UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS ◆

JUDUL: A STUDY OF ESTABLISHING WBV'S PROFILE FOR BUS DRIVERS ALONG ROAD FROM EAST TO WEST COAST OF MALAYSIA

SESI PENGAJIAN: 2011/2012

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A STUDY OF ESTABLISHING WBV’S PROFILE FOR BUS DRIVERS ALONG ROAD FROM EAST TO WEST COAST OF MALAYSIA

SITI NORAZARINA BINTI RAZALI

Report submitted in partial fulfillment of the requirements
for the award of Bachelor of Mechanical Engineering

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JUNE 2012

UNIVERSITI MALAYSIA PAHANG
FACULTY OF MECHANICAL ENGINEERING

I certify that the project entitled "A Study of Establishing WBV'S Profile for Bus Drivers along Road from East to West Coast of Malaysia" is written by Siti Norazarina Binti Razali. I have examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. I herewith recommend that it be accepted in partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering.

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DEDICATION

I specially dedicate to my mom and Busu,

family, Halim, friends,

and those who have guided

and motivated me for this project

Not forget to Mickey and Jebat

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ABSTRACT

Many bus drivers are exposed to health risks, due to repeated exposure to vibration and noise. Vibration arises when a body moves back and forth or oscillates due to internal and external forces then it can be transmitted to the human body such as leg and arms but most commonly through the buttocks while seated in the vehicle. The vibration energy can be passed through the part in contact with the vibrating surface like the seat of the mobile machine, vehicles on rough roads, or vibrating tools. Noise termed as unwanted or undesirable sound, which effects in our living and working environment. Noise levels can be affected by a number of variables, including elevation, terrain, distance from the source, and weather. In addition, noise level's decrease with distance from a noise source. The change in noise level depends on the type of terrain, as well as the type of source. Weather conditions alter both noise levels and the transmission of noise from a source to where it is received. This paper presents recent results from an investigation of vibrations and noise, which imposed on the bus driver from the road along Kuantan to Kuala Lumpur. The vibrations have been evaluated in accordance with the new standard ISO 2631-1:1997. Meanwhile, noise is compared with OSHA Permissible Noise Exposure. 20 subjects completed a questionnaire regarding their general health, and specifically whether they experienced low back pain and if so, the extent and severity of this pain. It was expected that the individuals subject to the highest vibration levels would tend to report LBP, with severity of pain increasing with the intensity of exposure. This study did not support that belief. However, it may be that chronic exposure to whole-body vibration is a stronger predictor than daily expose levels. In conclusion, bus drivers should pay particular attention to safety and security of the driver and where circumstances are particularly difficult use, two people operated buses and if needed stop for a short break before continue the journey. Therefore, it is required that more research should be conducted in various transportation sectors in Malaysia to emphasize the effect of whole-body vibrations and noise to the driver.

ABSTRAK

Kebanyakan pemandu bas terdedah kepada risiko kesihatan, disebabkan oleh pendedahan yang berulang kali kepada getaran dan bunyi. Getaran terjadi apabila badan bergerak ke depan dan ke belakang atau berayun yang disebabkan oleh tekanan dalaman dan luaran lalu dihantar kepada tubuh manusia seperti kaki dan lengan tetapi kebanyakannya melalui punggung ketika duduk di dalam kenderaan. Tenaga getaran boleh dipindahkan melalui bahagia yang bersentuh dengan permukaan bergetar seperti kerusi pada mesin mudah alih, kenderan di jalan kasar atau alat bergetar. Bunyi dikenali sebagai bunyi yang tidak diingini atau tidak dapat dikesan dalam kehidupan dan persekitaran kerja. Tahap bunyi boleh dipengaruhi oleh beberapa pembolehubah, termasuk ketinggian, ripa bumi, jarak dari sumber dan cuaca. Di samping itu, tahap kebisingan berkurangan dengan jarak dan punca bising. Perubahan dalam paras bunyi bergantung kepada jenis bentuk muka bumi serta jenis sumber. Keadaan cuaca mengubah kedua-dua tahap bunyi bising dan penghantataran bunyi bising daripada sumber yang diterima. Kertas kerja ini membentangkan keputusan dari kajian getaran dan bunyi yang diterima oleh pemandu bas sepanjang jalan Kuantan ke Kuala Lumpur. Getaran telah dinilai selaras dengan standard baru ISO 26311-1:1997. Sementara itu, bunyi dibezakan dengan "OSHA Permissible Noise Exposure". 20 orang subjek telah dipilih secara rawak untuk mengisi soalan soal selidik mengenai kesihatan umum mereka, dan secara khusus sama ada mereka mengalami sakit belakang atau tidak. Jika ya, setakat manakah sakit itu. Dijangkakan individu yang terdedah kepada tahap getaran yang tertinggi akan cenderung untuk melaporkan sakit belakang dan kesakitan itu akan meningkat dengan pendedahan yang lama terhadap getaran. Namun, kajian ini tidak menyokong kenyataan tersebut. Ini mungkin terjadi kerana pendedahan dalam jangka masa panjang kepada getaran seluruh badan adalah sakit belakang yang lebih teruk berbanding dengan tahap pendedahan harian. Kesimpulannya, pemandu bas perlu memberi perhatian khusus kepada keselamatan diri dan untuk perjalanan yang jauh dua pemandu bas perlu ada bagi mengelakkan keletihan dan jika perlu berhenti seketika untuk bereahat sebelum meneruskan perjalanan. Oleh itu, lebih banyak penyelidikan perlu dijalankan dalam pelbagai sektor pengangkutan di Malaysia untuk menekankan kesan getaran seluruh tubuh dan bunyi terhadap pemandu.

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LIST OF ABBREVIATIONS

WBV	Whole Body Vibrations
LBP	Low Back Pain
MSDs	Musculoskeletal Disorder

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Express bus has a very good system in Malaysia since it's the easiest, cheapest and most popular way to travel between states in Malaysia. The express buses are modern and comfortable, service is frequent, and fares are low to moderate. Express buses in Malaysia are fast, economic and comfortable, and seats can be reserved. Today there are two types of bus are using in this country which is single bus and double-deck bus.

1.2 Background of Study

The purpose of the research is to find out the problem occurred to the bus driver because of the whole-body vibration and noise for bus driver and passenger they get along the road from the East to West Coast of Malaysia. At the end of this study, some recommendations to improve the problem will be laid down.

Vibration arises when a body moves back and forth or oscillates due to internal and external forces then it can be transmitted to the human body such as leg and arms but most commonly through the buttocks while seated in the vehicle. The vibration energy can be passed through the part in contact with the vibrating surface like the seat of the mobile machine, vehicles on rough roads, or vibrating tools (Guide to good practice on Whole Body Vibrations).

Noise termed as unwanted or undesirable sound, which effects in our living and working environment. Noise levels can be affected by a number of variables, including elevation, terrain, distance from the source, and weather. In addition, noise level's decrease with distance from a noise source. The change in noise level depends on the type of terrain, as well as the type of source. Weather conditions alter both noise levels and the transmission of noise from a source to where it is received.

1.3 Problem of Statement

From research that has been done on these topics, there are a lot of studies on Whole Body Vibrations and noise in various fields has been conducted since a long time ago. It is included all aspects about the Whole body Vibrations and noise. In Malaysia, most of the studies have been focusing in transportation, athletes and operators. For transportation, buses have been a lack study in Malaysia.

Therefore, it is important to investigate the effect of whole-body vibrations and noise to the bus drivers. Since the public bus is the higher demands from the Malaysian people, and nowadays many report we get because of the accidents happen because of the public buses so the research on this topic is very important. The finding in whole-body vibrations and noise should be compared to the latest journal to find out the differences.

1.4 Objective of Study

This study is going to conduct the human perception as well as quantitative measurement of WBV's for bus driver and also noise for bus driver and passenger and analysis the data by using design of Experiment. The objectives of this study are:

a. To study the effect of WBV's to the bus driver.
b. To study the effect of noise to the bus driver and passenger.
c. To perform survey approach among the bus drivers in order to collect the relevant data for whole-body vibrations and noise assessment and perception

to the effect of whole-body vibrations and noise level at the working environment.

d. To compare the findings of whole-body vibrations and noise to the bus driver and passenger with other previous studies in whole-body vibrations and noise

1.5 Scopes of Study

The scopes of this study are:

a. Conduct the human perception as well as quantitative measurement of WBV's for a bus driver
b. Conduct the human perception as well as quantitative measurement of noise for bus driver and passenger.

1.6 Significant of Study

The whole-body vibrations and noise study on the bus driver in Malaysia is a good step to assess the effect to the bus drivers for a long term period. From this research, it will help to reduce the problems occurs on the bus driver because of whole-body vibrations and noise.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In order to conduct a research, it is important to understand the concepts of the whole body vibrations (WBV) and noise and the factors that influence the WBV and noise. To more familiar with the concepts of WBV and noise, the previous studies in WBV and noise are been reviewed. This chapter is really will be helpful for the further study in this research.

2.2 Whole Body Vibration (WBV)

Many people say when something is move, that's thing is vibrate. In these modern industrial environments which human used powered tools, machinery, vehicle and heavy equipment, yes it is right. As we know, vibration arise when a body moves back and forth or oscillates due to internal and external forces then it can be transmitted to the human body such as leg and arms but most commonly through the buttocks while seated in the vehicle.

The vibration energy can be passed through the part in contact with the vibrating surface like the seat of the mobile machine, vehicles on rough roads, or vibrating tools. Vibration can be described in two ways which is whole body vibration which is where the vibration is transmitted to the body as a whole by its supporting surface like seat or floor and segmental which is where the vibration is transmitted to a specific segment of the body such as the hand/arm or foot/leg.

Griffin (2006) said that, we know that many persons experience back pain and that some of these are exposed to whole-body vibration. We know that in the population at large, occupational exposures to whole-body vibration are not the main cause of back problems and that ergonomic factor (e.g., lifting and twisting) and personal factors are often involved. We know vibration and shock can impose stresses that could supplement other stresses. We may claim to know that measurement methods and evaluation methods have been defined in which the frequencies, directions, and durations are weighted so as to predict the relative severity of different vibrations and indicate the magnitudes that might be hazardous.

Besides that, Griffin (2006) continued said that what we do not know is that we are not able to predict the probability of any disorder from the severity of an exposure to whole-body vibration. We do not know whether there is any disorder specific to whole-body vibration or what disorders are aggravated by exposure to whole-body vibration. We do not know the relative importance of vibration and other risk factors in the development of back disorders.

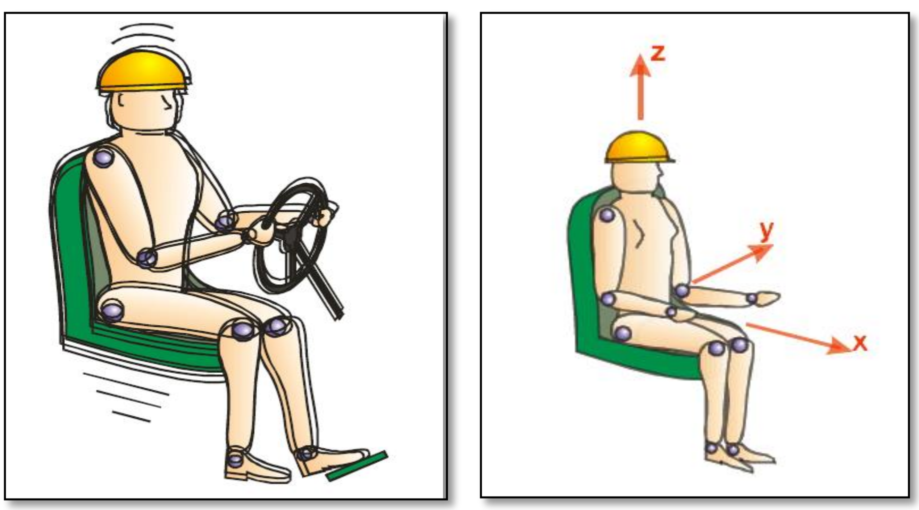


Figure 2.1: Direction of WBV through the human body

(Sources: Guide to good practice on Whole Body Vibrations)

The transmission of vibration to human body is dependent on their body posture and the effects of vibration to them. Exposure to whole body vibration will causes motions and forces within the human body that may cause discomfort, adversely affect performance, aggravate pre-existing back injuries and present a health and safety risk. Motion sickness can be occurring when our body exposed to a low frequency vibration. In order to obtain passenger satisfaction, vehicle manufacturers are continuous constantly seeking to improve vibration comfort. Many factors influence the transmission of vibration to and through the body (as indicate in Figure 2.2).

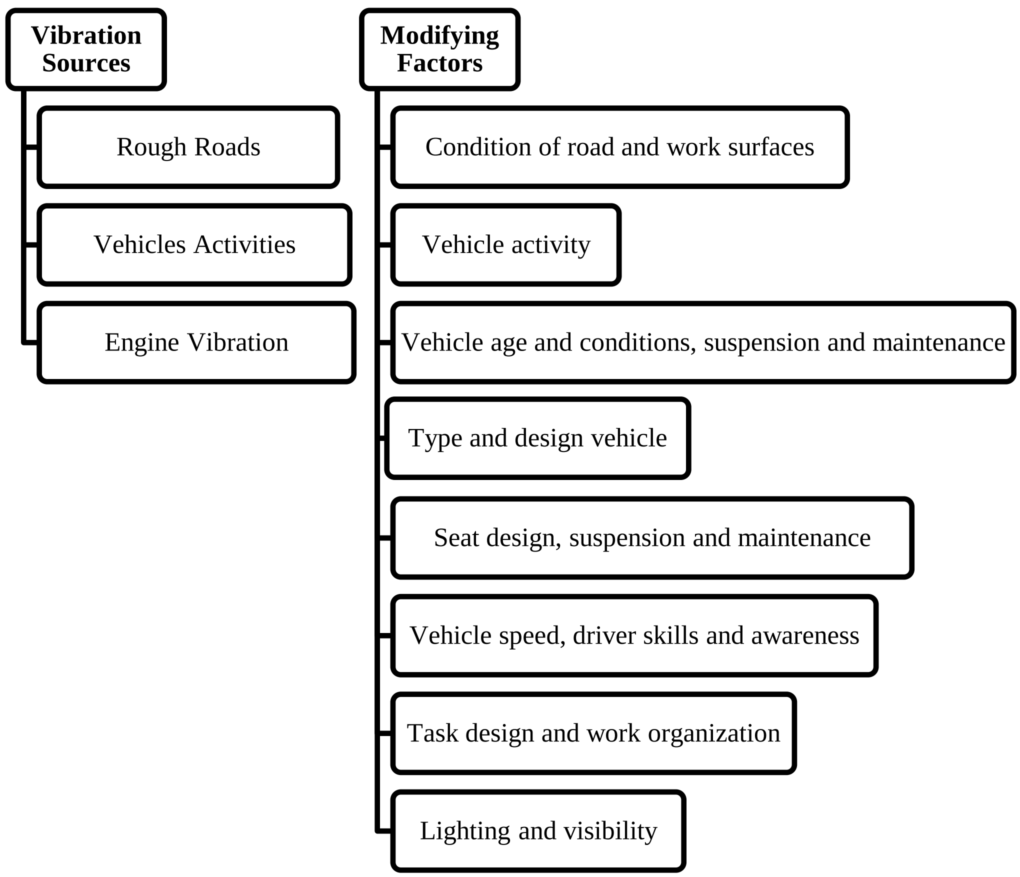


Figure 2.2: Factors that influence the transmission of vibration to and through the body

(Sources: Bad Vibration-A handbook on Whole Body exposures in Mining)

Poor roads and uneven work areas contribute significantly to rough rides and discomfort but they are not the only cause of acute injuries. A good road with a single, unexpected pothole can cause severe neck and back injuries in passengers if the vehicle is travelling at speed. On the other hand a poor travelling road can slow personnel transport and production and may cause long-term damage to drivers and passengers. The administrative problems of maintaining roads in a satisfactory condition are common to all mines. However, road maintenance is not always given the same priority and attention as production (Bad Vibration-A handbook on Whole Body Exposures in Mining, 2001).

Bad Vibration-A handbook on Whole Body Exposures in Mining (2001) come out with principal problems with roads or work surfaces which are:

a. Rough work areas such as those that are being cleaned up by a bulldozer or an LHD
b. Secondary roads that are not maintained to the standard of the main travelling roads but which are used by vehicles such as LHDs underground and fitters' vehicles in open-cuts
c. Excessive water leading to rapid deterioration of road surfaces
d. Poor road building and/or maintenance programs
e. Unexpected potholes, soft spots or mud in otherwise good roads
f. Poor road conditions that are not reported and corrected quickly

The second factor that causes a vibration is old age vehicles which many older vehicles have little suspension. Sometimes poor suspension can exaggerate roughness especially if the engine bottoms out. Most suspension systems can reduce damaging vibration but they deteriorate over time especially in a rough mining environment. For instance, in a recent survey of four-wheel drive personnel transport and maintenance vehicles it was found that vehicle suspension and therefore ride roughness deteriorated markedly after 40,000km. Older vehicles were much rougher than the newer vehicles in terms of their vibration dose values. However, one of the newer vehicles gave a ride that was as rough as the older vehicles due to its stiff suspension, which was intended for heavier loads. Planned vehicle maintenance schedules may not include assessment and/or overhauls of the suspension systems early enough (Bad Vibration-A handbook on Whole Body exposures in Mining, 2001).

Principal problems with the age and condition of the vehicle and maintenance of suspension systems are (Bad Vibration-A handbook on Whole Body exposures in Mining, 2001):

a. Inadequately maintained vehicles are rougher
b. The rough conditions experienced at mines means that suspension systems are likely to deteriorate quickly
c. Maintenance programs need to encompass frequent assessment and overhaul of suspension systems
d. Older vehicles tend to be rougher than newer vehicles of the same make and model

Griffin in 1990 suggested that a seated person may be exposed to both whole-body and local vibration of the head example from head or neck rest, the hands example on a steering wheel and the feet example on the floor or pedal. Complaints about seats are the higher comments come from the driver. Because of the complaints, much effort has gone into seat design and to reducing vibration. However, complaints about seats are still common.

McPhee (2001) said that this could be related to incorrect installation and adjustment; inadequate maintenance; poor design; or lack of adjustability for particular individuals especially those with back or neck pain. Sometimes there is inadequate space in the cab, which does not allow correct adjustment of the seat. Risks of neck and back injury for driver are increased significantly under these circumstances. Suspension seats can help but do not completely solve the problem. When seats are not maintained or replaced on a regular basis they can add to vibration problems because seats suspension systems deteriorate over time. Seats that bottom out or that cannot be adjusted adequately for all users may cause serious injury.

Bad Vibrations-A handbook on Whole Body Vibrations exposing in Mining (2001) said that principle problems of seat design, suspension and maintenance are:

a. Vehicle seat design varies and some seats are better designed for the machine and tasks than others
b. Many seats lack basic design features such an adequate lumbar support
c. Poor cab design or orientation may eliminate or reduce the benefits of good seating
d. Lack of visibility or the need to see backwards may limit the benefits of a good seat
e. Many seats are not maintained to designers specifications and are not replaced regularly
f. Poor seat maintenance can contribute to rougher rides
g. ‘Troop carrier’ style personnel transport often has poorly designed bench seats with no lateral stability

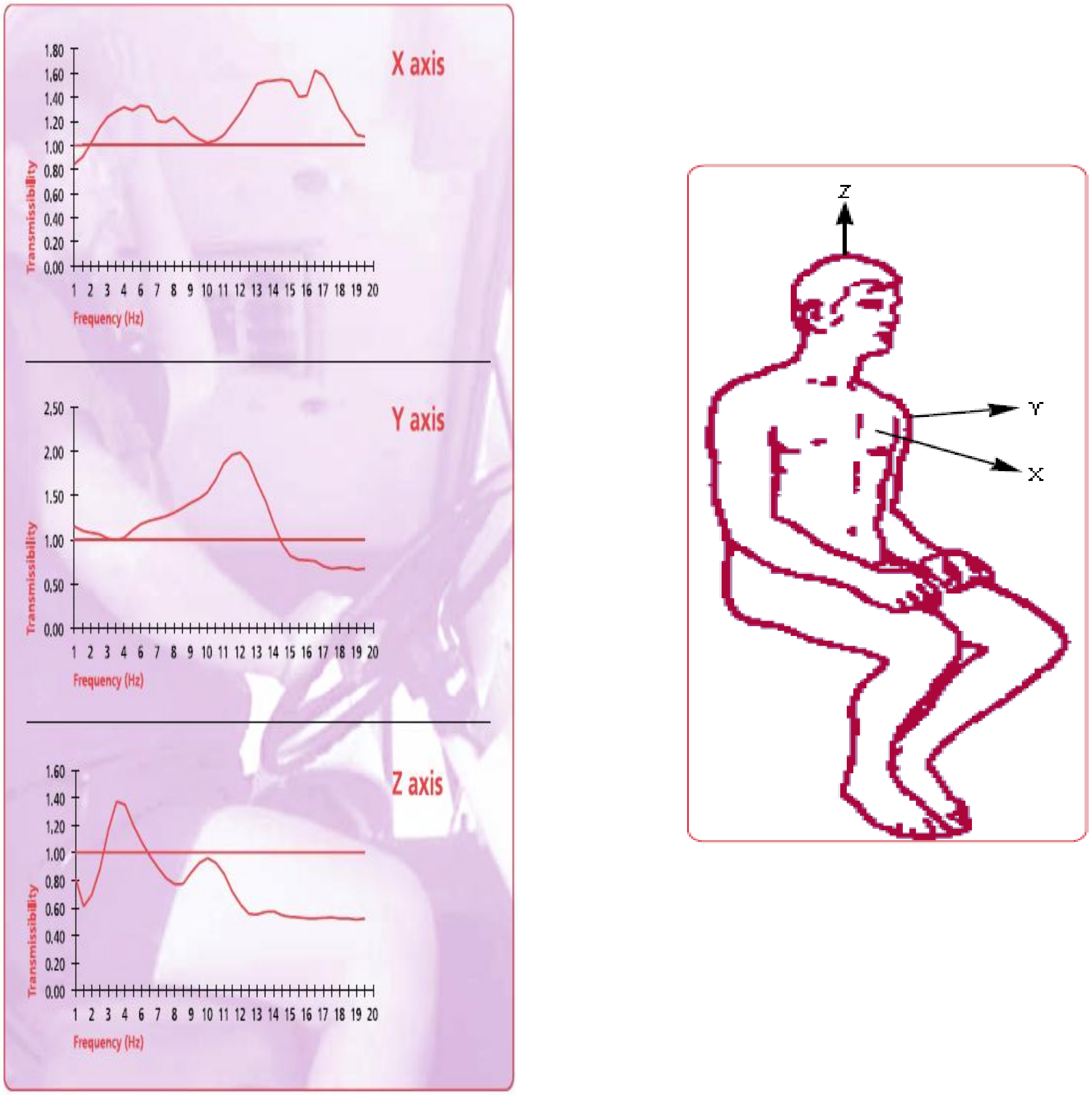


Figure 2.3: Transmissibility of dozer seat in the x-axis (front to back), y-axis (side to side) and the z-axis (up and down). The seat is amplifying vibration at frequencies where the curve is above the line transmissibility greater than 1.00). When the curve falls below the line transmissibility less than 1.00) the seat is reducing the vibration at these frequencies.

(Sources: Bad Vibrations-A handbook on Whole Body Vibrations exposure in Mining, 2001)

McPhee et al. (2001) also had said that drivers of vehicles in rough environments are usually very tolerant of discomfort. However, the long-term damage that could be occurring may show up 10 to 20 years later and the individual makes no link with the exposures that may have contributed over time to the problems. Increased speeds accentuate ride roughness. There appears to be an optimum speed – neither too slow nor too fast – for different conditions. Drivers' skills and awareness of the conditions are important in establishing this optimum speed, especially when it is coupled with speed limits and safety requirements.

Drivers need to be particularly careful when they are carrying passengers in rear seats. The ride in the back of a vehicle is usually much rougher than in the front, particularly if passengers are sitting behind the rear axles as they do in the typical 'troop carriers'. The term 'drive to conditions' tends to be meaningless if it has not been defined or described. In practical terms it does not provide enough guidance to operators and drivers in difficult or abnormal conditions. Drivers are expected to be 'sensible' but different people can interpret this differently. Less experienced drivers are particularly at risk in these situations, as many see no link between rough rides and back and neck injuries (McPhee et al., 2001).

