UNIVERSITI PUTRA MALAYSIA

PREVALENCE OF MUSCULOSKELETAL SYMPTOMS AND ITS ASSOCIATED RISK FACTORS AMONG UPM BUS DRIVERS

BY
AINI NURLIYANA BINTI AZHAR

lp
FPSK4 2012 2

ABSTRACT

PREVALENCE OF MUSCULOSKELETAL SYMPTOMS AND ASSOCIATED RISK FACTORS AMONG UPM BUS DRIVERS

AINI NURLIYANA AZHAR

Introduction: Musculoskeletal disorder is a significant public health because of high numbers of cases reported especially in the working population. **Objective:** The aim of this study is to determine the prevalence of musculoskeletal symptoms and its associated risk factors among Universiti Putra Malaysia (UPM) bus drivers. **Methodology:** A cross sectional study was done on all UPM bus drivers. A modified, validated Standardized Nordic Questionnaire was used to obtain information about socio demography, health status, job characteristics, perceived ergonomics risk factors and musculoskeletal symptoms among 47 bus drivers. Height and weight were measured and BMI was calculated. A calibrated Human Vibration Meter was used to measure whole body vibration (WBV) exposure while postural analysis was used to evaluate awkward working posture. **Results:** The prevalence of musculoskeletal symptoms (MSS) among university bus drivers was 97.9%. Majority (78.7%) of the respondents experienced musculoskeletal symptoms involving lower back compared to other body parts. Other common sites were knee (63.8%), leg (59.6%) and neck (53.2%). The level of whole body vibration (WBV) magnitude did not exceed exposure action value (EAV) of European Directive (0.27 m/s^2). There was significant association between duration of working hours per day and prolong sitting with MSS ($p<0.05$). **Conclusion:** Work related exposures were the significant associated risk factors of musculoskeletal symptoms among university bus drivers. Actions need to be taken by the management to improve the working condition of the bus drivers.

Keyword : Musculoskeletal symptoms, bus drivers, risk factors

ABSTRAK

PREVALENS SIMPTOM OTOT RANGKA DAN FAKTOR YANG BERKAITAN DI KALANGAN PEMANDU BAS UPM

AINI NURLIYANA AZHAR

Pendahuluan: Sakit otot rangka menjadi masalah utama dalam bidang kesihatan awam kerana kes yang telah dilaporkan menunjukkan bilangan yang tinggi terutamanya di kalangan pekerja. **Objektif:** Tujuan utama kajian ini adalah untuk mengkaji prevalens simptom otot rangka dan faktor yang berkaitan di kalangan pemandu bas UPM. **Kaedah:** Kajian keratan rentas telah dilakukan terhadap semua pemandu bas UPM. Borang soal selidik Nordic yang disahkan dan diubah suai telah digunakan untuk mendapatkan maklumat tentang demografi pemandu, maklumat pekerjaan, maklumat kesihatan, faktor risiko ergonomik, dan aduan simptom otot rangka dari 47 orang pemandu bas. Tinggi dan berat diukur dan BMI dikira. Alat pengukuran getaran juga digunakan untuk mengukur getaran and analisa postur juga dilakukan untuk menilai postur janggal. **Keputusan:** Prevalens simptom otot rangka di kalangan pemandu bas UPM ialah 497.9%. Kebanyakan (78.7%) pemandu mengalami simptom otot rangka di bahagian belakang bawah berbanding bahagian badan yang lain. Bahagian badan yang lain ialah lutut (63.8%), kaki (59.6%) dan leher (53.8%). Tahap magnitude getaran seluruh badan tidak melebihi nilai pendedahan European Directive (0.27 m/s^2). Tempoh masa memandu dalam sehari dan duduk yang lama telah menunjukkan hubungan yang ketara dengan simptom otot rangka. **Penutup:** Risiko yang ketara ialah faktor yang berkaitan dengan pekerjaan. Tindakan perlu dilakukan oleh pengurusan untuk memperbaiki keadaan kerja pemandu bas.

Keyword : Simptom otot rangka, pemandu bas, faktor risiko

ACKNOWLEDGEMENT

First of all, I would like express my fullest gratitude to Allah the Almighty that with His Blessings I can finish my project successfully. My gratitude goes next to my project supervisor Dr. Huda Binti Zainuddin for her support, guidance and advices in my project. I am grateful and lucky being able to learn her insights that had helped me to complete my work on time.

I also like to thank Dr. Saliza Mohd Elias, the coordinator for our final year project. Her invaluable guidance and comments also had helped me to success complete my project. Apart from that, I would like to express my sincere thanks to all lecturers and staff of Environmental and Occupational Health Department who had contributed directly in making this study success.

Finally, I would like to thank my parents and friends for their invaluable encouragement and endless moral support throughout this project. Besides that, I would like to thank the Vehicle Services Section, UPM for their consent in permitting me conducting the study. Not to forget, yet the most important is the drivers of UPM bus and Suasana Edaran bus who willing to participate and give co-operation in this study.

CONTENTS

CHAPTER 2 : LITERATURE REVIEW

CHAPTER 5 : DISCUSSION, CONCLUSION, AND RECOMMENDATION

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

BMI	Body Mass Index
CPG	Clinical Practice Guidelines
DOSH	Department of Occupational Safety and Health
EAV	Exposure Action Value
ELV	Exposure Limit Value
EU	European Union
MSDs	Musculoskeletal Disorders
MSS	Musculoskeletal Symptoms
NIOSH	National Institute of Occupational Safety and Health
RULA	Rapid Upper Limb Assessment
UPM	Universiti Putra Malaysia
VDV	Vibration Daily Dose
WBV	Whole Body Vibration
WHO	World Health Organization
WRMS	Weighted Root Mean Square

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Musculoskeletal symptoms such as pain, paraesthesia, stiffness, swelling, redness, weakness, tingling and numbness are characterized by musculoskeletal disorder (MSD) (Zakaria *et al,* 2002). Musculoskeletal disorders include a wide range of inflammatory and degenerative condition affecting the muscles, tendons, ligaments, joints, peripheral nerves, and supporting blood vessels. These include clinical syndromes such as tendon inflammations and related conditions (tenosynovitis, epicondylitis, bursitis), nerve compression disorders (carpal tunnel syndrome, sciatica), and osteoarthritis, as well as less well standardized conditions such as myalgia, low back pain and other regional pain syndromes not attributable to known pathology (Laura & David, 2004).

MSDs are also known as musculoskeletal injuries (MSI), repetitive strain injuries (RSI), repetitive motion injuries (RMI), cumulative trauma disorder (CTD), and work related musculoskeletal disorder (WMSD). MSD occur when there is soft tissue injury in which muscle, nerves and tendons become irritated or inflamed. The disorders occur when the body part is called on to work harder, stretch farther, impact more directly or otherwise function at a greater level. The immediate impact may be minute, but when it occurs repeatedly, the constant trauma causes damage (Zakaria *et al*, 2002). Body regions most commonly involved are the low back, neck, shoulder, forearm, and hand, although recently the lower extremity has received more attention (Laura & David, 2004). MSDs also can affect other parts of the body such as upper back, hips, ankles and knees.

There are many causes of musculoskeletal disorder in medical context. Muscle tissue can be damaged with the wear and tear of daily activities. Trauma to an area (auto accidents, falls, fractures, sprains, dislocations, and direct blows to the muscle) cause musculoskeletal pain. Other causes of pain include postural strain, repetitive movements, overuse, and prolonged immobilization. Changes in posture or poor body mechanics may bring about spinal alignment problems and muscle shortening, then causing other muscles to be misuse and become painful (Laura & David, 2004).

The causes are divided into occupational and non-occupational. For occupational, the physical job features that are frequently cited as risk factors for MSD (Laura & David, 2004). For non occupational, the risk factor for the prevalence of MSDs can be individual factors such as age, gender, anthropometry (height, weight, and BMI), non ocupational activities such as hobbies, part time jobs and household activities, medical condition and psychosocial factor (How *et al.* 2004, Miranda *et al.*, 2001).

The work related risk factor or occupational risk factor for MSD can be the biomechanical factors such as reptitive, forceful or prolong exertions, frequent or prolong lifting, pulling, pushing or carrying heavy loads, fixed or awkward postures, vibrating or impact tools. Work organisation is categorized as occupational factors which include work-rest cycles, lack of task variability, and excessive work pace or duration. There is also external risk factors that contribute to MSDs such as lighting, temperature, noise and work stress.

1.2 Problem Statement

Musculoskeletal disorders become the major public health significant because of high number of cases reported. In some studies, MSD have been described as one of the main health problems especially in the working population (How *et al.,* 2004, Jzenlenberg & Burdoft, 2004). Although MSD symptoms are often intermittent and episodic, especially in the early stages and even when they do not correspond to defined clinical syndromes, they may be of major public health significance (Laura & David, 2004).

Based on many researches, it has been proven that MSDs represent a major health and financial burden to the industry, where it can cause significant temporary and permanent disability of workers, symptoms, time lost from work, reduced productivity, and increasing the worker's compensable cost (Webster & Snook, 1994). The cases of musculoskeletal disorder can raise the number of compensation given to workers. In United States, musculoskeletal symptoms are common health problems in working population. There are about one fourth of worker's compensation claims for back pain and one third of worker's compensation costs are paid to claims (How *et al.,* 2004).

Besides, the worker's productivity is also affected. In some studies, most frequent reason to seek care from physician because of low back pain symptoms was reported to be the main cause of work absenteeism (Merlino *et al.*, 2003).

In recent years attention and awareness of MSDs has increased noticeably due to rise in number of reported MSD. Based on the occupational disease reported by non govermental employees in Malaysia, musculoskeletal disorders were one of the most (28%) frequently reported conditions. The average incidence rate reported for musculoskeletal disorders was 3.5 per 100 000 workers (Abas *et al.*, 2008).

The MSDs also have been reported among the drivers. There are many studies shown that there are increasing risk of low back pain, such as bus drivers (Puteri, 2004) and train drivers (Johanning, 1991).

1.3 Study Justification

In Malaysia, studies on risk factors among bus driver are limited and most of the risk factor's studies were done in manufacturing industries since this industry play important role in economic development in Malaysia. Study on ergonomics risk factor of bus drivers should be done because bus drivers are exposed to risk factors which are prolong sitting and whole body vibration.

The study on prevalence of the MSS among UPM bus drivers will help to identify the risk factors that contribute to musculoskeletal symptoms of this population. Data obtained can be used as baseline information and recorded for further uses. This research also can lead to better understanding and awareness about MSS and its health effects on UPM bus drivers. This study will also help to identify the most related risk factors of driving the bus. Therefore, intervention and preventive measures can be done by the university management.

Musculoskeletal disorders also can increase absenteeism among bus drivers. The increasing numbers of absenteeism can affect the productivity of the UPM. Low productivity of the company will affect the nation economy.

Moreover, the musculoskeletal disorders also can affect the quality of life among bus drivers who cannot do their work because of musculoskeletal symptoms. Besides, it will also disturb the job productivity. Besides, MSDs also can cause economic burden to the university management as its employees claim for their medical expenses on treating MSDs and also reduce the quality and productivity of their works due to high percentage of sick absence. In some studies, it found that back pain is the most common reason for sick absence from work and ranks as the fifth most common reason for physician office visits (Webster & Snook, 1994).

1.4 Study Objectives

1.4.1 General Objective

To determine the prevalence of musculoskeletal symptoms and its associated risk factors among UPM bus drivers.

1.4.2 Specific Objectives

1. To determine the socio demographic characteristics, health status, job characteristics and perceived ergonomics risk factors among UPM bus drivers.
2. To determine the whole body vibration magnitude of the buses.
3. To determine the prevalence of MSS among UPM bus drivers.
4. To determine the association of socio demographic characteristics and health status with musculoskeletal symptoms.

5. To determine the association of job characteristics and perceived ergonomics risk factors with musculoskeletal symptoms.
6. To determine the association between level of whole body vibration magnitude and musculoskeletal symptoms.

1.5 Study Hypothesis

1. There is significant association of socio demographic characteristics and health status with musculoskeletal symptoms.
2. There is significant association of job characteristics and perceived ergonomics risk factors with musculoskeletal symptoms.
3. There is significant association between levels of whole body vibration magnitude and the musculoskeletal symptoms.

1.6 Conceptual Definition

1.6.1 Musculoskeletal Symptoms

Musculoskeletal symptoms are characterized by discomfort, complaint of pain and they represent subjective feelings, often self-reported and could eventually lead to musculoskeletal disorder (MSD) (Burton *et al.*, 2008). Musculoskeletal disorder has been defined as disorder of muscles, nerve, tendons, ligaments, joints, cartilage, or spinal disc, which are not typically result of any instantaneous or acute event, such as slip, trip, fall but reflect more gradual or chronic development (Kawowski and Mavras, 1999).

1.6.2 Risk Factors

A risk factor is any attribute, characteristic or exposure of an individual that increases the likelihood of developing a disease or injury (WHO, 2004).

1.6.3 Body Mass Index (BMI)

Body weight and height are classified based on the following formula:

$$\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height}^2 \text{ (m)}}$$

(Standard Guidelines by WHO, 2012)

1.6.4 Whole Body Vibration

The vibration of the entire human body due to transmission via solid material (Tayyavi and Smith, 1997).

1.7 Operational Definition

1.7.1 Musculoskeletal Symptoms

Musculoskeletal symptoms studied are identified using translated Standardized Nordic Questionnaire categorized by symptoms of musculoskeletal system during past 12 months and past 7 days by body parts, which are neck, shoulder, elbow, wrist or hand, upper back, low back, hips, knee and feet or ankles. Besides, the severity of symptoms shown by either the symptoms can disturb normal work during past 12 months are also studied.

1.7.2 Body Mass Index (BMI)

BMI is calculated by dividing weight (kg) with height^2 (m). The categories are as follows:

Table 1.1 : Classification of BMI by Ministry of Health, Malaysia

Classification	BMI
Underweight	< 18.5
Normal	18.5 – 22.9
Overweight	≥ 23
Pre-obese	23.0 - 27.4
Obese I	27.5 – 34.9
Obese II	35.0 – 39.9
Obese III	≥ 40

(CPG 2004, Ministry of Health, Malaysia)

1.7.3 Whole body vibration

Vibration of the buses that caused from engine or road surfaces measured using human vibration meter model HVM 100 and trial axial ICP accelerometer. The vibration measured at the seat of each particular vehicle, which is directly in contact with lumbar region where the erector spine muscle is located.

1.8 Conceptual Framework

The risk factors that can contribute to the prevalence of MSS can be divided to non-occupational, occupational and other risk factors. Non-occupational risk factors include demographic characteristics, medical status and other factors. Socio demographic characteristics such as age, gender, body weight, height, BMI sport and gardening are also contribute to low back pain (Leboef-Yde, 2002). The discs in lumbar area which is from L3 until sacrum are the easiest to degenerate because of aging (Kumar & Narayanan, 1999). Therefore, the age factor is included in this study. For occupational risk factors, it can be divided into working characteristics, ergonomics risk factors and external risk factors. Ergonomics risk factors which are prolong sitting or standing, repetitive movement, awkward posture, contact surface, vibration and heavy workload. Awkward posture including static posture can increase the development of injuries and low back pain (Wikstrom *et al.,* 1994). Besides, prolong sitting factors is also studied. There is increasing prevalence of low back pain among drivers which depend on duration and frequency of driving (Bovenzi & Betta, 1994). External factors include the environment conditions which are lighting, noise, heat and vibration. The whole body vibration is one of the major risk factors of low back pain (Kumar et *al.,* 2001). Therefore, the vibration factor was studied.

Other risk factors of musculoskeletal are personality, attitude, risk behavior and psychosocial factors. In the some studies, psychosocial factors had studied among working population (Lee *et al.,* 2005, Tamrin *et al.,* 2007).

The highlighted boxes are showing the variables within the scope of this study. This study focused on the association between socio demographic factor, job characteristics, health condition, vibration and ergonomics risks factor with the prevalence of MSS among bus drivers.

