A STUDY OF WHOLE BODY VIBRATION EXPOSURE FOR A BUS DRIVER ALONG KUANTAN TO JOHOR BHARU.

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

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DEDICATION

I specially dedicate to my beloved parents, Luqman Zaki
and those who have guided
and motivated me for this project

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At last it is successfully to complete a report within the prescribed time after a lot of effort. However, without the help of many people, this report may not be completed. First and firmest I show my gratitude to Allah because Allah gives me strength in order to finish this report.

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ABSTRACT

In whole body vibration is important to be learned and discovered because it can reduce accidents. Statistics show accidents involving public transport such as buses are often happen. Therefore, a bus driver must be disclosed in more detail about the whole body vibration. This is because when a bus had a higher Whole Body Vibration throughout the body, the bus driver should take a rest for a moment before continuing his journey. The main purpose of this study was to investigate the Whole Body Vibrations (WBV) throughout the body to a bus driver who drives a bus in a sitting position. In addition, this study is to investigate the noise produced on the bus during the journey to the destination which is from Kuantan to Johor Bahru. There are two steps taken to obtain data which are survey questions as well as direct observation. For the survey, a total of 20 bus drivers were randomly selected to answer the survey form provided. The survey form consists of part A until G. Direct observation is a process where everything that happens along the way is recorded to facilitate discussions of the process. To obtain the value of whole body vibration and noise effects, instruments called dosimeter and accelerometer sensor is used. Accelerometer sensor is a device to measure the vibrations. This device is placed on the driver seat. Later, the bus driver would sit on the equipment along the way to the destination. Then, all data will be entered into a program at Quest Software to make graphs. Overall, the vibrations are recorded for 4jam of 0.5467 m / s^2. Data were compared with data from ISO 2631. According to ISO 2631, for the time worked 4hours, RMS value is 4 m / s^2. Thus, the value obtained shall not exceed the value of ISO 2631. For sound effects, the trip takes about 6 hours should not exceed 92dB. The results recorded are 95.6dB. This value exceeds its recoverable amount. Also studied was about back pain and muscle aches or arthritis. Many have complained that they never or always these problems. In conclusion, the higher the value of the vibration in a bus, a bus driver will feel back pain or aching muscles or joints frequently. Therefore, the vibration must always review and monitored at all times.

ABSTRAK

Getaran pada seluruh tubuh badan adalah penting untuk dipelajari dan didalami kerana pendedahan kepada nya boleh mengurangkan kemangalan. Statistic menunjukkan kemalangan yang melibatkan kenderaan awam seperti bas adalah sering kerap berlaku. Oleh sebab itu, seorang pemandu bas haruslah didedahkan dengan lebih mendalam tentang getaran pada seluruh tubuh badan. Ini kerana apabila seorang bas mengalami getaran seluruh badan secara kuat, pemandu bas itu boleh berhenti rehat seketika sebelum menyambung perjalanannya. Tujuan utama kajian ini adalah untuk mengkaji getaran diseluruh badan untuk seorang pemandu bas yang memandu bas dalam posisi duduk. Selain itu, kajian ini juga adalah untuk mengkaji bunyi yang dihasilkan di dalam bas sepanjang perjalanan menuju ke destinasi iaitu dari Kuantan ke Johor Bharu. Langkah yang diambil untuk mendapatkan data dibahagikan kepada dua iaitu soalan survey dan juga pemerhatian secara langsung. Bagi survey, seramai 20 orang pemandu bas dipilih secara rawak untuk menjawab boring survey yang disediakan. Boring survey itu mengandungi beberapa bahagian besar seperti maklumat peribadi dan sebagainya. Pemerhatian secara langsung adalah proses di mana segala apa yang berlaku sepanjang perjalanan dicatat untuk memudah kan proses membuat perbincangan. Bagi mendapatkan nilai Getaran seluruh tubuh dan juga kesan bunyi, alat yang diberi nama “Dosimeter” dan “accelerometer sensor” digunakan. Accelerometer sensor adalah alat untuk mengukur getaran. Alat ini diletakkan di atas kerusi pemandu bas. Kemudiannya, pemandu bas tersebut akan duduk di atas alat itu sepanjang perjalanan menuju ke destinasi.Kemudian, semua data akan dimasukkan ke satu program Quest Software untuk di jadikan graf. Secara keseluruhannya, nilai Getaran yang direkod untuk 4jam adalah sebanyak 0.5467 m/s^2. Data yang diperoleh dibandingkan dengan data dari ISO 2631. Menurut ISO 2631, untuk 4jam masa bekerja nilai RMS adalah 4 m/s^2. Maka, nilai yang diperoleh adalah tidak melebihi nilai dari ISO 2631. Bagi kesan bunyi pula, untuk perjalanan yang mengambil masa selama 6jam sepatutnya tidak melebihi 92dB. Keputusan yang direkod adalah 95.6dB. Nilai ini adalah melebihi nilai yang sepatutnya. Turut dikaji adalah mengenai sakit belakang dan juga sakit-sakit urat atau sendi. Ramai yang mengadu bahawa mereka pernah atau sentiada mengalami masalah tersebut. Kesimpulannya, semakin tinggi nilai getaran dalam sebuah bas, makin kuat seorang pemandu bas akan merasa sakit belakang atau sakit-sakit urat atau sendi. Oleh sebab itu, getaran haruslah sentias dikaji dan dipantau setiap masa.