McPhee et al. (2001) said that human responses to whole-body vibration can be evaluated by two main standards which are the British Standard BS 6841 (BS 6841) (1987) and the International Standard 2631 (ISO 2631) (1997). The BS 6841 considers a frequency range of 0.5 to 80 Hz. This standard recommends measuring four axes of vibration on the seat (fore-aft, lateral, and vertical vibration on the seat surface as well as and fore-aft vibration at the backrest) and combining combines these them in an evaluation procedure that to assesses the vibration severity. The ISO 2631 suggests vibration measurements in the three translational axes on the seat pan, but only the axis with the greatest vibration is used to estimate vibration severity.

2.3 Noise

As said by Mohktar M et al. (2007), sound can be measured objectively but noise is a subjective phenomenon. Bridger as defined noise as a sound or sounds at such amplitude as to cause annoyance or interfere with communication. Kroemer et al. mentioned that noise was psychological and subjective feeling. Single, short tones of low intensity may be considered noise under certain conditions. In fact just as loud, lasting, complex sounds may be deemed noise under other circumstances. Any sound which is annoying or level of sound exceeds 75 dBA may be conceived as noise.

The threshold for noise annoyance varies. It depends on the conditions, including the sensitivity and mental state of an individual. Generally, noise can create negative emotions, feeling of surprise, frustration, anger and fear. Noise also delay the onset of sleep, awaken a person from sleep or disturb someone's rest and make it difficult to hear desirable sounds. The effects of noise may produce temporary or permanent alterations in body chemistry, and temporarily or permanently change one's hearing capability too. These could also interfere with some human sensory and perceptual capabilities and thereby degrade the performance of a task (Mohktar M et al., 2007).

Mokhtar M et al. (2007) also said that the level of noise necessary to produce adverse effects was greatly dependent upon the type of task. Simple tasks may remain unaffected at noise level as high as 115 dB or above, while more complex tasks may get disrupted even at much lower levels. In many studies, noise was found to degrade human performance. The performance of human being was adversely affected due to noise-induced stresses.

Office noise (such as speech), disrupted performance on office-related tasks that would require memory for prose and mental arithmetic whereas office noise without speech disrupted the performance only on mental arithmetic task. Smith cited that noise impaired performance on the focused attention task. Fu et al. explored that noise deteriorated the performance of subjects in vowel and consonant recognition task. Cho et al. stated that the cortical activity of subjects diminished substantially when exposed to large acoustic sound. They added that when subjects were exposed to a loud acoustic sound, there was an increase in total motor activation.

Carl E. Hanson et al. (2006) said that noise can be described in 3 variables of terms which are:

a. Amplitude

Loudness of a sound depends on the amplitude of the fluctuations above and below atmospheric pressure associated with a particular sound wave. The mean value of the alternating positive and negative pressure fluctuations is the static atmospheric pressure, not a useful descriptor of sound. However, the effective magnitude of the sound pressure in a sound wave can be expressed by the “root-mean-square” (rms) of the oscillating pressure measured in Pascals, a unit named after Blaise Pascal a 17th century French mathematician.

In calculation of the ‘rms’, the values of sound pressure are squared to make them all positive and time-averaged to smooth out variations. The ‘rms’ pressure is the square root of this time-averaged value. The quietest sound that can be heard by most humans, the “threshold of hearing," is a sound pressure of about 20 microPascals, and the loudest sounds typically found in our environment range up to 20 million microPascals.

Because of the difficulty in dealing with such an extreme range of numbers, acousticians use a compressed scale based on logarithms of the ratios of the sound energy contained in the wave related to the square of sound pressures instead of the sound pressures themselves, resulting in the “sound pressure level” in decibels (dB). The ‘B’ in dB is always capitalized because the unit is named after Alexander Graham Bell, a leading 19th century innovator in communication. From equation (1):

$$Lp = 10\log 10\left(\frac{p_{rms}^2}{p_{ref}^2}\right) = 20\log 10\left(\frac{p_{rms}}{p_{ref}}\right) \quad \ldots.(1)$$

$$where\ p_{ref} = 20\ microPascals$$

Inserting the range of sound pressure values mentioned above results in the threshold of hearing at 20 microPascals at 0 dB and a typical loudest sound of 20 million microPascals is 120 dB.

b. Decibel Addition

The combination of two or more sound pressure levels at a single location involves 'decibel addition' or the addition of logarithmic quantities. The quantities that are added are the sound energies (p_{rms}^2). For example, a doubling of identical sound sources results in a 3 dB increase, from equation (2):

$$10\log 10\left(\frac{2p_{rms}^2}{p_{ref}^2}\right) = 10\log 10\left(\frac{p_{rms}^2}{p_{ref}^2}\right) + 10\log 10(2)$$

$$= 10\log 10\left(\frac{p_{rms}^2}{p_{ref}^2}\right) + 3 \quad \ldots.(2)$$

For example, if the noise from one bus resulted in a sound pressure level of 70 dB, the noise from two buses would be 73 dB. Figure 2.4 provides a handy graph that can be used to add sound levels in decibels. For example, if two sound levels of 64 dB and 60 dB are to be added, the difference in decibels between the two levels to be added is 4 dB. The curve intersects the "4" where the increment to be added to the higher level is "1.5." Therefore the sum of the two levels is 65.5 dB.

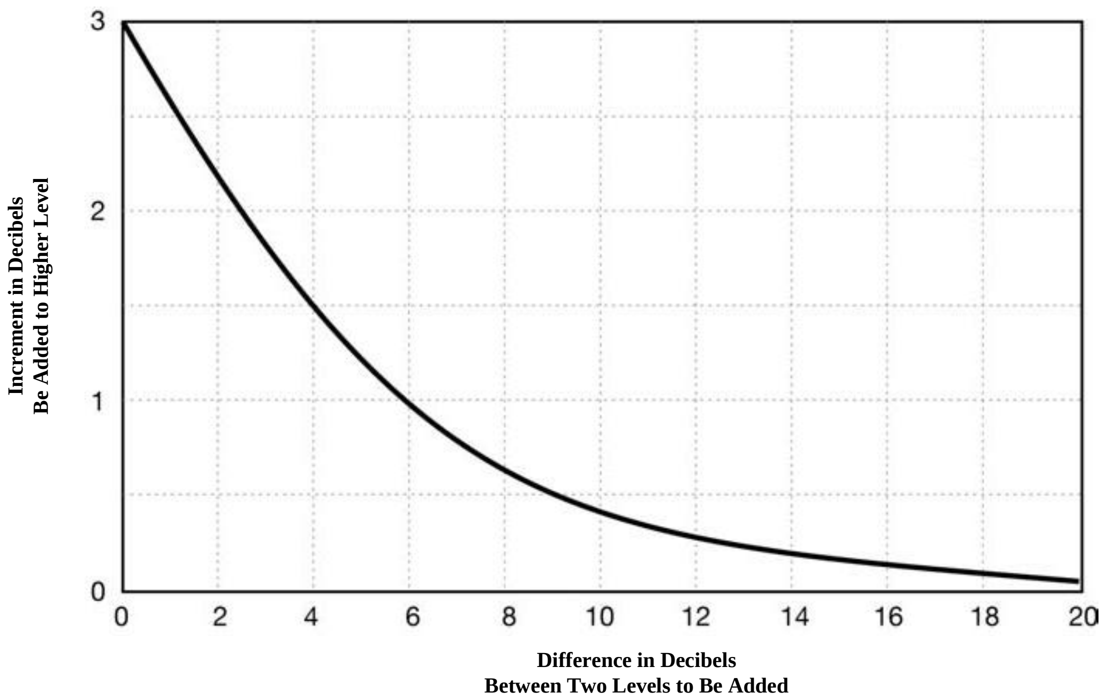


Figure 2.4: Graph for Approximate Decibel Addition

(Sources: Carl E. Hanson, David A. Towers, and Lance D. Meister, 2006)

c. Frequency

Sound is a fluctuation of air pressure. The number of times the fluctuation occurs in one second is called its frequency. In acoustics, frequency is quantified in cycles per second, or Hertz (abbreviated Hz), named after Heinrich Hertz, a famous 19th century German physicist. Some sounds, like whistles, are associated with a single frequency; this type of sound is called a "pure tone." Most often, however, noise is made up of many frequencies, all blended together in a spectrum.

Human hearing covers the frequency range of 20 Hz to 20,000 Hz. If the spectrum is dominated by many low frequency components, the noise will have a characteristic like the rumble of thunder. The spectrum in Figure 2.5 illustrates the full range of acoustical frequencies that can occur near a transit system. In this example, the noise spectrum was measured near a train on a steel elevated structure with a sharp curve. This spectrum has a major low frequency peak centered around 80 Hz. Although not dominant in this example, frequencies in the range of 500 Hz to 2000 Hz are associated with the roar of wheel /rail noise. However a strong peak above 2000 Hz is associated with the wheel squeal of the train on the curve.

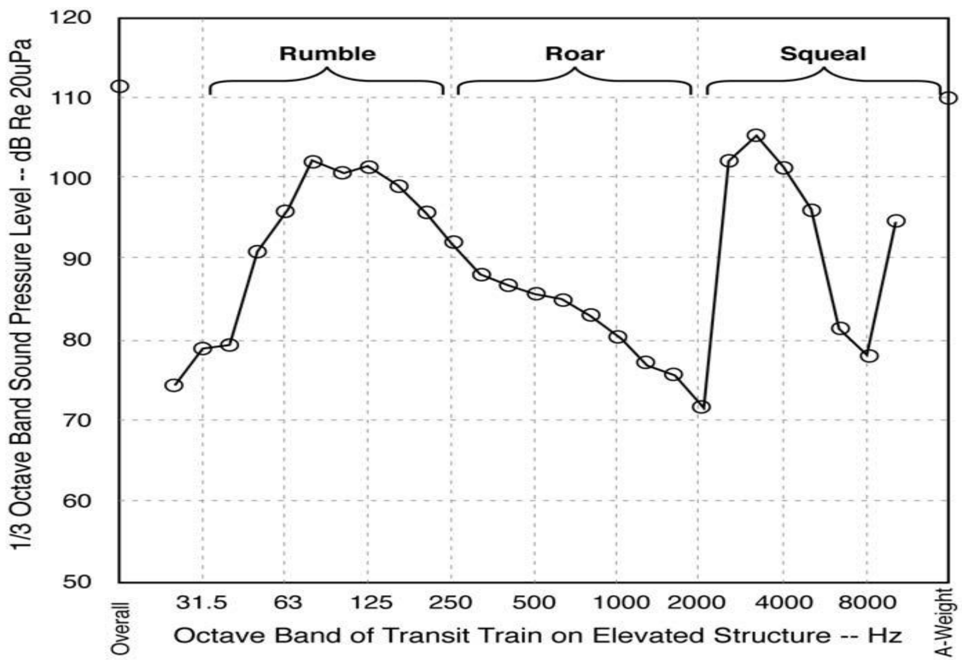


Figure 2.5: Graph for Approximate Decibel Addition

(Sources: Carl E. Hanson, David A. Towers, and Lance D. Meister, 2006)

In new era, engine from transportation exposed more sound population to the environment compare than other. Engine noise is caused by various types of force generation within the engine and is transmitted to the radiating outer surfaces. The transmission path properties are determined by the vibration modes of the structure. The properties of the outer surface will also influence the sound radiation. Much of the work is being done all over the world to limit high level environmental and occupational noise levels within the comfortable limits. The human ear can perceives a change in sound levels more effectively than absolute sound levels. The range of perceptible magnitudes is so large that noise levels are generally expressed on a logarithmic scale in units called decibels (dB). While a 3-dB increase is barely perceptible to the human ear, a 5-dB increase sounds as if the noise is about one and a half times as loud. A 10-dB increase is perceived as a doubling in noise level to most listeners. Table 2.1 shows summarize sources of transit noise separately by vehicle type and/or type of facility.

Table 2.1: Sources of Transit Noise

Vehicle or Facility	Dominant Components	Comments
Rail Rapid Transit (RPT), or Light Rail Transit (LRT) on exclusive right-of-way	Wheel/rail interaction and guide way amplification	Depends on condition of wheels and rails.
	Propulsion system	When accelerating and at higher speeds.
	Brakes	When stopping.
	Auxiliary equipment	When stopped.
	Wheel squeal	On tight curves.
	In general	Noise increases with speed and train length.
Light Rail Transit (LRT) in mixed traffic	Wheel squeal	On tight curves.
	Auxiliary equipment	When stopped.
	Horns and crossing bells	At grade crossings.
	In general	Lower speeds mean less noise than for RRT and LRT on exclusive right-of-way.
Commuter Rail	Diesel exhaust	On diesel-hauled trains.
	Cooling fans	On both diesel and electric-powered trains.
	Wheel/rail interaction	Depends on condition of wheels and rails.
	Horns and crossing gate bells	At grade crossings.
	In general	Noise is usually dominated by locomotives and horns at grade crossings.

Table 2.1: Continued

Vehicle or Facility	Dominant Components	Comments
Low and Intermediate Capacity Transit	Propulsion systems, including speed controllers	At low speeds.
	Ventilation systems	At low speeds.
	Tire/guideway interaction	For rubber-tired vehicles, including monorails.
	Wheel/rail interaction	Depends on condition of wheels and rails.
	In general	Wide range of vehicles: monorail, rubber- tired, steel wheeled, linear induction. Noise characteristics depend upon type
Diesel Buses	Cooling fans	While idling.
	Engine casing	While idling.
	Diesel exhaust	At low speeds and while accelerating.
	Tire/roadway interaction	At moderate and high speeds.
	In general	Includes city buses and commuter buses
Electric Buses and Trackless Trolleys	Tire/roadway interaction	At moderate speeds.
	Electric traction motors	At moderate speeds.
	In general	Much quieter than diesel buses.
Bus Storage Yards	Buses starting up	Usually in early morning.
	Buses accelerating	Usually near entrances/exits.
	Buses idling	Warm-up areas
	In general	Site specific. Often peak periods with significant noise.
Rail Transit Storage Yards	Wheel squeal	On tight curves.
	Wheel impacts	On joints and switches.
	Wheel rolling noise	On tangent track
	Auxiliary equipment	Throughout day and night. Includes air-release noise.
	Coupling/uncoupling	On storage tracks
	Signal horns	Throughout yard site
	In general	Site specific. Often early morning and peak periods with significant noise.
Maintenance Facilities	Signal horns	Throughout facility
	PA systems	Throughout facility
	Impact tools	Shop buildings
	Car/bus washers/driers	Wash facility
	Vehicle activity	Throughout facility
	In general	Site specific. Considerable activity

Table 2.1: Continued

Vehicle or Facility	Dominant Components	Comments
		throughout day and night, some outside.
Stations	Automobiles	Patron arrival/departure, especially in early morning.
	Buses idling	Bus loading zone
	P.A. systems	Platform area
	Locomotive idling	At commuter rail terminal stations.
	Auxiliary systems	At terminal stations and layover facilities.
	In general	Site specific, with peak activity periods.
Subways	Fans	Noise through vent shafts.
	Buses/trains in tunnels	Noise through vent shafts.
	In general	Noise is not a problem

(Sources: Carl E. Hanson, David A. Towers, and Lance D. Meister, 2006)

2.4 Effect of Whole Body Vibrations and Sound to the Bus Driver

As a bus driver who travels down a road or highway it encounters bumps, potholes, bridge expansion joints, and other disturbances that produce unwanted vehicle motion are exposed to many types of stress such as exposure to noise or vibration and health risks. Back disorders are costly to society and are the main causes of sick leave in the working community. They cause great pain to those suffering, and are a significant economical burden to society. Professional bus drivers are one group of workers that have been found to be at high risk for back disorders.

Numerous types of back disorders are caused by ride vibration. Many epidemiological studies have been made on the relationship between back disorders and vehicle operation with vibration exposure. The results show overwhelming evidence of a relationship that is consistent and strong, which increases with increasing exposure, and is biologically plausible. The risk is elevated in a broad range of driving occupations, including bus drivers. Vibration exposure data indicate that current buses are likely to expose drivers to vibration levels in excess of levels recommended in ISO standards, and that common control measures, such as seat suspension, are often ineffective.

Long term exposed to WBV can cause a range of problems. These include disorders of the joints and muscles and especially the spine (WBV), disorders of the circulation (hand-arm vibration), cardiovascular, respiratory, endocrine and metabolic changes (WBV), problems in the digestive system (WBV), reproductive damage in females (WBV), impairment of vision and/or balance (WBV), interference with activities and discomfort. The most frequently reported problem from all sources of WBV is low-back pain arising from early degeneration of the lumbar system and herniated lumbar disc. Muscular fatigue and stiffness have also been reported. Some studies have associated the degeneration of the lumbar spine with intense long-term exposure to WBV.

The two main factors that occurs low-back pain are long-term exposure to whole body vibration (WBV) and long term sitting. For example driver who is exposed to whole body vibration for a long period without being able to change position. When you sit, your pelvis rolls backward and the small of your back flattens out. This increases the pressure in the discs of the spine. In this position, the discs are less prepared to handle the vibrations from your car or truck. Ligaments in your back help to hold the spine together as you move.

These ligaments will stretch and slacken if you sit down for a long time. After standing up, they remain slack for a while and cannot support the spine as they normally do. If your seat is not correctly adjusted, you could develop pressure points in the buttocks and back of the legs, and muscle strain in the low back. Continuous upper back and neck muscle work is often required to hold the head in position, especially if vibration is present. Continuous muscle activity can lead to muscle strain. Holding a foot pedal down over a long period of time may cause stiffness and spasm in the legs and low back.

This causes neck and back muscles to tire more quickly, and decreases the support these muscles can give to the spine. Even if the muscles are working very lightly, activity for an extended time without rest will lead to fatigue and increase the risk of back injury.

For example neck, back and shoulder pain, cramps, pressure points and poor circulation in the legs and buttocks, immediately after driving, there is an increased chance of low back injury from lifting and long term potential for degeneration of spinal discs and disc herniation. The risks are greatest when the vibration magnitudes are high, the exposure durations long, frequent, and regular, and the vibration includes severe shocks or jolts.

Back pain also can occur because of the ergonomics factors such as a poor posture while driving and sitting for a long period without ability to change their position but the risk will be increased where a driver is exposed to one or more of these factors while being exposed to whole body vibration. Environmental factor also can be one of reason why back pain occurs such as temperature and time.

The vibration exposure of professional drivers has been correlated with road roughness, vehicle type and condition, as well as with driving behavior such as speed. Among the conclusions were that many heavy vehicle drivers are exposed to vibrations (shocks) above the Action Value A(8) = 0.5 m/s2. Within reasonable ranges, road roughness was found to have a much larger impact than other factors. In general, transient vibrations with multiple shocks are more hazardous than stationary vibration. In practice, this means that bumpy rides typically are unhealthier than ride vibration, i.e. from modestly wash-boarded gravel roads.

2.5 Reviews on Previous Whole Body Vibration and Sound Study

Here are some of the research and journal that have been done on WBV and noise study by assessing different aspects including working environment, gender, personal factors and many more. These studies are important to reviewed, find the comparisons in term of approaches and results besides making them as a guidance to complete this research.

2.5.1 Whole Body Vibration and Sound on the Transportation

Olanrewaju O.O et al. (2006) performed study at city bus drivers to investigate the typical exposures of city bus drivers to driving posture demands, manual material handling (MMH) and vibration as well as the prevalence and nature of low back pain (LBP). Possible strategies for controlling the LBP also discussed. They used both self-assessments by a questionnaire and systematic (direct) observation (including measurement). At the end of the study, they find out that:

a. City bus drivers clock up considerable hours of daily work time, and spend about 60% of the time actually driving. They often drive with the torso straight or unsupported, perform occasional and light MMH, and experience discomforting shock/ jerking vibration events.
b. LBP is prevalent among city bus drivers (such as were considered in the present study), but largely transient and mild LBP, which is not likely to interfere with work or customary levels of activity.
c. Taking regular breaks from sitting during driving and fitting buses with remotely operated retracting access ramps and lift platforms and use of buses with manual transmissions rather automatic transmissions are strategies that can help control precipitation of LBP.

Meanwhile, Johan Granlund and Anders Brandt (2005) said that the study conduct by them are to compare a sample of different speed bump designs with respect to health risks, in terms of back disorders related to transient ride vibration, for professional bus drivers. They come out with results from an investigation of vibrations imposed on the driver bus from some twenty speed bumps in the Stockholm area (Sweden). The vibrations have been evaluated in accordance with the new standard ISO 2631-5. This finding made the Swedish Work Environment Administration prohibit line bus traffic on the related streets until some speed bumps were altered. The health risk depends on the number of daily shock exposures.

On the other hand, Silviu Nastac and Mihaele Picu (2010) had chosen train as their part of WBV study which is constitutes one aspect of the physical environment that can cause discomfort to passengers. The authors has come out with some factors that influence passenger comfort in the rail transport systems, such as the environmental factors of noise level, visual stimuli, temperature and humidity. Other influential factors include the effect of vibration on task (such as reading, writing, eating or drinking) or the physical construction of the carriage or rail infrastructure, and there are also less tangible factors such as expectation (which could be biased by the price paid for the ticket or class of carriage). There are several standardized methods of measurement and assessment of whole-body vibration in moving trains. This paper discussed the fundamental principles of these methods including a description of the measurement hardware and the necessary calculations that need to be carried out in order to comply with the relevant international standards.

Hassan Nahvi et al. (2009) said that the current objectives of their study are to evaluated of vehicle comfort characteristics based on standard mathematical formula and frequency analysis. A variety of road types were selected and quantified from the International Roughness Index (IRI). To assess vibrations transmitted to the passengers, vibration dose values (VDV), kurtosis, frequency response functions (FRF), and power spectral densities (PSD) of the compartment recorded signals were evaluated. This paper is a subdivision of general research conducted to evaluate vibro-acoustical comfort inside the vehicle compartment. The first part was to define a vehicle acoustical-comfort index using objective and subjective evaluations.

Daruis D.D.I. et al. (2008) has chosen to study WBV and Sound Quality of Malaysian cars. The purpose of their study are to compare the results of the same vibration and sound quality measurements and evaluations on two different types of Malaysian car, which is categorized as a 2.0cc premium sedan and a 1.3cc compact car at different roads with different International Roughness Index (IRI) values. Apart from that, the standardized accelerometer position on seats is challenged with localized positions. Further, the different cars feature different aspect of sound quality which is investigated through vehicle acoustical comfort index established earlier.

Besides that, Hsieh-Ching Chen et al. (2009) had chosen riders of twelve motorcycles, comprising 6 full-scale motorbikes and 6 motor-scooters, and 5 sedan vehicles, performed test runs on a 20.6 km paved road composed of 5 km, 5 km, and 10.6 km of rural, provincial and urban routes, respectively. The authors compare the predicted health risks of motorcycle riders according to ISO 2631-1 and ISO 2631-5 standards. Experimental data suggest that the vibration dose value of ISO 2631-1 and daily dose of equivalent static compression stress of ISO 2631-5 have roughly equivalent boundaries for probable health effects. The authors found that WBV exposure levels of sedan drivers and motorcycles riders were significantly different. Effectively reducing the health risks of motorcycle riders associated with WBV may still require good maintenance of road surfaces, and improved design of vehicle cushion systems.

Furthermore, Lenka Justinova (2005) has summarized studies of low back pain problems among the car drivers published during the last three decades. Twenty-one articles, published between 1975 and 2004, were selected and reviewed. Case-control studies have been reported in six papers, cross-sectional studies in thirteen papers and longitudinal studies in two papers. Although evidence is often sparse, most of the studies concluded that exposure to whole-body vibration associated with driving was linked to an increased risk of low back pain. Almost all of the studies included in this review concluded that there is relationship between low back problems and car driving. However, it cannot be concluded that whole-body vibration is the main cause of low back problems among car drivers because most of the reviewed studies did not provide sufficient quantification of the vibration exposure.