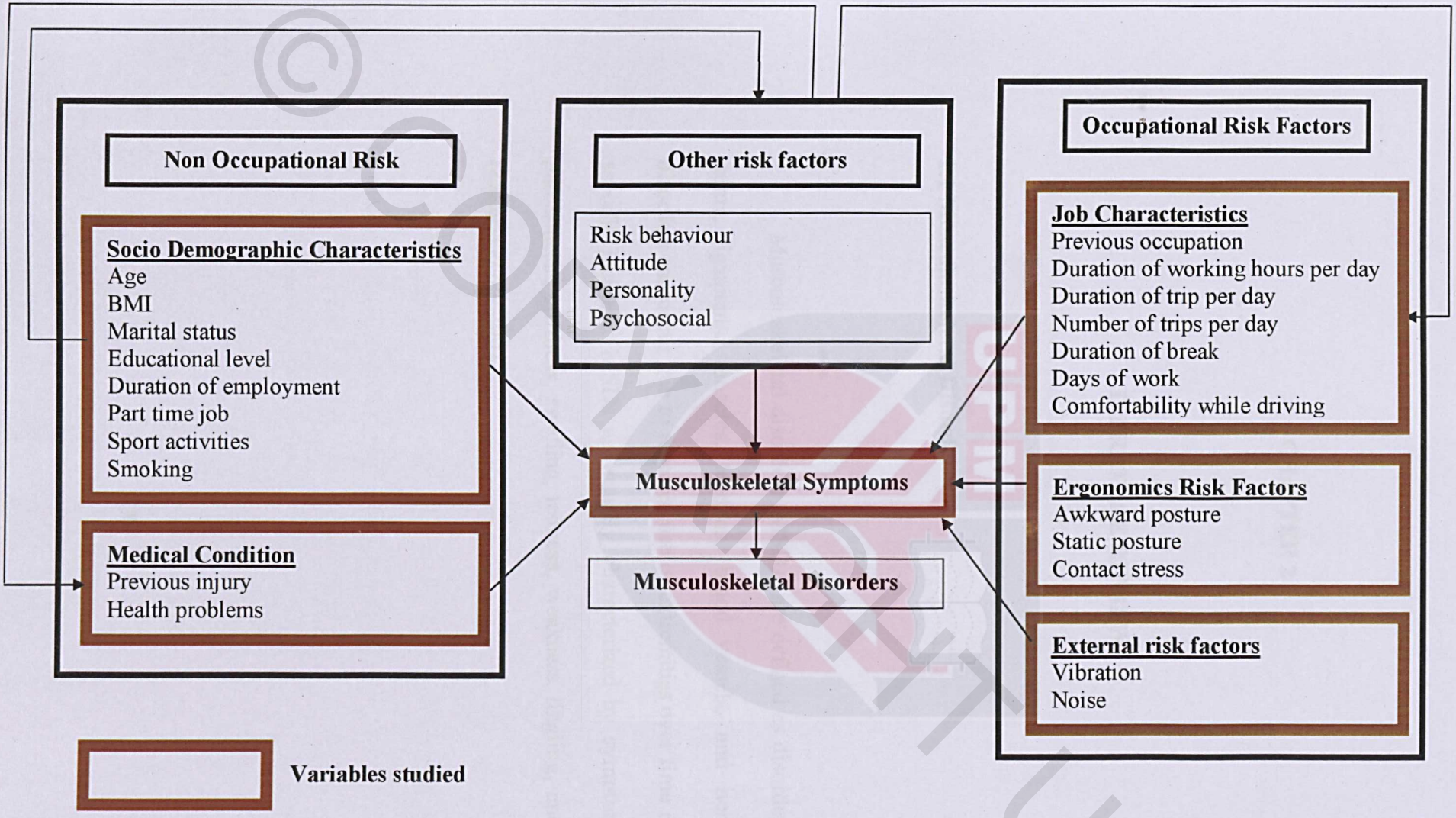


Figure 1.1 : Conceptual Framework

CHAPTER 2

LITERATURE REVIEW

2.1 Musculoskeletal Disorder

Musculoskeletal disorders (MSDs) are defined as disorders as bones, joints, ligaments, muscles, tendons, blood vessels, and nerves. These disorders can occur due to repeated use of extremities over time rather than a specific incident. MSDs are usually characterized by symptoms of pain, paraesthesia, stiffness, swelling, redness, weakness, tingling, and numbness (Zakaria *et al.,* 2002).

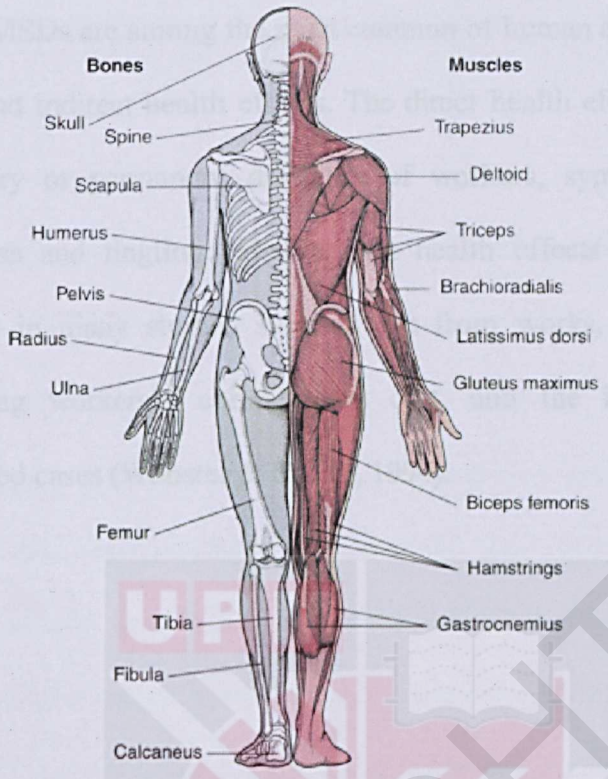


Figure 2.1 : Musculoskeletal System

Besides, MSDs may affect tendons, joints, nerves and related soft tissue anywhere in the body. The lower back and upper extremities including the neck and shoulders, are the most common sites. Because of repeated risk factor exposure of the same muscle, tendon or region may result in injury and inflammation to the affected area, such as cumulative trauma disorder, repetitive motion injury, reptition strain injury, and occupational overuse syndrome have been applied to the disorder (James *et al.*, 1995).

MSDs are among the most common of human afflictions. It can cause direct and indirect health effects. The direct health effect can be significant temporary or permanent disability of workers, symptoms such as pain, numbness and tingling. The indirect health effects of MSDs have been reported in many studies such as lost from works, reduced productivity, increasing workers's compensable cost, and the increasing number of associated cases (Webster & Snook, 1994).

2.2 Risk Factors of Musculoskeletal Disorders

There are many causes or risk factor which can develop the musculoskeletal symptoms. The causes can be divided to occupational and non-occupational. For occupational, the physical job features that are frequently cited as risk factors for MSDs, based on both experimental science and epidemiologic investigations, include rapid work pace and repetitive motion patterns; insufficient recovery time; heavy lifting and forceful manual exertions; non-neutral body postures (either dynamic or static); mechanical pressure concentrations; segmental or whole-body vibration; local or whole-body exposure to cold; and any of these in combination with each other or with undesirable features of the psychosocial work environment like high demands and low degree of control over one's own work (Laura & David, 2004). In addition, individual factors such as age, gender, body weight, smoking habits and psychosocial factors are known to play an important role in occurrence of MSDs (NIOSH, 1997).

On the other hand, in the study on ergonomics job analysis to identify risk factors, which are associated with overextension injuries and disorders, stated that there are six risk factors that are found broadly in any industry which includes forceful exertion, awkward posture, localized contact stress, temperature extremes, vibration and repetitive motions (Keyserling *et al.*, 1991).

2.3 Socio Demography Risk Factors of MSDs

2.3.1 MSDs and Age

Age is obvious to be causal for the incident of many major MSDs such as osteoarthritis and osteoporosis. At the increasing age, bone and joints problems also will increase and become the major cause of very high prevalence of chronic pain and physical disability. The previous study has shown that there is significant association between age and prevalence of MSDs (Razlan, 2000). Besides, in some studies also found that age had significant association with MSDs and workers between 45 until 64 years of age is the highest prevalence of both genders (How *et al,* 2004).

On the other hand, in some studies, age was examined as a factor for the four areas of musculoskeletal pain; it was found that the younger age groups tended to show higher prevalence rates. One possible explanation for the greater prevalence of pain in younger drivers, may be the "survivor bias" factor (Grace & Peggo, 2007).

Age is an important factor for low back pain among adult between 30 to 50 years of age based on exposure time and duration of employment (Khalil *et al*., 1993). The development of musculoskeletal problems such as low back pain depends on many contributing factors such as duration of employment, time of exposure, working environment and body mechanics of human (Chaffin *et al*., 1999).

2.3.2 MSDs and Educational Level

Education related to job held by workers, therefore the association between education level and prevalence of MSDs can be attributable to job content. The association between educational level and MSDs has been documented for back among workers in Taiwan (How *et al,* 2004).

2.3.3 MSDs and Employment Duration

The employment duration also play significant role in development of MSDs among worker population. There is a study reported a higher rate of mechanical neck pain and back pain among bus drivers during the first 5 years of driving, after which the rate would decline (Anderson,1992). This study also reported similar findings that drivers with experience of 5 years or less had a significant increase of hazard rate (1.36) of low back injury (Krause N. *et al.,* 2004). Overseas published studies that examined musculoskeletal problems in drivers have also reported an increased risk due to age and driving years (Anderson, 1992).

2.3.4 MSDs and BMI

Obesity and overweight is associated with musculoskeletal pain and osteoarthritis, especially hips and knees (WHO, 2005). A study done found that a large percentage of back injuries among overweight and obese employees are compared with normal size employees (Keisha *et al.,* 2007). The excess body fat would affect the ability of their body to resist forces (Keisha *et al.,* 2007). In other study, the BMI was found that BMI is one of the major factors that significantly associated with symptom of lower extremities among working population (Peltonen, 2003). Overweight cause

body to bear more load and lower extremities such as hips and legs are prone to MSDs (Peltonen, 2003). The obesity surgery and weight loss has been shown reduce the risk of musculoskeletal problems and osteoarthritis (Peltonen, 2003).

2.3.5 MSDs and Alcohol Consumption and Smoking Habit

Consumption of alcohol and smoking habit is lifestyles which have significant effect to non-communicable disease among human population. MSDs not only cause by occupational factors but can be cause by lifestyle and human habit. There is a study found that smoking habit and alcohol consumption shown significant association with prevalence of MSDs (Peltonen, 2003).

2.4 Occupational Risk Factors of MSDs

2.4.1 MSDs and Posture

There are many risk factors that can be contribute to prevalence of MSDs among bus drivers. One of the risk factor is prolong sitting. Prolong sitting is one of the cause of low back pain. Muscle fatigue cause by driving is increasing the pressure to the spine. Load capacity to be bear by spine cause increased in minor injuries which is repeated will cause degenaration of muscle. This condition become worst cause by transmision of impact from road which increasing of workload of the muscles and spine (Troup, 1978). In other studies, prolong sitting also one of the potenial factors to development of low back pain (Hales & Bernand, 1996). While sitting, the pressure in prolong time will increase the risks to low back muscles disks problems (Videman *et al*., 1990). Continous activity for some muscles in back pain area will increasing muscles fatigue (Hagg & Suurkula, 1991). In occupational setting, study shown that individual who involve with occupations which needed prolong sitting reported high numbers of low back pain incidents.

Prolong sitting will reduce the posture variation. In drivers, driving which involved prolong sitting will reduced the posture variation (Andrew, 2002). Sitting posture reduce the movement, it will reduce the fluid exchange between vertebra disc and muscles and causes the continous load on muscles and vetebra disc. This will increase the risk of low back injuries (McGill, 1997).

2.4.2 MSDs and Vibration

Exposure to whole body vibration by the vehicles is associated with low back pain. Low back pain is one of the musculoskeletal problems. Driving over rough surfaces for prolong time also incrase the exposure to whole body vibration (Keyserling *et al.,* 1991).Tayyavi and Smith (1997) reported that vibration of the vehicles can be transmitted to the entire body parts through the stering wheels, pedals, and seats. The vibration produce from the vehicles engines will be transferred to the solid materials such as steering wheels and seat. This vibration then will affect the erector spinae muscles through the back which is in contact with the seat. This vibration can affect the erector spinae muscles, blood vessels and nervous system. Epidemiological studies suggested that, muscles activities, blood vessels and nerves can affect the physiological function and relate to the symptoms of low back pain (Tayyavi & Smith, 1997).

2.5 Vibration

Vibration is defined as the potential kinetic energy of each particular vehicles which is produced by engine and can be measured by vibration analyzer in frequency, Hz (NIOSH, 1989). NIOSH, USA recommended the occupational safety level for vibration should be less than 5Hz (NIOSH, 1989). American Conference of Government Indsutrial Hygienes (ACGIH) recommended that the WBV should not exceed more than 20 Hz/hour (OSHA, 1998). Based on international standard, ISO 2631-1 (1997), WBV deriving the tri-axial vibration total value, which are X,Y, and Z axis and separately for each direction of vibration in seating, standing or reclining posrition. The uncomfortable condition for workers is when the vibration magnitude is more than 0.315 $ms^{2.}$ for 8 hours working. The international standard of whole body vibration is as follows for 8 hours exposure :

Table 2.1 : The International Standard, ISO 2631-1 (1997) for whole body vibration

Less than 0.315 ms^2	**comfortable**
0.315 ms^2 until 0.63 ms^2	slightly comfortable
0.5 ms^2 until 1.0 ms^2	moderately comfortable
0.8 ms^2 until 1.6 ms^2	uncomfortable
1.25 ms^2 until 2.5 ms^2	highly uncomfortable
More than 2.0 ms^2	extremely uncomfortable

Based on EU Directive, the daily exposure action value for 8 hours of whole body vibration are as follow :

Table 2.2 : Daily exposure action level of EU Directive

Criteria	Values
Daily exposure action value (EAV)	0.5 $ms^{2.}$ A(8)
Daily exposure action value vibration dose value (VDV)	9.1 $ms^{1.75}$
Daily exposure limit value (ELV)	1.15 $ms^{2.}$ A(8)
Daily exposure limit vibration dose value (VDV)	21.0 $ms^{1.75}$

(Adapted from : Nelson and Brereton, 2005)

2.5.1 Effects of vibration

The most common effect of vibration by machine is low back pain. This is caused by various vibration effecting the vertebral column. It can be aggravated with bad body paoture and vibration. The resonance frequencies between 4Hz and 6Hz can affect the upper torso and the pelvis (Palmer *et al.*, 2000).

Vibration can cause damage to the nerves during long exposure (Jeffery, 1991). Vibration of machine can lead to excessive muscular workload and also can cause physical stress in the work environment (Randall & Altmaier, 1994).

A study reported that mechanical factors such as vibration can increase low back pain which is often caused by increase in disc degeneration (Kumar *et al*, 1999).

Continous vibration can disturb the vertebra spinae and miscle fatigue. Moreover, whole body vibration causes vascular damage which is located at veterbra spinae and affect the structure of dorsal tissue (McLain & Weinsten, 1994).

2.6 Musculoskeletal Disorders among Drivers

Professional drivers can be defined as those workers whose main task is to operate a motor vehicle in traffic conditions. This includes chauffeurs, bus, truck, tram, trolley, taxi and ambulance drivers (Belkic, 2000). The health condition of public transport drivers is very important, as it is one of the factors in assuring the safety of passengers using this service (Scubert & Sobala 2005). Those who drive vehicles for a living are three times more likely to suffer from diagnosable back trouble, such as prolapsed intervertebral discs compared with the rest of the population (Troup, 1978).

A review of 22 epidemiological studies among bus drivers' disorders concluded that there are three main groups of health problems among them which are cardiovascular, gastrointestinal, and musculoskeletal disorders (MSD) (Winkleby *et al.,* 1998). A number of studies have examined these problems in drivers of different types of vehicles from trucks and lorries (Massaccesi M. *et al*., 2003, Hulshof CT, 2006), urban transit buses (Krause N. *et al.,* 2004), taxis (Tengku, 2011) and rally cars (Porter & Gyi, 2002). Driving different types of vehicles may impose different stresses to the body, as the driver's seat, control mechanisms and vibration generated may vary (Grace & Peggo, 2007).

Many activities related to daily life and occupation may result in episodes of back or neck pain, however, none is more consistently implicated than driving a motor vehicle for extended periods of time (Kelsey & Hardy, 1975). It has been shown that driving can lead to musculoskeletal problems and drivers are often subjected to postural stress leading to back, neck, and upper extremity pain in their working environment (Pope *et al.*, 2002).

Work-related musculoskeletal disorders (WMSD) affect workers in many occupations including drivers of large vehicles. Urban bus drivers have been found to have high prevalence rates of back problems in overseas studies (Grace & Peggo, 2007). Bus drivers had been reported to have a high prevalence of WMSD in studies in the USA and Europe, but there has been very little research done on Asian drivers, especially bus drivers (Grace & Peggo, 2007). Among the different types of musculoskeletal problems that drivers may have, low back pain has been reported more extensively in past research (Magnusson M. L. et al., 1996, Krause N. *et al.*, 2004).

A survey was conducted on the prevalence of low back pain in bus drivers, truck drivers and sedentary workers. They found that 81% of American bus drivers and 49% of Swedish bus drivers had experienced low back pain. The authors also reported that bus drivers had the highest risk of low back pain among the three occupational groups (Magnusson M. L. *et al,* 1996).

In California, 80% of the respondents who were motor coach operators experienced back or neck pain in contrast with 50% of those who were non-drivers (Anderson, 1992). Weekly driving hours and "ergonomic problems" were found to be strongly associated with back pain. In recent years, there has also been a rapid increase in the number of female drivers employed by the major bus companies, and there has been very little published data on their musculoskeletal health. A study also examined female workers in their study and found that women had a significantly higher hazard rate for back pain (Krause N. *et al.,* 2004).

In Malaysia, a study was conduct to determine the prevalence of MSD among Malaysian bus drivers and to determine the risk factors that may contribute to MSD problems, including work characteristics, ergonomics, and physical and psychological factors. The results from that study show that

82% of them had complained of MSD from any of their body part (Tamrin *et al,* 2007). The prevalence based on the nine body parts indicate that low back was the highest complaint among Malaysian bus drivers followed by the neck, upper back, shoulder, whole leg, knee, hip and thigh, arms, and elbow pains (Tamrin *et al,* 2007).

