantity (pieces)										Average
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	(pieces)
1	12	11	8	9	8	8	11	13	12	11	10
2	7	7	5	6	4	4	5	6	7	7	5.5
3	8	4	5	5	5	7	5	5	8	4	5.5
4	7	4	2	4	4	5	4	5	7	4	4.38
5	6	4	6	4	4	7	4	5	6	4	5
6	11	11	8	5	5	6	7	6	11	11	7.38
7	5	7	5	7	4	4	4	7	5	7	5.38
8	8	7	8	5	6	5	5	7	8	7	6.38
9	4	3	4	4	7	6	5	4	4	3	4.63
10	11	10	8	8	10	11	9	10	11	10	9.63
11	3	5	6	7	5	5	6	5	3	5	5.3
12	9	10	9	12	9	10	15	8	9	10	10.3
13	9	10	10	9	9	9	8	7	9	10	8.88
14	9	9	8	7	10	11	7	6	9	9	8.38
15	6	7	7	4	5	4	5	7	6	7	5.63
16	4	4	3	3	5	5	3	5	4	4	4
17	4	4	5	5	5	5	4	4	4	4	4.5
18	7	10	9	9	7	7	8	9	7	10	8.3
19	13	10	11	9	10	8	9	8	13	10	9.75
20	5	9	6	9	8	9	8	8	5	9	7.75

Table E-2 Total scan quantity per minute of working on the non-OSHA's guidelines workstation

Measurement	Total scan quantity (pieces)										Average (pieces)
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	
1	5	4	5	4	5	3	4	4	5	4	4.25
2	3	4	4	5	4	4	3	5	3	4	4
3	7	7	9	6	8	9	9	9	7	7	8
4	6	8	8	7	8	8	9	8	6	8	7.75
5	4	4	4	4	4	5	6	3	4	4	4.25
6	7	8	8	6	6	7	7	7	7	8	7
7	7	6	5	7	5	7	7	7	7	6	6.38
8	7	8	8	8	9	8	7	7	7	8	7.75
9	3	5	4	5	4	4	4	3	3	5	4
10	4	4	4	4	4	4	5	5	4	4	4.25
11	7	8	7	6	7	6	5	6	7	8	6.5
12	5	4	3	4	4	5	3	2	5	4	3.75
13	9	10	9	8	8	8	7	8	9	10	8.38
14	8	8	7	8	7	8	9	6	8	8	7.63
15	6	6	6	7	7	6	7	8	6	6	6.63
16	4	5	4	5	5	5	4	4	4	5	4.5
17	9	7	7	7	6	7	8	7	9	7	7.25
18	7	8	7	7	7	6	7	7	7	8	7
19	8	7	8	8	7	7	7	7	8	7	7.38
20	8	8	10	10	9	10	9	9	8	8	9.13

APPENDIX F
STATISTICS

One-way analysis of variance (One-way ANOVA)

Table F-1 Descriptives of the median frequency (MF) of trapezius muscle, gastrocnemius muscle and tibialis anterior muscle between service in OSHA's and non-OSHA's guidelines workstations throughout 4 working-hours.

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
MFTRA	osha	360	45.61	10.42	.55	44.53	46.69	10	130
	non-osha	360	46.45	6.15	.32	45.81	47.08	28	82
	Total	720	46.03	8.56	.32	45.40	46.65	10	130
MFGAS	osha	360	85.83	22.20	1.17	83.52	88.13	9	137
	non-osha	360	79.96	17.87	.94	78.11	81.82	21	124
	Total	720	82.89	20.35	.76	81.41	84.38	9	137
MFTIBIA	osha	360	70.85	19.07	1.01	68.88	72.83	10	132
	non-osha	360	65.85	14.22	.75	64.38	67.33	31	103
	Total	720	68.35	16.99	.63	67.11	69.60	10	132

Table F-2 Analysis of variance of the median frequency (MF) of trapezius muscle, gastrocnemius muscle and tibialis anterior muscle between service in OSHA's and non-OSHA's guidelines workstations throughout 4 working-hours.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
MFTRA	Between Groups	127.513	1	127.513	1.742	.187
	Within Groups	52542.986	718	73.180		
	Total	52670.499	719			
MFGAS	Between Groups	6183.472	1	6183.472	15.229	.000
	Within Groups	291528.5	718	406.029		
	Total	297712.0	719			
MFTIBIA	Between Groups	4500.000	1	4500.000	15.905	.000
	Within Groups	203144.4	718	282.931		
	Total	207644.4	719			

Table F-3 Descriptives of the median frequency (MF) of trapezius muscle, gastrocnemius muscle and tibialis anterior muscle between left and right muscles.