According to the Bo¨ Rje Rehn et al. (2005), the purpose of their study was to characterize WBV exposure from various all-terrain vehicles (ATVs) such as snow groomers, snowmobiles and forwarders and to investigate how frequently the drivers' cervical spine is positioned in a non-neutral rotational position during operation. The authors measured the field of measurements of WBV accordingly to the International Standard ISO 2631-1 in 19 ATVs and conclude that vibration magnitudes in ATVs are considerably high compare than the EU's action value and the health guidance caution zones in ISO 2631-1. The dominant vibration direction varies depending on the machine type. Duration and frequency of non-neutral rotational positions do not seem to constitute single ergonomic risk factors for musculoskeletal symptoms in the neck among professional drivers of ATVs. However, synergistic effects with other factors are conceivable.

Ana Picu (2009) said the purpose of her study is to measure the whole body vibration for drivers, during their work time, knowing that they are exposed for the entire work schedule, as opposed to fares that are exposed only occasionally. In this paper, 6 different types of busses and minibuses were analyzed, with 8 drivers of 28-54 years of age. The routes covered by these busses were inside but also outside the city. The roads were of different qualities (asphalt, macadam, and pavement). The vibrations accelerations were measured on the axes (x-, y- and z-axes), and these values were compared to the ones from SR ISO 2631-1/2001. The results showed that, in certain cases, the discomfort limits were exceeded.

Ruth K. Raanaaas and Donald Anderson (2007) carried out a questionnaire among taxi drivers in Norway to determine the prevalence of musculoskeletal pain and to identify work-related factors that are likely to increase the risk of neck, shoulder or lower back pain. Nearly 1500 taxi drivers were chosen nationally to form the subject pool. One-year musculoskeletal pain prevalence (MSP) was assessed with the Nordic Musculoskeletal Questionnaire (NMQ), and work-related factors with a questionnaire designed for the purpose. The response included 929 (63.4%) of the drivers contacted. The results revealed that taxi drivers have an elevated risk of musculoskeletal problems compared to a Norwegian reference population. When workload and lifestyle factors were analyzed simultaneously, independent risk factors for MSP were identified as driving hours per shift and per week, sleeping in the car during rest breaks, experience of violence, body mass index (BMI), unhealthy eating habits and little physical exercise. Significant demographic variables were gender and ethnic origin; female drivers and non-western immigrants being at higher risk. In addition, employed drivers had higher risk for MSP than taxi owners.

Olanrewaju O.O et al (2006) choose to study about City bus driving and low back pain: A study of the exposures to posture demands, manual materials handling and whole body vibration. The present study was conducted to investigate typical exposures of city bus drivers to driving posture demands, MMH and vibration as well as the prevalence and nature of LBP. Possible strategies for controlling the risk of LBP also are discussed. The results showed that city bus drivers spend about 60% of the daily work time actually driving, often with the torso straight or unsupported, perform occasional and light MMH and experience discomforting shock/jerking vibration events. Transient and mild LBP (not likely to interfere with work or customary levels of activity) was found to be prevalent among the drivers and a need for ergonomic evaluation of the drivers' seat was suggested.

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. Hong Kong is a densely populated city and has a large number of double-deck buses that constitute a major means of public transportation. Grace and Peggo (2007) aimed at investigating the prevalence and characteristics of WMSD in male and female bus drivers who operate double-deck buses in Hong Kong. Writers have choosen 481 bus drivers (404 males, 77 females) participated in the study that consisted of a questionnaire survey as well as physical assessment. The questionnaire included questions on work, musculoskeletal complaints and perceived occupational risk factors associated with each discomfort. Physical assessment consisted of measurement of lumbar spine mobility, hand grip strength, sit-and-reach test, and observation of standing and sitting postures. The present results showed high prevalence rates of WMSD among bus drivers in Hong Kong which warrants further investigation.

2.5.2 Conferences and Handbooks on Whole Body Vibrations and Noise

In a 2nd American Conference on Human Vibration Proceedings (2008), the conference addressed contemporary issues regarding occupational health, prevention measures, and scientific data collection used to study the complex, dynamic human response to vibration. The agenda included a rich and diverse scientific program as researchers and medical professionals from around the world gathered to examine human responses to hand-transmitted vibration and whole-body vibration.

On the other hand, Barbara et al. (2001) had written a book about Bad Vibrations – A handbook on WBV exposure in mining which this book stated the result of research undertaken by the authors in the NSW coal industry from 1996 to 2000 with funding from the Joint Coal Board Health and Safety Trust (JCB H&ST) and Work safe Australia and also is to assist people in the mining industry to identify and manage the risks associated with vibration exposure. The Handbook is divided into five sections:

a. A description of WBV and its effects on humans
b. Identification of possible sources of WBV
c. Assessment and evaluation of WBV
d. Control of harmful vibration
e. Examples of problems

Besides that, Jim Parison (2010) conclude that although the problem of poor ride quality is often overlooked because it is accepted as part of the job; it nevertheless directly affects drivers, key contributors to the profitability of trucking businesses. With any radical innovation, we recognize that some period of commercial use is required to definitively prove economic benefits. In the meantime, however, we have found that 84% of the over the- road drivers that used the Bose Ride™ system reported improved comfort benefits, 75% reported having less soreness and stiffness, and 66% reported decreased driving fatigue. From the quality-of-life improvements, we are confident that better ride quality can lead to higher job satisfaction, lower driver turnover, and lower operating costs for fleets.

European Agency for Safety and Health at Work (European risk observation report) has come out with Workplace exposure to vibration in Europe: An expert review. The objective of this report is to provide an overview of various aspects of prevention of vibration hazards to workers following the entry into force of the vibration directive. It will show that vibration is increasingly important on account of the vibration directive, increasing exposure of women, ageing of exposed persons, and the development of new tools for prediction.

Griffin et al. (2006) said that the purpose of this guide is to help employers comply with the Vibration Directive as it applies to whole-body vibration. The guide is intended to cover the methodology used for determining and evaluating risks; dealing with the choice and correct use of work equipment, the optimization of methods and the implementation of protection measures (technical and/or organizational measures) on the basis of a prior risk analysis.

Jackie Cooper (2009) has come out with final comprehensive guide to the facts about whole body vibration therapy. Whole body vibration therapy, when used in correctly way will help you to gently and safely ease into a higher level of fitness, health, well-being and weight loss in far less time than with conventional exercise. Even better – this wonderful wellness technology is now affordable enough that you can enjoy it in the privacy and convenience of your own home.

2.5.3 Whole Body Vibration among the Athletes and Operators

S. Rahmatalla et al. (2007) said that the aim of this study was to introduce a methodology that estimates the 3D motion of the various parts of a seated subject’s body, specifically the lower thoracic and lumbar areas of the spine, while they are conducting tasks in a WBV environment. The proposed methodology is based on the implementation of motion capture systems with reflective markers to measure the 3D trajectories of selective points. The hypothesis is that the trajectories of the physical markers that cannot be seen by the cameras due to the existence of the seatback can be retrieved using virtual (calculated) markers. The virtual markers can be derived from the surrounding physical markers and additional (redundant) markers that are positioned on the segments of interest.

This study involved 9 men between the ages of 19 and 23 (height: 176.4 ± 7.8 cm; weight: 80.0 ± 11.2 kg; percentage body fat: 12.35 ±4.5%; isometric squat [IS] peak force [PF]: 1,815.61 ± 415.81 N).Subjects were involved in resistance training and some type of recreational sporting activities. The volunteers were notified about the potential risks involved and gave their written informed consent, approved by the Institutional Review Board at Appalachian State University. The focus of this investigation was to determine the acute impact of a bout of whole-body vibration on athletic performance. Prue et al. (2006) concluded that whole-body vibration may be a plausible warm-up procedure for increasing vertical JH. However, the optimal dose of vibration is still unclear. The findings of this study are specific to the vibration settings used (frequency, 30 Hz; amplitude, 2.5 mm). It appears that vibration can have a potentiating effect on JH and can induce fatigue, as well. The exact mechanism for the effect of vibration on increasing vertical JH needs further investigation, because changes in muscle activity levels were not observed in the current investigation.

Besides that, Eduard et al. (2008) said that the aim of this study was to investigate the effectiveness of a 6-week traditional exercise program with supplementary whole-body vibration (WBV) in improving health status, physical functioning, and main symptoms of fibromyalgia (FM) in women with FM. Thirty-six (36) women with FM (mean ± standard error of the mean age 55.97 ± 1.55) were randomized into 3 treatment groups: exercise and vibration (EVG), exercise (EG), and control (CG). Exercise therapy, consisting of aerobic activities, stretching, and relaxation techniques, was performed twice a week (90 min/day). Following each exercise session, the EVG underwent a protocol with WBV, whereas the EG performed the same protocol without vibratory stimulus. The Fibromyalgia Impact Questionnaire (FIQ) was administered at baseline and 6 weeks following the initiation of the treatments. Estimates of pain, fatigue, stiffness, and depression were also reported using the visual analogue scale. A significant 3 × 2 (group × time)-repeated measures analysis of variance interaction was found for pain ($p = 0.018$) and fatigue ($p = 0.002$) but not for FIQ (p = 0.069), stiffness (p = 0.142), or depression (p = 0.654). Pain and fatigue scores were significantly reduced from baseline in the EVG, but not in the EG or CG. In addition, the EVG showed significantly lower pain and fatigue scores at week 6 compared to the CG, whereas no significant differences were found between the EG and CG (p > 0.05). They suggest that a 6-week traditional exercise program with supplementary WBV safely reduces pain and fatigue, whereas exercise alone fails to induce improvements.

On the other hand, Christophe et al. focus their study about the changes in knee-extensor and knee-flexor strength, maximal knee-extension velocity, jump performance, sprint running velocity and force-time characteristic of start action were measured following a 5 week training period of additional WBV training in sprint-trained athletes. Twenty experienced sprint-trained athletes (13 females, 7 males and 17-30 years old) were randomly assigned to a WBV group (N=10: 6 females and 4 males) or a control group (N=10: 7 females and 3 males). During a 5 week experimental period all subjects continued their conventional training program, but the subjects of the Whole Body Vibration group additionally performed three times weekly a Whole Body Vibration training prior to their conventional training program. In conclusion, this specific Whole Body Vibration protocol of 5 weeks had no surplus value upon the conventional training program to improve speed-strength performance in sprint-trained athletes.

N. Kumar Kittusamy et al. (2004) had chosen an operators of construction equipment perform various duties at work that expose them to a variety of risk factors that may lead to health problems. A few of the health hazards among operators of construction equipment are: (a) whole-body vibration, (b) awkward postural requirements (including static sitting), (c) dust, (d) noise, (e) temperature extremes, and (f) shift work. It has been suggested that operating engineers (OEs) are exposed to two important risk factors for the development of musculoskeletal disorders: whole-body vibration and non-neutral body postures. This review evaluates selected papers that have studied exposure to whole-body vibration and awkward posture among operators of mobile equipment. There have been only few studies that have specifically examined exposure of these risk factors among operators of construction equipment. Thus other studies from related industry and equipment were reviewed as applicable. In order to better understand whole-body vibration and postural stress among OEs, it is recommended that future studies are needed in evaluating these risk factors among OEs.

2.5.4 Other Research on Whole Body Vibrations and Noise.

Seats are one of the most important components of vehicles and they are the place where professional driver spend most of their time. For example, according to Occupational Outlook Handbook by United State Department of Labor, the truck drivers frequently work 50 or more hours a week. The truck drivers sit while they are driving their 50 hours per week. Assuming four weeks' vacation and one more for holidays, which is about 2350 hours driving time per year. Automotive seats, which are in contact with vehicle occupants, play an important role in improving the comfort and work environment of a driver and passengers. The improvement of automotive seating systems, particularly for the driver, has been the subject of intense interest for many years since a driver feels more fatigue than passengers. The paper describes a large variety of studies and up-to-date techniques developed for vehicle seats used by different type of transportation system such as cars, trucks, tractors, trains and aircrafts. Fai et al. (2007) said that the objective of their study is to review the state of the art of vehicle seat design.

Noorloos et al. (2007) focus on how to determine whether body mass index (BMI) influences the risk of low back pain (LBP) in a population exposed to whole body vibration (WBV). For this a self-administered questionnaire was sent to 467 participants, driving occupational vehicles. Vibration measurements were performed according to ISO 2631–1 on a representative sample (n = 30) of this population. For each participant, we calculated the current root mean square (r.m.s.) over an 8 h (A(8)) working day. The questionnaire response rate was 47% (n = 221). We did not find a significant correlation between BMI and the onset of LBP in the last 7 days (r = 0.07, p = 0.34) nor for LBP in past 12 months (r = -0.30, p = 0.63). No significant increased risk was found for the onset of LBP with the increase of BMI, neither for the last 7 days (OR 1.02; 95% CI: 0.93 1.23) nor for the past 12 months LBP (OR 0.98; 95% CI: 0.89 1.09). Introducing the interaction with WBV exposure in the logistic regression model, did not result a significant increased risk in the onset of LBP 7 days (OR 0.97; 95% CI: 0.92 1.01) nor in the onset of LBP 12 months (OR 0.97; 95% CI: 0.93 1.01) either. Occupational participants exposed to WBV, with a high BMI do not have an increased risk for the development of LBP.

Bovensi (2005) said that the health disorders caused by occupational exposure to whole-body vibration (WBV) and hand-transmitted vibration (HTV) are reviewed. Long-term occupational exposure to intense WBV is associated with an increased risk for disorders of the lumbar spine and the connected nervous system. With a lower probability, the neck-shoulder, the gastrointestinal system, the female reproductive organs, the peripheral veins, and the cochleo-vestibular system are also assumed to be affected by WBV. However, there is a weak epidemiologic support for WBV-induced disorders of organ systems other than the lower back. Prolonged exposure to HTV from powered processes or tools is associated with an increased occurrence of symptoms and signs of disorders in the vascular, neurological and osteoarticular systems of the upper limbs. The complex of these disorders is called hand-arm vibration syndrome. This paper provides qualitative and quantitative information on occupational exposure to mechanical vibration in the European Union based on a report by the European Agency for Safety and Health at Work (2000). Protection and health surveillance of vibration-exposed workers are discussed in the context of the European Directive 2002/44/EC on mechanical vibration and the guidelines prepared by the Italian Society of Occupational Medicine and Industrial Hygiene.

Table 2.2: Summarizes of Whole Body Vibrations and Noise Journals

#	Title	Writer	Purpose of Study
1	City Bus Driving and Low Back Pain: A Study of The Exposures To Posture Demands, Manual Materials Handling and Whole Body Vibration (2006)	Olanrewaju O. Okunribido, Steven J. Shimbles, Marianne Magnusson, and Malcolm Pope	To investigate the typical exposures of city bus drivers to driving posture demands, MMH and vibration as well as the prevalence and nature of LBP.
2	Three-dimensional motion capture protocol for seated operator In whole body vibration (2007)	S. Rahmatallaa,T. Xiab, M. Contrattoc, G. Koppc, D. Wilderb, L. Frey Lawa, and James Ankrum	To introduce a methodology that estimates the 3D motion of the various parts of a seated subject's body, specifically the lower thoracic and lumbar areas of the spine, while they are conducting tasks in a WBV environment.
3	Acute effects of whole-body vibration on muscle activity, strength, and power (2006)	Prue Cormie, Russell S. Deane, N. Travis Triplett, and Jeffrey M. Mcbride	To determine the acute impact of a bout of whole-body vibration on athletic performance and to address the issue of using whole-body vibration as a viable warm-up before strength and power activities.
4	Bus drivers' exposure to mechanical shocks due to speed bumps	Johan Granlund, and Anders Brandt	To compare a sample of different speed bump designs with respect to health risks, in terms of back disorders related to transient ride vibration, for professional bus drivers.
5	Evaluating methods of whole-body-vibration exposure in trains. (2010)	Phd. Silviu Nastac, and Phd. Mihaela Picu	This paper studies the whole-body vibration in trains which constitutes one aspect of the physical environment that can cause discomfort to passengers.
6	Evaluation of whole-body vibration and ride comfort in a passenger car (2009)	Hassan Nahvi, Mohammad Hosseini Fouladi and Mohd Jailani Mohd Nor	To investigated at different vehicle speeds for ride comfort and vibration of characteristics of a passenger car. The vehicle was driven over smooth and rough road surfaces.
6	Evaluation of whole-body vibration and ride comfort in a passenger car	Hassan Nahvi, Mohammad Hosseini Fouladi and Mohd Jailani Mohd Nor	To investigated at different vehicle speeds for ride comfort and vibration of characteristics of a passenger car. The vehicle was driven over smooth and

Table 2.2: Continued

#	Title	Writer	Purpose of Study
	(2009)		rough road surfaces.
6	Evaluation of whole-body vibration and ride comfort in a passenger car (2009)	Hassan Nahvi, Mohammad Hosseini Fouladi and Mohd Jailani Mohd Nor	To investigated at different vehicle speeds for ride comfort and vibration of characteristics of a passenger car. The vehicle was driven over smooth and rough road surfaces.
7	Six weeks of whole-body vibration exercise improves pain and fatigue in women with fibromyalgia (2008)	Eduard Alentorn-Geli, M.D., M.S., Jaume Padilla, M.S., Gerard Moras, Cristina Lázaro Haro, and Joaquim Fernández-Solà, M.D.	To investigate the effectiveness of a 6 week traditional exercise program with supplementary WBV in improving health status, physical functioning, and main symptoms of FM in women with FM
8	Whole-body vibration and sound quality of malaysian cars	Dian Darina Indah Daruis, Mohd Jailani Mohd Nor, Baba Md Deros, and Mohammad Hosseini Fouladi	To compare the results of the same vibration and sound quality measurements and evaluations on two different types of Malaysian car, which is categorized as a 2.0cc premium sedan and a 1.3cc compact car at different roads with different International Roughness Index (*IRI*) values.
9	Whole-body vibration exposure experienced by motorcycle riders – an evaluation according to iso 2631-1 and iso 2631-5 standards (2009)	Hsieh-Ching Chen, Wei-Chyuan Chen, Yung-Ping Liu, Chih-Yong Chen, and Yi-Tsong Pan	To compares measured WBV exposure with the upper boundary of health guidance caution zone (HGCZ) recommended by ISO 2631-1 (1997, Fig. B.1) and with the limit value associated with a high probability adverse health effects recommended by ISO 2631-5 (2004, Figs. A.1 and A.2).
10	Effects of whole body vibration training on muscle strength and sprint performance in sprint-trained athletes	Christophe Delecluse, Machteld Roelants, Rudi Diels, Erwin Koninckx, and Sabine Verschueren	To study the changes in knee-extensor and knee-flexor strength, maximal knee-extension velocity, jump performance, sprint running velocity and force-time characteristics of start action were measured following a 5 week training period of additional WBV training in sprint-trained athletes.

Table 2.2: Continued

#	Title	Writer	Purpose of Study
11	American conference on human vibration (2008)	Farid Amirouche, Alan G. Mayton, and Robert J. Tuchman	This conference addressed contemporary issues regarding occupational health, prevention measures, and scientific data collection used to study the complex, dynamic human response to vibration. The agenda included a rich and diverse scientific program as researchers and medical professionals from around the world gathered to examine human responses to HTV and WBV.
12	Bad vibrations - a handbook on whole-body vibration exposure in mining	Barbara McPhee, Gary Foster, and Airdrie Long	This Handbook is the result of research undertaken by the authors in the NSW coal industry from 1996 to 2000 with funding from the Joint Coal Board Health and Safety Trust (JCB H&ST) and Worksafe Australia and also is to assist people in the mining industry to identify and manage the risks associated with vibration exposure.
13	Whole-body vibration and postural stress among operators of construction equipment: A literature review	N. Kumar Kittusamya, and Bryanbuchholz	This review evaluates selected papers that have studied exposure to whole-body vibration and awkward posture among operators of mobile equipment.
14	The amazing wellness benefits of whole body vibrations (2009)	Jackie Cooper	In this guide, writer will let us know what the true facts about the whole body vibrations are and how it was first used and the kinds of result we can realistically when we use it.
15	The bose ride™ system (2010)	Jim Parison	In one evaluation of performance, Bose has shown that the new system reduces vibration to levels much lower than those experienced in high-end air-ride seats, and even slightly lower than those in a premium-quality automobile.
16	Workplace exposure to vibration in Europe (2008)	Patrice (Manu) Donati, Marianne Schust, Janusz Szopa, Jukka	The objective of this report is to provide an overview of various aspects of prevention of vibration hazards to

Table 2.2: Continued

#	Title	Writer	Purpose of Study
		Starck, Eduardo Gil Iglesias, Luis Pujol Senovilla, Siegfried Fischer, Eva Flaspöler, Dietmar Reinert, and Rick Op de Beeck	workers following the entry into force of the vibration directive. It will show that vibration is increasingly important on account of the vibration directive, increasing exposure of women, ageing of exposed persons, and the development of new tools for prediction.
17	Guide to good practice on whole body vibration (2006)	Professor M.J. Griffin & Dr H.V.C. Howarth, Mr P M Pitts, Dr S Fischer & Mr U Kaulbars, Dr P.M.	This guide will help employers comply with the Vibration Directive as it applies to whole-body vibration. The guide is intended to cover the methodology used for determining and evaluating risks; dealing with the choice and correct use of work equipment, the optimization of methods and the implementation of protection measures (technical and/or organizational measures) on the basis of a prior risk analysis.
18	Work-related Musculoskeletal Disorders in Urban Bus Drivers of Hong Kong (2007)	Grace P. Y. Szeto · Peggo Lam	The purpose of this study was to investigate the prevalence and characteristics of work-related musculoskeletal disorders (WMSD) among urban bus drivers in Hong Kong. The musculoskeletal problems were examined to identify any correlation with various occupational risk factors such as prolonged sitting, vibration, anthropometric factors, control of steering wheel and gear box.
19	Back problems among car drivers: a summary of studies during the last 30 years	Lenka Justinova	The aim of this paper is to review epidemiological studies of car drivers published during the past thirty years and consider evidence for low back problems associated with vehicular vibration.
20	Whole-Body Vibration Exposure and Non-neutral Neck Postures	Bo¨ Rje Rehn, Tohr Nilsson, Bodil Olofsson and Ronnie Lundstrom	The aim of the present study was to characterize WBV and shock from forest machines, snowmobiles and snow groomers. A further objective was to

Table 2.2: Continued

#	Title	Writer	Purpose of Study
	During Occupational Use of All-terrain Vehicles (2005)		simultaneously record non-neutral rotational positions of the neck used by the drivers during operation.
21	Vehicle seat design: State of the art and recent development (2007)	T.C Fai, F. Delbressine and M. Rauterberg	This paper describes the research and development for vehicle seats based on literature review of journals, technical reports and thesis.
22	Whole Body Vibration Analysis For Bus Drivers (2009)	Ana PICU	The purpose of this study is to measure the whole body vibrations for drivers, during their work time, knowing that they are exposed for the entire work schedule, as opposed to fares that are exposed only occasionally.
23	Does body mass index increase the risk of low back pain in a population exposed to whole body vibration? (2007)	Danie¨ lle Noorloos, Linda Tersteeg, Ivo J.H. Tiemessen_, Carel T.J. Hulshof, and Monique H.W. Frings-Dresen	The aim of our study is to investigate whether BMI influences the risk of LBP complaints in a population of occupational drivers already exposed to WBV.
24	Health effects of mechanical vibration (2005)	M. Bovenzi	This paper provides qualitative and quantitative information on occupational exposure to mechanical vibration in the European Union based on a report by the European Agency for Safety and Health at Work (2000).
25	Whole-body vibration and ergonomic study Of US railroad locomotives (2006)	Eckardt Johanning, Paul Landsbergis, Siegfried Fischer, Eberhard Christ, and Benno Go¨ res, Raymond Luhrman	The goal of this study was the description and evaluation of cab and seating conditions in US built locomotives, including the subjective rating of seats and vibration effects by the locomotive engineers.
26	Power absorbed during whole-body vertical vibration: Effects of sitting posture, backrest, and footrest (2010)	Naser Nawayseh, and Michael J. Griffin	This paper reports the power absorbed by the human body due to vibration applied simultaneously and in-phase at the seat, backrest, and feet during whole-body vertical vibration. The main objective is to determine to what extent the power absorbed by the body during vertical excitation is affected by contact