2.6.1 Ergonomics Risk Factors of Musculoskeletal Disorders among Bus Drivers

Work-related musculoskeletal disorders are affected by both physical and psychosocial risk factors. There are many physical factors that may contribute to increase physical loading in the musculoskeletal system of bus drivers, resulting in discomfort and pain. The most commonly identified physical factors are prolonged sitting, whole body vibration, ergonomic mismatch between driver and seat, the vehicle type and driving mechanisms (Magnusson M. L. *et al.,* 1996, Anderson, 1992, Krause N. *et al.,* 2004). Occupational factors of prolonged sitting and anthropometric mismatch were perceived to be most related to musculoskeletal discomfort (Grace & Peggo, 2007). Professional drivers have been found to be at high risk of developing such problems due to prolonged sitting and vibratory exposure (Grace & Peggo, 2007).

In terms of individual factors, age, gender, weight and height or body mass index (BMI), as well as general health status of the driver are also important risk factors associated with WMSD in drivers (Magnusson M. L. *et al.,* 1996, Massaccesi M. *et al*, 2003) Psychosocial factors such as job satisfaction, ability to handle stress, and psychological status are also important factors to consider in occupational health (Hulshof C. T. *et al,* 2006, Krause N *et al.,* 1998,)

2.7 Rapid Upper Limb Assessment (RULA)

RULA is a validated tests because it was used in both industrial and office settings by ergonomists from Institute for Occupational Ergonomics and by physiotherapists who attended introductory courses in ergonomics (McAtmney & Corlett, 1993). A sample of truck drivers working in two different sitting positions was studied with RULA, a tool which allows to evaluate the loads sustained by the musculoskeletal system due to work posture, muscle use and force exerted and to calculate the exposure risk factors associated with work related upper limb disorders (McAtamney & Corlett, 1993).

RULA have been applied in working population such as to evalate the posture of VDU operators (McAtamney &Corlett, 1993), computer users (Cook and Kothital, 1998) and biomedical scientist (Kilroy & Dockrell, 2000). Besides, RULA also have been applied to drivers which is truck drivers (Massaccesi *et al.*,2003). Furthermore, the study among trick drivers shown significant association between trunk and neck posture and any reported pain, ache or discomfort in the trunk or neck regions (Massaccesi *et al.*,2003).

CHAPTER 3

METHODOLOGY

3.1 Study Location

Study was conducted at Universiti Putra Malaysia (UPM). Universiti Putra Malaysia is located at Serdang, Selangor. There are 16 faculties and 8 institutes in the university. There are 4 complexes in UPM namely the main campus, Faculty of Medicine and Health Sciences, Faculty of Veterinary and Faculty of Engineering complex. The university provides bus services for students to commute between one complex to the other and also the nearby residential areas. The bus coverage is about 5 km radius from the main campus.

3.2 Study Design

This design was cross sectional study.

3.3 Study Population

The study population of this study is all bus drivers who work in UPM. There were a total of 68 bus drivers in UPM. 48 of them managed by UPM Vehicle Services Section and 20 drivers were managed by Suasana Edaran Sdn Bhd which is a contractor of Vehicle Services Section in UPM. All of the drivers were male and they drove buses and coaster. Bus services start from 7.00 am until 11.30 pm every day. Bus drivers worked on rotation every 2 to 3 hours every day. In cases of travelling out from UPM, the bus drivers would be changed every 4 hours.

3.4 Study Sample

The study sample consisted of bus drivers who worked in UPM and fulfill the inclusion criteria.

Inclusion criteria :

- At least 3 months experience of working as bus driver in UPM.

Exclusion criteria :

- Medical leave during data collection period.
- Foreign workers.

3.5 Sampling Frame

List of names of all bus drivers working in UPM.

3.6 Sampling Unit

A bus driver who fulfill the inclusion criteria.

3.7 Sampling Method

The sampling method was universal sampling where all bus drivers who fulfilled the inclusion criteria were selected as sample.

3.8 Sample Size

The sample size in this study is based on formula of Kirkwood (1998). The formula is as follow :

$$N = (P)(Q) / e^2$$

Whereby,

e = 0.05 (selected sampling error at significant level 95%

P = lifetime prevalence of musculoskeletal disorders in driver, 82% (Tamrin *et al.*,2011)

Q = 1 – P

The sample size for the study (N) = $(0.82)(0.18) / (0.05)^2$

= 59

Considering 5% drop out of the sample population, the total sample was 63 persons.

3.9 Variables

3.9.1 Dependent Variable

1. Musculoskeletal symptoms by body part include neck, shoulder, elbow, lower arm, upper arm, low back, upper back, leg, knees, and thigh.

3.9.2 Independent Variables

1. Socio demography including age, BMI, smoking habit, marital status, education level, part time work, sports and duration of employment.
2. Job characteristics including previous occupation, duration of working hours per day, duration of trip per day, number of trips per day, duration break hours, number of days of working per week and comfortability while driving.
3. Health status including previous injury and medical illness.
4. Perceived ergonomics risk factors including prolong sitting, contact stress, noise, and awkward posture.
5. Whole body vibration magnitude and perceived sources of vibration.

3.10 Study Instruments

3.10.1 Questionnaire

The questionnaire used was translated and modified Standardized Nordic Questionnaire (SNQ) (Kuorinka *et al,* 1987). There are five part of questionnaire. Part A is about socio demography of respondents and Part B is about working characteristics. The socio demography question is about age, marital status, height, weight, smoking habit, part time work and hobbies. The questions about working characteristics are including previous occupation, duration of work, part time works and job task. Part C is about medical illness and previous injury. Part D is about workplace condition. The questions were about respondents' knowledge about the sources of vibration and comfortably while driving.

Part E is about the occurrence of musculoskeletal symptoms at the neck, shoulder, elbow, wrist or hand, upper back, lower back, hips, feet, ankles and knee. These questionnaires provide useful and reliable information on musculoskeletal symptoms of the respondent. The respondents should answer the prevalence of symptoms during 12 months and 7 days. Besides, the questionnaire about the severity of musculoskeletal symptoms also

include by asking if the symptoms disturb their normal work. This information either gives rise to further in depth investigation or gives hints for decision-making of preventive measures. Part F is about ergonomics risk factors including environmental factors (Appendix 5).

3.10.2 Measuring Tape

A measuring type was used to measure the height of the respondents involved in this study. The purpose of measuring height and weight was to calculate the Body Mass Index (BMI). Measuring tape used is SECA body meter with accuracy of 0.1 meter. The measurement is done from the foot to the head.

Figure 3.1 : SECA Body Meter

3.10.3 Weighing Scale

A weighing scale was used to measure the weight of the respondents involve in this study. The purpose of measuring height and weight was to calculate the Body Mass Index (BMI). Weighing scale used is TANITA weighing scale with accuracy of 0.1 kg.

Figure 3.2 : TANITA Weighing Scale

3.10.4 Posture analysis

Posture analysis was used RULA (rapid upper limb assessment) ergonomics tools. RULA is a survey method developed focus in ergonomics investigations of workplace where work related upper limb disorders were reported. RULA is a validated tests because it was used in both industrial and office settings by ergonomists from Institute for Occupational Ergonomics and by physiotherapists who attended introductory courses in ergonomics (McAtmney & Corlett, 1993). This tool is used to analyse the posture of the bus drivers for prolong sitting and upper limb movement.

It is used to assess biomechanical and postural loading on the whole body with particular attention to the neck, trunk, arm, wrist and leg. RULA assessment required little time to complete and the scoring generated an action list, which indicated action level of intervention required to reduce the risks of injury due to physical loading on the operator. Three steps involved first observing and selecting the posture to assess, second scoring and recording the postures and then determine the action level. RULA have been used as a part of a broader ergonomics study (Appendix 8).

Table 3.1 : Action level of RULA posture analysis

Action Level	Score	Indication
1	1 - 2	Acceptable postures
2	3 - 4	Further investigation is need and changes to the working environment or work practices maybe required.
3	5 - 6	Further investigation and changes are required soon.
4	7	Investigations and changes are required immediately.

3.10.5 Human Vibration Meter

The human vibration meter use was Maestro Vibration Meter. It was used with a tri-axial accelerometer. The accelerometer is put the driver seat in order to measure the transmission of vibration from the vehicle to the human body. It was used to measure the magnitude of whole body vibration transferred to the body of the bus drivers from the vehicles in 3 axis, which were x, y and z axis. The measurement taken will be transfer to the computer and analyzed (Appendix 9 : Figure 1).

Figure 3.3 : Human Vibration Meter

3.11 Data Collection

The data collections are from secondary data and raw data. Secondary data are the name list of the respondents and location of buses services were obtained from the management. The raw data obtained from the interview and measurements in the study.

3.11.1 Questionnaire Administration

The respondents have been explained about study to be conduct. The respondents who volunteered were given the questionnaire and the consent form. Upon giving a written consent, the researchers interviewed the respondents face-to-face based on the questionnaire (Appendix 9 : Figure 3).

3.11.2 Height and Weight Measurement

After the questionnaires have been filled in, the measurement of height and weight was done using the SECA Body Meter and TANITA weighing scale. Before that, the weighing scale and body meter must be calibrated. While measurement, the respondents stand straight and should not wear the shoes or cap (Appendix 9 : Figure 4).

3.11.3 Vibration Measurement and Posture Analysis

For vibration measurement and posture analysis, the researcher had to go along with the bus drivers while at work. In the bus, the measurement of vibration was conducted. The accelerometer was put on the driver's seat before driving. Before that, the vibration meter was calibrated and the batteries were prepared every time the measurement was conducted. The measurement started when the bus depart until it reached its destination. The measurement of vibration were in 3 axis which x, y and z axis. Weighted root mean square (WRMS) and vibration daily dose (VDV) were computed. During the journey, the respondents were observed of their posture and RULA method was used to analyze the posture of the respondents.

3.11.4 Data Collection Flow

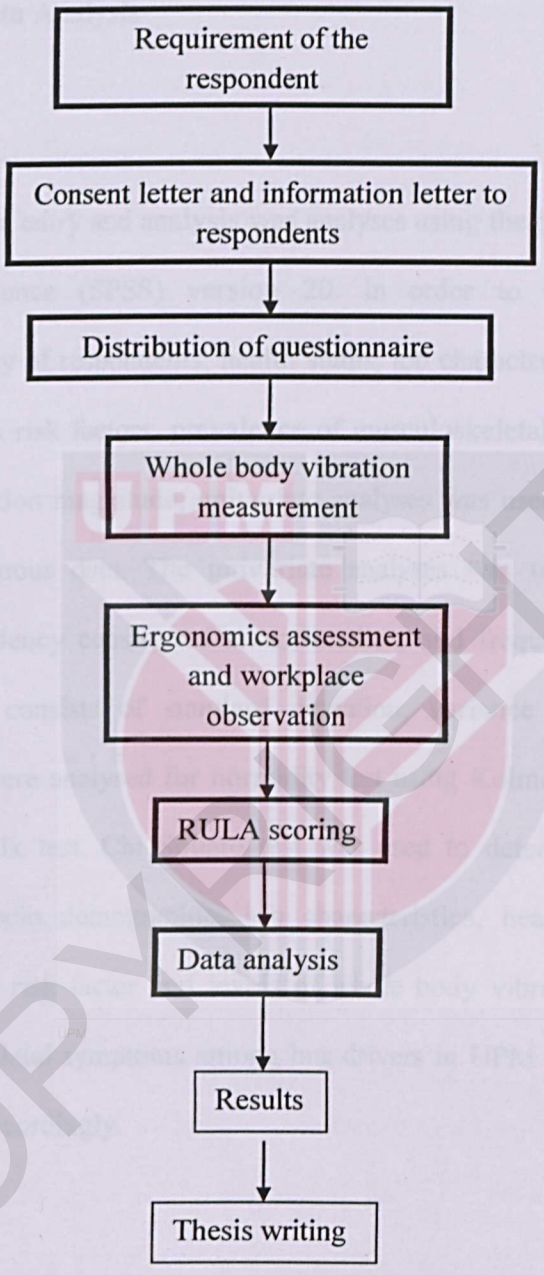


Figure 3.4 : Data Collection Flow

3.12 Data Analysis

Data entry and analysis was analyses using the Statistical Program for Social Science (SPSS) version 20. In order to determine the socio demography of respondents, health status, job characteristic, BMI, perceived ergonomics risk factors, prevalence of musculoskeletal disorders and whole body vibration magnitude, univariate analyses was used for both categorical and continuous data. The univariate analyses was used the measure the central tendency consists of mean, median, and frequency and measure of dispersion consists of standard deviation, variance and range. All the variables were analysed for normality test using Kolmogorov Smimnov and Shapiro-Wilk test. Chi Square test was used to determine the association between socio demographic, job characteristics, health status, perceived ergonomics risk factor and levels of whole body vibration magnitude with musculoskeletal symptoms among bus drivers in UPM and Fisher Exact test was used accordingly.

3.13 Quality Control

3.13.1 Pretest

The questionnaire was pretest on bus drivers (10% of the estimated sample size) who were randomly select from Kajang bus station. The questionnaire was pre-tested to ensure the clarity of the language used and make it more relevant to the research needs. The respondents are allowing commenting and giving suggestion to correct and improve the questionnaire. Reliability analysis of the questionnaire showed cronbach alpha coefficient of 0.865.

3.13.2 Intra reliability test

The measurement of height and weight was done twice for every respondent. The mean for both measurements were recorded. For the posture analysis, RULA method, the researcher did the observation and scoring of posture in both tools twice for every posture.

3.13.3 Standard operating procedures

The measurement of height and weight followed the standard procedures to ensure the data is correct. Besides, the vibration measurement was done based on Guidelines of Vibration 2003, prepared Department of Occupational Safety and Health and ISO 2631-1, the International Standard.

3.13.4 Calibration

The SECA body meter, TANITA weighing scale and human vibration meter were calibrated once a year by the supplier. Every instrument must be assured to have the SIRIM Certificate.

3.14 Ethical Issue

Approval from Medical Research Ethics Committee, Faculty of Medicine and Health Sciences, University Putra Malaysia was obtained prior to data collection. Permission from head of Vehicle Services Section was obtained. All the respondents were given detailed description about the purpose and procedure of the study.

Respondents who were willing to participate in the study were asked to sign a consent form. Respondents are free to withdraw themselves any time during the study duration if they feel uncomfortable participating in the study. All information obtained from this study was kept in confidentiality.

3.15 Study Limitations

Since this is a cross sectional study, it can only detect the risk factors and problem during the study period. The temporal relationship between risk factors and musculoskeletal disorders can be determined. The information regarding MSS was conducted through a questionnaire, therefore recall bias is possible. Besides, respondents may also have to provide information, which do not accurately characterize their health condition, which may lead to information bias. Psychosocial factors such as job stress are not measured in this study, adding to another limitation. Besides, the low numbers of the involvement of the respondents in this study because there was shortage of drivers and most of the drivers were busy and outstation.

CHAPTER 4

RESULTS

4.1 Socio Demographic Characteristics and Health Status of Respondents

The study was conducted on 47 of 63 bus drivers in UPM thus response rate was 74.6%. Table 4.1 show the socio demography and health status of 47 respondents. The age of respondents ranged from 24 until 61 years old where the mean age was 42.91 years (9.39). Majority (36.2%) of the respondents were 31 to 40 years old followed by 41 to 50 years old (29.8%), more than 51 years old (23.4%) and 21 to 30 years old (10.6%) (Table 4.1(a)).

The BMI of respondents ranged from 18 until 37.75 with a mean BMI of 27.13 (4.61). The BMI categories were based on Clinical Practice Guidelines from Ministry of Health, Malaysia 2004 showed 18 (38.3%) respondents had BMI of 27.5

to 34.9, which is Obese I. For BMI 23.0 until 27.4, there were 15 (31.9%) respondents and they were categorized under overweight or pre-obese, 10 (21.3%) respondents had BMI of 18.5 to 22.9 which was categorized under normal BMI. Minority 3 (6.4%) had BMI of 35.0 to 39.9 categorized under Obese II and only 1 (2.1%) respondent was categorized as underweight with BMI of less than 18.

Majority 40 (85.1%) of the respondents were married, 5 (10.6%) respondents were single and 2 (4.3%) were divorced. Respondents who complete their studies at PMR level were 44.7%, 40.4% up to SPM level whiles those who completed STPM or diploma and degree level were 6.4%. Moreover, 4 (8.5%) respondents only had education at primary or UPSR level (Table 4.1(a)).

Majority 26 (55.3%) of the respondents were smokers and 21 (44.7%) respondent were non-smoker. Majority 35 (74.5%) of respondents did not have part time work and 12 (25.5%) of the respondents did part time job. Other activities of respondents also taken into consideration since its can induce musculoskeletal symptoms (MSS). There were 19 (40.4%) respondents enjoyed sports during their leisure time. However, some respondents did not involve in sport were 28 (59.6%). Majority 18 (38.3%) of respondents had worked for about less than 5 years as bus drivers in UPM and 16 (34.0%) 6 to 10 years. Besides, 13 (27.7%) respondents had worked for more than 10 years (Table 4.1 (b)).

Majority 29 (61.7%) of the respondents did not experience injury in the past time but 18 (38.3%) had experienced injury in past time at any part of the bodies. From all respondent which have previous injury, 9(12.8%) have their injury at the shoulder, 3 (6.4%) at arm, 1 (2.1%) at upper back, 4 (8.5%) at knee, and 5 (10.6%) at leg (Table 4.1 (b)).