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
MFTRA	left	360	46.96	8.00	.42	46.13	47.79	25	99
	right	360	45.09	9.00	.47	44.16	46.02	10	130
	Total	720	46.03	8.56	.32	45.40	46.65	10	130
MFGAS	left	360	72.57	19.09	1.01	70.59	74.55	9	136
	right	360	93.22	15.84	.83	91.58	94.86	55	137
	Total	720	82.89	20.35	.76	81.41	84.38	9	137
MFTIBIA	left	360	61.65	14.24	.75	60.17	63.12	10	103
	right	360	75.06	16.89	.89	73.31	76.81	28	132
	Total	720	68.35	16.99	.63	67.11	69.60	10	132

Table F-4 Analysis of variance of the median frequency (MF) of trapezius gastrocnemius muscle and tibialis anterior muscle between left and right muscles.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
MFTRA	Between Groups	629.068	1	629.068	8.679	.003
	Within Groups	52041.431	718	72.481		
	Total	52670.499	719			
MFGAS	Between Groups	76797.356	1	76797.356	249.601	.000
	Within Groups	220914.6	718	307.681		
	Total	297712.0	719			
MFTIBIA	Between Groups	32374.422	1	32374.422	132.623	.000
	Within Groups	175270.0	718	244.109		
	Total	207644.4	719			

Table F-5 Descriptives of the median frequency (MF) of trapezius muscle, gastrocnemius muscle and tibialis anterior muscle throughout 4 working-hours.

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
MFTRA	0	80	44.65	9.77	1.09	42.48	46.82	25	87
	30	80	48.08	14.08	1.57	44.94	51.21	28	130
	60	80	46.41	6.80	.76	44.90	47.93	29	68
	90	80	47.23	9.75	1.09	45.06	49.39	20	101
	120	80	46.26	6.26	.70	44.87	47.66	35	68
	150	80	46.01	6.13	.68	44.65	47.38	30	64
	180	80	45.69	5.86	.66	44.38	46.99	28	66
	210	80	44.55	7.43	.83	42.90	46.20	10	61
	240	80	45.36	7.41	.83	43.71	47.01	25	82
	Total	720	46.03	8.56	.32	45.40	46.65	10	130
MFGAS	0	80	72.78	24.93	2.79	67.23	78.32	9	136
	30	80	81.81	20.99	2.35	77.14	86.48	42	137
	60	80	84.61	20.34	2.27	80.09	89.14	46	136
	90	80	81.65	21.08	2.36	76.96	86.34	21	137
	120	80	89.86	18.94	2.12	85.65	94.08	47	135
	150	80	86.10	19.57	2.19	81.75	90.45	43	130
	180	80	83.73	18.67	2.09	79.57	87.88	54	132
	210	80	81.91	17.60	1.97	78.00	85.83	43	125
	240	80	83.60	16.65	1.86	79.89	87.31	54	124
	Total	720	82.89	20.35	.76	81.41	84.38	9	137
MFTIBIA	0	80	65.94	16.09	1.80	62.36	69.52	43	114
	30	80	68.33	14.88	1.66	65.01	71.64	45	114
	60	80	71.47	16.77	1.88	67.74	75.21	46	123
	90	80	71.56	18.41	2.06	67.47	75.66	37	125
	120	80	70.66	18.72	2.09	66.50	74.83	10	132
	150	80	67.93	18.91	2.11	63.72	72.13	28	124
	180	80	66.74	17.10	1.91	62.93	70.54	27	120
	210	80	65.60	15.57	1.74	62.13	69.07	30	112
	240	80	66.95	15.51	1.73	63.50	70.40	35	109
	Total	720	68.35	16.99	.63	67.11	69.60	10	132

Table F-6 Multiple comparisons of median frequency (MF) of gastrocnemius muscle.