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RMS	Root mean square
WBV	Whole Body Vibration
VDV	Vibration Dose Value
PEL	Permissible Exposure Limit

CHAPTER 1

INTRODUCTION

1.1 Introduction

Whole body vibration (WBV) is when we applied through a supporting surface such as a seat or a platform. This statement also defined the basicentric coordinates system used in the standards, (O. Bruyere, et al. 2003). Exposure of the body and vibration or shock of this kind produces a complex distribution of oscillation motions and forces within the body which can degrade health, impair activities, impair comfort and cause motion sickness,(O.O. Okunribido et al. 2006). Degraded health includes back ache and spinal damage resulting from exposure to seat vibration. Almost any part of the body can be damaged by vibration or shock, in some cases by a single event, in others by long term exposure. Vibration can disturb one's comfort. Low frequency vibration can cause motion sickness syndrome. WBV measurements were performed according to the International Standard ISO guidelines using a tri-axial seat accelerometer, (I J H Tiemessen et al. 2008). Noise is unwanted sound and measured in dB or sound power level to avoid hearing damage and to fulfil regulations. (P. H. T. Zannin, 2008).

1.2 Background of study

Whole body vibration is an oscillation that is a movement back and forth as time passes. An example is a swinging pendulum. The source of all vibrations is forces. A force causes initial movement and force sustains the continued motion. A heavy spot on a rotor causes a centrifugal force as it rotates. This force going around during rotation creates a strain on the shaft which transmits through the bearings to the housing. Mass imbalanced is just one force causing vibration in machinery. There are other forces that can set machinery into oscillatory motion. (N. K. Kittusamy et al. 2004).

Even under steady-state operating conditions, the vibrations generated is rarely perfectly repetitive in amplitude. It must be recognized that rotating machinery is a dynamic condition and that other factors add into the total response, such as resonances, random effects due to turbulence and interference from the other sources. Nevertheless, many machine vibrations are repetitive, and they can be analysed as oscillatory motions. (M. Funakoshi et al. 2004)

Exposure to whole body vibration can cause physiological changes to the cardiovascular, respiratory and musculoskeletal system. Clinical affects attributed to whole body vibration include headache, motion sickness, sleep and visual disturbance. The only effect with reasonable evidence is low back pain. In drivers, low back pain may occur as a result of vibration, poor posture within the vehicle cab and other work duties. (D.J. Oborne, 2005).

Vibration, as well as Whole-body vibration, was commonly considered as an Occupational hazard and it has been highlighted for its detrimental effects on human condition and comfort. It is normally associated with lower back disorders, muscle and nerve tissue damage, Raynaud's Disease (vibration white finger) and interference with cognitive processes. Although vibration may produce undesirable side effects, several studies have shown the positive impacts of vibration (i.e. On the bone density of postmenopausal women and disabled children), back pain, stroke, multiple sclerosis and muscle spasticity of cerebral palsy sufferers. Physiologists and physiotherapists have also been reported to use vibration as a therapeutic. (A.D.Woolf et al. 2010).