Table 4.1(a) : Socio demographic characteristics and health status of the respondents (N=47)

Variables	Frequency	%	Mean (SD)	Median (IQR)
Socio Demography				
Age			42.91 (9.39)	41 (13)
21 - 30	5	10.6		
31 - 40	17	36.2		
41 - 50	14	29.8		
>51	11	23.4		
BMI			27.13 (4.61)	26.99 (5.88)
<18.5	1	2.1		
18.5-22.9	10	21.3		
23.0 -27.4	15	31.9		
27.5-34.9	18	38.3		
35.0-39.9	3	6.4		
Marital status				
Single	5	10.6		
Married	40	85.1		
Divorce	2	4.3		
Education level				
Primary/UPSR	4	8.5		
PMR	21	44.7		
SPM	19	40.4		
STPM/Diploma and Degree	3	6.4		

Table 4.1(b) : Socio demographic characteristics and health status of the respondents (N=47)

Variables	Frequency	%
Smoking habit		
Yes	26	55.3
No	21	44.7
Part time job		
Yes	12	25.5
No	35	74.5
Sport		
Yes	19	40.4
No	28	59.6
Previous Injury		
Yes	18	38.3
No	29	61.7
Body part of Injuries (N=18)		
Shoulder	6	12.8
Arm	2	4.3
Upper back	1	2.1
Knee	4	8.5
Leg	5	10.6

4.2 Job Characteristics

Majority 43 (91.5%) of the respondents had previous jobs before they work as bus drivers in UPM and only 4 (8.5) did not have previous jobs. Majority 26 (53.3%) of the respondents work as drivers before they work as bus drivers in UPM and 21 (44.7%) of them works as others occupation likes secretary, army and others (Table 4.2 (a)).

The duration of working hours of driving ranged from 7 until 16 hours which a mean working hours of 11.15 (3.712). Majority 45 (95.7%) of respondents had worked for more than 8 hours per day. Minority 2 (4.3%) had worked for less than 8 hours per day (Table 4.2 (a)).

The duration of trips ranged from 7 minutes until 45 minutes with a mean duration of trips of 23.19 minutes (9.42). There were 57.4% respondents who had to drive for less than 20 minutes in each trip of driving and 31.9% of respondents drove for more than 20 minutes to 30 minutes in each trip of driving. Minority (10.6%) of the respondents drove more than 30 minutes to complete each trip. The number of trips per day ranged from 6 trips until 100 trip which a mean trips of 29.78 (22.11).

Majority 27(57.4%) of the respondents had to complete less than 20 trips per day and 10 (21.3%) needed to complete 21 to 45 and more than 45 trips in a day. The duration of break ranged from 15 minutes until 2 hours which a mean of breaks duration 95.53(86.02). Respondents had rest in between trips for less than 1 hour (46.8%), 1 to 2 hours (31.0%), and more than 2 hours (21.3%) (Table 4.2 (a)).

The number of working days ranged from 5 trips until 7 days in a week which a mean days of 6.81(0.5). Majority 40 (85.1%) of the respondents had been works for 7 days in a week. On the other hand, 7 (14.9%) respondents had been work for less than 6 days a week. Majority 28 (59.6%) of the respondents comfortable while driving but 19 (40.4%) of the respondents were not comfortable while driving. Out of those who did not felt comfortable, 19.1% of the respondents were uncomfortable because the seat was not suitable, the cushion was hard (6.4%), bus condition (6.4%), too many students (6.4%), others factor (4.2%) and uncomfortable because of prolong sitting (2.1%) (Table 4.2 (a)).

There were 36.2% respondents who scored from 1 to 2 indicating that their posture was acceptable. Majority (40.4%) of respondents scored from 3 to 4 which indicated that further investigation is needed and changes may be needed while 23.4% of respondents obtained a score of 5 to 6 indicating that further investigation needed and changes should be made to the task soon (Table 4.2 (b)).

Table 4.2 (a) : Job characteristics of the respondents (N= 47)

Variables	Freq	%	Mean (SD)	Median (IQR)
Previous occupation				
Yes	43	91.5		
No	4	8.5		
Types of previous job (N=43)				
Drivers	26	55.3		
Others	17	36.2		
Duration of working hours per day			11.15(3.712)	8 (8)
<8 hours	2	4.3		
≥8 hours	45	95.7		
Duration of trip per day			23.19(9.42)	20(15)
≤ 20 minutes	27	57.4		
>20-30 minutes	15	31.9		
>30 minutes	5	10.6		
Number of trips per day			29.29(22.11)	20(19)
<20 trips	27	57.4		
21-45 trips	10	21.3		
>45 trips	10	21.3		
Duration of Breaks			95.53(86.02)	60(90)
0-59 minutes	22	46.8		
1-2 hours	15	31.9		
>2 hours	10	21.3		
Days of Work			6.81(0.50)	7(0)
<7 days	7	14.9		
7 days	40	85.1		
Comfortable While Driving				
Yes	28	59.6		
No	19	40.4		
Reason for Uncomfortable (N=19)				
Hard cushion	3	6.4		
Not suitable seat	9	19.1		
Prolong sitting	1	2.1		
Bus condition	2	4.3		
Too many students	2	4.3		
Others	2	4.3		

Table 4.2 (b) : Job characteristics of the respondents (N= 47)

Variables	Freq	%
RULA Score		
1-2	17	36.2
3-4	19	40.4
5-6	11	23.4

RULA : Rapid Upper Limb Assessment

4.3 Perceived Ergonomics Risk Factors

Majority (95.7%) of respondents had to sit in static posture during driving but 4.3% respondents claimed that they did not have to remain in the same posture for a long time while driving. Majority (89.4%) of respondents did not have contact with any edges at their working area and 10.6% had contact with edges at their working area (Table 4.3).

Majority (25.5%) of the respondents bent forward and their body were twisted while driving followed by 17.0% bent forward, twisted their body, and extend their neck while driving, 10.6% twisted their body, 6.4% bent forward, 4.3% extend their neck or/and twist their body, 4.3% bent forward or/and extended their neck and only 2.1% respondent needed to extend their neck while driving (Table 4.3).

Minority (19.8%) of the respondents did not bend forward, extend their neck and twist their body while driving. Thirty three (70.2%) respondents were exposed to noise while driving and were not exposed to noise (29.8%) (Table 4.3).

Table 4.3 : Perceived ergonomics risk factors (N= 47)

Variables	Frequency	%
Perceived Ergonomics Risk factor		
Static Posture		
Yes	45	95.7
No	2	4.3
Contact Stress		
Yes	5	10.6
No	42	89.4
Awkward Posture		
Bend forward	3	6.4
Neck extension	1	2.1
Body twist	5	10.6
Bend forward or/and neck extension	2	4.3
Bend forward or/and body twist	12	25.5
Neck extension or/and body twist	2	4.3
All	8	17.0
None	14	29.8
Noise		
Yes	33	70.2
No	14	29.8

4.4 Vibration Assessment

The weighted root mean square (WRMS) mean for all axes was 0.27 m/s^2. The vibration daily dose (VDV) mean for all axes was 8.65 $m/s^{1.75}$. The maximum vibration magnitude was 0.9630 m/s^2 for WRMS and 16.00 $m/s^{1.75}$ for VDV. The minimum vibration magnitude for WRMS was 0.0507 m/s^2 and 5.38 $m/s^{1.75}$ for VDV (Table 4.4).

The magnitude of the Z-axis (0.17 m/s^2) was higher reading compared to x and y-axis. Based on ISO 2631-1, the vibration magnitude (0.27 m/s^2) for WRMS did not exceed 0.50 m/s^2, which is the exposure action value (EAV) and (1.15 m/s^2) exposure limit value (ELV). The vibration magnitude (8.6517m/s^2) for VDV was not exceeding (<9.1 m/s^2) exposure action value (EAV) and (<21.0 m/s^2) exposure limit value (ELV) (Table 4.4).

There were 10 (21.3%) respondents said that the source of vibration was engine and 10 (21.3%) road while 9 (19.1%) respondents said the source of vibration was steering and 9 (19.1%) seat. Minority 8 (17.0%) of the respondents said the vibration's sources were from the condition of the bus (Table 4.5).

Table 4.4 : Profile of vibration magnitude

Variables	Min	Max	Mean	SD
WRMS (m/s^2)				
x	0.03	0.37	0.11	0.12
y	0.03	0.50	0.09	0.11
z	0.04	0.55	0.17	0.18
xyz	0.05	0.96	0.27*	0.28
VDV($m/s^{1.75}$)				
x	1.94	8.47	3.83	1.76
y	1.45	6.73	2.50	1.26
z	4.93	15.10	6.88	2.63
xyz	5.38	16.00	8.65*	3.34

WRMS: Weighted root mean square

VDV: Vibration daily dose

* Did not exceed Exposure Action Value (EAV) and Exposure Limit Value (ELV)

Table 4.5 : Perceived sources of vibration

Variables	Frequency	%
Sources of Vibration		
Steering	9	19.1
Seat	9	19.1
Gear	1	2.1
Road	10	21/3
Engine	10	21.3
Bus condition	8	17.0

4.5 Prevalence of Musculoskeletal Symptoms

Table 4.6 shows the overall prevalence of total MSS and by body part. Majority 46 (97.9%) of the respondents experienced musculoskeletal symptoms at any body part. The highest prevalence of musculoskeletal symptoms by body part was lower back 37 (78.7%) followed by knee (59.6%), leg (59.6%), neck (53.2%), shoulder (34%), thigh (19.1%), lower arm (14.9%) and elbow (10.6%).

Table 4.6 : Prevalence of musculoskeletal symptoms (N=47)

Body region	N	%
Any body part	46	97.9
Neck	25	53.2
Shoulder	16	34.0
Elbow	5	10.6
Lower arm	7	14.9
Upper back	15	31.9
Lower back	37	78.7
Thigh	9	19.1
Knee	30	63.8
Leg	28	59.6

4.6 Association between Socio Demographic and Health Status with Musculoskeletal Symptoms

There was no significant relationship between age, BMI, educational level, smoking habit, part time job, sport activities, duration of employment and previous injury with musculoskeletal symptoms ($p>0.05$) (Table 4.7 (a) and Table 4.7 (b)).

Table 4.7(a): Association between socio demographic and health status with musculoskeletal symptoms

Variables	MSS		χ^2	$p-$value*
	Yes	No		
Socio Demography				
Age				
≤ 40 years old	21	0	0.825	1.000
> 40 years old	25	1		
BMI				
< 22.9	11	0	0.312	1.000
> 23.0	35	1		
Education level				
Primary and lower secondary	24	1	0.899	1.000
Upper secondary and tertiary	22	0		
Smoking habit				
Yes	26	0	1.265	0.447
No	20	1		

*Fisher's Exact Test

Table 4.7(b): Association between socio demographic and health status with musculoskeletal symptoms

Variables	MSS		χ^2	$p-$value*
	Yes	No		
Duration of employment				
≤ 10 years	33	1	1.646	0.383
>10 years	13	0		
Health status				
Previous Injury			1.646	0.383
Yes	17	1		
No	29	0		

*Fisher's Exact Test

4.7 Association between Job Characteristics and Perceived Ergonomics Risk Factors with Musculoskeletal Symptoms

There was no significant relationship between previous occupation and types of occupation of the previous job with MSS ($p>0.05$). There was significant association between duration of working hours per days with MSS ($p<0.05$). However, there was no significant association duration of trips per day, duration of breaks and numbers of working days with MSS ($p>0.05$). Besides, there was no significant between comfortablity while driving and MSS ($p>0.05$) (Table 4.8 (a) and Table 4.8 (b)).

However, there was a statistically significant association between prolong static posture and MSS ($p < 0.05$). However, there was no significant association between contact stress and the complaint of MSS by respondents ($p > 0.05$).). It is found that there was no significant association between awkward posture while driving and complaint of MSS by respondents ($p > 0.05$). The environmental factor which is noise exposure while driving showed no significant association with MSS complaints by the respondents ($p > 0.05$) (Table 4.8 (b)).

Table 4.8 (a): Association between job characteristics and perceived ergonomics risk factors with musculoskeletal symptoms

Variables	MSS		χ^2	p – value*
	Yes	No		
Job characteristics				
Previous occupation				
Yes	43	0	10.984	0.085
No	3	1		
Types of Previous Job				
Drivers	25	1	0.825	1.000
Others	21	0		
Duration of working hours per day				
< 8 hours	1	1	22.989	0.043**
≥ 8 hours	45	0		
Duration of Trip per day				
≤ 20 minutes	27	1	0.693	1.000
> 20 minutes	19	0		
Number of Trips per day				
≤ 20 trips	26	1	0.757	1.000
> 20 trips	20	0		

*Fisher's Exact Test **significant at $p<0.05$

Table 4.8 (b): Association between job characteristics and perceived ergonomics risk factors with musculoskeletal symptoms

Variables	MSS		χ^2	$p-$value*
	Yes	No		
Duration of Breaks				
0-59 minutes	21	1	0.757	1.000
>1 hours	15	0		
Days of Work				
<7 days	7	0	0.179	1.000
7 days	39	1		
Comfortable While Driving				
Yes	28	0	1.506	0.404
No	18	1		
Perceived Ergonomics Risk factor				
Static Posture				
Yes	45	0	22.989	0.043**
No	1	1		
Contact Stress				
Yes	5	0	0.122	1.000
No	41	1		
Awkward Posture				
Yes	32	1	0.433	1.000
No	14	0		
Noise				
Yes	33	0	2.408	0.298
No	13	1		

*Fisher's Exact Test **significant at $p<0.05$

4.8 Association between Levels of Whole Body Vibration Magnitude with Musculoskeletal Symptoms

There was no significant association shown between level of vibration magnitude and the complaint of MSS by respondents ($p>0.05$) (Table 4.9).

Table 4.9 (b): Association between levels of vibration magnitude with musculoskeletal symptoms

Variables	MSS		χ^2	p – value*
	Yes	No		
Vibration				
WRMS				
< EAV	35	1	0.312	1.000
> EAV	11	0		

*Fisher's Exact Test

CHAPTER 5

DISCUSSION, CONCLUSION, AND RECOMMENDATION

5.1 Socio Demographic Characteristics and Health Status of the Respondents

The response rate reported from this study was low (74.6%). A study by Rozali *et al.,* (2009) among military armoured vehicle drivers reported response rate of 90.8%. Besides, studies by Gou *et al.,* (2004) and Lee at al., (2005) reported response rate of 84.3% and 85.3% respectively. Drivers were busy during period of study because there was shortage of drivers. Therefore, some were reluctant to participate. The respondents' age ranged from 24 until 62 years old because it is the working age in Malaysia. A study by Mahadi (2000) stated that the working age was from 15 to 64 years old. At this age, most of the people need to work for their family. In this study, majority of respondents age from 31 to 40 years old and 41 to 50 years old. A study by Mahadi (2000) predicted in 2010, there will 42.9 % of Malaysian citizen age from 25 until 59 years old.

The mean BMI of respondents was 27.13. It is in the same range with a study by Grace and Peggo (2007) among Hong Kong bus drivers reported that the mean of BMI was 25.24. Most of the respondents were categorized under overweight and obese I. From observation, the drivers did not frequently do the physical activity because of their nature of work. Besides, majority (59.6%) of the respondents were not involved in any sports (Table 4.1(b)).

Majority of the respondents were married. It is similar with a study among Malaysia's bus drivers by Tamrin *et al.,* (2007) reported that 696 (91.6%) of respondents are married. Most of the respondents completed their studies at PMR. A study by Tamrin *et al.,* (2007) reported that majority of 277(36.4%) respondents completed their studies at lower secondary level, which is PMR level.

During face-to-face interview, most of the respondents say that they smoke because of stress and influenced from their community. Most of their friends were smokers, therefore they were prone to smoke. Most of respondents did not have part time work because of their nature of work which they had to work from morning until night. Most respondents had worked up to 5 years. It was contrast with a study by Grace and Peggo (2007) reported that 131 (32.4%) respondents had worked for 6 to 10 years.

Most of respondents experienced previous injury because of the motorcycles accidents. In Malaysia, the numbers of motorcycles accident on the road was high, 28 269 (RMP, 2010).

5.2 Job Characteristics

Most of respondents had previous job before they worked with UPM. Moreover, majority 18 (38.3%) of respondents had worked for less than 5 years in UPM (Table 4.1(b)). Therefore, there would be most of respondents had their previous job before started working in UPM. However, most of respondents had worked as lorry drivers, long distance bus drivers, school bus drivers and others because they were familiar with the nature of works as drivers (Table 4.2 (a)). It is similar with a study by Tamrin *et al.,* (2007) reported 107 (13.7%) bus drivers had previous job involving driving vehicles.

Most of the respondents had drove for more than 8 hours. Based on the result, we can say that the respondents working hours exceeded the normal duration of works. This is due to students' demand. Moreover, UPM buses are the major transportation in the UPM campus. Sometimes, they have to work overtime because

of the students' scheduled. A study by Tamrin *et al.,* (2011) reported only 344 (35.8%) had drove for more than 8 hours.

Duration of trips is based on the destination. Places in the UPM campus such as Tun Perak College, Twelve College take shorter time. Besides, the longer duration of trips taken when the buses have to travel outside the campus. The example of destination is Hentian Komuter, Desaminium and others. Most of respondents take less than 20 minutes to complete their trips. However, it was contrast with a study among Malaysian bus driver by Tamrin *et al.,* (2011) who showed that 844 (88.4%) drivers took more than 20 minutes to complete their trips. Respondents took less than 20 minutes to complete to trips because the distance between the destinations was shorter.

Number of trips depends on the numbers of buses. Less numbers of buses need more trips to fulfil the need of students. Most of respondents needed to complete less than 20 trips. A study by Tamrin *et al.,* (2011) showed that 476 (49.5%) more than 5 trips daily. Based on study, the respondents have short time of break and had to work more than 6 days a week because the numbers of drivers and buses was not sufficient to fulfil the students' needs.