Multiple Comparisons

Dependent Variable: MFGAS
LSD

(I) TIME	(J) TIME	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
0 min	30 min	-9.04*	2.66	.001	-14.27	-3.81
	60 min	-11.84*	2.66	.000	-17.07	-6.61
	90 min	-8.88*	2.66	.001	-14.10	-3.65
	120 min	-17.09*	2.66	.000	-22.32	-11.86
	150 min	-13.32*	2.66	.000	-18.55	-8.10
	180 min	-10.95*	2.66	.000	-16.18	-5.72
	210 min	-9.14*	2.66	.001	-14.37	-3.91
	240 min	-10.82*	2.66	.000	-16.05	-5.60
30 min	0 min	9.04*	2.66	.001	3.81	14.27
	60 min	-2.80	2.66	.294	-8.03	2.43
	90 min	.16	2.66	.951	-5.07	5.39
	120 min	-8.05*	2.66	.003	-13.28	-2.82
	150 min	-4.29	2.66	.108	-9.52	.94
	180 min	-1.91	2.66	.473	-7.14	3.32
	210 min	-.10	2.66	.970	-5.33	5.13
	240 min	-1.79	2.66	.502	-7.02	3.44
60 min	0 min	11.84*	2.66	.000	6.61	17.07
	30 min	2.80	2.66	.294	-2.43	8.03
	90 min	2.96	2.66	.266	-2.27	8.19
	120 min	-5.25*	2.66	.049	-10.48	-2.05E-02
	150 min	-1.49	2.66	.577	-6.72	3.74
	180 min	.89	2.66	.739	-4.34	6.12
	210 min	2.70	2.66	.311	-2.53	7.93
	240 min	1.01	2.66	.704	-4.22	6.24
90 min	0 min	8.88*	2.66	.001	3.65	14.10
	30 min	-.16	2.66	.951	-5.39	5.07
	60 min	-2.96	2.66	.266	-8.19	2.27
	120 min	-8.21*	2.66	.002	-13.44	-2.98
	150 min	-4.45	2.66	.095	-9.68	.78
	180 min	-2.07	2.66	.436	-7.30	3.15
	210 min	-.26	2.66	.922	-5.49	4.97
	240 min	-1.95	2.66	.464	-7.18	3.28
120 min	0 min	17.09*	2.66	.000	11.86	22.32
	30 min	8.05*	2.66	.003	2.82	13.28
	60 min	5.25*	2.66	.049	2.05E-02	10.48
	90 min	8.21*	2.66	.002	2.98	13.44
	150 min	3.76	2.66	.158	-1.47	8.99
	180 min	6.14*	2.66	.021	.91	11.37
	210 min	7.95*	2.66	.003	2.72	13.18
	240 min	6.26*	2.66	.019	1.03	11.49
150 min	0 min	13.32*	2.66	.000	8.10	18.55
	30 min	4.29	2.66	.108	-.94	9.52
	60 min	1.49	2.66	.577	-3.74	6.72
	90 min	4.45	2.66	.095	-.78	9.68
	120 min	-3.76	2.66	.158	-8.99	1.47
	180 min	2.38	2.66	.373	-2.85	7.60
	210 min	4.19	2.66	.116	-1.04	9.42
	240 min	2.50	2.66	.348	-2.73	7.73
180 min	0 min	10.95*	2.66	.000	5.72	16.18
	30 min	1.91	2.66	.473	-3.32	7.14
	60 min	-.89	2.66	.739	-6.12	4.34
	90 min	2.07	2.66	.436	-3.15	7.30
	120 min	-6.14*	2.66	.021	-11.37	-.91
	150 min	-2.38	2.66	.373	-7.60	2.85
	210 min	1.81	2.66	.496	-3.42	7.04
	240 min	.13	2.66	.963	-5.10	5.35
210 min	0 min	9.14*	2.66	.001	3.91	14.37
	30 min	.10	2.66	.970	-5.13	5.33
	60 min	-2.70	2.66	.311	-7.93	2.53
	90 min	.26	2.66	.922	-4.97	5.49
	120 min	-7.95*	2.66	.003	-13.18	-2.72
	150 min	-4.19	2.66	.116	-9.42	1.04
	180 min	-1.81	2.66	.496	-7.04	3.42
	240 min	-1.69	2.66	.527	-6.92	3.54
240 min	0 min	10.82*	2.66	.000	5.60	16.05
	30 min	1.79	2.66	.502	-3.44	7.02
	60 min	-1.01	2.66	.704	-6.24	4.22
	90 min	1.95	2.66	.464	-3.28	7.18
	120 min	-6.26*	2.66	.019	-11.49	-1.03
	150 min	-2.50	2.66	.348	-7.73	2.73
	180 min	-.13	2.66	.963	-5.35	5.10
	210 min	1.69	2.66	.527	-3.54	6.92

Based on observed means.

*. The mean difference is significant at the .05 level.

BIOGRAPHY

NAME	Miss Woraluk Somboonnadee
DATE OF BIRTHDAY	3 June 1974
PLACE OF BIRTH	Naknonratchasima, Thailand
INSTITUTIONS ATTENDED	Mahidol University, 1996**:**
	B.Sc. (Occupational Health and Safety)
	Mahidol University, 2008:
	M.Sc. (Industrial Hygiene and Safety)
POSITION&OFFICE	Bangkok Seeds Industry Co., Ltd.
	187 Moo 13 Tambon Pattananikhom,
	Ampure Pattananikhom, Lopburi 15140
	Position: Safety Officer
	Tel. 036-491335-6
	E-mail : koy_wo@yahoo.com
HOME ADDRESS	90 Moo 1 Tambon Poklang, Ampure Muang,
	Nakhonratchasima 30000
	Tel. 044-266644