1.3 Problem statement

As the bus undergo to a certain route, the bus driver for sure will spend most of their working time by sitting down on the driver seat. This is because they have to drive. Furthermore, the bus driver will also experience the low back pain. It is a must to study a way to help the bus driver to reduce the whole body vibration exposure along the journey. Most of the bus driver also lack of knowledge about whole body vibration and how can the whole body vibration effect the performance to drive. The collected data will be comparing to the exposure limit standard as per ISO 2631. By comparing the data, the conclusion either the bus stop at the right place to take rest will be reveal.

1.4 Objective of study

The study will be including Transnasional bus which undergoes the route from Kuantan to Johor Bharu. Objective for this study is:

a) To conduct the human perception as well as quantitative measurement of WBVs for bus driver along from Kuantan to Johor Bharu.
b) To conduct measurement of noise for bus driver and passenger.
c) To compare the collected data to the exposure limit standard as per ISO 2631.

1.5 Scope of study

The study will include the transnasional bus express. The route is from Kuantan to Johor Bharu. About 30 drivers from terminal Kuantan will be ask to fill a form of questionnaire. Collaboration with local agencies such as SIRIM and NIOSH also will be a most important. This is because; to get the actual data we have to ask from the Sirim and NIOSH. It also includes the time. The route to Johor Bharu is quite long. Therefore, the decided time is day and night. It is to compare if the vibration during day time is longer than night time.

1.6 Significant of study

This study is about whole body vibration that occurs in bus driver. This is also to study about the noise in the bus during the journey. This study is to help bus driver to aware about whole body vibration during driving. This is because whole body vibration may lead to degrade health, impair activities, impair comfort and cause motion sickness.

It is also a hope to reduce accident involving a bus. This study is also to help passengers and the bus driver to aware about the noise in the bus so that, their maintenance especially can be improved to reduce noise.

1.7 Structure of report

This report included four chapters. The first chapter is the introduction where it contain the introduction about whole body vibration and noise, the background so that we can briefly know about the study, the objective of the study, problem statement and also significant of the study. Significant of the study means what benefit can the bus driver and passenger can get from this study.

The second chapter is the literature review. Under this chapter, the previous study on whole body vibration and noise will be summarizing so that the idea can be develop. Under this chapter also will be include the impact for whole body vibration and noise. Under this chapter also, the parameter that cause the whole body vibration and noise also will be discuss. In conclusion, literature review is actually a way to a better understanding for the topic study.

The third chapter is methodology. This chapter will highlight the method to use in this study. A flow chart will also be including for an easier reference for this study. Under this topic, the subject also will be discussing. A simple procedure will be under this chapter. The result from the questionnaire also will be included in this chapter. The measurement for overall parameter will be stated clearly by using graph or pie chart will be shown. Also the instrument used to do the measurement will be shown. So, basically chapter 3 is the procedure to undergo the study.

The fourth chapter are the chapter that all the result and discussion will be display. Every graph or data collected will be put under this topic. All the result then will be discussed.

The last but not least chapter is chapter five. This chapter is the conclusion for the overall chapter one, two, three and four.

CHAPTER 2

LITERITURE REVIEW

2.1 Introduction.

Literature review helps in to undergo a research. Therefore, under this topic it is focusing on the definition for whole body vibration and also the definition for noise. Also included factors that may lead to whole body vibration become greater and also effect from the whole body vibration.

2.2 Definition for Whole Body Vibration (WBV) Exposure.

Everyday vibration occur either we notice it or not. Vibration can be known as oscillatory motions of solid bodies. Simple example for vibrating system is represented by a weight suspended on a spring and set into an up and down motion. The vibrating weight is displaced above and below an average position.

Vibration can be divided into two main parts:

i. Whole-body (WBV) - Where the vibration is transmitted to the body as a whole by its supporting surface. The mechanical vibration that, when transmitted to the whole-body, entails risks to the health and safety of workers, in particular, lower-back morbidity and trauma of the spine

ii. Segmental - The mechanical vibration that, when transmitted to the human hand arm system, entails risks to the health and safety of workers, in particular, vascular, bone or joint, neurological or muscular disorders.