Most of respondents were comfortable while driving. However, there were also respondents who were not comfortable while driving. From the observation, the seats were not suitable because there was some drivers put the pillow at their seat. It has shown that the seats are not suitable with their bodies and consequently will affect their skeletal parts. It was supported with a study by Grace and Peggo (2007), stated that 196 of respondents perceived that there was mismatch between drivers and seat dimensions.

5.3 Perceived Ergonomics Risk Factors

Most of the respondents claim that they have to sit for a long time and have to maintain that posture. Majority 25(53.2) of respondents had worker for more than 8 hours daily (Table 4.2(a)). In a study by Grace and Peggo (2007), showed the highest number (355) of subjects identified prolonged sitting. Based on the observation, there were less sharp edges at the driver's area which can results in contact stress. However, there were sharp edges at the fire extinguisher nearby to the driver's area that will results in injuries.

Most of the respondents bend forward and twist their body while driving. Sometimes, drivers need to bend forward while driving because there were a lot of students in the bus which disturb the visibility of the drivers. Besides, the drivers also need to twist their body while make a turn because of the big steering. In a study, 5 (8.2%) drivers indicated that the torso bent posture was often adopted during driving, and 35 (57.4%) drivers indicated the torso against backrest posture (Okunribido *et al.*, 2007). Moreover, they also needed to extend their neck when they need to see the students who have arrived at their destination. Therefore, most of respondents experienced awkward posture while driving. However, a study by Tamrin *et al.*, (2011) showed that 187(94.4%) of respondents have experienced less than 40% awkward posture. Most of the respondents claim that they were exposed to noise. The noise came from the noisy student and also comes from the engine.

5.4 Vibration Magnitude

Based on the results, the magnitude of the Z-axis of the buses was higher than Y and X-axis. It is similar to the study stated that Z-axis had the higher reading than others axis. (Bovenzi *et al.,* 2006). The highest reading of z-axis may be due to the road condition in UPM, there were a lot of potholes.

The whole body vibration magnitude did not exceed the EAV and ELV for both WRMS and VDV. A study by Tamrin *et al.,* (2007) reported WRMS value that the vibration magnitude did not exceed action level and exposure limit value of ISO 2631-1. Furthermore, a study on professional drivers including bus drivers reported the vibration magnitude did not exceed VDV of EU Directive (Bovenzi *et al.,* 2006).

5.5 Prevalence of Musculoskeletal Symptoms (MSS)

Prevalence of musculoskeletal symptoms among UPM bus drivers was high (97.9%). In another study done in Malaysia, the overall prevalence of MSD was 81.8% (Tamrin *et al.,* 2011). Bus drivers in UPM tend to drive more than 8 hours per day because there was shortage of number buses. Long driving hours was influenced by demand of the student because of high numbers of students. There was also high numbers of students in UPM who use the transport services to travel in the campus. There were many activities in the campus where the students need to travel from one place to another.

Besides, the bus condition also affected the availability of the buses since buses have taken to the workshop for repair. Therefore, the bus drivers need to complete many trips per day to meet the students' demand. Prolong driving would lead to muscle fatigue and induce MSS (McGill, 1997). Therefore, a higher prevalence of MSS was observed among UPM bus drivers.

The highest prevalence by body parts among bus drivers was back pain followed by knee, leg, neck, shoulder, upper back, thigh, lower arm and elbow. Our finding showed that low back pain was the most prevalence of MSS (78.7%)

followed knee, leg, neck, shoulder, upper back, thigh, lower arm and elbow. This finding is similar to other studies (Kelsey & Hardy, 1975; Winkleby *et al.*, 1998; Anderson, 1992; Magnusson *et al.,* 1996; How *et al.,* 2004, Grace & Peggo, 2007) which stated that prevalence of low back pain in drivers ranged from 60% to 90%.

Besides, a study by Magnusson *et al.* (1996) reported that prevalence of low back pain show the highest (60%) prevalence followed by neck pain (45%). Tamrin *et al.* (2007) in their study among Malaysian bus drivers also showed that low back pain was the highest prevalence (60.4%) followed by (51.6%) neck pain complaints. A study by Grace and Peggo (2007) on Hong Kong bus drivers also showed low back pain was the highest (62%) and followed by neck pain (53%).

In contrast, most of the studies showed the second highest prevalence was neck pain but in our study, knee pain showed the highest prevalence after low back pain follow by leg. The lower prevalence of neck pain maybe due to low proportion of drivers in our study had to work in awkward posture of the neck (2.1 %) (Table 4.3). There is a study some studies that found the second highest prevalence of MSD were other than neck pain, a study by Gourdeau (1997) on school bus drivers reported that neck pain was the highest prevalence (38%) and followed by (37%) shoulder pain.

5.6 Association between socio demographic characteristics and health status with musculoskeletal symptoms

Finding of this study showed that none of socio demographic characteristics and health status of the respondents may affect the prevalence of musculoskeletal symptoms in bus drivers. There was no significant association between socio demographic risk factor with MSS. However, a study by Mohd Rotpi (2003) stated that there was significant relationship between smoking and MSD. It was stated that smoking could increase chronic coughing which put more pressure on the intervertebral disc and influence disc prolapsed and sciatica (Mohd Rotpi, 2003). Smoking also could change disc nutrition and reduce bone mineral content, making the disc more vulnerable to micro features. Therefore, prolong exposure to tobacco smoke could induce MSD.

5.7 Association between job characteristics and perceived ergonomics risk factors with musculoskeletal symptoms

Finding of this study showed that some job characteristics and perceived ergonomics risk factors may affect the prevalence of musculoskeletal symptoms in bus drivers. There was significant relationship between duration of working hours per day with MSS. A study by *Guo et al., (*2002) showed that there was significant association between duration of working hours and MSD. Besides, there was increased incident of low back pain among driver who drives more than four hours without stop while using unadjusted seat (Porter and Gyi, 2002). The finding of this study is also supported by a study by Tamrin *et al.,* (2011) who find that duration of driving daily were associated with MSD. A study in Iran, show that the numbers of hours spent on the job, duration of driving per week, average continuous driving per day were higher among bus drivers who experienced LBP compared to healthy drivers. There was also significant relationship found among bus drivers with long driving hours compared to those with shorter driving hours (Sadri, 2003). The study also concluded that MSD are associated with driving condition (Sadri, 2003).

For perceived ergonomics risk factor, there was significant association between static postures which is prolong sitting with MSS among UPM bus drivers. It is consistent with a study by NIOSH in 1997 that concluded a significant association between posture and MSD (NIOSH, 1997). A study by Grace and Peggo (2007) also reported prolong sitting were associated with MSD.

It is found that there was no significant association between awkward posture and MSS. In contrast, awkward postures had shown significant association with MSD in the study by Bovenzi *et al.,* (2006) who stated that factors which contribute to development of low back pain was the insufficient nutrient on back bone disc because of the less movement while sitting and depend only on the physiology factors rather than the posture. In this study, the posture analysis of RULA shows that majority (40.4%) of the respondents score from 3 to 4 and score from 1 to 2 (36.2%) rather than score more than 4 (Table 4.2(b)). Score from 3 to 4 indicated the action level of 2 which is further investigation and changes may be needed. Score from 1 to 2 indicated the action level of 1 which is acceptable posture. These shown that the posture was in the acceptable level. Therefore, there was no significant association between awkward posture and MSS.

5.8 Association between levels of vibration magnitude with musculoskeletal symptoms

There was no association between whole body vibration magnitude with MSS complaint and vibration magnitudes of bus have not exceeded the EAV and ELV based on the ISO 2631-1: 1997. It is similar to study by Mohd Rotpi, (2003) who stated that the vibration magnitude did not show significant association with MSD.

5.9 Recommendation

It is recommended that the management should take preventive measures against the occurrence of MSS among bus drivers. Newly recruited bus drivers should be given health education regarding ergonomics on the job and periodic trainings should be organised to all divers in order to prevent MSS. Physical activities among the drivers such as exercise should be encouraged and practiced. Health promotion also should be done to increase awareness on ergonomics and physical hazard of driving and its health effects. Job schedule also should be revised again. The work shifts should be divided equally to all the workers.

In addition, the UPM management should take care of the maintenance of the buses. Maintenance must include the engine and suspension. The maintenance should be scheduled and recorded. A further study is recommended which include clinical aspects to determine the MSD. It is should be included laboratory diagnosis to determine the MSD rather than complaint from questionnaire. The study also should include bus drivers from others universities.

5.10 Conclusion

The prevalence of musculoskeletal symptoms among UPM bus drivers was high. The highest prevalence was low back pain compared to other body parts. There was a hypothesis is accepted. There is significant association between job characteristics and perceived ergonomics risk factors with musculoskeletal symptoms. The other two hypotheses were not accepted. There was no significant association between socio demographic characteristics and health status with musculoskeletal symptoms and there was no significant association between levels of whole body vibration magnitude and musculoskeletal symptoms. Based on this study, the significant factors that contributed to the occurrence of MSS were duration of driving in a day and static posture for a long time while driving. Although WRMS and VDV were within normal limit, many other factors can affect MSD especially posture and duration of exposure to the hazards.

REFERENCES

Abas, A B; Said, A R; Mohammed, M A; Sathiakumar, N;. (2008). Occupational Disease among Non-governmental Employees in Malaysia : 2002-2006. *International Journal of Occupational and Environmental Health*, 14(4), 263-271.

Anderson, R. (1992). The back pain of bus drivers. Prevalence in an urban area of California. *Spine.* 17(12) , 1481-1488.

Andrew (2002). Effective management of musculoskeletal injury : A clinical ergonomics approach to prevention, treatment and rehabilitation. 7, 63-68

Bovenzi M., Rui F., Negro C., D'Agostin F., Angotzi, G., Bianchi S. (2006). An epidemiological study of low back pain of profesional drivers. *Journal of Sound and Vibration*, 298, 514-539.

Bovenzi, M. & Betta, A. (1994). Low-back disorders in agricultural tractor drivers exposed to whole-body vibration and postural stress. *Applied Ergonomics*, 25, 231-241.

Burton, A. K., Kendall, N. A. S., Pearce, B. G., Birrell, L. N., Bainbridge, L. C. (2008). Management of Upper Limb Disorders and the Biopsychosocial Model (RR 596). Health & Safety Executive.

Chaffin, D. B., Andersson, G. B., & Martin, B. J. (1999). *Occupational Biomechanics Third Edition.* New York (pp:471-481). A. Wiley Intersection Publication.

Cook C. J. & Kothiyal K. (1998). Influence of mouse position on musculoskletal activity in the neck, shoulder and arm in computer users. *Applied Ergonomics*. 29. 439-443.

DOSH (2003). Guidelines on Occupational Vibration, Ministry of Human Resources Malaysia.

Gourdeau P. (1997). Study of the prevalence of neck and shoulder musculoskeletal disorders in schoolbus drivers. *Canadian Journal of Public Health*, 271-274.

Grace P. Y. S. & Peggo L. (2007). Work-related Musculoskeletal Disorders in Urban Bus Drivers of Hong Kong. *Journal of Occupational Rehabilitation*, 17, 181-198.

Guo, H. R. (2002). Working hours spent ion repeated activities and prevalence of back pain. *Occupational and Environmental Medicine*, 59, 680-688.

Hagg G. M. & Suurkul, J. (1991). Zero crossing rate of electromyograms during occupational work and endurance tests as predictors for work related myalgia in the shoulder/neck region. *European Journal of Applied Physiology*, 6296), 436 - 444.

Hales T. R., Bernard B. P. (1996). *Epidemiologic of work related musculoskeletal disorders.* Ortophedic Clinics of North America. 27, 679-701.

How R. G., Ya C. C., Wen Y. Y., Chun W. C. & Yueliang L. G. (2004). Prevalence of Musculoskeletal Disorder among Workers in Taiwan : A Nationwide Study. *Journal of Occupational Health*, 46, 26-36

Hulshof C. T., Verbeek J. H., Braam I. T. J., Bovenzi M., Van Dijk F. J. H. (2006). Evaluation of an occupational health intervention programme on whole-body vibration in forklift truck drivers: a controlled trial. *Occupatonal and Environmental Medicine* , 63:461–8.

Jzelenberg W. & Burdoft A. (2004). Impact of Musculoskeletal Co-morbidity of Neck and Upper Extremities on Health Care Utilization and Sickness Absence of Low Back Pain. *Occupational Environmental Medicine.* 61, 806-810.

James M., Miles J., Faucett J., Janowitz I., Tajeda D., Weber E. (1995). Ergonomics risk factors for musculoskeletal disease in wine grape vineyard work. A presentation for National Inststitute for Farm Safety.

Jeffery W. V. (1995). *Basic Guidelines to Industrial Hygiene.* New York: Van Nostrad Reinhold.

Johanning, E., Jorgersen , G., Wilder, D. G., Landrigam , D. J., & Pope, M. H. (1991). WBV in subway cars and review of adverse helath effect. Journal of Occupational Medicine, 33(5), 605-612.

Kawowski W. & Mavras S. (1999). Occupational Ergonomics Hand Book, CRC Press, Boca Raton

Keisha M., Gary S., Martin D., Linda C., Kanta S., Oyebad T., Mark R. (2007). Association between BMI and acute traumatic workplace injury in hourly manufacturing employees. *American Journal of Epidemiology* , 166 (2), 204-211.

Kelsey J. L., Hardy J. R. (1975). Driving of motor vehicles as a risk factor for acute herniated lumbar intervertebral disc. *American Journal of Epidemiology* , 102:63–73.

Keyserling, W. M., Armstrong, T. J., & Punnet, L. (1991). Ergonomics Job Analysis: A Structured Approach for Identifying Risk Factors Associated with Overexertion Injuries and Disorders. *Applied Occupational and Environmental Hygiene* , 6(5) 353-363.

Khalil T. M., Abdel-Moty E. M., Rosomoff R. S., Rosomoff H. L. (1993). Ergonomics and back pain. In *A guide to prevention and rehabilition* (pp:31-32). New York. Van Nostrad Reinhold Publishing.

Kilroy N. & Dockrell S. (2000). Ergonmic Intervention : its effect on working posture and musculoskeletal symptoms in female biomedical scientist. *Br J Biomed Sci*, 57, 199-206.

Krause N., Rugulies R, Ragland D. R., Syme S. L. (2004). Physical workload, ergonomic problems, and incidence of low back injury: A 7.5 year prospective study of San Francisco Transit Operators. *Journal Industrial Medicine*, 46, 570-585.

Kumar , S., & Narayanan, Y. (1999). Muscle fatigue in trunk rotation axial and combine motion. In M. A. Hanson, E. J. Lovesy, & S. A. Robertson, *Contemporary Ergonomics* (pp. 255-258). USA: Taylor and France Publishing.

Kumar, S., Narayan, Y., Richard, B. S., Snijders, C. (2001). Muscle fatigue in axial rotation of the trunk. *International Journal of Industrial Ergonomics* , 113-125.

Kuorinka I., Jonsson B., Kilbom A., Vinterberg H., Biering-Sørensen F., Andersson G., & Jørgensen K. (1987). Standardised Nordic questionnaires for the analysis musculoskeletal symptoms. *Applied Ergonomics*, 18.3, 233-237

Laura P. & David H. W. (2004). Work-related musculoskeletal disorders: The epidemiologic evidence and the debate. *Journal of Electromyography and Kinesiology*, 14, 13-23.

Leboef-Yde C. (2002). Body weight and low back pain : A systematic literature review of 56 journal articles reporting on 65 epidemiological studies, *Spine*. 25 (20), 226-236

Lee H. Y., Yeh W. Y., Chen C. W. & Wang J. D. (2005). Prevalence of musculoskeletal and psychosocial risk factors of upper extremity musculoskeletal pain in industries of Taiwan : A natiowide study. *Journal of Occupational Health*, 47, 311-318.

Magnusson M. L., Pope M. H., Wilder D. G., Areskoug B. (1996). Are occupational drivers at an increased risk for developing musculoskeletal disorders? *Spine* , 21:710–717.

Mahadi S. A. (2000). *Perubahan struktur umur penduduk : impak dan cabaran kepada pembangunan negara.* Fakulti sastera dan sains sosial.

Massaccesi M., Pagnotta A., Socceti A., Masali M., Masiero C., Greco F. (2003). Investigation of work-related disorders in truck drivers using RULA method. *Applied Ergonomics* , 34:303–7.

McAtamney L. & Corlett E. N. (1993). RULA : A survey method for the investigation of work related upper limb disorders. *Applied Ergonomics*, 24(2), 91-99.

McGill S. M. (1997). The biomechanics of low back injury : Implications on current practice in industry and the cllinic. *Journal of Biomechanics*, 30 (5), 465-475.

Merlino L. A., Rosecrance J. C., Anton D. & Cook T. M. (2003). Symptoms of Musculoskeletal Disorders among Apprentice Construction Workers. *Applied Occupational and Environmental Hygiene* , 18(1), 57-64.

Ministry of Health, Malaysia. (2004). Clinical Practices Guidelines on Management of Obesity. Pg 8.

Miranda H., Viikari-Juntura E., Martikainen R., Takala E. & Rihimaki H. (2001). A prospective study of work related factors and physical exercise as predictors of shoulder pain. *Occupational and Environmental Medicine*, 88, 528-534.

Mohd Rotpi (2003). Getaran seluruh badan dan kesannya ke atas otot erector spina pemandu bas. (B. Sc. Universiti Putra Malaysia)

Nelson C. M. & Brereton D. F. (2005). The European Vibration Directive, Industrial Health, 472-479.