Table 2.2: Continued

#	Title	Writer	Purpose of Study
			with a vibrating footrest and a vibrating backrest.
27	A questionnaire survey of Norwegian taxi drivers' musculoskeletal Health, and work-related risk factors (2007)	Ruth K. Raanaas, and Donald Anderson	To determine the prevalence of musculoskeletal pain and to identify work-related factors that are likely to increase the risk of neck, shoulder or lower back pain.
28	Effective seat-to-head transmissibility in whole-body vibration: Effects of posture and arm position (2011)	Salam Rahmatalla, and Jonathan DeShaw	In this work, the concept of the effective seat-to-head transmissibility (ESTHT) is introduced, in which the single-input/multiple- output and multiple-input/multiple-output transmissibility matrix is transformed into a single graph, similar to those for single-input and single-output. The singular value decomposition and maximum distortion energy theory were used to achieve that goal.
29	Vibration of Mechanical Systems (2010)	Alok Sinha	In this book, all the basic concepts in mechanical vibration are clearly identified and presented in a simple manner with illustrative and practical examples.
30	City bus driving and low back pain: A study of the exposures to posture demands, manual materials handling and whole-body vibration (2006)	Olanrewaju O. Okunribido_, Steven J. Shimbles, Marianne Magnusson, and Malcolm Pope	The present study was conducted to investigate the typical exposures of city bus drivers to driving posture demands, MMH and vibration as well as the prevalence and nature of LBP. Possible strategies for controlling the risks for LBP are also discussed.
31	Commercial Truck and Bus Safety : Motor coach Industry Hours of Service And Fatigue Management	John F. Brock, Gary A. Golembiewski, Gerald P. Krueger, Carmen Daecher, Richard Bishop, and Gene Bergoffen	The report identifies and documents the unique features of the extended workday that typifies motor coach operations and identifies techniques that motor coach managers, front-line employees, and drivers use to reduce fatigue-related incidents resulting from

Table 2.2: Continued

#	Title	Writer	Purpose of Study
	Techniques (2005)		the irregular on-duty conditions facing the motor coach driver.
32	Ergonomics and Driving	Occupational Health Clinics for Ontario Workers Inc.	This pamphlet informs you of the ergonomic risks from driving, and provides you with a few simple but important safety tips to help keep you healthy.
33	Is Age More Important than Gender, Corporeal Mass Index (CMI) or Vision on Whole-Body Human Vibration Comfort Levels?	Duarte, Maria Lúcia Machado, Pereira, Matheus de Brito, Misael, Marcos Roberto, Freitas Filho, and Luiz Eduardo de Assis	This paper is organized to presents some human body resonance frequencies, describes the methodology applied, the experimental results and their discussions and shows the conclusions drawn in this study.
34	Is vibration truly an injurious stimulus in the human spine? (2009)	TarynE.Hill, Geoffrey T.Desmoulin, and Christopher J.Hunter	The aim of this report is to summarize the critical findings to date, indicate existing deficiencies in the state of knowledge, and argue that further careful study of vibration in the IVD is of vital importance to progress on numerous fronts.
35	Low back pain in drivers: The relative role of whole-body Vibration, posture and manual materials handling (2006)	O.O. Okunribidoa, M. Magnussona, and M.H. Pope	The objective of this work was to investigate the relative role of whole-body vibration (WBV), posture and MMH as risk factors for LBP.
36	Rules on Drivers' Hour and Tachograph - Passenger-carrying vehicles In GB and Europe	Alastair Peoples, and Philip Brown	This guide provides advice to drivers and operators of passenger vehicles, whether used privately or commercially. It explains the rules for drivers' hours and the keeping of records, and updates previous guidance from 2009
37	The Influence of Body Mass on Whole-Body Vibration: A Quad-Bike Field Study	Ramakrishnan Mani, Stephan Milosavljevic and S. John Sullivan	The primary aim of this field study was to explore the relationship between body mass and quad bike WBV exposure in a group of New Zealand rural workers when controlling for such extrinsic factors. The secondary aim

Table 2.2: Continued

#	Title	Writer	Purpose of Study
	(2011)		was to explore personal factors such as age, height and quad bike driving experience as co-variates to determine whether these are also associated with exposure.
38	Hilbert transform applications In mechanical vibration (2011)	Michael Feldman	To present a modern methodology and examples of non stationary vibration signal analysis and nonlinear mechanical system identification. This book covers modern advances in the application of the Hilbert transforming vibration engineering, where researchers can now produce laboratory dynamic tests more quickly and accurately.
39	Whole-body vibration as potential intervention for people with low bone mineral density and osteoporosis: A review (2009)	Julia O. Totosy de Zepetnek, Lora M. Giangregorio, and Catharine Craven	The aims of this review are to provide an overview of the physiological basis for the potential effects of WBV on the skeletal system, review WBV-related terminology and safety considerations associated with the use of WBV as an intervention, and summarize the current literature regarding the use of WBV as an intervention for preventing bone density decline or improving bone mass among astronauts, older adults, and individuals with physical or neurological impairments.
40	Proceedings of the First American Conference on Human Vibration (2006)	Ren Dong, Kristine Krajnak, Oliver Wirth, and John Wu	This conference provided us with a historic opportunity to exchange information regarding this critical occupational health issue. The agenda promised a rich and diverse scientific program as researchers and medical professionals from around the world have gathered to examine human responses to hand-transmitted vibration and whole-body vibration.
41	Low back pain in drivers exposed to whole body	I J H Tiemessen, C T J Hulshof and M H W Frings-Dresen	The aim of our study is to describe a possible dose–response pattern between WBV exposure and driving-related

Table 2.2: Continued

#	Title	Writer	Purpose of Study
	vibration: analysis of a dose-response pattern (2008)		LBP, chronic LBP, LBP intensity and LBP disability in a prospective cohort, while controlling for possible contributing risk factors.
42	Effects of Occupational Exposure to Whole-Body Vibration in Tractor Drivers with Low Back Pain in Punjab (2010)	Shyamal Koley, Lalit Sharma and Sukhpal Kaur	To investigate the severity of low back pain in drivers exposed to tractor vibrations in and around Ludhiana, Punjab, India, using the modified Oswestry Pain Questionnaire.
43	All-terrain vehicle use in agriculture: Exposure to whole body vibration and Mechanical shock	Stephan Milosavljevic, Frida Bergman, Borje Rehn, and Allan B. Carman	The aims of this study are to use the International Organization for Standardization guidelines (ISO 2631-1 and 2631-5) to determine WBV and mechanical shock exposure on New Zealand farmers who regularly use ATVs in their daily work activities.
44	The role of seat geometry and posture on the mechanical energy Absorption characteristics of seated occupants under vertical vibration (2005)	W. Wanga, S. Rakhejaa, and P.-E´. Boileau	In this study, the energy absorption characteristics of seated human occupants exposed to vertical WBV are investigated under different postural conditions, using an indirect method in conjunction with the measured APMS data.
45	Impact of seating posture on user comfort and typing performance for People with chronic low back pain (2007)	Scott Haynes_, Karen Williams	The purpose of this study was to use a tilt and recline wheelchair seating system to determine what effect these alternative postures have on typing performance and comfort.
46	Evaluation of reaction time performance and subjective workload During whole-body	Geraldine S. Newell, Neil J. Mansfield	The objectives of the current study were to investigate reaction time performance and perceived workload during whole-body vibration exposure while seated in upright and twisted postures, with and

Table 2.2: Continued

#	Title	Writer	Purpose of Study
	vibration exposure while seated in upright and Twisted postures with and without armrests (2007)		without armrests. The combined effect of whole-body vibration and twisted posture were assessed to determine if these stressors could have a cumulative effect on participants' ability to perform the task with a lower workload demand.
47	Effects of seated whole-body vibration on postural control of the trunk during unstable seated balance (2007)	Gregory P. Slota, Kevin P. Granata, and Michael L. Madigan	The goal of this study was to investigate the acute effects of seated WBV on the postural control of the trunk. Seated WBV was investigated because machine operators are typically exposed to vibration while seated.
48	Vibration induced low back disorders-Comparison of the vibration evaluation according to ISO 2631 with a force-related evaluation (2005)	Martin Fritza, Siegfried Fischerb, and Peter Bro¨ de	In the present study the forces in the leg joints and the spine are simulated by the model and the relationships between these internal forces and the vibration acceleration are described by transfer functions.
49	The apparent mass of the seated human exposed to single-axis and Multi-axis whole-body vibration (2006)	Neil J. Mansfielda, and Setsuo Maedab	This paper reports a study investigating the biomechanical response of the seated human to single- and tri-axial vibration to indicate whether single-axis apparent mass data can be applied to complex multi-axis environments.
50	Low back pain in car drivers: A review of studies published 1975 to 2005 (2006)	Lenka Gallais, and Michael J. Griffin	To investigate the quality of epidemiological studies of back pain among car drivers. The review considers studies published during the last 30 years and looks for evidence of an association between car driving and low back pain, evidence that low back pain in car drivers is caused by vehicular vibration, and evidence of an association between other physical, psychosocial and individual factors and low back pain in car drivers.

Table 2.2: Continued

#	Title	Writer	Purpose of Study
51	A comparison of green and conventional diesel bus noise Levels (2007)	Jason C. Ross, and Michael A. Staiano	This paper presents a general description of these bus technologies, a comparison of available noise emission levels of some of the more common bus technologies being used by North American transit agencies and a comparative overview of the noise emission results.
52	A study on the effects of noise on industrial workers in Malaysia (2007)	Mohzani Mokhtar, Sahrul Kamaruddin, Zahid A. Khan and Zulquernain Mallick	This paper presents the outcome of the investigation with the objective of finding ill effects of noise among industrial workers and to suggest specific recommendations to prevent workers from these effects. The methodology adopted for this study is described and the results are presented.
53	Motor vehicle air pollution public health impact and control measures	Dietrich Schwela, Olivier Zali and Philipp Schwela	To provide essential information and encouragement to all countries in their efforts to deal with the problems created by the intense motorization process. This report is an updated and revised version of a corresponding 1992 publication on motor vehicle air pollution.
54	Diesel fuels technical review	Global Marketing	The subject of this review is diesel fuel – its performance, properties, refining, and testing. A chapter in the review discusses diesel engines, especially the heavy-duty diesel engines used in trucks and buses, because the engine and the fuel work together as a system.
55	Air and Noise Pollution Reduction from Tricycles (2005)	Asian Development Bank	This report provides valuable information on the various options and strategies for the reduction of air and noise pollution from tricycles in Quezon City and Puerto Princesa City.
56	Transit noise and vibration impact assessment (2006)	Carl E. Hanson, David A. Towers, and Lance D. Meister	This manual provides guidance for preparing and reviewing the noise and vibration sections of environmental documents.

Table 2.2: Continued

#	Title	Writer	Purpose of Study
57	Traffic noise reduction in Europe (2007)	L.C. (Eelco) den Boer and A. (Arno) Schroten	This report describes the health effects of rail and road transport noise and presents a number of recommendations as to how to address them. This report highlights the scale and scope of the traffic noise problem, which affects a very substantial proportion of the European populace. It serves as a background report to a T&E brochure and is based on a thorough literature review. The report covers health effects and social costs, and reviews noise reduction policies and measures to reduce noise exposure. In conclusion, a number of recommendations for action are given. The report focuses on road and rail transport.
58	Transport, environment and health	Carlos Dora and Margaret Phillips	A major purpose of this book is to alert policy analysts, decision-makers and politicians to current knowledge about the health effects of transport and the means to reduce them. It summarizes the latest scientific evidence on the impact of transport-induced air pollution, noise and accidents on physical health, barrier effects (changes in behavior in reaction to transport risks) and effects on mental health. This book highlights the considerable potential health benefits from non-motorized forms of transport.
59	Assessment of traffic noise pollution in Banepa, A semi urban town of Nepal (2007)	V. Krishna Murthy, Ahmad Kamruzzaman Majumder, Sanjay Nath Khanal, and Deepak Prasad Subedi	The main objective of the study was to measure the environmental noise levels and assess the noise pollution in the Banepa Valley predominantly due to traffic mobility.
60	Status of the vehicular pollution control programme in India	Central pollution control board	The document presents a review of the vehicular emission problems in Indian cities, the various developments that have taken place in the past including

Table 2.2: Continued

#	Title	Writer	Purpose of Study
	(2010)		the studies conducted for assessment of the air quality in cities, the legislation and standards adopted for the control of vehicle emissions, the role of the various concerned agencies, the steps taken for improvement in the quality of the automotive fuel, the overall impact of these measures and the future strategy to be adopted for vehicular emission reduction and related issues.
61	Understanding the effect of noise, vibration and seat discomfort towards a passenger's vehicle driver through self-reported survey (2008)	Dian Darina Indah Daruis, Baba Md Deros and Mohd Jailanimohd Noor	The attempts were to understand the Malaysian drivers' general perspective on noise, vibration and seat discomforts in driving. It is interesting to know whether noise and vibration have more effects during idle or accelerating. Secondly, whether the lumbar area is the most discomfort area of the body when Malaysian drivers are concerned as suggested in literature. The final objective is to study whether gender has significant effect on the overall discomfort factors investigated in the survey.
62	A cross-sectional study of back belt use and low back pain amongst forklift drivers (2007)	Darren M. Jouberta,_, Leslie London	To determine the association between back belt usage and back pain amongst forklift drivers exposed to whole-body vibration (WBV).
63	An epidemiological study of low back pain in professional drivers (2006)	Massimo Bovenzia, Francesca Ruia, Corrado Negroa, Flavia D'Agostina, Giuliano Angotzib, Sandra Bianchib, Lucia Bramantib, GianLuca Festab, Silvana Gattib, Iole Pintob, Livia Rondinab, and Nicola	The aim of this study was to investigate the period prevalence of low back pain outcomes in various groups of Italian professional drivers. Vibration measurements were performed on a representative sample of the machines and vehicles used by the various driver groups.

Table 2.2: Continued

#	Title	Writer	Purpose of Study
64	Ergonomics Analysis for sitting posture and chair	Yu Mingjiu Ye Jun Zhang Quan Lu Changde	It analyzes human's physical structure and pressure in sitting posture, and designs chair in the point of ergonomics.
65	Positive and negative evidence of risk factors for back disorders	Alex Burdorf, and Gary Sorock	The primary goal of this review is to identify the important risk factors for work-related back disorders, to present information on the strength of the associations, and to estimate their relative contribution to the occurrence of back disorders in occupational populations.
66	Effects of seated whole-body vibration on seated postural sway	Gregory P. Slota, Kevin P. Granata, and Michael L. Madigan	The purpose of this study was to measure the acute effect of seated WBV on the postural control of the trunk during unstable seated balance.
67	All-terrain vehicle use in agriculture: Exposure to whole body vibration and mechanical shock (2009)	Stephan Milosavljevic, Frida Bergman, Borje Rehn, and Allan B. Carman	The aims of this study are to use the International Organization for Standardization guidelines (ISO 2631-1 and 2631-5) to determine WBV and mechanical shock exposure on New Zealand farmers who regularly use ATVs in their daily work activities. It is hypothesized that exposures will exceed ISO recommended limits and be a factor in increased risk of LBP.
68	The transmission of vertical vibration through seats: Influence of the characteristics of the human body (2011)	Martin G.R. Toward, Michael J. Griffin	The objective of this study was to determine the manner in which the principal factors affecting the vertical apparent mass of the human body (i.e. age, weight, body mass index, gender, backrest contact, and magnitude of vibration [10]) affect the transmissibility of a seat and its dynamic stiffness.
69	Inter-cycle variation in whole-body vibration exposures of operators driving track-type loader	Geraldine S. Newell, Neil J. Mansfield, and Luca Notini	The objective of this study was to investigate how much variation is typically found between work cycles of one type of earth-moving machines: track-type loaders.

Table 2.2: Continued

#	Title	Writer	Purpose of Study
	machines (2006)		
70	Trends and drivers of change in the EU transport and logistics sector: Mapping report	European Foundation for the Improvement of Living and Working Conditions	This report aims to identify trends and key drivers of change in the EU transport and logistics sector with a particular focus on competitiveness, skills and working conditions. The report is based on a study of existing literature and statistics.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, methodological part will be discussed briefly in order to complete this project according to the time frame given. By using a complete structure of methodology consisting of clear illustration and well-planned of project strategy it hopes that this project would finish successfully by obtaining the project objectives.

Based from the previous study, there are two method has been used in evaluating the WBV exposure on the driver which is 1st ISO 2631-1:1997 and 2nd ISO 2631-5:2004 (Sylvester, 2009) but in this studies it will focus on the 1st method since the device used are complied with this method.

In this chapter, all the methods that have been used are including literature survey, data collection, data analysis and discussion. Every part of these methods will be explained in detail in order to get clear understanding on the method that need to be done to execute this study.

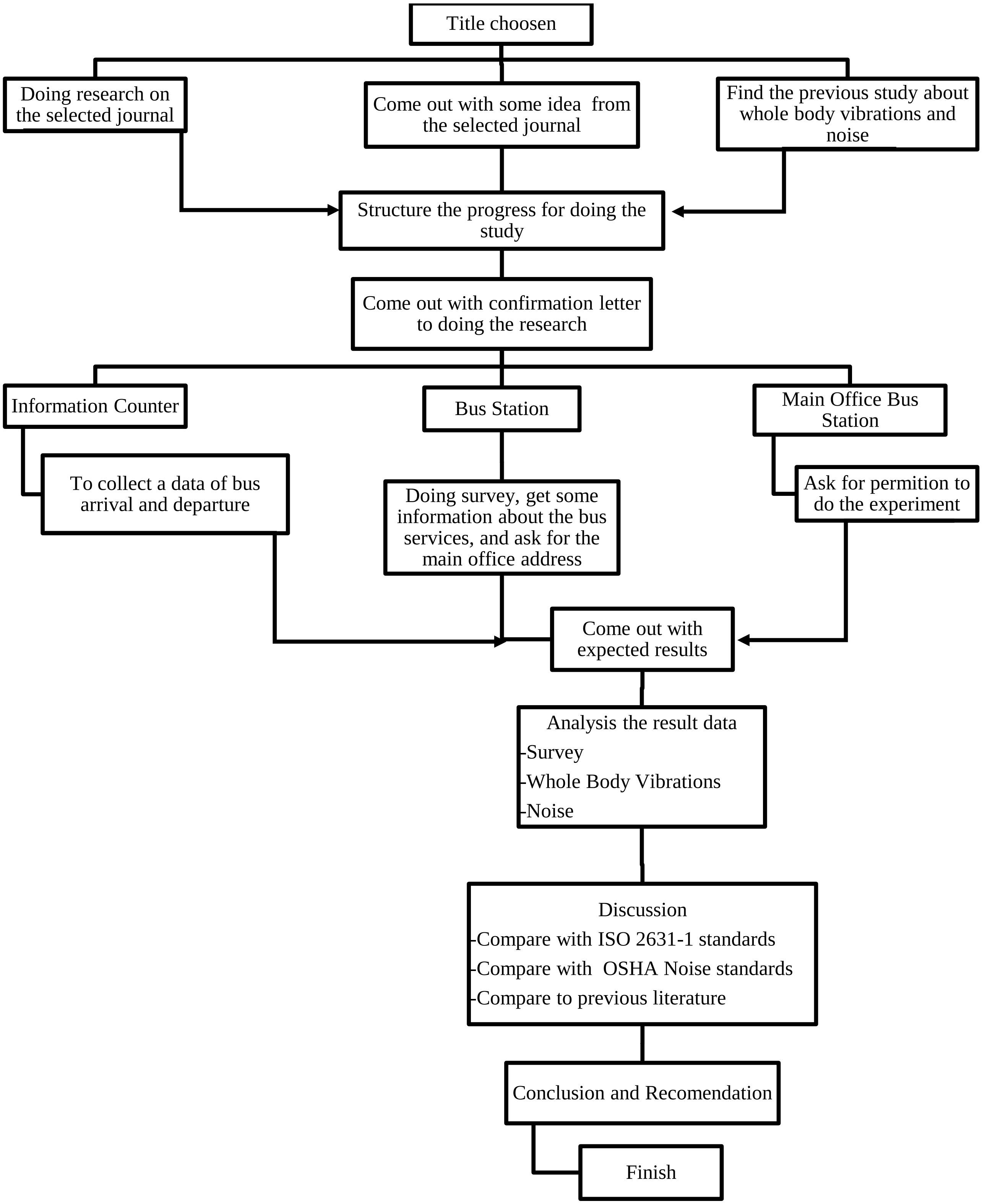


Figure 3.1: Flow chart for progress of study

3.2 Subjects of study

One of the most important steps in the research process is to select the respondents who will participate in the study (Fraenkel and Wallen 1996:91). The respondent of this study are 20 people of bus driver from differences types of Bus Company. The subjects are a heterogeneous group. They consist of 100% males. They are from aged between 25 until 40 years, where consist 4 (13%) for aged between 25-29 aged, 13 (44%) for aged between 30-35 aged and 13 (43%) from 36-40 aged (See Figure 3.2).

Table 3.1: Respondent - Distributed By Age

Age	No of respondents	Percentages (%)
20-29	4	25
30-39	13	25
40-49	13	50
TOTAL	**30**	**100**

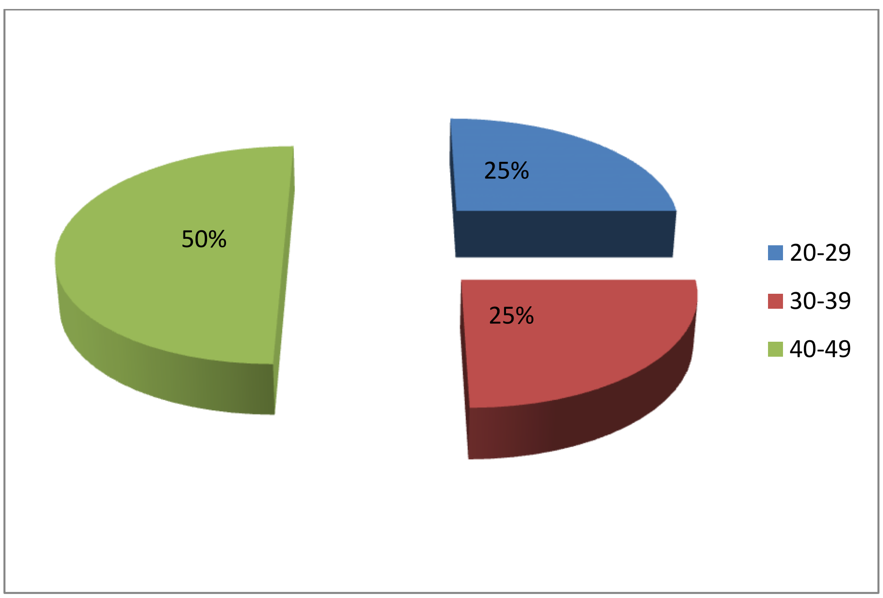


Figure 3.2: Respondent - Distributed By Age

Differences types of bus are selected for this study because they have been differences conditions and safety for each types of the bus. Scania is the most popular selected bus among the buses company. From the figure 3.2, 18 (60%) are Scania bus driver, 10 (33%) are MAN bus driver and 2 (7%) are Hiro bus driver (See Figure 3.3).