According to a Handbook on Whole Body Vibration In Mining, vibration arises from various mechanical sources with which humans have physical contact. Vibration energy can be passed on to operators from vehicles on rough roads; vibrating tools; vibrating machinery; or vibrating work platforms and may give rise to adverse health effects. It can be transmitted through the feet and legs, the hands and arms but most commonly through the buttocks while seated in a vehicle. The magnitude of the effect of vibration depends on the severity and length of exposures.

Whole-body vibration (WBV) produces systemic effects on the entire body. Information regarding the chronic effects of WBV is still in infancy. However, there is abundant information regarding subjective responses to vibration. Some limitations of these studies are that they were performed in laboratory settings and that they only evaluated sinusoidal vibration, and thus are not representative of real-life conditions. (N. K. Kittusamy et al. 2005).

Whole-body vibration refers to those vibration responses which involve extensive regions of the human body and which are caused by vibration stimuli containing energy at relatively low frequencies, typically less than 100 Hz. Whole body vibration in passenger cars means that the person is exposed to vibration from the supporting surface which supports him/her i.e. the car seat. (D.D. I. Daruis et al. 2008)

Griffin (1990) suggested that a seated person may be exposed to both whole-body and local vibration of the head (e.g. from head or neck rest), the hands (e.g. on a steering wheel) and the feet (e.g. on the floor or pedal). The two main standards are BS6841 (British Standards Institution 1987) and ISO 2631-1 (International Organization for Standardization 1997). It is important to mention which standard is used for the measurement and evaluation because there are dissimilarities although almost identical, especially the frequency weightings to be used. (D.D. I. Daruis et al. 2008).

A major portion of the vibrations experienced by the occupants of an automobile enters the body through the seat. Whole-body vibrations, which are mainly vertical vibrations, tend to affect the human body the most. These vibrations are transmitted to the buttocks and back of the occupant along the vertebral axis via the base and back of the seat. Since the natural frequency for the human trunk falls in the range of 4-8 Hz, it is expected that the whole-body vibrations that will most largely affect passengers will occur in this frequency range. (T.C.Fai et al. 2008).

Whole body vibration should be measured at the interface between the body and the source of vibration. For seated person this involves the placement of accelerometers on the seat surface beneath the ischial tuberosities of subjects. Vibration is also sometimes measured at the seat back and also the feet and hands. Epidemiological data alone are not sufficient to define how to evaluate the whole body vibration so as to predict the relative risks to health from the different types of vibration exposure. A consideration of epidemiological data in combination with an understanding of biodynamic responses and subjective responses is used to provide current guidance.

Noise is unwanted sound and measured in dB or sound power level to avoid hearing damage and to fulfil regulations. A gold standard in predicting sound quality is still on its way (Bruel & Kjaer 2004), the common approach is to define an annoyance or an index which involves objective and subjective measures (Bodden 1997; Nor *et al.* 2008; Rossi *et al.* 2003). The objective measurements especially in measurement tools available in the market often comprises of these parameter such as loudness, sharpness, fluctuation strength and roughness. Then the objective and subjective assessments are correlated to usually produce acoustical or sound quality index

2.3 Vibration discomfort.

For very low magnitude, the percentage of persons who will be able to feel vibration and the percentage that will not be able to feel the vibration may be estimated. For higher vibration magnitudes, an indication of the extent of subjective reactions is available in a semantic scale of discomfort.

The relative discomfort caused by two or more alternative motions is often greater interest and can be predicted from measurements of the vibration. Vibration limits to prevent discomfort vary between different types of transport. The design limit depends on external factors and the comfort in alternative environments.

2.3.1 Effects of vibration magnitude.

The absolute threshold for the perception of vertical whole body vibration in the frequency range 1 to 100 Hz is very approximately 0.01ms $^{-2}$ will be noticeable. Magnitudes around 1 ms^{-2} rms are usually uncomfortable and magnitudes of 10ms^{-2} are usually dangerous. The precise values depend on vibration frequency and the exposure duration and they are different for other axes of vibration (Griffin, 1990).

Doubling the vibration magnitude produces an approximate doubling of the sensation of discomfort. A halving of vibration magnitude can therefore produce a very considerable improvement in comfort. For some types of whole body vibration, differences as small as 10% in the vibration magnitude will be detected by the majority people.