NIOSH. (1997). *Musculoskeletal disorder and workplace factors. A critical Review of epidemiological evidence for WRMS pf neck, upper extremities and low nack.* Cinncinnati, US: Department of Health and Human Services.

NIOSH, USA. (1989). NIOSH criteria for a recommendation studies occupational exposure to hand arm vibration, USA, 12, 18-87, 102

Okunribido O. O., Shimbles S. J., Magnusson M., & Pope M. (2007). City bus driving and low back pain: A study of the exposures to posture demands, manual materials handling and whole-body vibration. *Applied Ergonomics*, 38, 29-38.

Palmer K. T., Griffin M. J., Haward B., Bendall H., Coggon D. (2000). Validity of self reported occupational exposures to hand transmiitted and whole body vibration, USA. *Occupational and Environmental Medicine*, 57, 237-241.

Peltonen M., Lindross A. K., Torgerson J. S. (2003). Musculoskeltal pain in the obese: A comparison with general population and long term changes after conventional and surgical obesity treatment pain. 104(3), 549-557.

Porter J. M., & Gyi D. E. (2002). The prevalence of musculoskeletal troubles among car drivers. *Journal of Occupational Medicine* , 52 (1), 4-12.

Puteri Y. (2005). Analisis ovaco terhadap tempoh duduk lama dan perkaitan dengan aduan sakit belakang bawah di kalangan pemandu bas komersial. (B.Sc. Universiti Putra Malaysia)

Randall, R R; Altamier, E M. (1994). *Intervention in occupational stress.* London: SAGE Publishing.

Razlan Musa, Win Kyi, Rampal K. G. (2000). Work related musculoskeletal disorders among batik workers in Kelantan, Malaysia. *Journal Of Medicine Science*, Volume 7, No. 2, July 2000, 13-17.

Royal Malaysian Police (RMP), (2011), Retrived May 2012, from Statistical. Reported road Accident malysia 2010, KL

Sadri, G. H. (2003). Risk factors of musculoskeletal disorders in bus drivers. *Archives of Iranian Medicines*, 6, 214-221.

Scubert Z. & Sobala W. (2005). Health reasons for work disability among municipal transport drivers. *Medycyna Pracy* , 56(4), 285-293.

Tamrin S. B., Yokoyama K., Aziz N. A., Maeda S. (2011). Association of Risk Factors with Musculoskeletal Disorders among Male Commercial Bus Drivers in Malaysia. *Human Factors and Ergonomics in Manufacturing & Service Industries.*

Tamrin S. B., Yokoyama K., Jalaludin J., Aziz N. A., Jemoin N., Nordin R. (2007). The association of risk factors and low back pain among commercial vehicle drivers in Peninsular Malaysia : A preliminary results. *Industrial Health*, 268-278.

Tayyavi F., Smith J. L. (1997). Occupational ergonomics, principle and application, 337-347

Tengku H. (2011). Whole body vibration ang low back pain among taxi drivers in Alor Star, Kedah. (B. Sc. Universiti Putra Malaysia)

Troup, J. D. G. (1978). Driver's back pain and its prevention : A review of the postural, vibratory and muscular factors, together with the problem of transmitted road-shock. *Applied Ergonomics* , 207-214.

Videman T, Nurminen M, Troup J. D. G. (1990). *Lumbar Spinal Pathology in Cadaveric Material in Realtion to History of Back Pain : Occupational Physical Loading* (pp:728). Spine : 15.

Webster B. S. & Snook S. H. (1994). The cost of compensable upper extremity cumulative trauma disorders. *Journal of Occupational Medicine*, 36, 713-727.

Wikstrom B. O., Kjelberg A. & Landstrom U. (1994). Health effect of long term occupational exposure to whole body vibration : A review. *International Journal of Industrial Ergonomics.* 14, 273-292.

Winkleby M. A., Ragland D. R., Fisher J. M., Syme S. L.(1998). Excess risk of sickness and disease in bus drivers : A review and synthesis of epidemiological studies. *International Journal of Epidemiology* , 17(2), 255–262.

World Health Organization. (2012). BMI Classification. Retrived from http://apps.who.int/bmi/index.jsp?introPage=intro_3.html

World Health Organization. (2004). Health Topic, Risk Factors. Retrived from http://www.who.int/topics/risk_factors/en/

Zakaria D., Robertson J., Mac Dermid J., Hartford K. & Koval J. (2002). Work related Carpal Tunnel Syndrome of Upper Extremities:Navigating the Epidemiological Literature. *American Journal of Industrial Medicine*, 42(3), 258-269.

APPENDIX 1

ETHICAL CLEARANCE

APPENDIX 2

APPLICATION LETTER

APPENDIX 3

INFORMATION SHEET

BORANG PENERANGAN RESPONDEN

Sila baca maklumat berikut dengan teliti, jangan ragu untuk membincangkan soalan dengan penyelidik anda.

TAJUK KAJIAN

Prevalens Simptom Otot Rangka dan Faktor Risiko yang Berkaitan di kalangan Pemandu Bas UPM

PENGENALAN

Kajian ini mengkaji faktor risiko yang menyebabkan masalah otot rangka di kalangan pemandu bas UPM. Antaranya faktor risiko yang terlibat ialah bahagian badan yang tidak betul semasa bekerja, duduk terlalu lama, dan getaran pada kenderaan. Aktiviti pekerjaan ini akan menyebabkan otot menjadi letih dan boleh menyebabkan kesakitan pada bahagian seperti leher, tangan, tulang belakang, dan kaki.

APAKAH YANG HARUS DILAKUKAN OLEH RESPONDEN?

Responden dikehendaki menandatangani borang penyertaan di mana ia menyatakan anda bersetuju menyertai kajian ini tanpa sebarang paksaan. Ia boleh dilakukan setelah anda membaca dan memahami isi kandungan penerangan tersebut. Borang tersebut perlu dikembalikan kepada pengkaji sebelum responden menjawab soalan soal selidik dan pengukuran berat badan dan tinggi dijalankan. Selepas itu, pengukuran getaran dan analisis postur akan dijalankan. Alat accelerometer akan diletakkan di tempat duduk untuk mengukur getaran dari kenderaan. Tambahan pula, pergerakan semasa bekerja akan dinilai. Responden hanya perlu membawa kenderaan seperti biasa. Pengukuran ini tidak menganggu pemanduan responden.

SIAPA YANG TIDAK PERLU MENYERTAI KAJIAN INI?

Responden yang tidak menepati kriteria kajian iaitu pemandu perempuan dan pemandu yang baru bekerja di UPM kurang dari tiga bulan tidak perlu menyertai kajian ini. Kriteria kajian adalah lelaki dan mempunyai pengalaman memandu bas UPM sekurang-kurangnya selama tiga bulan.

APAKAH FAEDAH YANG AKAN DIPEROLEHI DARIPADA KAJIAN INI :

(a) KEPADA ANDA SEBAGAI RESPONDEN?

Kajian ini mengkaji faktor risiko dan masalah otot rangka di kalangan pemandu bas. Sekiranya aktiviti pekerjaan anda berisiko tinggi dan memberi kesan kepada kesihtan anada, maklumat kajian ini berguna untuk tindakan selanjutnya. Melalui kajian ini, beberapa polisi boleh digubal atau dilaksanakan oleh pihak majikan untuk meningkatkan taraf kesihatan anda.

b) KEPADA PENYELIDIK?

Maklumat dari kajian ini akan mengenal pasti faktor risiko sakit otot rangka yang utama. Oleh itu, maklumat dan keputusan dari kajian boleh dijadikan data garis panduan untuk kajian akan datang. Daripada kajian ini juga, penyelidik dapat menimba ilmu pengetahuan dan mendapat pengalaman berkomunikasi dan sebagainya.

ADAKAH TERDAPAT SEBARANG RISIKO?

Tidak, kajian ini tidak memberi risiko kepada responden.

APAKAH HAK ANDA SEBAGAI RESPONDEN?

Kajian ini bersifat sukarela dan tidak memaksa responden untuk menyertainya. Jika responden rasa tidak selesa untuk mengikuti kajian ini, responden boleh menarik diri pada bila-bila masa. Keputusan anda untuk menarik diri pada bila-bila masa akan dihormati.

ADAKAH SEMUA MAKLUMAT DIJAMIN SULIT ?

Ya, segala maklumat mengenai responden dijamin sulit dan hanya akan digunakan untuk kajian sahaja.

SIAPAKAH YANG PERLU SAYA HUBUNGI JIKA SAYA MEMPUNYAI SOALAN TAMBAHAN SEMASA KAJIAN?

Aini Nurliyana Binti Azhar (013-3154280)
Penyelidik
B Sc (Kesihatan Persekitaran dan Pekerjaan)

APPENDIX 4

CONSENT FORM

BORANG PERSETUJUAN (RESPONDEN)

TAJUK PENYELIDIKAN : PREVALENS SIMPTOM OTOT RANGKA DAN FAKTOR RISIKO YANG BERKAITAN DI KALANGAN PEMANDU BAS UPM

PENYELIDIK : AINI NURLIYANA BINTI AZHAR

Saya ..... No. Kad Pengenalan ..... alamat ..... dengan ini secara sukarela bersetuju mengambil bahagian dalam penyelidikan klinikal (kajian klinikal, kajian soal selidik/dadah percubaan) yang dinyatakan di atas.

Saya telah dimaklumkan tentang sifat penyelidikan klinikal dari segi metodologi, kemungkinan kesan buruk dan komplikasi (rujuk Helaian Maklumat). Saya faham bahawa saya mempunyai hak untuk menarik diri dari kajian ini klinikal pada bila-bila masa tanpa memberikan apa jua sebab. Saya juga faham bahawa kajian ini adalah sulit dan semua maklumat yang diberikan mengenai identiti saya akan kekal sulit dan persendirian

Saya ingin *tahu / tidak ingin mengetahui keputusan ujian yang dilakukan ke atas sampel saya.

* Potong di mana perlu

Tandatangan .....
(*Respondent*)

Tarikh :.....

Tandatangan .....
(*Saksi*)

Nama :.....

No I/C . :.....

Saya mengesahkan bahawa saya telah menjelaskan kepada responden sifat dan tujuan penyelidikan klinikal yang tersebut di atas.

Tarikh .....

Tandatangan .....
(Penyelidik)

APPENDIX 5

MODIFIED STANDARDIZED NORDIC QUESTIONNAIRE

FAKULTI PERUBATAN DAN SAINS KESIHATAN
UNIVERSITI PUTRA MALAYSIA, 43400 UPM
SERDANG,
SELANGOR, MALAYSIA

TAJUK KAJIAN : PREVALEN SIMPTOM SAKIT OTOT RANGKA DAN FAKTOR RISIKO YANG BERKAITAN DI KALANGAN PEMANDU BAS UPM

NO RESPONDEN :
TARIKH SOAL SELIDIK :
MASA :
TEMPAT :

Terima kasih kerana sudi untuk turut serta di dalam kajian ini. Kerjasama anda memberikan segala maklumat yang benar dan tepat amatlah dihargai. Segala maklumat adalah rahsia dan hanya khas untuk kajian ini sahaja.

Sekian Terima Kasih.

HAGIAN A: MAKLUMAT RESPONDEN

Arahan : Sila jawab semua soalan pada bahagian yang disediakan dan tandakan √ pada soalan yang berkenaan.

1. Umur : ☐☐ tahun A1

2. Status perkahwinan : 1. ☐ Bujang 2. ☐ Berkahwin A2
3. ☐ Bercerai

3. Tahap pendidikan : 1. ☐ SRP/PMR 2. ☐ SPM A3
3. ☐ STPM/Diploma 4. ☐ Ijazah

4. Adakah anda melakukan kerja sampingan sebelum/selepas bekerja? A4

0. ☐ Tidak 1. ☐ Ya

5. Adakah anda merokok? A5

0. ☐ Tidak 1. ☐ Ya

6. Adakah anda kerap melibatkan diri dalam aktiviti-aktiviti dibawah?

i. Aktiviti persatuan/sukarela di kawasan rumah anda(bergotong royong) A6i

0. ☐ Tidak 1. ☐ Ya

ii. Menjaga anak, memasak, melakukan kerja rumah A6ii

0. ☐ Tidak 1. ☐ Ya

iii. Berkebun A6iii

0. ☐ Tidak 1. ☐ Ya

iv. Aktiviti bersukan/aktiviti luar (mendaki bukit) A6iv

0. ☐ Tidak 1. ☐ Ya

BAHAGIAN B: MAKLUMAT KESIHATAN

7. Pernahkah anda mengalami kecederaan yang serius/ kepatahan pada bahagian badan? B7i

0. ☐ Tidak 1. ☐ Ya

Jika Ya, sila nyatakan bahagian mana yang terlibat (sila rujuk lampiran) B7ii

1. ☐ Leher 2. ☐ Bahu 3. ☐ Siku
4. ☐ Pergelangan tangan 5. ☐ Belakang atas
6. ☐ Belakang bawah 7. ☐ Satu/kedua belah peha
8. ☐ Satu/kedua belah lutut 9. ☐ Satu/kedua belah kaki

8. Adakah anda pernah mendapat cuti sakit daripada masalah di atas? B8

0. ☐ Ya 1. ☐ Tidak

9. Pernahkah anda berjumpa dengan doktor, ahli fisioterapi, ahli perubatan trauma atau ahli-ahli perubatan yang lain disebabkan masalah di atas ? B9

0. ☐ Ya 1. ☐ Tidak

10. Pernahkan anda berjumpa tukang urut tradisional untuk mendapatkan rawatan bagi masalah di atas? B10

0. ☐ Ya 1. ☐ Tidak

11. Pernahkan anda menjalani pembedahan disebabkan oleh masalah di atas? B11

0. ☐ Ya 1. ☐ Tidak

BAHAGIAN C: MAKLUMAT PEKERJAAN

12. Pernahkah anda bekerja di tempat lain sebelum ini? C12 i

0. ☐ Tidak 1. ☐ Ya

Jika Ya, sila nyatakan pekerjaan anda : _____ C12 ii

13. Berapa lamakah anda bekerja di syarikat ini? C13

_____ tahun

14. Berapa lamakah anda memandu setiap hari? C14

_____ jam

15. Berapa lamakah diperlukan untuk melengkapkan satu trip/perjalanan C15

_____ minit/jam

16. Berapakah trip yang perlu dilengkapkan dalam 1 hari? C16

_____ kali

17. Nyatakan kenderaan yang sering digunakan untuk pergi/balik kerja C17

1. ☐ Motosikal 2. ☐ Kereta 3. ☐ Bas

4. ☐ LRT/Komuter 5. ☐ Berjalan kaki

18. Berapa lamakah anda boleh berehat selepas setiap shif? C18

_____ jam _____ minit

19. Berapa hari anda bekerja dalam seminggu? C19

_____ hari

BAHAGIAN D : MAKLUMAT PERSEKITARAN DAN FIZIKAL TEMPAT KERJA

20. Adakah anda duduk dalam keadaan selesa semasa memandu ?

0 ☐ Ya 1. ☐ Tidak D20

21. Jika tidak, mengapa ? D21

1. ☐ Kusyen kerusi terlalu keras
2. ☐ Kerusi tidak sesuai dengan bentuk badan
3. ☐ Duduk terlalu lama
4. ☐ Lain-lain, sila nyatakan : _____

22. Dari pengalaman anda, getaran semasa anda memandu berpunca dari... D22

1. ☐ Stering (tangan)
2. ☐ Tempat duduk / kerusi
3. ☐ Gear
4. ☐ Kaki
5. ☐ Lain-lain, sila nyatakan : _____

BAHAGIAN E : MASALAH OTOT RANGKA
Untuk menjawab soalan ini, sila rujuk gambarajah (lampiran)

	Bahagian badan	Adakah anda mengalami masalah bila-bila masa, didalam tempoh 12 bulan kebelakangan (perit,sakit,tidak selesa) pada bahagian anggota berikut:	Adakah anda pernah merasa sakit, lenguh-lenguh, perit, atau tidak selesa pada bahagian anggota badan dibawah dalam masa 7 hari kebelakangan ini?	Adakah dalam tempoh 12 bulan kebelakangan ini, masalah yang dihadapi menghalang anda melakukan kerja secara normal? (ditempat kerja/dirumah)	Adakah anda merasakan maslah itu berpunca dari tempat kerja?
23	i Tengkuk/leher 1. ☐ Ya 0. ☐ Tidak Jika **ya**, jawab soalan ii,iii dan iv. Jika **tidak** terus ke soalan berikutnya		ii 1. ☐ Ya 0. ☐ Tidak	iii 1. ☐ Ya 0. ☐ Tidak	iv 1. ☐ Ya 0. ☐ Tidak
24	i Bahu 1. ☐ Ya 0. ☐ Tidak Jika **ya**, jawab soalan ii,iii dan iv. Jika **tidak** terus ke soalan berikutnya		ii 1. ☐ Ya 0. ☐ Tidak	iii 1. ☐ Ya 0. ☐ Tidak	iv 1. ☐ Ya 0. ☐ Tidak
25	i Siku 1. ☐ Ya 0. ☐ Tidak Jika **ya**, jawab soalan ii,iii dan iv. Jika **tidak** terus ke soalan berikutnya		ii 1. ☐ Ya 0. ☐ Tidak	iii 1. ☐ Ya 0. ☐ Tidak	iv 1. ☐ Ya 0. ☐ Tidak