Table 3.2: Respondent - Distributed By Types of Bus

Types	No of respondents	Percentages (%)
Scania	18	60
Man	10	33
Hiro	2	7
TOTAL	**30**	**100**

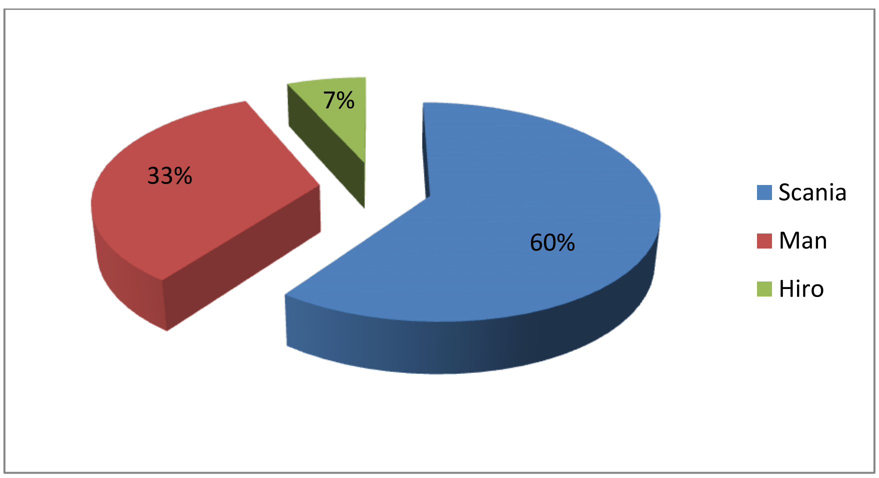


Figure 3.2: Respondent - Distributed By Types of Bus

To run this experiment, two bus drivers from Transnasinal, with an age between 28 to 35 years old, were chosen to participate in this study. All participants were male, with an average height and mass of 175 cm and 69 kg respectively. Each bus driver had at least 5 years experience of bus riding, and was familiar with the test route adopted in this study. Each bus driver was divided into two groups of morning and night trip. All bus had the same type of bus which is Scania. The vibration signals were measured while driving along the East to West Coast of Malaysia and the speed was controlled manually by the driver.

For a routes from Kuatan to Kuala Lumpur (Figure 3.4) which is about 259 km and take about 3 hours 30 minutes to arrive, there are about eight company buses have provide this services with difference time departure. These express services operate with limited stops along the route and enjoy uninterrupted travel on expressway on part of the journey. Usually, the bus driver only will stop once for pray and take same rest. Table 3.3 shows some of the time departure for the certain buses.

Figure 3.4: Maps for roads along Kuantan to Kuala Lumpur

(Sources: Google Maps)

Table 3.3: Time Table Bus Departure

No.	Bus	Departure time			
1	Transnasional	i.	01.00 am	vii.	02.30 pm
		ii.	08.00 am	viii.	03.30 pm
		iii.	10.30 am	ix.	04.30 pm
		iv.	11.30 am	x.	08.00 pm
		v.	12.30 pm	xi.	09.30 pm
		vi.	01.30 pm	xii.	10.30 pm
2	Sani ekpress	i.	09.30 am	iii.	05.30 pm
		ii.	02.00 pm	iv.	10.30 pm
3	Utama ekpress.	i.	09:00am	v.	14:30pm
		ii.	10:30am	vi.	16:30pm
		iii.	11:30am	vii.	22:30pm
		iv.	12:30pm		00:30am
4	Plusliner	i.	02.00am	vi.	2.00pm
		ii.	07.45am	vii.	02.30pm
		iii.	09.15am	viii.	03.30pm
		iv.	10.00am	ix.	06.30pm
		v.	11.00am		
7	Bulan restu	i.	08.00am	v.	04.00pm
		ii.	10.00am	vi.	06.00pm
		iii.	12.00pm	vii.	08.00pm
		iv.	02.00pm		
8	Mara Liner	i.	9.30 am	ii.	4.30 pm

3.3 Study Design

For this study, it comprised of two parts which is self-assessments by a questionnaire (2 types of questionnaire) based survey and systematic observation (including noise and WBV measurement) as a technique to collect a data. Male person who drive buses and/or coaches occupationally represented the source population. Subjects for the study were chosen randomly among bus drivers who had spent at least one complete year in present job or had at least 5 years continuous bus driving experience from several buses company in the Terminal Makmur Bus Station.

3.4 Questionnaire Assessment

For 1st set of questionnaire, information about Low Back Pain and driving experience (sitting) posture was obtained using a validated questionnaire. This involves the collection of data to answer questions concerning the problem about the WBV and sound. A set of questionnaire regarding driving experience were in terms of years of driving and types of bus, style of driving and discomfort from different modes of vibration. The questionnaire contains two parts. For parts one it is open ended question and for part two it is multi choices question where each question was provided with five choices of responses, i.e. AGREE, STRONGLY AGREE, NOT SURE, DISAGREE and STRONGLY DISAGREE. A total of 20 bus drivers were selected randomly to complete the questionnaires. Responses were collected and analysis was made. Finally, the findings are discussed (Refer Appendix).

Meanwhile for 2nd set of questionnaire, twenty bus drivers are selected randomly to fulfill this survey. For this questionnaire, its consists 7 section which is section A is about respondents personal details, section B consists respondents working environment, section C is about musculoskeletal disorders, section D survey about low back pain among the respondents, section E inability of arm, shoulders and hand, section F consists general respondents health information's, and for the last section which is section G consists of other factors (Refer Appendix).

3.5 Observation Study

Two bus drivers were observed in their assigned duty service route driving over the duration of at least one complete round trip – to and from. He observation times is on daily day and night day. Firstly, the drivers were observed for their sitting posture which was noted and recorded once in every minute. Secondly, the drivers were observed for their style of driving as well as how many times they made stops. Thirdly, the types of road surfaces driven were noted. The ages of the vehicles varied between 1 years and 8 years.

In all, 2 sets of measurements were taken covering two vehicles, two working time which is daily day and night day and driving along one service route. Only one driver was involved during the vibration measurement. The vibration were measured at the driver seat interface using a tri-axial seat pad accelerometer (Figure 3.6) which was placed on the seat below the driver's seat (Figure 3.5) where when the driver sitting on it and connected to a portable field computer packaged in a rugged instrument case.

Figure 3.5: WBV plate on the driver seat

The vibrations were recorded using the VI-400PRO (Figure 3.7) which the measurement result are easily can be download to any PC using the USB 1.1 interface and QuestSuite® Professional II software. QuestSuite® Professional II software also can be used to store user setup profiles and program them into the VI-400Pro. The VI-400PRO, using the computational power of its built-in digital signal processor, can perform real-time 1/1 or 1/3 octave and (optional) real-time FFT analysis. Robust, lightweight construction allows the VI-400PRO to be used in harsh environmental conditions.

Figure 3.6: WBV plate

Figure 3.7: VI 400 Pro Data Acquisation system

Meanwhile, the dose value of noise exposure to the bus driver and passenger in the bus driver cockpit were recorded using the Dosimeter (Edge 5) in Figure 3.8. This device will be clip on top of the driver and passenger pocket which is near to the human ears. After completing the data measurement the data obtained from this device will be transfer to the computer for further analysis (Figure 3.9).

Figure 3.8: Dosimeter

Figure 3.9: Edge 5 has been setup using laptop.

3.6 Measurement Procedure

For the measurement procedure, they will be a standard of procedure to be practice in order to get accurate vibration reading of bus driver. The process of measurement procedure will be mention below:

i. Devices will be calibrate and setup before taking measurement for the whole body vibration.
ii. VI 400 Pro and Edge 5 noise device is turn on.
iii. Triaxial accelerometer plate will be installing on the driver seat and the Edge 5 noise will clip on the bus driver pocket.
iv. Measurement process is started once the bus starts moving.
v. The entire device will be pause temporarily when the bus stops by at the rest and relief station.
vi. All the device operation will be resuming when the driver back to work.
vii. All the measurement process will be terminate once bus has reach the destination.
viii. Transferring the obtained data to the computer.
ix. Repeat steps i until viii for the next data collected procedure

3.7 Safety Precautions

In order to make sure that the measured data obtained accurately, safety precaution for data measurement need to be carry out according to Human response to vibration - Measuring instrumentation (ISO 8041:2005) which is stated that:

i. The device should be calibrated and compared with the international standard value for specific device (1 or 2 years after date purchased).
ii. Checking for mechanical vibration sensitivity with vibration calibrator.
iii. Checking the maximum change in the vibration reading sensitivity in normal use.

iv. Logging the date and time of the calibration test, initial sensitivity and also the adjustment that has been made to the device sensitivity.

Figure 3.10: One of the calibration process, calibrating dosimeter before data measurement process.

3.8 Data Analysis

The information used in this study was taken from the questionnaires responded by bus drivers from Terminal Makmur Bus Station. The questionnaires were divided in two parts. In the first part the objectives was to collect information on the respondents such as age, gender and types of buses. The second part of the survey had 10 questions related to the bus drivers. Thus, the results will be analyzed using graph and percentages (%).

Statistical analysis of the data was performed using the statistical package SPSS 11.1 for windows. Continuous data were summarized with the average (mean) as measure of central tendency and the SD as measure of dispersion. The difference between two means was tested by Student's t-test. In all tests, po0.05 was accepted as the minimum for significance.

For whole body vibration, the maximum result saved in the buffer's file and can be calculated by using to the formula in equation (1):

$$MAX = max_{T_b}(p_w(t)) \qquad \text{…. (1)}$$

and the maximum main result is calculated according to the formula in equation (2):

$$MAX = max_T\left(p_w(t)\right) \qquad for\ \tau \neq 1\ sec \qquad \text{…. (2)}$$

The maximum transient vibration value (MTTV), save as the main result, and is defined (according to the ISO 8041 standard) as in equation (3):

$$MTVV = max_T\left(p_w(t)\right) \qquad for\ \tau = 1 sec \qquad \text{…. (3)}$$

The RMS result is calculated according to the formula in equation (4):

$$RMS = \left(\frac{1}{T}\int_0^T r_w^2(t)dt\right)^{\frac{1}{2}} \qquad \text{…. (4)}$$

where the RMS result saved in the files of the buffer (time history) $T = T_b$

The fourth power vibration dose value (VDV) expressed in meters per second taken to the power of 1.75 (m/s$^{1.75}$) is calculated from the formula in equation (5):

$$VDV = \left(\int_0^T {r_w}^4(t)dt\right)^{\frac{1}{4}} \qquad \text{…. (5)}$$

where this result is calculated in the case when the Human Vibration Option is available.

The vector result is calculated from the formula in equation (6):

$$VEC = \sqrt{\sum_{i=1}^{4} K_i^2 RMS_i^2} \qquad \text{…. (6)}$$

where:

K_i is coefficient for channel i. For channels not selected for vector calculation, K_i equals to zero.

RMS is the RMS value from channel i.

For symbol definitions, here are how to calculated VDV (equation (7)) and RMS (equation (8)):

$$VDV_{WB} = max(1.4VDV_x, 1.4VDV_y 1.4VDV_z) \qquad \text{…. (7)}$$

$$RMS_{WB} = max(1.4RMS_x, 1.4RMS_y 1.4RMS_z) \qquad \text{…. (8)}$$

where:

T_0	Reference duration of 28 800 seconds (8 hours)
T_E	Exposure time
T	Measurement time
EAV_A	Exposure Action Value expressed in m/s^2
ELV_A	Exposure Limit Value expressed in m/s^2
EAV_V	Exposure Action Value expressed in $m/s^{1.75}$
ELV_V	Exposure Limit Value expressed in $m/s^{1.75}$

The current exposure result is calculated according to the formula in equation (9):

$$CExp = RMS_{WB}\sqrt{\frac{T}{T_0}} \qquad \text{…. (9)}$$

and the daily exposure result is calculated according to the formula in equation (10):

$$A(8) = RMS_{WB}\sqrt{\frac{T_E}{T_0}} \quad \text{…. (10)}$$

For noise measurement, the equations that will used to calculate DOSE (equation (11)) and L-avg are in equation (12):

$$DOSE = \frac{100}{TC}\left(\int_0^{RTIME} 2^{\frac{LS-CL}{ER}}\, dt\right)\% \quad \text{…. (11)}$$

$$L - avg = ER\left(log_2 \int_0^{RTIME} 2^{\frac{LS}{ER}}\, dt - \ log_2\,(RTIME)\right)\ dB \quad \text{…. (12)}$$

where:

RTIME	Run Time (seconds)
LS	Sound level, in decibels, that exceeds the Threshold Level. The response time is indicated by the second letter (slow or fast)
CL	Criterion Level (40 to140 dB)
ER	Exchange Rate (3, 4, 5, or 6 dB)
TC	8 Hour Criterion Time (28800 seconds)

CHAPTER 4

RESULT & DISCUSSION

4.1 Introduction

This chapter was aimed to show the result of whole body vibration and noise measurement for a bus driver from Kuantan to Kuala Lumpur. For WBV, one of the bus driver's from Transnasional was used as a subject and two bus drivers' from Transnasional was used as a subject for noise. The bus driver has been work at least five years as a bus driver for this bus company. Vibration and noise exposure levels were measured during the normal daytime route and night time route. The whole body vibration and noise result will be compared by using 2631-1:1997 standard and OSHA Permissible Noise Exposure.

Transnasional are one of the eight bus company that have a trip for passenger to going Kuantan to Kuala Lumpur and Kuala Lumpur to Kuantan. Transnasional at least have 12 trips a day for this destination and the most many trips compare than other bus company. Transnasional are using Scania type of bus which is the most suitable and expensive types of bus. For the long distance, this type of bus is more compatible and comfort for passenger and bus driver. Besides that, questionnaire also has been conduct for the bus drivers and the result from the questionnaire is interpreted via plotted graph. Then, the graph will be analyzed to obtain the result and to come out with some suggestion how to improve the whole body vibration and noise effect to the bus driver.

4.2 Survey Studies

Twenty bus drivers are selected randomly to fulfill this survey. For this questionnaire, its consists 7 section which is section A is about respondents personal details, section B consists respondents working environment, section C is about musculoskeletal disorders, section D survey about low back pain among the respondents, section E inability of arm, shoulders and hand, section F consists general respondents health information's, and for the last section which is section G consists of other factors.

From the Table 4.1 it shows that the summary of the respondent answer that has been conduct between the 20 bus drivers. Most of them are already had been a bus driver at least 5 years and all of them are male. Majority of the bus driver is between 20 to 29 year old and 90% of them are smoker. 40% of the bus drivers are single and 60% they are already married.

Table 4.1: Characteristics, BMI and LBP outcomes of participants (n=20)

Characteristics		Percentage from the population (%)
Age	20-29	45
	30-39	40
	40-49	15
Sex	Male	100
Race	Malay	100
Status	Single	40
	Married	60
Smoking	Yes	90
	No	10
Weight	50-60	25
	61-70	30
	71-80	35
	81-90	10

Table 4.1: Continued

Characteristics		Percentage from the population (%)
Height	150-160	20
	161-170	35
	171-180	30
	181-190	15

4.2.1 Data analysis for musculoskeletal disorder

Most work-related MSDs develop over time and are caused either by the work itself or by the employees' working environment. They can also result from accidents, e.g. fractures and dislocations. Typically, MSDs affect the back, neck, shoulders and upper limbs; less often they affect the lower limbs. Health problems range from discomfort, minor aches and pains, to more serious medical conditions requiring time off work and even medical treatment. In more chronic cases, treatment and recovery are often unsatisfactory - the result could be permanent disability and loss of employment. Many problems can be prevented or greatly reduced by complying with existing safety and health law and following guidance on good practice. This includes assessing the work tasks, putting in place preventive measures, and checking that these measures stay effective (http://osha.europa.eu/en/topics/msds/index_html).

Grace P. Y. Szeto and Peggo Lam (2007) said that 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 mechanism. 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. Psychosocial factors such as job satisfaction, ability to handle stress, and psychological status are also important factors to consider in occupational health.

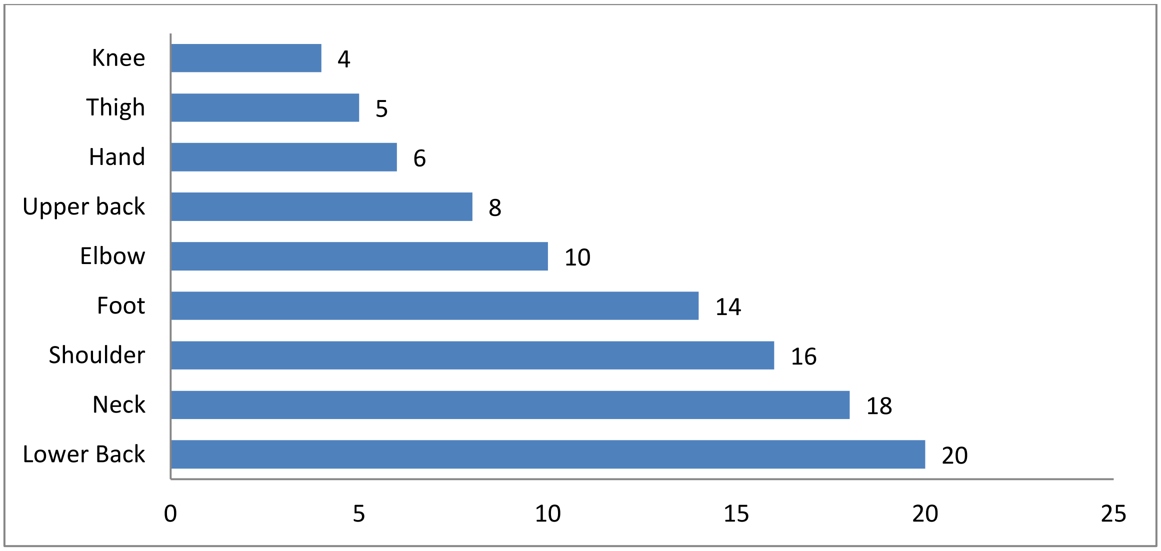


Figure 4.1: Part of the driver body that experiencing the MSDs

Figure 4.1 shows that the most pain suffers by bus driver is lower back which is all of the 20 bus drivers agreed with this and follow by neck, shoulder, foot, elbow, upper back, hand, thigh, and knee. This shows that most of the bus drivers are in a musculoskeletal disorders symptom. A job which requires an individual to seat in a static position for a long time and exposed to whole body vibration can cause a fatigue induced pain in an individual without a prior injury.

Grace P. Y. Szeto and Peggo Lam (2007) mentioned that among the different types of musculoskeletal problems that drivers may have, low back pain has been reported more extensively in past research. Magnusson et al. (1996) conducted a survey 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. Previous studies also reported that male truck drivers were four times more likely than sedentary workers to develop a herniated lumbar disc.

Anderson (1992) reported that 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. Krause and associates (1997, 1998 and 2004) conducted a series of studies on over 1,000 transit vehicle operators in a 7.5 years prospective study (2004), and 5-year prospective study (1998). Their studies mainly focused on low back pain and neck pain in transit drivers in California who operated mainly 4 different types of vehicles: diesel buses, electric trolley buses, light rail trains and cable cars. Both physical and psychosocial factors were examined. Weekly driving hours and "ergonomic problems" were found to be strongly associated with back pain. However, there may be some differences in terms of occupational exposure in driving electric trolley cars or cable cars in San Francisco, compared to driving double-deck buses in a densely populated city like Hong Kong.

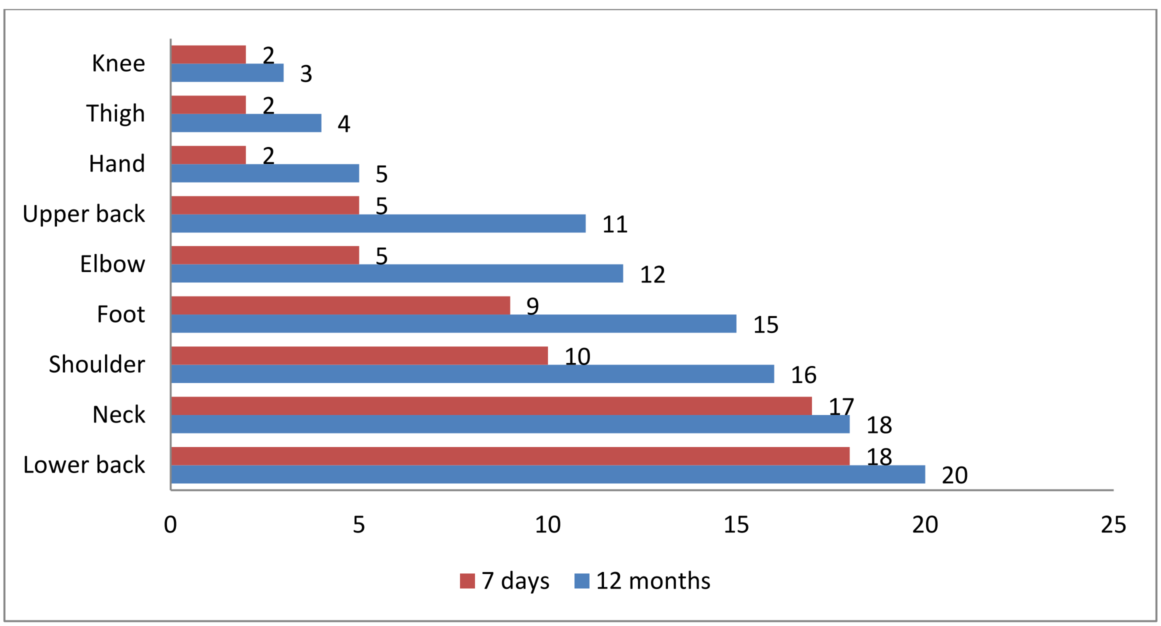


Figure 4.2: 12 months and 7 days discomfort in different body areas reported by bus drivers (MSDs)

Figure 4.2 shows that the most pain suffers by bus driver in 12 months and 7 days ahead is lower back which is 20 and 18 bus drivers agreed with this. The result seems to be same as in Figure 4.1. This happen maybe because of the majority of the driver is in arranging 20 to 39 years old which is not much experience in driving. Grace P. Y. Szeto and Peggo Lam (2007) said that when 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. The "survivor bias" predicted that those who had severe pain may have already quit their jobs so the more experienced workers would continue to remain in the jobs, and it is likely that they had lower prevalence or severity of work-related musculoskeletal problems.

On the other hand, there may also be a "practice" effect for those with more experience in their job so that they were less likely to get injured as compared to young drivers with less experience. Both these factors may have contributed to higher rates of discomfort among the younger drivers. Anderson (1992) also 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. Krause et al. (2004) 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. Future studies may consider a longitudinal or prospective approach to examine different cohorts of workers over a period of time, in order to determine whether their pains were started before or after they join this line of work.

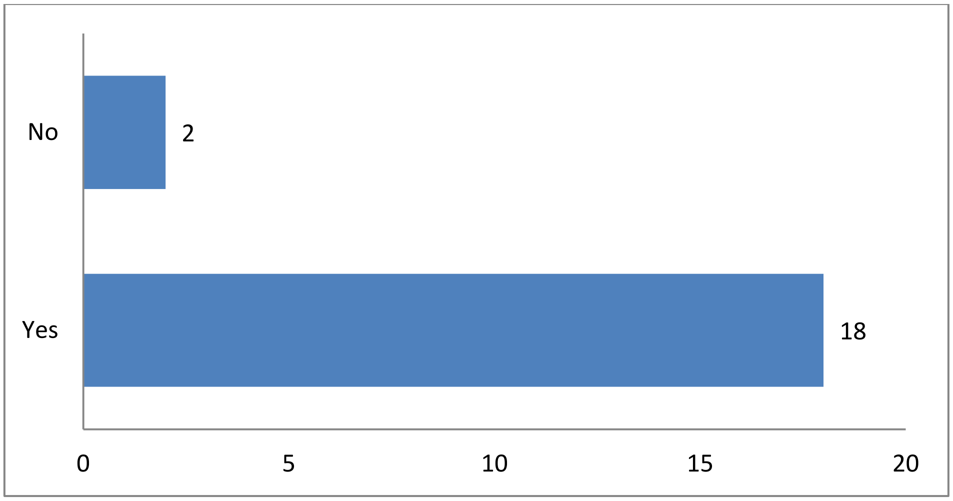


Figure 4.3: The result for the low back pain complaint

Figure 4.3 shows that 80% of the bus driver mentioned that they are having a low back pain while 20% bus driver mentioned no. One of them has been going to the hospital because of this problem and has been treatment for a month to recovery his low back pain sickness. According to Olanrewaju et al. (2006) who had also conduct the questionnaire about low back pain among the bus driver mentioned that the questionnaire data showed that 36 drivers (59.0%) experienced LBP during the last 12 months of which, 19 also reported current LBP (i.e., pain in immediate past 7 days). For these persons, more than six episodes of LBP were experienced, each typically lasting between a few minutes and 2 days and for which considerable but not severe pain was perceived, i.e., between 3 and 7 on a scale from 1 [little pain] to 10 [very bad pain].