2.3.2 Effects of vibration frequency and direction.

The extent to which a given vibration acceleration will cause a larger or smaller effect on the body at different frequencies is reflected in frequency weightings, frequency capable of causing the greatest effect are given the greatest weight and others are attenuated in accord with their decreased importance.

Two different frequency weightings (one for vertical and one for horizontal vibration of seated or standing person) were presented in International Standard 2631 (1974,1985) and have been reproduced in other relevant standards. However, ISO 2631 has recently undergone major revision (International Organization for Standardization, 1997). The revision of International Standard has a form broadly similar to Bristish Standard 6841 (1987) but it contains various errors and inconsistencies that make it difficult to use.

2.3.3 Effects of vibration during duration.

Vibration discomfort tends to increase with increasing duration of exposure to vibration. The rate of increase may depend on many factors but a simple fourth power time-dependency is used to approximate how discomfort varies with duration of exposure from the shortest possible shock to a full day of vibration exposure. (M.J.Griffin, 2004).

2.4 Causes that lead to Whole Body Vibration (WBV) Exposure.

Nowadays, we even can still see the rough road and also poor work surface condition. 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.

Economic activity is another factor that can contribute to vibration. According to the fourth EWCS, about 24 % of all EU-27 workers reported being exposed to vibration at work at least a quarter of the time below shows exposure by sector, from which it is evident that most exposure is found in construction (63 % of workers), manufacturing and mining (44 %), agriculture and fishing (38 %), electricity, gas and water supply (34 %) and transport and communication (23 %).

Alem and Strawn et al. (1996) designed and evaluated an energy absorbing truck seat for a 5 ton military truck for increased protection from landmine blasts. Seat designers can use this method for evaluating seat comfort such as support, fitness and accommodation.

Cho and Yoon et al. (2001) developed a biomechanical model of humans on a seat with a backrest for evaluating the vehicular ride quality. Rakheja et al.(2007) was developed a model to study the seated occupant interactions with seat backrest and pan and biodynamic response under vertical vibration. Wang et al. was studied the role of seat geometry and posture on the mechanical energy absorption characteristics of seated occupants under vertical vibration. The results show that the absorbed power quantity increases approximately quadratically with the exposure level by the person. The results also reveal that the absorbed power is strongly dependent upon the individual anthropometry variables such as body mass, fat and mass index. But there is no real proof of the variables given.

Another factor that may lead to a higher value of Whole Body Vibration (WBV) Exposure is the type for the vehicle and also its design. If the vehicle does not have a better suspension system, they will face the higher WBV in it along the journey. Because of the suspension, it will give a rough ride.

Gender is also an important factor that cause to higher whole body vibration. According to research, Misael et al 2001. and thought women were, intuitively, more sensitive to vibration than men, when they looked at the curves obtained. However, when they analyzed the results using the non-parametric test of Mann-Whitney, they concluded that gender do not interfere on the volunteer's responses. (Misael et al 2001)

For an operator with longer work histories consistently reported greater percentages of symptoms, missed work, and physician visits than the less experienced group. For all body regions the percentage of work-related symptoms, missed work, and physician visits varied greatly among the five different types of equipment (backhoe, crane, pushcart/dozer, pull scraper, and end loader). Operators using older equipment reported a higher percentage of missed work and physician visits due to musculoskeletal symptoms than those using newer equipment, and those using a combination of both newer and older equipment. (N.K. Kumar et al. 2005).

Bottoms and Barber (1978) evaluated a tractor seat with a swivel of up to 20 degrees from the normal forward facing position. From their study, results showed a decrease in muscle activity in the shoulder and neck regions when the seat was swiveled up to 20 degrees. The way we placed the seat play most important. Measured angles of the body twist showed that the full potential benefit of the swivelling seat was not used by the subjects, although the mean twist between the shoulders and hips was reduced significantly with increased swivel angle. This study confirmed that a swivelling seat was of benefit to the tractor driver specifically performing tasks that required rearward visual monitoring.

Awkward postures during the operation of heavy construction equipment are a consequence of improper design and work procedures. Poor visibility of the task, limited room, and excessive forces required operating levers or the pedals, and improper seat designs are some of the characteristics of poorly designed vehicles. Awkward posture of any body part can result in increased risk of fatigue, pain, or injury if we still did not control it. Awkward posture is another important risk factor observed among operating engineers. (N.K. Kumar et al. 2005).