	Bahagian badan	Adakah anda mengalami masalah bila-bila masa, didalam tempoh 12 bulan kebelakangan (perit,sakit,tidak selesa) pada bahagian anggota berikut:	Adakah anda pernah merasa sakit, lenguh-lenguh, perit, atau tidak selesa pada bahagian anggota badan dibawah dalam masa 7 hari kebelakangan ini?	Adakah dalam tempoh 12 bulan kebelakangan ini, masalah yang dihadapi menghalang anda melakukan kerja secara normal? (ditempat kerja/dirumah)	Adakah anda merasakan maslah itu berpunca dari tempat kerja?
26	i Lengan bawah/tangan 1. ☐ Ya 0. ☐ Tidak Jika **ya**, jawab soalan ii,iii dan iv. Jika **tidak** terus ke soalan berikutnya		ii 1. ☐ Ya 0. ☐ Tidak	iii 1. ☐ Ya 0. ☐ Tidak	iv 1. ☐ Ya 0. ☐ Tidak
27	i Belakang atas 1. ☐ Ya 0. ☐ Tidak Jika **ya**, jawab soalan ii,iii dan iv. Jika **tidak** terus ke soalan berikutnya		ii 1. ☐ Ya 0. ☐ Tidak	iii 1. ☐ Ya 0. ☐ Tidak	iv 1. ☐ Ya 0. ☐ Tidak
28	i Belakang bawah/pinggang 1. ☐ Ya 0. ☐ Tidak Jika **ya**, jawab soalan ii,iii dan iv. Jika **tidak** terus ke soalan berikutnya		ii 1. ☐ Ya 0. ☐ Tidak	iii 1. ☐ Ya 0. ☐ Tidak	iv 1. ☐ Ya 0. ☐ Tidak
29	i Satu atau kedua-dua belah peha 1. ☐ Ya 0. ☐ Tidak Jika **ya**, jawab soalan ii,iii dan iv. Jika **tidak** terus ke soalan berikutnya		ii 1. ☐ Ya 0. ☐ Tidak	iii 1. ☐ Ya 0. ☐ Tidak	iv 1. ☐ Ya 0. ☐ Tidak

	Bahagian badan	Adakah anda mengalami masalah bila-bila masa, didalam tempoh 12 bulan kebelakangan (perit,sakit,tidak selesa) pada bahagian anggota berikut:	Adakah anda pernah merasa sakit, lenguh-lenguh, perit, atau tidak selesa pada bahagian anggota badan dibawah dalam masa 7 hari kebelakangan ini?	Adakah dalam tempoh 12 bulan kebelakangan ini, masalah yang dihadapi menghalang anda melakukan kerja secara normal? (ditempat kerja/dirumah)	Adakah anda merasakan maslah itu berpunca dari tempat kerja?
30	i Satu atau kedua-dua belah lutut 1. ☐ Ya 0. ☐ Tidak Jika **ya**, jawab soalan ii,iii dan iv. Jika **tidak** terus ke soalan berikutnya		ii 1. ☐ Ya 0. ☐ Tidak	iii 1. ☐ Ya 0. ☐ Tidak	iv 1. ☐ Ya 0. ☐ Tidak
31	i Satu atau kedua-dua belah kaki 1. ☐ Ya 0. ☐ Tidak Jika **ya**, jawab soalan ii,iii dan iv. Jika **tidak** terus ke soalan berikutnya		ii 1. ☐ Ya 0. ☐ Tidak	iii 1. ☐ Ya 0. ☐ Tidak	iv 1. ☐ Ya 0. ☐ Tidak

BAHAGIAN F : FAKTOR RISIKO ERGONOMIK

12. Adakah kerja anda memerlukan anda mengekalkan posisi dan kedudukan badan anda untuk jangka masa yang lama? F32

0 ☐ Ya 1 ☐ Tidak

13. Adakah kerja anda memerlukan anda mengendali peralatan yang mempunyai bucu yang tajam? F33

0 ☐ Ya 1 ☐ Tidak

14. Adakah anda melakukan mana-mana postur badan yang janggal seperti berikut semasa bekerja? F34

☐ Membongkok ke hadapan

☐ Mendongak

☐ Memusingkan badan

15. Adakah kawasan tempat kerja anda mempunyai perlindungan yang secukupnya daripada panas (matahari) atau sejuk cuaca (embun pagi dan hujan)? F35

0 ☐ Ya 1 ☐ Tidak

16. Adakah kawasan tempat kerja anda bising sehingga menganggu daripada bekerja seperti biasa? F36

0 ☐ Ya 1 ☐ Tidak

17. Adakah tempat kerja anda mempunyai pencahayaan yang cukup untuk anda bekerja? F37

0 ☐ Ya 1 ☐ Tidak

APPENDIX 6

CALIBRATION CERTIFICATE

~ Calibration Certificate ~

Per ISO 16063-21

Model Number: SEN027

Serial Number: P92411 (x axis)

Description: ICP® Triaxial Accelerometer **Method:** Back-to-Back Comparison (AT401-12)

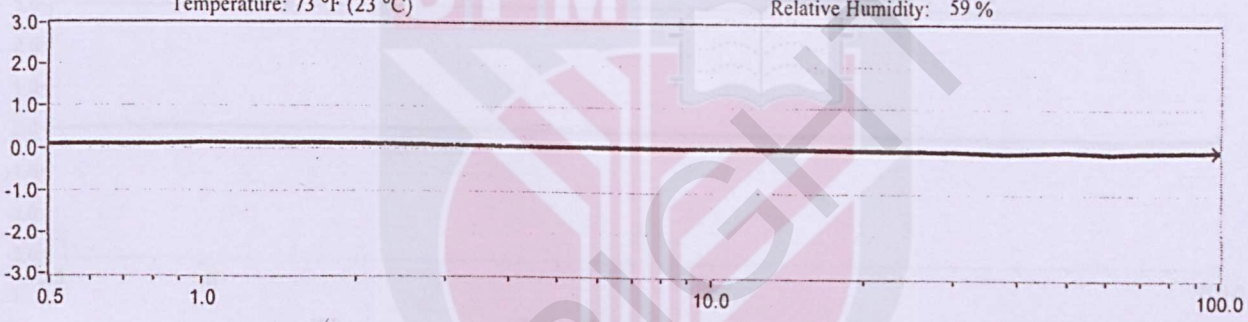
Manufacturer: PCB

Calibration Data

Sensitivity @ 100.0 Hz	**99.6**	**mV/g**	Output Bias	4.2	VDC
	(10.15	**mV/m/s²)**	Transverse Sensitivity	1.5	%

Sensitivity Plot

Temperature: 73 °F (23 °C) Relative Humidity: 59 %



Data Points

Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)
0.5	1.0	10.0	0.3	70.0	-0.3
1.0	1.3	15.0	0.2	REF. FREQ.	0.0
2.0	1.2	20.0	-0.0		
5.0	0.7	30.0	-0.2		
7.0	0.5	50.0	-0.0		

Mounting Surface: Stainless Steel w/Silicone Grease Coating Fastener: Stud Mount Fixture Orientation: Inverted Vertical

Acceleration Level (rms)[1]: 0.500 g (4.90 m/s²)²

[1]The acceleration level may be limited by shaker displacement at low frequencies. If the listed level cannot be obtained, the calibration system uses the following formula to set the vibration amplitude; Acceleration Level (g) = 0.133 x (freq)².

[2]The gravitational constant used for calculations by the calibration system is; 1 g = 9.80665 m/s².

Condition of Unit

As Found: n/a

As Left: New Unit, In Tolerance

Notes

1. Calibration is traceable to one or more of the following report numbers; PTB 1254, PTB 5400 and NIST 822/277342.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI/NCSL Z540-1-1994 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Measurement uncertainty (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: 0.5-0.99 Hz; +/- 1.8%, 1-30 Hz; +/- 1.0%, 30.01-199 Hz; +/- 1.5%, 200-1 kHz; +/- 3.0%.

Technician: Mike Ferrio Date: 07/30/09

ACCREDITED
ATION CERT #1862.01

PCB PIEZOTRONICS INC.
VIBRATION DIVISION
3425 Walden Avenue · Depew, NY 14043
TEL: 888-684-0013 · FAX: 716-685-3886 · www.pcb.com

CAL28 - 3331818043.18

~ Calibration Certificate ~

Per ISO 16063-21

Model Number: SEN027

Serial Number: P92411 (y axis)

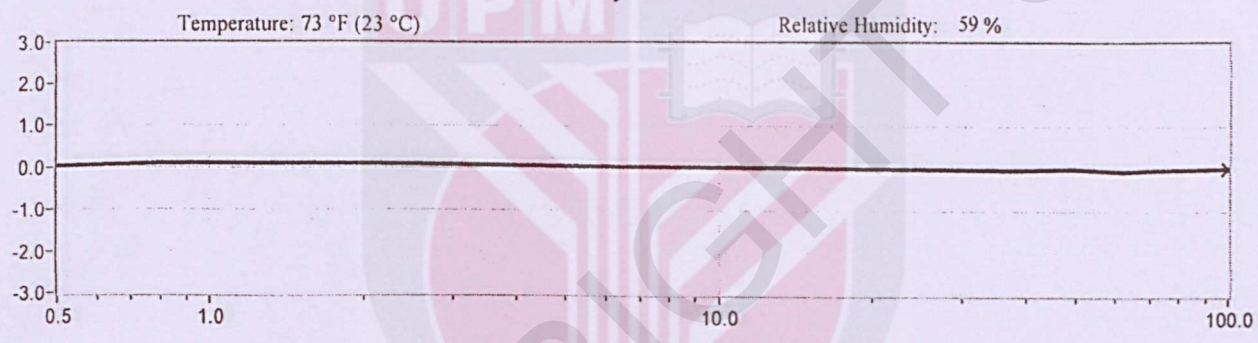
Description: ICP® Triaxial Accelerometer Method: Back-to-Back Comparison (AT401-12)

Manufacturer: PCB

Calibration Data

Sensitivity @ 100.0 Hz	97.1	mV/g	Output Bias	3.9	VDC
	(9.90	mV/m/s²)	Transverse Sensitivity	1.1	%

Sensitivity Plot



Data Points

Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)
0.5	0.3	10.0	0.2	70.0	-0.5
1.0	1.1	15.0	-0.0	REF. FREQ.	0.0
2.0	1.0	20.0	-0.2		
5.0	0.6	30.0	-0.4		
7.0	0.4	50.0	-0.2		

Mounting Surface: Stainless Steel w/Silicone Grease Coating Fastener: Stud Mount Fixture Orientation: Vertical

Acceleration Level (rms)[1]: 0.500 g (4.90 m/s²)[2]

[1]The acceleration level may be limited by shaker displacement at low frequencies. If the listed level cannot be obtained, the calibration system uses the following formula to set the vibration amplitude: Acceleration Level (g) = 0.133 x (freq)²

[2]The gravitational constant used for calculations by the calibration system is: 1 g = 9.80665 m/s².

Condition of Unit

As Found: n/a

As Left: New Unit, In Tolerance

Notes

1. Calibration is traceable to one or more of the following report numbers; PTB 1254, PTB 5400 and NIST 822/277342.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI/NCSL Z540-1-1994 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Measurement uncertainty (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: 0.5-0.99 Hz; +/- 1.8%, 1-30 Hz; +/- 1.0%, 30.01-199 Hz; +/- 1.5%, 200-1 kHz; +/- 3.0%.

Technician: Mike Ferrio Date: 07/30/09

ACCREDITED
ATION CERT #1862.01

PCB PIEZOTRONICS Inc.
VIBRATION DIVISION
3425 Walden Avenue · Depew, NY 14043
TEL: 888-684-0013 · FAX: 716-685-3886 · www.pcb.com

CAL28 - 3331818722.52

~ Calibration Certificate ~

Per ISO 16063-21

Model Number: SEN027

Serial Number: P92411 (z axis)

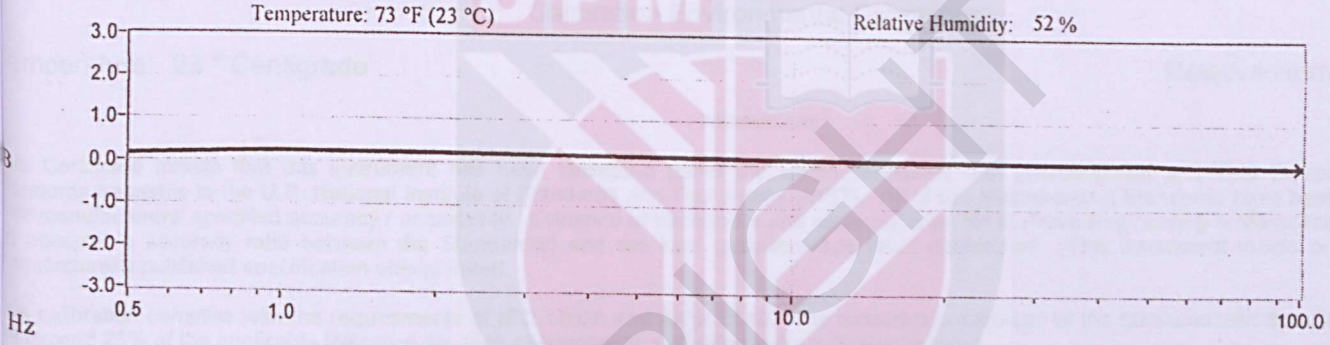
Description: ICP® Triaxial Accelerometer Method: Back-to-Back Comparison (AT401-12)

Manufacturer: PCB

Calibration Data

Sensitivity @ 100.0 Hz	**99.3**	**mV/g**	Output Bias	4.2	VDC
	(10.13	**mV/m/s²)**	Transverse Sensitivity	0.1	%

Sensitivity Plot



Data Points

Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)
0.5	1.6	10.0	1.4	70.0	0.0
1.0	2.5	15.0	1.0	REF. FREQ.	0.0
2.0	2.3	20.0	0.9		
5.0	1.8	30.0	0.6		
7.0	1.6	50.0	0.7		

Mounting Surface: Stainless Steel w/Silicone Grease Coating Fastener: Stud Mount Fixture Orientation: Vertical

Acceleration Level (rms)[1]: 0.500 g (4.90 m/s²)[2]

[1]The acceleration level may be limited by shaker displacement at low frequencies. If the listed level cannot be obtained, the calibration system uses the following formula to set the vibration amplitude; Acceleration Level (g) = 0.133 x (freq)².

[2]The gravitational constant used for calculations by the calibration system is: 1 g = 9.80665 m/s².

Condition of Unit

As Found: n/a

As Left: New Unit, In Tolerance

Notes

1. Calibration is traceable to one or more of the following report numbers; PTB 1254, PTB 5400 and NIST 822/277342.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI/NCSL Z540-1-1994 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Measurement uncertainty (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: 0.5-0.99 Hz; +/- 1.8%, 1-30 Hz; +/- 1.0%, 30.01-199 Hz; +/- 1.5%, 200-1 kHz; +/- 3.0%.

Technician: Mike Ferrio Date: 07/31/09

ACCREDITED
CALIBRATION CERT #1862.01

PCB PIEZOTRONICS INC.
VIBRATION DIVISION
3425 Walden Avenue · Depew, NY 14043
TEL: 888-684-0013 · FAX: 716-685-3886 · www.pcb.com

CAL28 - 3331910309.33

PCB PIEZOTRONICS
A PCB GROUP COMPANY

Certificate of Calibration and Conformance

Certificate Number 2009-120253

nstrument Model HVM100, Serial Number 01780, was calibrated on 17JUL2009. The instrument neets factory specifications per Procedure D0001.8098, ISO 8041:1990(E).

New Instrument
Date Calibrated: 17JUL2009
Calibration due:

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Larson Davis	2900 / 2239	0276 / 0105	12 Months	10NOV2009	2008-112602

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

Calibration Environmental Conditions

Temperature: 23 ° Centigrade

Relative Humidity: 32 %

Affirmations

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with the requirements of ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. A one year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of the issuer.