Olanrewaju et al. (2006) also said that back pain only and back pain with radiating pain to the leg were the two common symptoms and seven of the drivers needed to take time off work because of LBP. For the bus drivers, muscle stiffness, muscle sprain and trapped nerve, were the three reported medically diagnosed underlying problems and actions such as standing after a long period of driving, flexing the torso and twisting, tended to initiate and/or aggravate pain. Furthermore, the questionnaire data indicated that back pain had little effect on ability to work and on ability to take part in recreational/social activities.

4.3 Data Presentation and Data Analysis of Whole Body Vibration and Noise

4.3.1 Vibration

From the experiment that have been conducted according to the real time condition, daily exposure to vibration A(8) value and vibration dose value (VDV) and exposure points values were measured. Table 4.2 shows the data that have been get from the measured experiment for a bus Transnasional from Kuantan to Kuala Lumpur during a daytime route. From the Table 4.2, its show that z-axis has the higher r.m.s compare than x and y-axis. Same goes to maximum peak signal and crest factor.

Table 4.2: Data for Driver

# Years Driving: 12 years					Average Hours/Week: 56		
Exposure R.M.S. (m/s^2)		**Max. Peak Signal**	**Crest Factors**	**A(8) (m/s^2)**		**VDV ($m/s^{1.75}$)**	
Sum of	**(x, y, & z)**	**Axes: (X, Y & Z respectively)**		**Sum of**	**Axes: (X,Y & Z respectively)**	**Sum of**	**Axes: (X,Y & Z respectively)**
0.8407	0.2685 0.3377 0.5848	3.0409 2.9410 10.3157	11.3240 8.7096 17.6401	0.8407	0.3759 0.4727 0.5848	15.3330	4.8975 6.1585 10.6654

Whole body vibration graph were represent in Figure 4.4 and 4.5. For Figure 4.4(a), Figure 4.4(b), and Figure 4.4(c) represent the graph for the r.m.s results at x, y, and z axes while Figure 4.5(a), Figure 4.5(b), and Figure 4.5(c) represent maximum peak signal result x, y, and z axes.

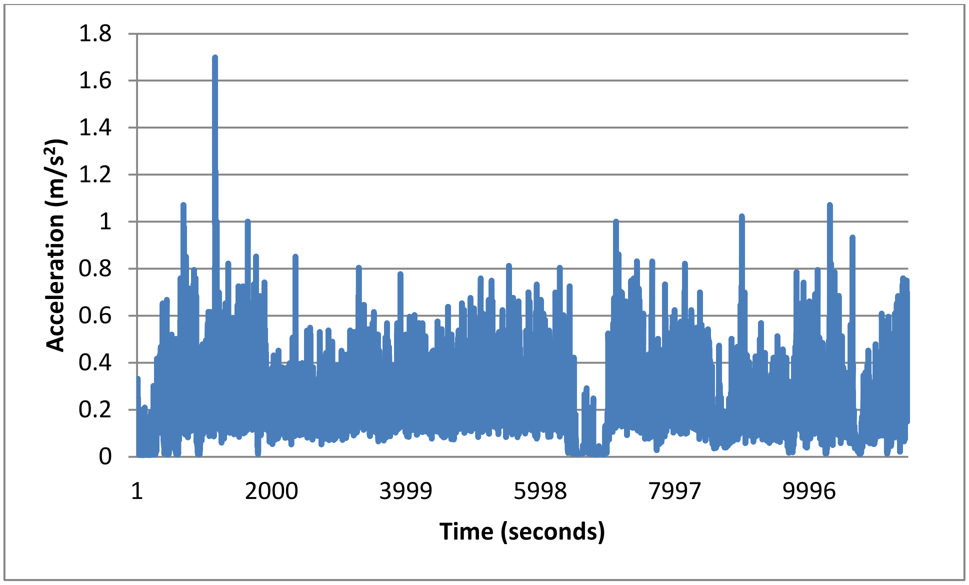


Figure 4.4(a): Graph r.m.s for x-axis

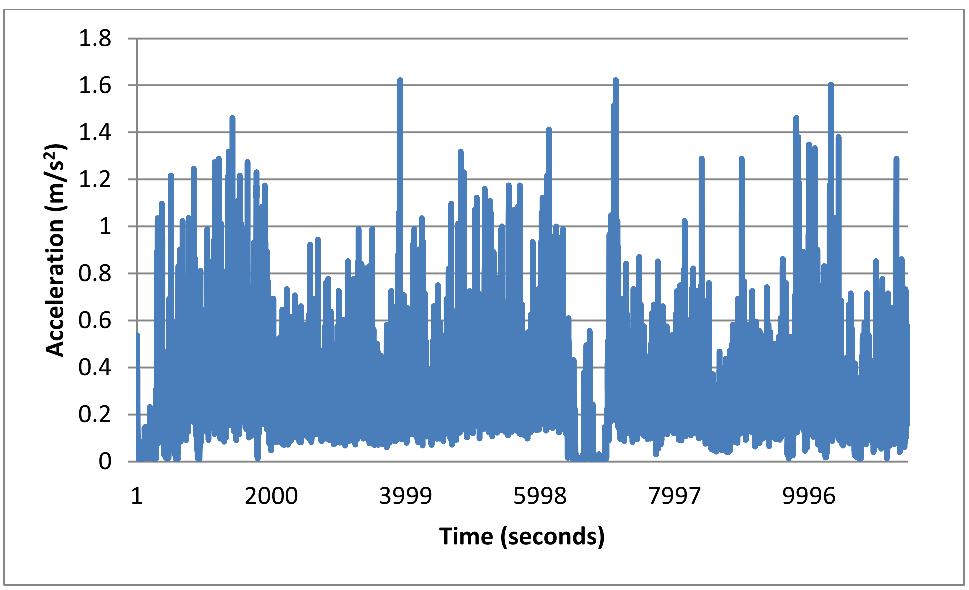


Figure 4.4(b): Graph r.m.s for y-axis

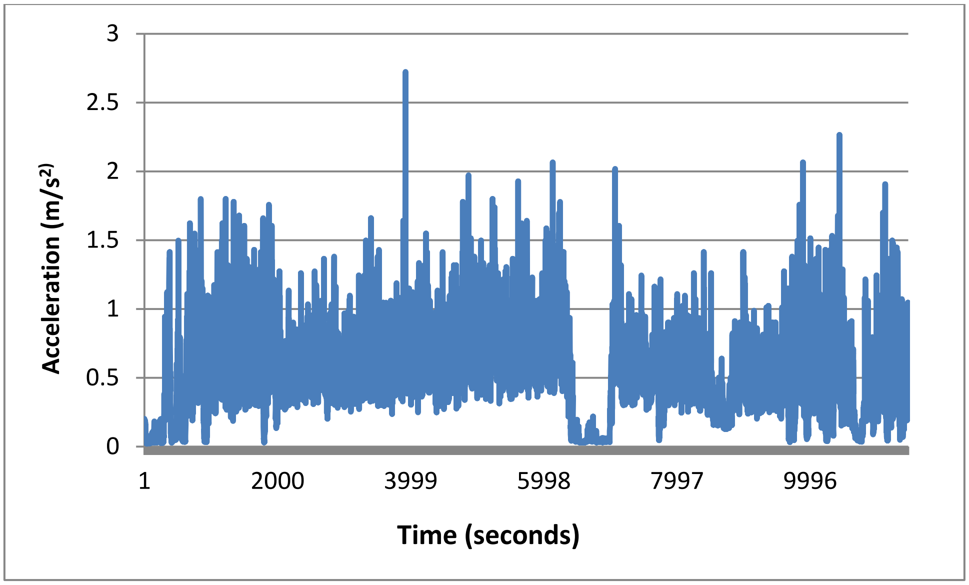


Figure 4.4(c): Graph r.m.s for z-axis

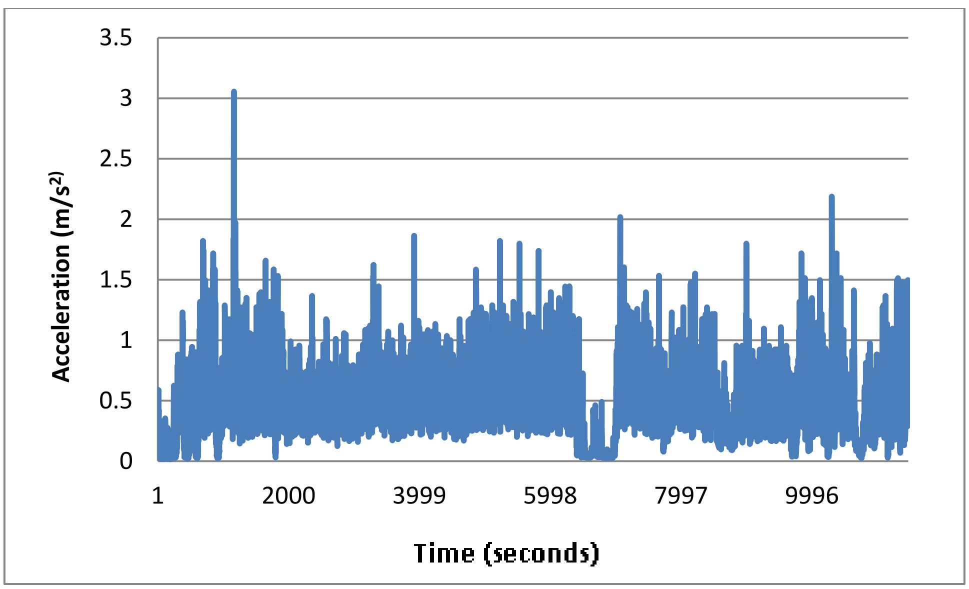


Figure 4.5(a): Graph max. peak signal for x-axis

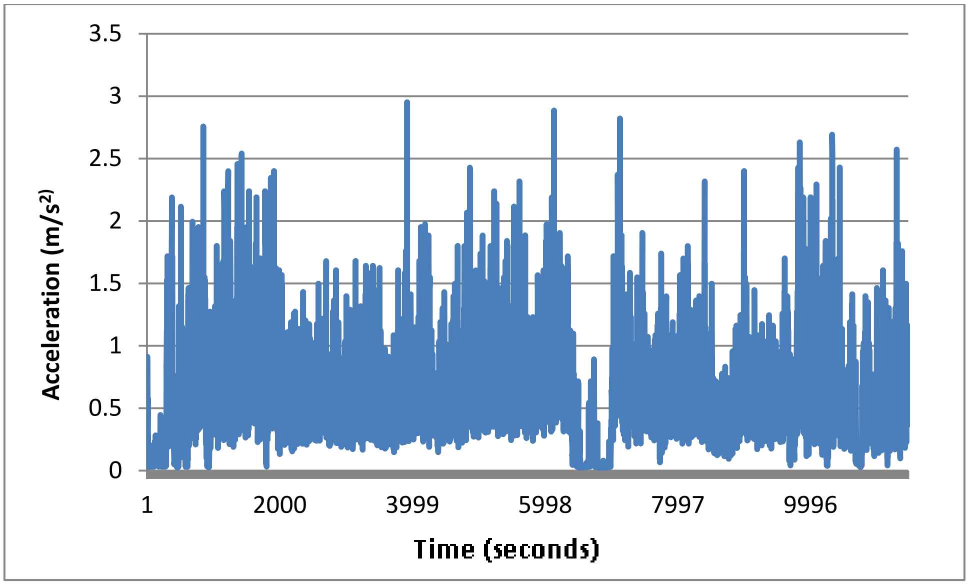


Figure 4.5(b): Graph max. peak signal for y-axis

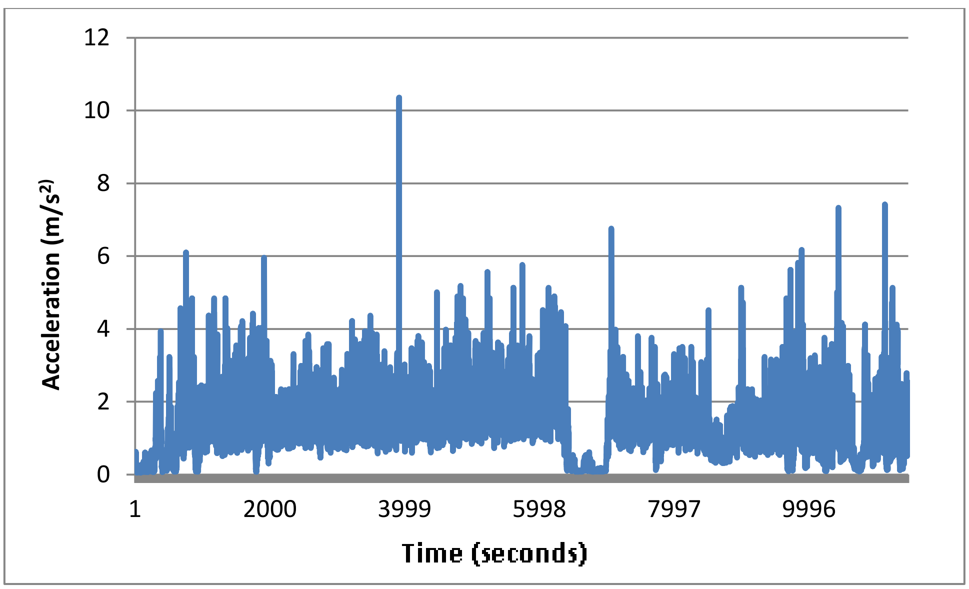


Figure 4.5(c): Graph max. peak signal for z-axis

From the result obtained, the frequency weighted value indicated in the measurement was closely to the permissible value of exposure limit according to ISO 2631-1:1997 standard. Table 4.3 below shows the standard value of r.m.s acceleration according to ISO 2631-1:1997 standard while table 4.4 shows the standard value of comfort reaction to vibration environment.

Table 4.3: Standard value of r.m.s acceleration according to ISO 2631-1:1997

Exposure Limit	RMS Acceleration
8 h	2.8 m sec^{-2}
4 h	4.0 m sec^{-2}
2.5 h	5.6 m sec^{-2}
1 h	11.2 m sec^{-2}
30 min	16.8 m sec^{-2}
5 min	27.4 m sec^{-2}
1 min	61.3 m sec^{-2}

Table 4.4: Standard value of comfort reaction to vibration environment

Exposure limit	Condition
Less than 0.315 m sec^{-2}	Not uncomfortable
0.315 m sec^{-2} to 0.63 m sec^{-2}	A little uncomfortable
0.5 m sec^{-2} to 1 m sec^{-2}	Fairy uncomfortable
0.8 m sec^{-2} to 1.6 m sec^{-2}	Uncomfortable
1.25 m sec^{-2} to 2.5 m sec^{-2}	Very uncomfortable
Greater than 2 m sec^{-2}	Extreme uncomfortable

According to the Table 4.3 and Table 4.4, the results show that the bus drivers did not exposure to the Whole Body Vibrations since the result is still below the range of standard. But when compare the results with the questionnaire survey, seems that this subject suffers from low back pain and subject also mentioned that it is hard for her to sleep well due to the low back pain problem. Besides that, subject also mentioned that he can’t do a daily job like before because of this problem. This shows the unexpected results since the result from questionnaire and experimental result are not tally.

Erik W. Gregory (2000) also conclude that her study produced some unexpected although explainable results. As mentioned earlier, it was expected that the individuals subjected to the highest vibration levels would tend to report LBP, with severity of pain increasing with levels of exposure. This study did not support this belief. However, it may be that the risk of developing LBP may indeed increase with increasing levels of WBV, after a period of years. In other words, LBP due to exposure from WBV should be considered a chronic condition, and should be studied accordingly.

4.3.2 Noise

Table 4.5 shows the result obtained from the noise experiment conducted for the bus driver and passenger from Kuantan to Kuala Lumpur and Kuala Lumpur to Kuantan. From the table 4.5, shows that bus driver exposure to noise more than passenger. According to the OSHA Permissible Noise Exposure from Table 4.6, the bus driver and passenger exposure to sound level is in a slow response and below than 95dB (for 4 hours duration per day).

Table 4.5: Data for bus driver and passenger

Routes	Sample	Dose (%)	Average Level (dB)
Kuantan - Kuala Lumpur	Driver	7.7	78.1
	Passenger	6.2	76.6
Kuala Lumpur - Kuantan	Driver	6.5	74
	Passenger	3.1	68.7

Table 4.6: OSHA Permissible Noise Exposure

Duration per day (Hours)	Sound level, dB(A) slow response
8	90
6	92
4	95
3	97
2	100
1 – 1/2	102

Table 4.6: Continued

Duration per day (Hours)	Sound level, dB(A) slow response
1	105
1/2	110
1/4 or less	115

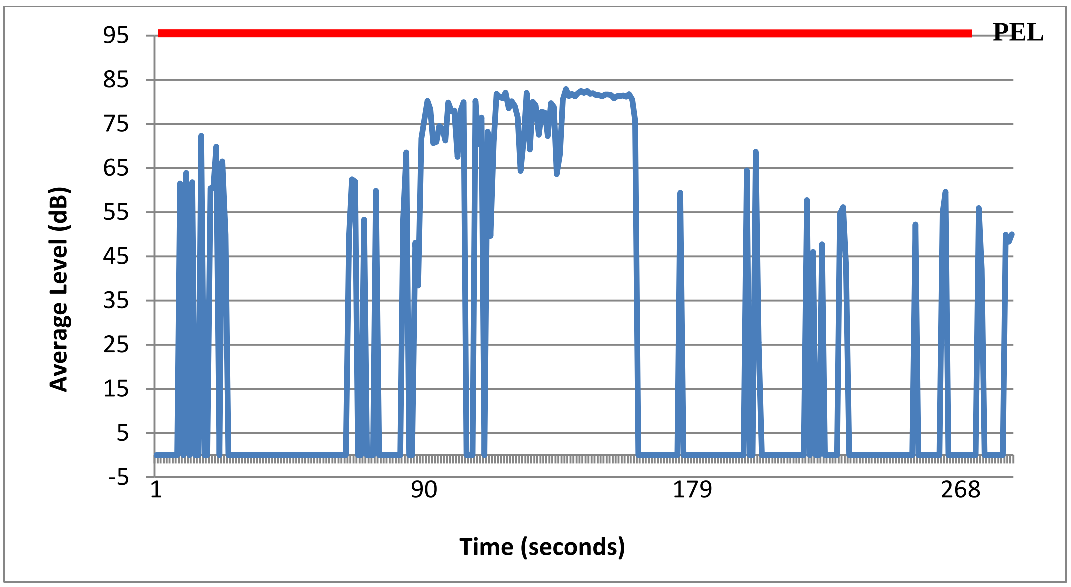


Figure 4.6(a): L-avg for Bus Driver (Kuantan – Kuala Lumpur)

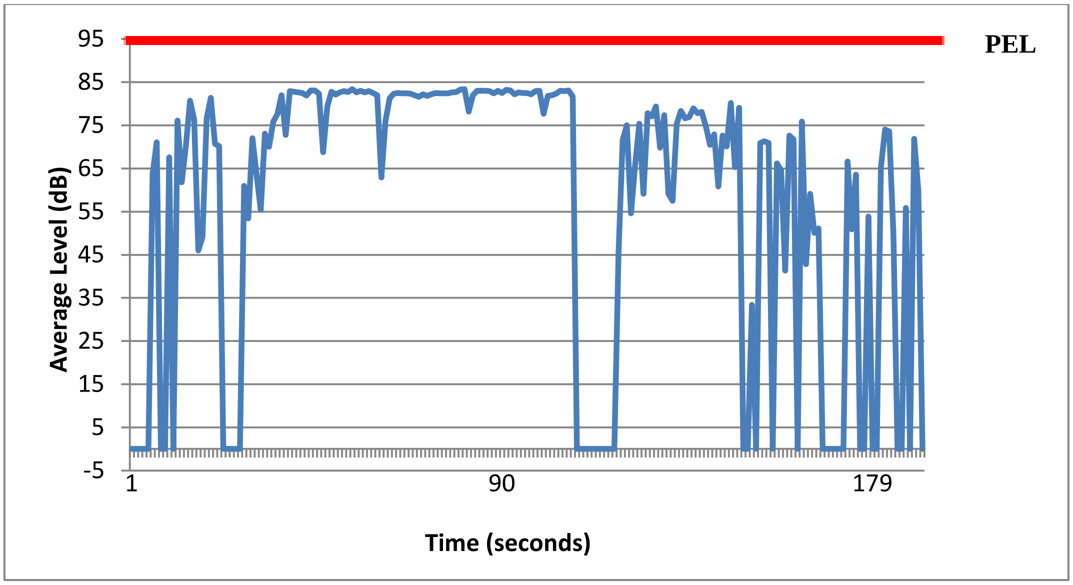


Figure 4.6(b): L-avg for Passenger (Kuantan – Kuala Lumpur)

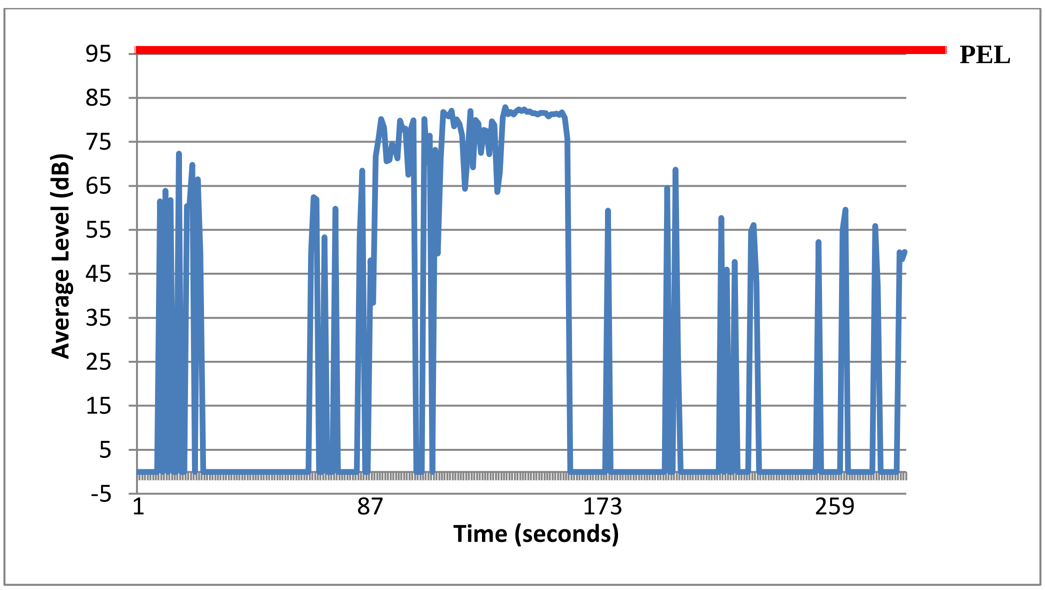


Figure 4.7(a): L-avg for Bus Driver (Kuala Lumpur - Kuantan)

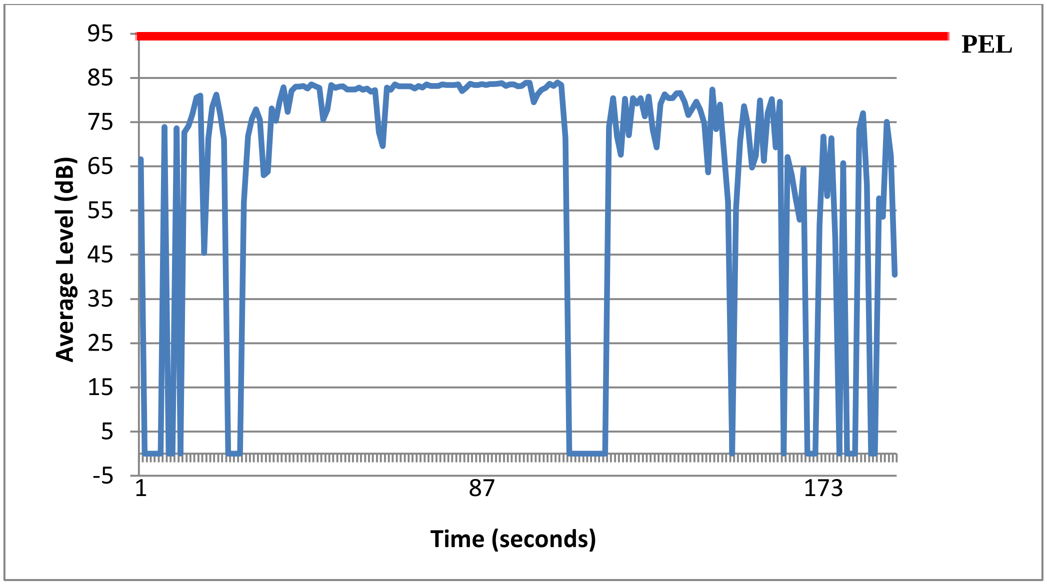


Figure 4.47(b): L-avg for Passenger (Kuala Lumpur - Kuantan)

Figure 4.6(a), Figure 4.6(b) and Figure 4.7(a), Figure 4.7(b) shows the graph for the noise profiling for the bus driver and passenger from Kuantan to Kuala Lumpur and Kuala Lumpur to Kuantan. From the data measured, the range of noise is still in a satisfied range and is not required to wear the ear protection. But for an individual protection, there is good behavior to wear the ear protection during the work time to protect the ear from any damage.