Signed: Shawna Strand
Technician: Shawna Strand

Provo Engineering and Manufacturing Center, 1681 West 820 North, Provo, Utah 84601
Toll Free: 888.258.3222 Telephone: 716.926.8243 Fax: 716.926.8215
ISO 9001-2000 Certified

APPENDIX 7

EXAMPLE VIBRATION RESULT

WBV

Time of Measurement : 17 Jan 12 09:56:30
Report Printed : 20 Jan 12 11:31:31

SETUP for :WBV 05

Operating Mode	: Whole Body		
Averaging	: SLOW	Store Time hh:mm	: 00:20
2nd History	: Peak	Auto Store	: Autostop
Accelerometer	: ICP	Integration	: None
Weighting	X: Wd	Y: Wd	Z: Wk
Sum Factor	X: 1.40	Y: 1.40	Z: 1.00
Gain	X: 0	Y: 0	Z: 0
Sensitivity	X: 9.960e+01 mV/g	Y: 9.710e+01 mV/g	Z: 9.930e+01 mV/g
AC/DC Output	X: AC: Weighted	Y: AC: Weighted	Z: AC: Weighted

DATA for :WBV 05

Run Time : 0:20:00

Value	Channel X	Channel Y	Channel Z	Sum	Units
Arms	.0637	.0297	.0387	.0971	m/s^2
Amin	.0267	.0263	.0313	.0365	m/s^2

Amax	1.8700	.7310	1.6700	2.6600	m/s^2
Peak	.0974	.0979	.0955	.1370	m/s^2
Aeq	.3700	.2110	.6620	.8880	m/s^2
Amp	3.1100	1.5200	5.0600	5.0700	m/s^2
CF	-----	-----	-----	-----	dB
CFmp	18.5	17.1	17.7	15.1	dB
VDV	3.4900	2.0200	6.0000	7.1300	m/s^(7/4)

♀

Larson Davis HVM100 SN:01782 rev 1.24 Page 02

WBV

Time of Measurement : 17 Jan 12 09:56:30

Report Printed : 20 Jan 12 11:31:31

HISTORY for :WBV 05

Units = m/s^2

TIME	X RMS	PEAK	Y RMS	PEAK	Z RMS	PEAK	S RMS	PEAK
0:18:01	.3680	.6320	.3120	.5390	.2430	.4300	.7170	1.0900
0:18:02	.2650	.4390	.2260	.2440	.1840	.3820	.5200	.6840
0:18:03	.1680	.1460	.1490	.1960	.1480	.3350	.3460	.2740
0:18:04	.4460	.9230	.1220	.1960	.1920	.4770	.6750	1.2300
0:18:05	.7470	1.6500	.1340	.3910	.2110	.4300	1.0800	2.1900
0:18:06	.7970	1.2200	.1650	.4410	.1950	.4770	1.1500	1.6400
0:18:07	.8070	1.4100	.2120	.5880	.1470	.3350	1.1700	1.9200
0:18:08	.8330	1.4600	.1610	.3910	.1540	.4300	1.2000	2.0500
0:18:09	.5700	.6320	.1810	.2940	.1530	.3350	.8490	.9590
0:18:10	.4960	.6820	.1140	.0979	.1490	.3350	.7270	.8220

0:18:11	.5390	1.1200	.1490	.3430	.1740	.5260	.8000	1.5100
0:18:12	1.1000	2.1900	.2400	.4890	.2480	.8610	1.6000	3.0100
0:18:13	.9280	1.7000	.2250	.5390	.2050	.8610	1.3500	2.3200
0:18:14	.7730	1.4100	.1630	.1960	.1430	.1910	1.1100	1.9200
0:18:15	.4860	.3410	.1500	.2940	.1280	.3820	.7230	.4110
0:18:16	.3120	.2430	.1200	.1960	.1020	.2380	.4780	.2740
0:18:17	.5850	1.0200	.0783	.0979	.0964	.2870	.8310	1.3700
0:18:18	.9570	1.8000	.0921	.2940	.1140	.3350	1.3500	2.4700
0:18:19	.7130	1.0200	.1310	.2940	.1690	.4770	1.0300	1.5100
0:18:20	.4800	.5360	.1410	.2940	.1270	.2870	.7100	.8220
0:18:21	.4090	.6320	.0951	.1470	.1110	.2380	.5970	.8220
0:18:22	.4010	.7300	.1090	.2440	.0781	.1910	.5860	.9590
0:18:23	.4540	.7300	.1510	.3430	.0754	.2380	.6730	1.0900
0:18:24	.3100	.4860	.1200	.2940	.0675	.1910	.4690	.6840
0:18:25	.1910	.1460	.0782	.0979	.0665	.2380	.2940	.1370
0:18:26	.1200	.0974	.0604	.1470	.0630	.1910	.1950	.1370
0:18:27	.0933	.1460	.0503	.0979	.0624	.1910	.1580	.1370
0:18:28	.1160	.3410	.0517	.1470	.0568	.1430	.1850	.4110
0:18:29	.0874	.1460	.0631	.1470	.0460	.1430	.1540	.1370
0:18:30	.0766	.1950	.0471	.0979	.0433	.1430	.1290	.2740
0:18:31	.0610	.0974	.0377	.0979	.0438	.1430	.1040	.1370
0:18:32	.0489	.1460	.0338	.0979	.0379	.1430	.0814	.1370
0:18:33	.0477	.1460	.0297	.0979	.0371	.0955	.0750	.1370
0:18:34	.0375	.0974	.0312	.0979	.0369	.1430	.0641	.1370
0:18:35	.0348	.0974	.0304	.0979	.0392	.1430	.0616	.1370
0:18:36	.0323	.0974	.0324	.0979	.0360	.0955	.0583	.0685
0:18:37	.0346	.0974	.0341	.0979	.0381	.0955	.0663	.1370
0:18:38	.0966	.2430	.0313	.0979	.0506	.1910	.1460	.2740♀

Larson Davis HVM100 SN:01782 rev 1.24 Page 03

WBV

aini_05

Time of Measurement : 17 Jan 12 09:56:30

Report Printed : 20 Jan 12 11:31:31

HISTORY for :WBV 05

Units = m/s^2

TIME	X RMS	PEAK	Y RMS	PEAK	Z RMS	PEAK	S RMS	PEAK
0:18:39	.1020	.1950	.0607	.1470	.0469	.1430	.1690	.2740
0:18:40	.0850	.1460	.0517	.0979	.0457	.1430	.1440	.1370
0:18:41	.1670	.4390	.0828	.1960	.0508	.1910	.2640	.5480
0:18:42	.1110	.1460	.0708	.1470	.0440	.1430	.1870	.1370
0:18:43	.1010	.1950	.0520	.0979	.0423	.1430	.1620	.1370
0:18:44	.1360	.2920	.0818	.1960	.0636	.1910	.2290	.4110
0:18:45	.1270	.2920	.0569	.0979	.0782	.2380	.2070	.2740
0:18:46	.1140	.2430	.0462	.0979	.0642	.2380	.1810	.2740
0:18:47	.0893	.1460	.0407	.0979	.0540	.1430	.1450	.1370
0:18:48	.0648	.0974	.0346	.0979	.0421	.0955	.1050	.1370
0:18:49	.0461	.0974	.0372	.0979	.0446	.1430	.0860	.1370
0:18:50	.0371	.0974	.0310	.0489	.0533	.1910	.0737	.1370
0:18:51	.0322	.0974	.0300	.0979	.0421	.1430	.0573	.0685
0:18:52	.0285	.0487	.0311	.0979	.0402	.1430	.0521	.1370
0:18:53	.0274	.0974	.0309	.0979	.0348	.0955	.0457	.0685
0:18:54	.0269	.0487	.0283	.0489	.0359	.1430	.0402	.1370
0:18:55	.1050	.2430	.0298	.0979	.0383	.1430	.1510	.2740
0:18:56	.1030	.2430	.0289	.0979	.0387	.1430	.1490	.2740
0:18:57	.0711	.0974	.0279	.0979	.0335	.0955	.1040	.0685
0:18:58	.0551	.0974	.0271	.0489	.0393	.0955	.0841	.0685
0:18:59	.0415	.0974	.0277	.0979	.0559	.1910	.0777	.1370
0:19:00	.0757	.1950	.0344	.0979	.0514	.1430	.1210	.1370
0:19:01	.1530	.4390	.0410	.0979	.0445	.1430	.2230	.5480
0:19:02	.1100	.1460	.0345	.0979	.0456	.1430	.1640	.1370

0:19:03	.0741	.0974	.0312	.0979	.0413	.1430	.1130	.1370
0:19:04	.0565	.0974	.0286	.0979	.0448	.1910	.0904	.1370
0:19:05	.0451	.0974	.0272	.0489	.0357	.0955	.0688	.1370
0:19:06	.0378	.0974	.0266	.0489	.0333	.0955	.0565	.0685
0:19:07	.0333	.0974	.0285	.0979	.0333	.0955	.0508	.0685
0:19:08	.0762	.1950	.0305	.0979	.0388	.1910	.1140	.1370
0:19:09	.1000	.2430	.0489	.1470	.0387	.0955	.1570	.2740
0:19:10	.0730	.1460	.0419	.0979	.0361	.0955	.1180	.1370
0:19:11	.0625	.1460	.0347	.0979	.0421	.1430	.1010	.1370
0:19:12	.0609	.1460	.0344	.0979	.0412	.1430	.0988	.1370
0:19:13	.0540	.1460	.0331	.0979	.0374	.1430	.0878	.1370
0:19:14	.0676	.1460	.0296	.0979	.0391	.1430	.1030	.1370
0:19:15	.0485	.0974	.0303	.0979	.0339	.0955	.0751	.1370
0:19:16	.0406	.0974	.0364	.0979	.0371	.1430	.0745	.1370♀

WBV

Time of Measurement : 17 Jan 12 09:56:30
Report Printed : 20 Jan 12 11:31:31

HISTORY for :WBV 05

Units = m/s^2

TIME	X RMS	PEAK	Y RMS	PEAK	Z RMS	PEAK	S RMS	PEAK
0:19:17	.0372	.0974	.0316	.0489	.0507	.1910	.0726	.1370
0:19:18	.0324	.0974	.0301	.0979	.0499	.1430	.0649	.1370
0:19:19	.0304	.0974	.0276	.0489	.0465	.1430	.0557	.1370
0:19:20	.0385	.0974	.0304	.0979	.0419	.1430	.0679	.1370

0:19:21	.0948	.2430	.0381	.0979	.0421	.1430	.1440	.2740
0:19:22	.1040	.2920	.0423	.1470	.0409	.1430	.1580	.4110
0:19:23	.0691	.0974	.0368	.0979	.0375	.1430	.1090	.1370
0:19:24	.0585	.1460	.0315	.0979	.0336	.0955	.0895	.1370
0:19:25	.0497	.0974	.0327	.0979	.0367	.1430	.0820	.1370
0:19:26	.1370	.3410	.0566	.1470	.0386	.1430	.2080	.4110
0:19:27	.1600	.3890	.0769	.1470	.0448	.1430	.2510	.5480
0:19:28	.1340	.2430	.0813	.1960	.0447	.1430	.2220	.2740
0:19:29	.0945	.1460	.0539	.0979	.0480	.1910	.1550	.1370
0:19:30	.0728	.1460	.0420	.0979	.0476	.1430	.1210	.1370
0:19:31	.1680	.4390	.0573	.1470	.0870	.3350	.2610	.5480
0:19:32	.1500	.3890	.0453	.0979	.0704	.1910	.2280	.4110
0:19:33	.6940	1.3100	.0846	.1960	.0895	.2870	.9810	1.7800
0:19:34	.6000	1.2200	.0829	.2440	.0853	.2380	.8510	1.6400
0:19:35	.4100	.3890	.0586	.0979	.0656	.1910	.5820	.4110
0:19:36	.2670	.2920	.0438	.0979	.0567	.1910	.3810	.4110
0:19:37	.1660	.1460	.0353	.0979	.0452	.0955	.2380	.1370
0:19:38	.1290	.1950	.0325	.0979	.0407	.0955	.1870	.1370
0:19:39	.1280	.2430	.0303	.0979	.0605	.1910	.1910	.2740
0:19:40	.1040	.2430	.0449	.1470	.0730	.2380	.1710	.2740
0:19:41	.1810	.3890	.0403	.0979	.0845	.1910	.2720	.5480
0:19:42	.1590	.2920	.0335	.0979	.0945	.2870	.2440	.4110
0:19:43	.1180	.1950	.0301	.0979	.0691	.1430	.1800	.1370
0:19:44	.0955	.1950	.0297	.0979	.0609	.1430	.1480	.1370
0:19:45	.0685	.0974	.0303	.0979	.0599	.1430	.1150	.1370
0:19:46	.0576	.1460	.0289	.0979	.0460	.0955	.0920	.1370
0:19:47	.0449	.0974	.0280	.0979	.0383	.0955	.0701	.0685
0:19:48	.0389	.0974	.0325	.0979	.0417	.1430	.0702	.1370
0:19:49	.0437	.1460	.0333	.0979	.0448	.1430	.0789	.1370
0:19:50	.0654	.1460	.0326	.0979	.0448	.1430	.1050	.1370
0:19:51	.0500	.0974	.0303	.0979	.0459	.1430	.0846	.1370
0:19:52	.0396	.0974	.0284	.0489	.0418	.1430	.0665	.1370
0:19:53	.0334	.0974	.0279	.0979	.0552	.1430	.0680	.1370
0:19:54	.0292	.0487	.0266	.0489	.0492	.1430	.0544	.1370♀

WBV

Time of Measurement : 17 Jan 12 09:56:30
Report Printed : 20 Jan 12 11:31:31

HISTORY for :WBV 05

Units = m/s^2

TIME	X RMS	PEAK	Y RMS	PEAK	Z RMS	PEAK	S RMS	PEAK
0:19:55	.0272	.0487	.0268	.0489	.0402	.0955	.0422	.0685
0:19:56	.0771	.2430	.0327	.0979	.0443	.1910	.1170	.2740
0:19:57	.1100	.2430	.0304	.0979	.0375	.1430	.1590	.2740
0:19:58	.1330	.2920	.0301	.0979	.0373	.1430	.1900	.2740
0:19:59	.0893	.1460	.0278	.0489	.0376	.1430	.1290	.1370
0:20:00	.0637	.0974	.0297	.0979	.0387	.0955	.0971	.1370

♀

APPENDIX 8

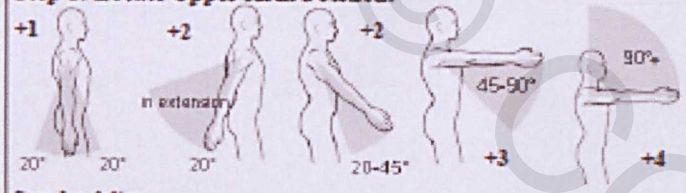
RULA SHEET

RULA Employee Assessment Worksheet

based on *RULA: a survey method for the investigation of work-related upper limb disorders*, McAtamney & Corlett, Applied Ergonomics 1993, 24(2), 91-99

A. Arm and Wrist Analysis

Step 1: Locate Upper Arm Position:



Step 1a: Adjust...
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

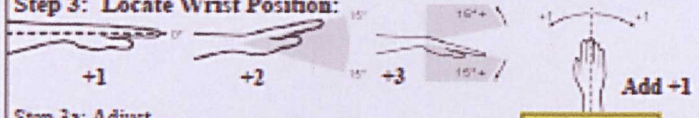
Upper Arm Score

Step 2: Locate Lower Arm Position:

Lower Arm Score

Step 2a: Adjust...
If either arm is working across midline or out to side of body: Add +1

Step 3: Locate Wrist Position:



Step 3a: Adjust...
If wrist is bent from midline: Add +1

Wrist Score

Step 4: Wrist Twist:
If wrist is twisted in mid-range: +1
If wrist is at or near end of range: +2

Wrist Twist Score

Step 5: Look-up Posture Score in Table A:
Using values from steps 1-4 above, locate score in Table A

Posture Score A

+

Step 6: Add Muscle Use Score
If posture mainly static (i.e. held>10 minutes),
Or if action repeated occurs 4X per minute: +1

Muscle Use Score

+

Step 7: Add Force/Load Score
If load < 4.4 lbs (intermittent): +0
If load 4.4 to 22 lbs (intermittent): +1
If load 4.4 to 22 lbs (static or repeated): +2
If more than 22 lbs or repeated or shocks: +3

Force/Load Score

=

Step 8: Find Row in Table C
Add values from steps 5-7 to obtain Wrist and Arm Score. Find row in **Table C**.

Wrist & Arm Score

SCORES

Table A: Wrist Posture Score

Upper Arm	Lower Arm	1 Wrist Twist 1	1 Wrist Twist 2	2 Wrist Twist 1	2 Wrist Twist 2	3 Wrist Twist 1	3 Wrist Twist 2	4 Wrist Twist 1	4 Wrist Twist 2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Table C: Neck, trunk and leg score

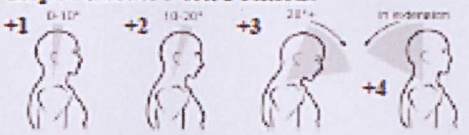
Wrist and Arm Score	1	2	3	4	5	6	7+
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8+	5	5	6	7	7	7	7

Scoring: (final score from Table C)
1 or 2 = acceptable posture
3 or 4 = further investigation, change may be needed
5 or 6 = further investigation, change soon
7 = investigate and implement change

Final Score

B. Neck, Trunk and Leg Analysis

Step 9: Locate Neck Position:



Step 9a: Adjust...
If neck is twisted: +1
If neck is side bending: +1

Neck Score

Step 10: Locate Trunk Position:

Step 10a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

Trunk Score

Step 11: Legs:
If legs and feet are supported: +1
If not: +2

Leg Score

Table B: Trunk Posture Score

Neck Posture Score	1 Legs 1	1 Legs 2	2 Legs 1	2 Legs 2	3 Legs 1	3 Legs 2	4 Legs 1	4 Legs 2	5 Legs 1	5 Legs 2	6 Legs 1	6 Legs 2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	5	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Step 12: Look-up Posture Score in Table B:
Using values from steps 9-11 above, locate score in Table B

Posture Score B

+

Step 13: Add Muscle Use Score
If posture mainly static (i.e. held>10 minutes),
Or if action repeated occurs 4X per minute: +1

Muscle Use Score

+

Step 14: Add Force/Load Score
If load < 4.4 lbs (intermittent): +0
If load 4.4 to 22 lbs (intermittent): +1
If load 4.4 to 22 lbs (static or repeated): +2
If more than 22 lbs or repeated or shocks: +3

Force/Load Score

=

Step 15: Find Column in Table C
Add values from steps 12-14 to obtain Neck, Trunk and Leg Score. Find Column in **Table C**.

Neck, Trunk & Leg Score

APPENDIX 9

PICTURES

Figure 1 : Accelerometer on the driver's seat

Figure 2 : UPM's bus

Figure 3 : Interview Session

Figure 4 : Weight Measurement