The Noise at Work Regulations (1989) requires personal hearing protection to be provided where noise levels reach 85 dB or more. Personal hearing protectors must not only be maintained and used correctly but must also be worn for the entire period of exposure to the noise to be effective. Failure to wear the protection for only 15% of the time renders it virtually useless. Noise protection is not an easy matter for drivers. Drivers need to be in aural contact with the outside world and need to be protected from the health damaging consequences of noise.

4.4 Discussion

According to Hassan Nahvi et al (2009) who had been studied about evaluation of whole-body vibration and ride comfort in a passenger car, said that Kurtosis and VDV correlate with IRI and may be use as two objective metrics together with jury evaluation to create a vehicle vibration comfort index in the future. However, T_{15} (time to reach severe discomfort), even in harsh conditions, is more than three hours, which exhibits the overall good quality of the vehicle suspension system.

Table 4.7: Time required to reach 15m/s$^{1.75}$ VDV on rough road surfaces

Road Conditions	Velocity(km/h)			
Road type	20	40	60	80
Pavement	32 h 20 m	12 h 50 m	11 h	6 h 15 m
Suburban	219 h	12 h 10 m	9 h	5 h 15 m
Bumpy	3 h 45 m	-	-	-

Table 4.7 above shows the required periods for VDV_{total} on the rough road surfaces to reach the action level of 15 m/s$^{1.75}$. On the smooth road, the needed time to reach 15 m/s$^{1.75}$ is so long in all speeds that it is not continuously drive such a long period of time. Therefore, it can be concluded that other factors than seat and cabin ergonomics affect drivers comfort while driving on well-maintained smooth roads.

By referring to Olanrewaju et al (2006) who is study about city bus driving and low back pain: A study of the exposures to posture demands, manual materials handling and whole body vibration said that city bus drivers spend about 60% of the daily work time actually driving, often with the torso straight or unsupported, perform occasional and light MMH and experience discomforting shock/jerking vibration events. Transient and mild LBP (not likely to interfere with work or customary levels of activity) was found to be prevalent among the drivers and a need for ergonomic evaluation of the drivers' seat was suggested.

By using validated questionnaire, information about driving experience, driving (sitting) posture MMH, and health history was obtained from 80 city bus drivers. Twelve drivers were observed during their service route driving (at least one complete round trip) and vibration measurements were obtained at the seat and according to the recommendations of ISO 2631 (1997), for three models of bus (a mini-bus, a single-decker bus, a double-decker bus) (Olanrewaju et al (2006)).

Health of professional drivers written by John Whitelegg (1995) said that the objectives of his report are to review the on evidence on the work related health problems of drivers and to make recommendations for a significant improvement in the working environment of this neglected group of professionals. He said that, for those who drive lorries and buses there has been a deterioration over the last 20 years in work conditions. This deterioration is largely the result of traffic congestion and its associated air and noise pollution but also with the pressures of maintaining a demanding schedule in circumstances that make that task almost impossible.

Besides that, John Whitelegg (1995) mentioned that buses find it almost impossible to maintain schedules and the pressure on lorry drivers to meet demanding schedules is intense. The driver in both circumstances has to absorb the failures of the transport system in the form of increased stress levels, conflict with customers and the intensification of a wide range of work pressures in a hostile environment. These circumstances damage the health of drivers in a way that is unacceptable.

Olanrewaju et al (2006) concluded that the health of drivers is an important issue in public health, occupational health, and transport policy and employment conditions. There has not been a concerted assault on those factors that cause poor health and this is an area of neglect that needs urgent attention. Measures to protect and improve the health of drivers should be pursued in a way that maximizes gains to all sectors of society. Lorries are perceived as noisy and dangerous and are certainly unwelcome in many city centre's and residential areas. It is in he interest of lorry drivers as well as members of the public that lorries are made much quieter, much less polluting and much less intrusive. If lorries are managed as part of a wider strategy to handle freight by all modes of transport then congestion problems could be reduced, time pressures eliminated and more jobs created in the multi-modal, transshipment activities that would result. It is important in lorry discussions to have a strategic view of the role and future development of lorry transport as well as a very practical view of how to improve conditions for drivers and members of the public now.

Olanrewaju et al (2006) continued said that similar arguments can be made for buses. Public transport in many parts of Europe is receiving investment at a rate many times greater than in Britain. Investments in the Netherlands, Germany, France and Denmark in new buses, new tram systems, bus lanes and traffic management systems that support buses will improve life for the driver and the general public. A driver behind the wheel of a new bus with excellent facilities for the disabled, state of the art communication technology, direct control over signaling at intersections, excellent linkage possibilities with all other modes and ticketing systems that almost eliminate taking fares on the bus will be a much happier and healthier bus driver than the UK version of this situation. When buses have preferential treatment in cities and cars are restrained then the job of a bus driver can refocus on high quality service to the customer in a safe well regulated environment. The advantages for bus drivers and passengers of a move in this direction are enormous.

Olanrewaju et al (2006) also come out with ten steps action that can be taken immediately to handle these issues which is:

a. Attention to cab design and ventilation to ensure that air quality is the highest attainable standard and noise levels are reduced to below 70 dB(A). Air in the cab should not be fed directly from the street and there should be no possibility of evaporative emissions entering the cab from fuel lines, fuel tanks etc.

b. Continuing progress with detailed attention to design matters to ensure that posture is correct and all tasks associated with driving can be accomplished with no strain on eyes, hearing, motor functions, reach etc.
c. The introduction of realistic work schedules that fully reflect the realities of traffic congestion, keeping to speed limits, the need for breaks and rest periods. This should be kept under constant review to ensure that drivers do not become the principal victims in absorbing the failures of the transport system and the workers that bear the brunt of cost cutting. If more time is needed to accomplish the tasks that have to be accomplished then the health of drivers and the safety of the public require that this be provided. Drivers should be given longer breaks and wherever possible breaks that facilitate interaction with other drivers.
d. The design and implementation of shift patterns and working practices that maximize the time than can be spent at home and/or the time that can be spent with co-workers
e. Install state of the art communications technology in all vehicles. Communications are important for work efficiency, for the safety of the driver and for eliminating the feelings of isolation.
f. Drivers should become more involved with management decision making about schedules, routes, timings and organization. They have considerable experience of these matters which are of value to the overall commercial success of the organization and studies (7) have shown that stress can be reduced and health improved by greater levels of involvement in the management process.
g. For lorry drivers change in working practices and drivers pay (by agreement with workers) to reward adherence to speed limits. Schneider in the US pays bonuses to truckers on the basis of observance of the 55mph speed limit. This reduces hassle for the trucker and saves the company money in fuel costs (20).
h. For lorry drivers install state of the art scheduling and roistering computer software to maximize use of vehicles, maximize the number of trips involving a return home in the evening or weekend and minimize mileages. A system of this kind would improve the health of drivers, improve the safety of the general public and reduce costs for the organization.

i. For bus drivers pay particular attention to safety and security of the driver and where circumstances are particularly difficult use two person operated buses.

j. For bus drivers ensure that bus stations and bus stops are well lit, well located, adequately supervised, easily accessed, fully equipped with state of the art information technology and where possible involve immediate and unimpeded access back into the traffic flow. Bus stops can be located on extensions to the pavement into the street so that when the bus stops all the other traffic stops behind it and cannot pass. When the bus moves off the normal flow of traffic resumes and cars can overtake where it is safe to do so. Buses are far more important than cars in urban areas and giving them physical priority in this way will improve timings, increase passenger satisfaction and reduce the hassle of driving a bus in congested streets.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

In this chapter, the conclusion for all chapters discuss before will be conclude. Recommendation also will be list out so some modification can be made to overcome the problem occurs.

5.2 Conclusion

Even though the conclusion of this study is unexpected, but the result still can be explained. As refer to the chapter two, it was expected that each individual are subjected to high magnitude of vibration but this study did not support the belief. However, it may that developing the risk of low back pain and musculoskeletal disorder may indeed increase with increasing level of whole body vibration through a long period of time.

5.3 Recommendation

Further studies on whole body vibrations and noise should be carried out to prevent adverse health effect in bus driver. It is recommended that future research studies should focus on the individuals with long-term exposure to WBV, assuming a similar exposure group can be found. Also, it would be useful to study the effect of caring a load just after exposure to WBV. This could be accomplished through a study of bus drivers and truck drivers (who unload their own freight), who have been exposed to WBV for a number of years and who are exposed to a similar level of WBV.

Besides that, for a long journey distance, it might be helpful if two bus drivers had been conducted the bus. If necessary, stop awhile for a short rest before continue the journey. Nowadays, most of the bus drivers like to drive the bus without take a short rest example like bus from Kuantan to Kuala Lumpur. These habits not good because it can occurs a low back pain to the bus driver since the bus driver can't changes the position of their seat.

The bus company also should provide a medical checkup for their bus drivers once for six months to see whether their staff had a low back pain or MSDs symptoms or not. In this way, law back pain and MSDs problems can be reduced among the bus drivers. The Bus Company also should give their staff enough rest before they can continue their work. 24/7 is not a relevant time work. The design of the seat also should be considered to make sure the bus drivers are comfortable during their work time. If the bus drivers are comfortable with their seat, get enough rest and not in a low back pain or MSDs problem, accident can be avoided and the driver can follow the time bus departure or arriving.

REFERENCES

A.R. Ismail, M.Z. Nuawi, C.W. How, N.F. Kamaruddin, M.J.M. Nor & N.K. Makhtar (2010). Whole Body Vibration Exposure to Train Passenger. 2010 Science Publications.

Anderson R. The back pain of bus drivers. Prevalence in an urban area of California. Spine 1992;17(12):1481–8.

Asian Development Bank (2005). Air and Noise Pollution Reduction from Tricycles. A Strategic Plan for Quezon City and Puerto Princesa City, Philippines. Publication Stock No. 101805

Bourje Rehn, Tohr Nilsson, Bodil Olofsson & Ronnie Lundstroum (2005). Whole-Body Vibration Exposure and Non-neutral Neck Postures During Occupational Use of All-terrain Vehicles. Oxford University Press.

Burdorf, A. and Sorock, G. (1997). Positive and negative evidence of risk factors for back disorders. Scand J Work Environ Health **23**: 243 -256.

Barbara McPhee, Gary Foster, and Airdrie Long (2001). Bad Vibrations - A Handbook on Whole-Body Vibration Exposure in Mining. Joint Coal Board Health and Safety Trust 21/44 Market Street Sydney NSW

Christophe Delecluse, Machteld Roelants, Rudi Diels, Erwin Koninckx & Sabine Verschueren. Effects of Whole Body Vibration Training on Muscle Strength and Sprint Performance in Sprint-trained Athletes. Faculty of Physical Education and Physiotherapy.

Carl E. Hanson, David A. Towers, and Lance D. Meister (2006). Transit Noise and Vibration Impact Assessment. Office of Planning and Environment Federal Transit Administratio

Carlos Dora and Margaret Phillips (2000). Transport, Environment and Health. WHO regional publications. European series ; No. 89

Central pollution control board (2010). Status of the Vehicular Pollution Control Programme in India. Programme Objective Series PROBES/ 136 /2010

Dian Darina Indah Daruis, Mohd Jailani Mohd Nor, Baba Md Deros, & Mohammad Hosseini Fouladi (2008). Whole-body Vibration and Sound Quality of Malaysian

Cars. Department of Mechanical and Material Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia.

Daruis D.D.I., Md Deros B and Mohd Nor M.J. (2008). Understanding The Effect of Noise, Vibration and Seat Discomfort towards a Passenger's Vehicle Driver through Self-Reported Survey. Department of Mechanical and Material Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia.

Darren M. Jouberta, and Leslie London (2007). A Cross-Sectional Study of Back Belt Use and Low Back Pain amongst Forklift Drivers. International Journal of Industrial Ergonomics 37 (2007) 505–513.

Danielle Noorloos, Linda Tersteeg, Ivo J.H. Tiemessen, Carel T.J. Hulshof & Monique H.W. Frings-Dresen (2008).Does body mass index increase the risk of low back pain in a population exposed to whole body vibration? Applied Ergonomics 39 (2008) 779–785.

Duarte, Maria Lúcia Machado, Pereira, Matheus de Brito, Misael, Marcos Roberto and Freitas Filho, Luiz Eduardo de Assis. Is Age More Important than Gender, Corporeal Mass Index (CMI) or Vision on Whole-Body Human Vibration Comfort Levels? Group of Acoustics and Vibration, Mechanical Engineering Department, Federal University of Minas Gerais, Belo Horizonte/MG, 31270-901, Brazil.

Dietrich Schwela, Olivier Zali and Philipp Schwela. Motor Vehicle Air Pollution Public Health Impact and Control Measures

Eduard Alentorn-Geli, M.D., M.S., Jaume Padilla, M.S., Gerard Moras, Cristina Lázaro Haro, Joaquim Fernández-Solà, (2008). Six Weeks of Whole-Body Vibration Exercise Improves Pain and Fatigue in Women with Fibromyalgia. Laboratory of Biomechanics, INEF–Exercise and Sport Sciences School, University of Barcelona, Spain. The Journal of Alternative and Complementary Medicine. Volume 14, Number 8, page 975-981. DoI: 10.1089/acm.2008.0050

Eckardt Johanning, Paul Landsbergis, Siegfried Fischer, Eberhard Christ, and Benno Go¨ res, Raymond Luhrman (2006). Whole-Body Vibration and Ergonomic Study of US Railroad Locomotives. Journal of Sound and Vibration 298: 594 – 600.

Erik W. Gregory (2000)**.** Whole-Body Vibration and the Lower Back: The Effect of Whole-Body Vibration on Pain in the Lower Back. Morgantown, West Virginia.

European Foundation for the Improvement of Living and Working Conditions. Trends and Drivers of Change in the EU Transport and Logistics Sector: Mapping Report

Farid Amirouche, Alan G. Mayton, and Robert J. Tuchman (2008). American Conference on Human Vibration

Grace P. Y. Szeto • Peggo Lam (2007). Work-related Musculoskeletal Disorders in Urban Bus Drivers of Hong Kong. Springer Science Business Media, LLC. J Occup Rehabil (2007) 17:181–198. DOI 10.1007/s10926-007-9070-7

Gregory P. Slota, Kevin P. Granata & Michael L. Madigan. Effects of seated whole-body vibration on seated postural sway. Virginia Polytechnic Institute & State University. Zheng Ke, Ming Zhang, Cheng Tan， Wei Su， Chao Ma, Zhili Li.

Geraldine S. Newell & Neil J. Mansfield (2008). Evaluation of reaction time performance and subjective workload during whole-body vibration exposure while seated in upright and twisted postures with and without armrests. International Journal of Industrial Ergonomics 38 (2008) 499–508.

Gregory P. Slota, Kevin P. Granata, and Michael L. Madigan (2007). Effects of Seated Whole-Body Vibration on Postural Control of the Trunk during Unstable Seated Balance. Clinical Biomechanics 23: 381-386.

Geraldine S. Newell, Neil J. Mansfield & Luca Notini (2006). Inter-cycle variation in whole-body vibration exposures of operators driving track-type loader machines. Journal of Sound and Vibration 298 (2006) 563–579.

Hassan Nahvi, Mohammad Hosseini Fouladi & Mohd Jailani Mohd Nor (2009). Evaluation of whole-body vibration and ride comfort in a passenger car. MEMS-Automotive Research Group, Dept. of Mechanical and Materials Eng.,Faculty of Eng, Universiti Kebangsaan Malaysia.

Hsieh-Ching Chen, Wei-Chyuan Chen, Yung-Ping Liu, Chih-Yong Chen & Yi-Tsong Pan (2009). Whole-body vibration exposure experienced by motorcycle riders – An evaluation according to ISO 2631-1 and ISO 2631-5 standards. Elsevier B.V

I J H Tiemessen, C T J Hulshof and M H W Frings-Dresen (2008). Low Back Pain in Drivers Exposed To Whole Body Vibration: Analysis of a Dose-Response Pattern

Johan Granlund and Anders Brandt (2005). Bus Drivers’ Exposure to Mechanical Shocks Due To Speed Bumps

Jackie Cooper (2009). The Amazing Wellness Benefits of Whole Body Vibrations

Jason C. Ross, and Michael A. Staiano (2007). A Comparison of Green and Conventional Diesel Bus Noise Levels

Julia O. Totosy de Zepetnek, Lora M. Giangregorio, and Catharine Craven (2009). Whole-Body Vibration as Potential Intervention for People with Low Bone Mineral Density and Osteoporosis: A Review

Jim Parison (2010). The Bose ride™ System

John F. Brock, Gary A. Golembiewski, Gerald P. Krueger, Carmen Daecher, Richard Bishop, and Gene Bergoffen (2005). Commercial Truck and Bus Safety: Motor Coach Industry Hours of Service and Fatigue Management Techniques

Krause N, Rugulies R, Ragland DR, Syme SL. Physical workload, ergonomic problems, and incidence of low back injury: A 7.5 year prospective study of San Francisco Transit Operators. Am J Ind Med 2004;46:570–85.

Krause N, Ragland DR, Greiner BA, Fisher JM, Holman BL, Selvin S. Physical Workload and Ergonomic Factors AssociatedWith Prevalence of Back and Neck Pain in Urban Transit Operators. Spine 1997;22:2117–26.

Krause N, Ragland DR, Fisher JM, Syme SL. Psychosocial job facotrs, physical workload, and incidence of work-related spinal injury: a 5-year prospective study of urban transit operators. Spine 1998;23(23):2507–16.

Lenka Justinova (2005). Back Problems among Car Drivers: A Summary Of Studies During The Last 30 Years. Human Factors Research Unit Institute of Sound and Vibration University of Southampton.

Lenka Gallais & Michael J. Griffin (2005). Low back pain in car drivers: A review of studies published 1975 to 2005. Journal of Sound and Vibration 298 (2006) 499–513.

L.C. (Eelco) den Boer and A. (Arno) Schroten (2007). Traffic Noise Reduction in Europe

M. Bovenzi (2005). Health effects of mechanical vibration. Clinical Unit of Occupational Medicine, Department of Public Health Sciences, University of Trieste, Italy.

Martin Fritza, Siegfried Fischerb, and Peter Bro¨ de (2005). Vibration Induced Low Back Disorders-Comparison of the Vibration Evaluation According To ISO 2631 with a Force-Related Evaluation

Mohzani Mokhtar, Sahrul Kamaruddin, Zahid A. Khan and Zulquernain Mallick (2007). A Study on the Effects of Noise on Industrial Workers in Malaysia

Michael Feldman (2011). Hilbert Transform Applications in Mechanical Vibration

Martin G.R. Toward, Michael J. Griffin (2011). The Transmission of Vertical Vibration through Seats: Influence of the Characteristics of the Human Body. Journal of Sound and Vibration 330: 6526 – 6543.

Magnusson ML, Pope MH, Wilder DG, Areskoug B. Are occupational drivers at an increased risk for developing musculoskeletal disorders? Spine 1996;21:710–7.

Massimo Bovenzi, Francesca Rui, Corrado Negro, Flavi D'Agostin,Giuliano Angotzi, Sandra Bianchi, Lucia Bramanti, GianLuc Festa,Silvana Gattib, Iole Pinto, Livia Rondina & Nicola Stacchini (2006). An epidemiological study of low back pain in professional drivers. Journal of Sound and Vibration 298 (2006) 514–539.

Naser Nawayseh & Michael J.Griffin (2010).Power absorbed during whole-body vertical vibration: Effects of sitting posture, backrest, and footrest. Journal of Sound and Vibration 329 (2010) 2928–2938.

N. Kumar Kittusamy & Bryan Buchholz (2004). Whole-body vibration and postural stress among operators of construction equipment: A literature review. Journal of Safety Research 35 (2004) 255– 261.

Neil J. Mansfielda, and Setsuo Maedab (2006). The Apparent Mass of the Seated Human Exposed To Single-Axis and Multi-Axis Whole-Body Vibration

Olanrewaju O. Okunribido, Steven J. Shimbles, Marianne Magnusson, Malcolm Pope (2006). City bus driving and low back pain: A study of the exposures to posture demands, manual materials handling and whole-body vibration. Department of Environmental and Occupational Medicine, Liberty Safework Research Centre, University of Aberdeen, Foresterhill, Aberdeen AB25 2ZP, Scotland.

Occupational Health Clinics for Ontario Workers Inc. Ergonomics and Driving

O.O. Okunribido, M. Magnusson & M.H. Pope (2006). Low back pain in drivers: The relative role of whole-body vibration, posture and manual materials handling. Journal of Sound and Vibration 298 (2006) 540–555.

PICU, A. (2009). Whole Body Vibration Analysis for Bus Drivers. SISOM and Session of the Comission of Acoustics, pp. 428 – 431.

Prue Cormie, Russell S. Deane, N. Travis Triplett, & Jeffrey M. Mcbride (2006). Acute effects of whole-body vibration on muscle activity, strength, and power. Neuromuscular Laboratory, Department of Health, Leisure & Exercise Science, Appalachian State University,Boone, North Carolina 28608.

Patrice (Manu) Donati, Marianne Schust, Janusz Szopa, Jukka Starck, Eduardo Gil Iglesias, Luis Pujol Senovilla, Siegfried Fischer, Eva Flaspöler, Dietmar Reinert, and Rick Op de Beeck (2008). Workplace Exposure to Vibration in Europe

Professor M.J. Griffin & Dr H.V.C. Howarth, Mr P M Pitts, Dr S Fischer & Mr U Kaulbars, Dr P.M. Donati, and Mr P.F. Bereton (2006). Guide to Good Practice on Whole Body Vibration

Rules on Drivers' Hour and Tachograph. Passenger Carrying Vehicles in GB and Europe. An executive agency of the Department for Transport. VOSA/CIS/2175/FEB 11.

Ruth K. Raanaas, Donald Anderson (2007). A questionnaire survey of Norwegian taxi drivers' musculoskeletal health, and work-related risk factors. Centre for Occupational and Environmental Medicine, Rikshospitalet University Hospital, Oslo, Norway.

Ramakrishnan Mani, Stephan Milosavljevic and S. John Sullivan (2011). The Influence of Body Mass on Whole-Body Vibration: A Quad-Bike Field Study

Ren Dong, Kristine Krajnak,Oliver Wirth & John Wu (2006). Proceedings of the First American Conference on Human Vibration. Department of Health and Human ServicesCenters for Disease Control and PreventionNational Institute for Occupational Safety and Health.

Sinha A. (2010). Vibration of Mechanical Systems. The Pennsylvanis State University. 2010 Published in the United States of America by Cambridge University Press, New York.

Silviu NASTAC & Mihaela PICU (2010). Evaluating methods of Whole-body-vibration exposure in trains. University Of Galatifascicle Xiv Mechanichal Engineering, ISSN 1224-5615.

Stephan Milosavljevic, Frida Bergman, Borje Rehn & Allan B.Carman (2010). All-terrain vehicle use in agriculture: Exposure to whole body vibration and mechanical shock. Applied Ergonomics 41 (2010) 530–535.

Salam Rahmatalla & JonathanDeShaw (2011). Effective seat-to-head transmissibility in Whole-body vibration: Effects of posture and arm position. Journal of Sound and Vibration 330 (2011) 6277–6286.

Shyamal, K., Sharma, L. and Kaur, S. 2010. Effects of occupational exposure to whole body vibration in tractor driver with low back pain in Punjab. Anthropologist, **12**: 183-18.

S. Rahmatalla, T. Xia, M. Contratto, G. Kopp, D. Wilder, L. Frey Law & James Ankrum (2008). Three-dimensional motion captures protocol for seated operator in whole body vibration. International Journal of Industrial Ergonomics 38 (2008) 425–433.

Stephan Milosavljevic, Frida Bergman, Borje Rehn & Allan B.Carman (2010). All-terrain vehicle use in agriculture: Exposure to whole body vibration and mechanical shock. Applied Ergonomics 41 (2010) 530–535.

Scott Haynes & Karen Williams (2008). Impact of seating posture on user comfort and typing performance for people with chronic low back pain. International Journal of Industrial Ergonomics 38 (2008) 35–46.

T.C Fai, F. Delbressine and M. Rauterberg (2007). Vehicle Seat Design: State Of The Art and Recent Development. Group Faculty of Industrial Design, Technical University Eindhoven.

Taryn E.Hill, Geoffrey T.Desmoulin, and Christopher J.Hunter (2009). Is Vibration Truly an Injurious Stimulus in the Human Spine? Elsevier Ltd.

V. Krishna Murthy, Ahmad Kamruzzaman Majumder, Sanjay Nath Khanal, Deepak Prasad Subedi (2007). Assessment of Traffic Noise Pollution in Banepa, a Semi Urban Town Of Nepal

W. Wang, S. Rakheja & P.-E´. Boileau (2006). The role of seat geometry and posture on the mechanical energy absorption characteristic of seated occupants under vertical vibration. International Journal of Industrial Ergonomics 36 (2006) 171–184.

Yu Mingjiu, Ye Jun, Zhang Quan & Lu Changde. Ergonomics Analysis for sitting posture and chair. College of Mechanical and Electrical Engineering, Northwestern Polytechnical University. Ronnie Lundstro, Patrik Holmlund & Lennart Lindberg (1998). Absorption of energy during vertical whole-body vibration exposure. Journal of Biomechanics 31 (1998) 317-326.

APPENDIX A1

BAHAGIAN A – MAKLUMAT RESPONDEN
Arahan: Sila jawab semua soalan pada bahagian yang disediakan dan tandakan (√)

1. Umur : __________________ tahun

2. Jantina : 1 ☐ Lelaki

   2 ☐ Perempuan

3. No telefon bimbit (jika ada) : ____________________________________

4. Bangsa : 1. ☐ Melayu 3. ☐ India

   2. ☐ Cina 4. ☐ Lain-lain;

   Nyatakan: ______________________

5. Status perkahwinan

   1. ☐ Bujang 3. ☐ Bercerai/Kematian suami @ Isteri

   2. ☐ Berkahwin

6. Tahap pendidikan

   1. ☐ SRP/ PMR

   2. ☐ SPM

   3. ☐ STPM / Diploma

   4. ☐ Ijazah

7. Pendapatan (sebulan)

   i. Gaji kasar [Elaun + Kerja lebih masa (OT)]: RM____________________

8. Adakah anda merokok?

   0. ☐ Ya 1. ☐ Tidak

   i. Jika Ya, nyatakan berapa batang dalam sehari: ______________ batang.

BAHAGIAN B – MAKLUMAT PEKERJAAN

1. Pernahkah anda bekerja di tempat lain sebelum ini?

   1. ☐ Ya　　　2. ☐ Tidak

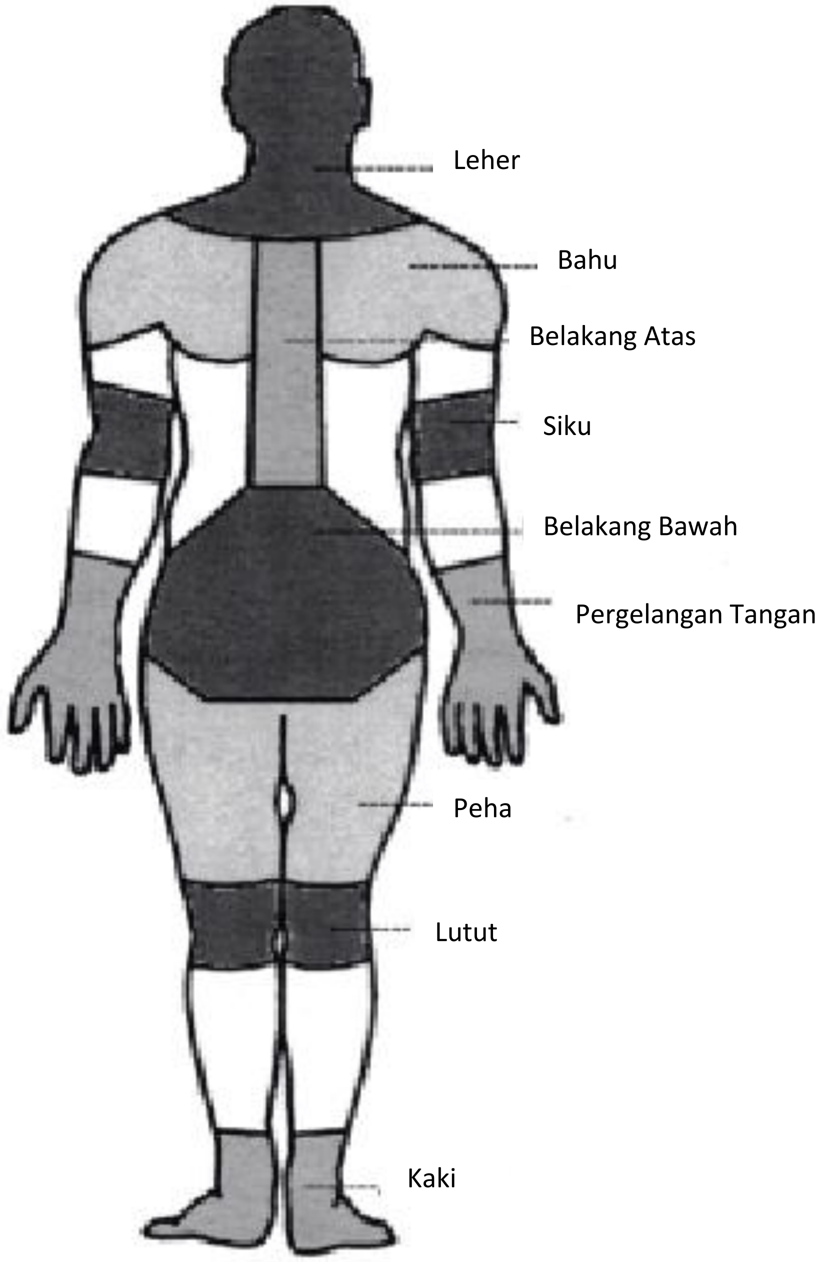
2. Berapa lamakah anda bekerja sebagai pemandu bas. _______________ tahun

3. Sila nyatakan purata tempoh masa anda bekerja (termasuk kerja lebih masa) jam / hari.

   ____

4. Berapa lamakah jumlah masa yang diberikan untuk anda berehat dalam tempoh bekerja? ___________ jam _____________ minit

<u>Gambarajah di bawah menunjukkan bahagian badan manusia. Sila rujuk gambarajah ini bagi menjawab soalan Bahagian C.</u>



BAHAGIAN C – MASALAH OTOT RANGKA (MSD)

Jika jawapan anda bagi soalan kotak (A) adalah TIDAK, anda tidak perlu menjawab soalan-soalan kotak (B) dan kotak (C).

Bahagian Badan	Adakah anda mengalami masalah bila-bila masa, di dalam hidup anda. (A)	Adakah anda hanya mengalami masalah bila-bila masa, di dalam tempoh 12 bulan kebelakangan ini. (B)	Adakah anda mengalami masalah bila-bila masa, di dalam tempoh 7 hari kebelakangan ini? (C)
	(Perit, sakit, tidak selesa pada bahagian anggota berikut)		
1. Tengkuk	☐ Ya ☐ Tidak	☐ Ya ☐ Tidak	☐ Ya ☐ Tidak
2. Bahu	☐ Ya ☐ Tidak	☐ Ya ☐ Tidak	☐ Ya ☐ Tidak
3. Satu / kedua belah siku	☐ Ya ☐ Tidak	☐ Ya ☐ Tidak	☐ Ya ☐ Tidak
4. Satu / kedua belah tangan	☐ Ya ☐ Tidak	☐ Ya ☐ Tidak	☐ Ya ☐ Tidak
5. Belakang atas	☐ Ya ☐ Tidak	☐ Ya ☐ Tidak	☐ Ya ☐ Tidak
6. Belakang bawah	☐ Ya ☐ Tidak	☐ Ya ☐ Tidak	☐ Ya ☐ Tidak
7. Satu/ kedua belah peha	☐ Ya ☐ Tidak	☐ Ya ☐ Tidak	☐ Ya ☐ Tidak
8. Satu/ kedua belah lutut	☐ Ya ☐ Tidak	☐ Ya ☐ Tidak	☐ Ya ☐ Tidak
9. Satu / kedua belah kaki	☐ Ya ☐ Tidak	☐ Ya ☐ Tidak	☐ Ya ☐ Tidak

10. Pernahkah anda mengalami masalah sakit belakang bawah (sakit / tidak selesa)?

    1. ☐ Ya 2. ☐ Tidak

    Jika jawapan anda Tidak, tidak perlu menjawab soalan 12-21.

11. Adakah anda pernah mengalami kesakitan / ketidakselesaan yang spesifik pada bahagian lumbar (belakang bawah) yang terjadi kurang dari tujuh hari?

    1. ☐ Ya 2. ☐ Tidak

12. Adakah anda pernah mengalami kesakitan / ketidakselesaan yang tidak spesifik pada bahagian lumbar yang terjadi di antara 7 hari – 7 minggu?

    1. ☐ Ya 2. ☐ Tidak

13. Adakah anda pernah mengalami kesakitan / ketidakselesaan yang tidak spesifik pada bahagian lumbar yang terjadi lebih daripada 7 hari – 7 minggu?

    1. ☐ Ya 2. ☐ Tidak

14. Pernahkah anda di masukkan ke hospital kerana masalah sakit belakang?

    1. ☐ Ya 2. ☐ Tidak

15. Adakah masalah sakit belakang menyebabkan aktiviti anda berkurang sepanjang 12 bulan kebelakangan ini?

    a. Aktiviti kerja (di rumah / luar rumah)

    1. ☐ Ya 2. ☐ Tidak

    b. Aktiviti masa lapang

    1. ☐ Ya 2. ☐ Tidak

16. Pernahkah anda berjumpa doctor, ahli fisioterapi, perubatan tradisional atau ahli-ahli perubatan yang lain kerana masalah sakit belakang bawah semenjak 12 bulan yang lalu?

    1. ☐ Ya 2. ☐ Tidak

17. Apakah pendapat anda tentang sakit belakang bawah yang anda alami ini?

    1. ☐ Ringan 3. ☐ Sederhana

    2. ☐ Sakit teruk 4. ☐ Tidak boleh tahan sakit

18. Adakah masalah ini disebabkan oleh kerja anda sebagai pemandu bas?
    1. ☐ Setuju
    2. ☐ Tidak setuju

19. Adakah masalah kesakitan menjejaskan prestasi kerja anda sebagai pemandu bas?
    1. ☐ Setuju
    2. ☐ Tidak setuju

20. Adakah anda pernah malaporkan sakit belakang yang dialami kepada pihak atasan ?
    1. ☐ Ya 2. ☐ Tidak

    Jika Ya, sila jawab soalan 20.

20. Adakah pihak atasan anda mengambil sebarang tindakan bagi mengatasi masalah ini?
    1. ☐ Ya ☐. Tidak

21. Adakah pekerjaan anda melibatkan pekerjaan yang berulang-ulang?
    1. ☐ Ya 2. ☐ Tidak

22. Berapa ramai orang yang bertugas dalam kumpulan / unit anda?
    1. ☐ Saya kerja berseorangan
    2. ☐ 2-3 orang

23. Adakah pekerjaan anda memerlukan aktiviti fizikal yang cepat dan berterusan?
    1. ☐ Ya 2. ☐ Tidak

24. Adakah pekerjaan anda memerlukan kekuatan fizikal yang sangat banyak?
    1. ☐ Ya 2. ☐ Tidak

25. Adakah anda mempunyai masa yang cukup untuk menyudahkan kerja?
    1. ☐ Ya 2. ☐ Tidak

26. Adakah pekerjaan anda sering memerlukan anda mngalih/ mengangkat benda-benda yang berat?
    1. ☐ Ya 2. ☐ Tidak

27. Adakah pekerjaan anda sangat sibuk?
    1. ☐ Ya 2. ☐ Tidak

28. Adakah anda sering bekerja dengan kedududkan kerja yang tidak selesa dalam jangkamasa yang lama?
    1. ☐ Ya 2. ☐ Tidak

29. Adakah anda boleh berehat sekejap jika anda mahu?
    1 ☐ Ya 2. ☐ Tidak

30. Adakah rakan-rakan sekerja anda membantu bagi memastikan kerja-kerja disiapkan?

1 ☐ Ya 2. ☐ Tidak

31. Adakah anda bebas membuat keputusan untuk bercuti?

1. ☐ Ya 2. ☐ Tidak

32. Adakah anda menentukan sendiri masa kerja anda?

1. ☐ Ya 2. ☐ Tidak

BAHAGIAN D- MASALAH SAKIT BELAKANG (Soal Selidik Roland Morris Disability)

Apabila bahagian belakang anda berasa sakit, anda dapati bahaawa sukar untuk melakukan perkara-perkara yang biasa anda lakukan.

Tandakan (√) pada penyataan yang menggambarkan anda baru-baru ini.

No	Jawapan	Soalan
1		Saya duduk di rumah hampir setiap masa disebabkan oleh masalah belakang yang saya alami
2		Saya berjalan lebih lambat berbanding biasa disebabkan oleh masalah belakang yang saya alami
3		Disebabkan oleh masalah belakang saya, saya tidak dapat melakukan apa-apa kerja yang selalu saya lakukan di sekeliling rumah.
4		Disebabkan oleh masalah belakang saya, saya terpaksa menggunakan susur tangan untuk menaiki tangga.
5		Disebabkan oleh masalah belakang saya, saya lebih kerap berbaring untuk berehat.
6		Disebabkan oleh masalah belakang saya, saya terpaksa berpaut pada sesuatu untuk bangun pada kerusi.
7		Disebabkan oleh masalah belakang saya, saya memerlukan bantuan orang lain untuk melakukan kerja untuk saya.
8		Saya memakai pakaian lebih lambat daripada biasa disebabkan oleh masalah belakang yang saya alami.
9		Saya hanya boleh berdiri untuk masa yang singkat sahaja disebabkan oleh masalah belakang yang saya alami.
10		Disebabkan oleh masalah belakang saya, saya cuba untuk tidak membongkok atau melutut.
11		Saya merasa sukar untuk bangun dari kerusi disebabkan oleh masalah belakang yang saya alami.
12		Bahagian belakang atau kaki saya berasa sakit hamper setiap masa.
13		Saya sukar untuk berpusing di atas katil disebabkan oleh masalah belakang saya.
14		Saya menghadapi masalah untuk memakai stokin disebabkan oleh masalah belakang yang saya alami.
15		Saya berkurangan tidur yang mencukupi disebabkan oleh masalah belakang yang saya alami
16		Saya terpaksa menghindarkan daripada melakukan kerja berat di rumah disebabkan oleh masalah belakang yang saya alami.
17		Disebabkan oleh masalah belakang saya, saya menjadi cepat marah, kepada orang lain berbanding biasa.
18		Disebabkan oleh masalah belakang yang saya alami, saya naik ke tingkat atas rumah lebih lambat daripada biasa.

SKOR =

BAHAGIAN E: KETIDAKUPAYAAN LENGAN, BAHU DAN TANGAN (Disability of the arm. shoulder. and hand (dash))

Sila tandakan keupayaan anda untuk melakukan aktiviti berikut sepanjang minggu yang lalu dengan membulatkan angka di bawah bagi tindakbalas yang sepatutnya.

		Tahap				
Bil.	**Perkara**	Tidak Susah	Sedikit susah	Sederhana susah	Sangat susah	Tidak mampu
1	Membuka balang yang baru atau ketat	1	2	3	4	5
2	Menulis	1	2	3	4	5
3	Memulas kunci	1	2	3	4	5
4	Menyediakan makanan	1	2	3	4	5
5	Menolak pintu yang berat	1	2	3	4	5
6	Meletakkan barang di atas para yang melepasi kepala	1	2	3	4	5
7	Melakukan kerja-kerja rumah yang berat (cth: membasuh lantai, mencuci tingkap)	1	2	3	4	5
8	Berkebun atau melakukan kerja Lapangan	1	2	3	4	5
9	Mengemas katil	1	2	3	4	5
10	Membawa beg membeli belah atau beg bimbit	1	2	3	4	5
11	Membawa barang yang berat (melebihi 4.5 kg)	1	2	3	4	5
12	Menukar mentol lampu di bahagian atas	1	2	3	4	5
13	Membasuh atau mengeringkan rambut	1	2	3	4	5
14	Membasuh bahagian belakang tubuh	1	2	3	4	5
15	Menyarung baju sejuk	1	2	3	4	5
16	Menggunakan pisau untuk menghiris makanan	1	2	3	4	5
17	Aktiviti rekreasi yang sedikit tenaga (cth; mengait, bermain kad)	1	2	3	4	5
18	Aktiviti rekreasi di mana anda memerlukan daya atau tekanan ke etas tangan, bahu atau lengan anda (cth; golf, tennis, berenang)	1	2	3	4	5
19	Aktiviti rekreasi di mana anda boleh menggerakkan tangan dengan bebas (cth; bermain badminton, bola jaring)	1	2	3	4	5

20	Mengendalikan kenderaan (bergerak dari satu tempat ke suatu tempat yang lain)	1	2	3	4	5
21	Aktiviti seksual	1	2	3	4	5
22	Sepanjang minggu lalu, sejauh manakah tangan, bahu atau lengan anda mengalami masalah ketika melakukan kegiatan sosial yang biasa dilakukan bersama keluarga, rakan, jiran atau kumpulan.	1	2	3	4	5
23	Sepanjang minggu lalu, adakah kerja atau kegiatan harian anda terbatas disebabkan masalah tangan, bahu atau lengan anda?	1	2	3	4	5
24	Kesakitan tangan, bahu atau tangan semasa anda melakukan apa jua aktiviti.	1	2	3	4	5
25	Terasa seperti dicucuk jarum di bahagian tangan, bahu atau lengan.	1	2	3	4	5
26	Kebas tangan, bahu atau lengan.	1	2	3	4	5
27	Sepanjang minggu lalu, sejauh mana anda merasa kesukaran untuk tidur disebabkan kesakitan di dalam tangan, bahu atau lengan.	1	2	3	4	5
28	Saya rasa kurang cergas, kurang keyakinan atau tidak berguna disebabkan masalah tangan,bahu atau lengan.	1	2	3	4	5

MODUL KERJA

Soalan seterusnya mengenai kesan masalah tangan, bahu atau lengan terhadap keupayaan anda melakukan kerja (termasuk membina rumah jika itu adalah kerja utama anda)

Sila nyatakan apakah jenis pekerjaan anda:

Saya tidak bekerja ☐ (anda terkecuali dari seksyen ini). Sila bulatkan angka yang paling baik untuk menerangkan keadaan fizikal anda untuk beberapa minggu yang lalu. Adakah anda mengalami sebarang kesukaran:

		Tahap				
Bil	**Perkara**	Tidak Susah	Sedikit susah	Sederhana susah	Sangat susah	Tidak mampu
1	Menggunakan teknik biasa semasa menggunakan instrument dan bersukan.	1	2	3	4	5
2	Menggunakan musical instrument atau bersukan disebabkan oleh kesakitan lengan, bahu atau tangan.	1	2	3	4	5
3	melakukan kerja anda dengan sebaik mungkin	1	2	3	4	5
4	menghabiskan masa yang sepatutnya dihabiskan untuk menjalankan tugas.	1	2	3	4	5

BAHAGIAN F – MAKLUMAT KESIHATAN SECARA UMUM (GHO -12)

Kami ingin mengetahui kesihatan anda secara umum, dalam beberapa minggu sebelum ini.

Sila bulatkan jawapan yang paling sesuai menggambarkan diri anda.

A. Kurang dari biasa

B. Sama seperti biasa

C. Lebih dari biasa

D. Berlebihan dari biasa

No	Soalan	Jawapan			
1	Kebolehan untuk member tumpuan / memfokus	**A**	**B**	**C**	**D**
2	Kesukaran untuk tidur	**A**	**B**	**C**	**D**
3	Memainkan peranan dalam sesuatu perkara	**A**	**B**	**C**	**D**
4	Kebolehan membuat keputusan	**A**	**B**	**C**	**D**
5	Mengalami tekanan	**A**	**B**	**C**	**D**
6	Kesukaran menghadapi masalah	**A**	**B**	**C**	**D**
7	Seronok melakukan aktiviti harian	**A**	**B**	**C**	**D**
8	Berani menghadapi masalah	**A**	**B**	**C**	**D**
9	Tidak gembira dan tertekan	**A**	**B**	**C**	**D**
10	Tiada kenyakinan diri	**A**	**B**	**C**	**D**
11	Merasa diri tidak berguna	**A**	**B**	**C**	**D**
12	Gembira apabila hanya ada sebab	**A**	**B**	**C**	**D**

SKOR GHQ =

BAHAGIAN G – FAKTOR-FAKTOR LAIN

No	Antropometri Responden	Ukuran (cm)
1	Berat (kg)	
2	Tinggi (berdiri)	
3	BMI	

4. Nyatakan kenderaan yang di gunakan untuk pergi / balik kerja?

1. ☐ Motosikal
2. ☐ Kereta
3. ☐ Bas
4. ☐ LRT / Komuter
5. ☐ Berjalan kaki

5. Adakah anda melakukan aktiviti fizikal / kerja lain sebelum dating bekerja? (cth: kerja sambilan)

1. ☐ Ya 2. ☐ Tidak

6. Adakah anda terlibat dengan aktiviti-aktiviti di bawah?

a (i-iv)

i. Persatuan / sukarela

1. ☐ Ya 2. ☐ Tidak

ii. Menjaga anak, memasak, melakukan kerja rumah

1. ☐ Ya 2. ☐ Tidak

iii. Berkebun

1. ☐ Ya 2. ☐ Tidak

iv. Aktiviti luar / bersukan/beriadah

1. ☐ Ya 2. ☐ Tidak

b. Sebarang aktiviti di atas **(di isi oleh penyelidik)**

1. ☐ Ya   2. ☐ Tidak

7. Adakah anda merasakan tugas (di rumah, kerja lain) adalah lebih berat jika disbanding dengan tugas sebagai pemandu bas?

1. ☐ Ya   2. ☐ Tidak

APPENDIX A2

Kaji selidik ini adalah untuk kegunaan Projek Sarjana Muda pelajar Universiti Malaysia Pahang.

Jantina: ___________________ Umur: ___________________

Tahun kerja: ___________________ Jenis bas: ___________________

Destinasi: ___________________ Kadar kelajuan: ___________________

Masa perjalanan: ___________________

***Sila tanda jawapan mengikut skala di bawah ini.**

1-Setuju 3-Tidak setuju 5-Tidak pasti

2-Sangat setuju 4-Sangat tidak setuju

A. Keselesaan	1	2	3	4	5
1. Kerusi boleh diubahsuai mengikut keselesaan sendiri.					
2. Keselesaan tempat duduk.					
3. Keadaan jalan baik.					
4. Masa perjalanan terlalu lama.					

B. Faktor sekeliling	1	2	3	4	5
1. Selalu mengalami masalah sakit pinggang.					
2. Mendapat rehat yang secukupnya.					
3. Tangan selalu mengalami kelenguhan.					
4. Perjalanan malam lebih cepat berbanding perjalanan siang hari.					
5. Saya pemandu berhemah.					
6. Jumlah penumpang mempengaruhi kadar kelajuan bas.					