Awkward postures refer to joint positions significantly deviated from the neutral body postures and may include static positioning or constrained body postures (twisting or elevated positioning; Putz-Anderson, 1988). Exposure to awkward posture can result in localized fatigue or pain and contribute to the development of musculoskeletal disorders. The relationship between awkward posture and the development of musculoskeletal disorders of the neck, shoulder, and trunk has been reported recently (National Institute for Occupational Safety and Health [NIOSH], 1997).

The significance of assessing the postural requirements of operators exposed to whole-body vibration has been echoed in the recent literature (e.g., Bongers et al., 1988; Bongers, Hulshof, Dijkstra, & Boshuizen, 1990; Bovenzi & Zadini, 1992; Johanning, 1991). A study by Kittusamy and Buchholz (2001) evaluated postural stress during excavating operations by a pilot. They evaluated postural requirements of the operators performing trench digging operations on two different pieces of construction equipment. For both pieces of equipment, they found that the trunk was either flexed or twisted for at least 25% of the cycle time.

The right shoulders were elevated a majority of the cycle time and the neck was either flexed or twisted for at least 22% of the cycle time for operators of either pieces of equipment. Working posture is believed to be influenced by many factors including workstation layout, location and orientation of work, individual work methods, and the workers' anthropometric characteristics (Hsiao & Keyserling, 1990; Keyserling, Punnett, & Fine, 1988). Awkward posture is one of the important risk factors in the development of musculoskeletal disorders (Chaffin & Andersson, 1984; Keyserling et al., 1988; Putz-Anderson, 1988).

A number of studies have shown that working activities like lifting, carrying, pulling and pushing are related to MSP (Anannontsak and Puapan, 1996; Hoozemans et al., 1998; Macfarlane et al., 1997; Magnusson et al., 1996), and since taxi drivers frequently have to handle luggage this was considered to be another potential risk factor. Sleeping in a sitting posture may induce MSP because some parts of the body are necessarily kept in a cramped position, so sleeping in the car seat.

2.5 Impact on Whole Body Vibration (WBV) Exposure and noise.

Kelsey and White (1980) reported that prolonged periods of driving increased the risk of disc prolapses and vibration was given as one of several associated causes. Vibration puts the back muscles under stress which is augmented by the need to maintain balance and whole body vibration is a particular risk factor for the onset of low back pain in drivers when coupled with other activities such as loading and unloading truck.

The back is not the only anatomical area affected. The vibration effects of handheld power tools have been linked to a variety of hand and wrist disorders, often described as hand-arm vibration syndrome and more specifically includes carpal tunnel syndrome and Raynaud's phenomenon. (Bonney, 1995: Atterbury et al. 1996).

For example in mining field, NSW Joint Coal Board (1990) indicated that that jarring and shock were responsible for up to 30% of all back injuries in open-cut mines some of which were severe. As well a number of workers' compensation claims have been made for back and neck injuries over the last 20 years some of which may have arisen from long-term exposures to rough rides. In 1989 a Canadian study of underground load-haul-dump vehicles (LHDs), found that 20 of 22 tested vehicles exceeded the old International Standard six-hour limit in the z-axis (vertical direction through the body).

Long term use of vibrating power tools can result in a cumulative trauma injury called vibration induced white finger, Raynaud’s disease or hand vibration syndrome (Griffin and Bowenzi, (2002). HAVS arises from structural damage to blood affected hand or finger. In later stages of disease, the finger alternates between blanching (whiteness) and cyanosis (blueness), which is symptomatic lead to gangrene, requiring amputation of the affected finger.

According to Bovenzi.M (2005) studies, neurological disorders have suggested that sensory disturbances in the hands of vibration exposed workers are likely due to vibration induced impairment to various skins. Clinical and epidemiologic surveys have revealed an increase in sensorineural disorders with the increase of daily vibration exposure, duration of exposure, or lifetime cumulative vibration dose. The currently available epidemiologic data, however, are insufficient to outline the form of a possible exposure-response relationship for vibration induced neuropathy.

Bone and joint disorder may cause because of the long journey that a person may take. This is usually will be referring to the truck driver or the bus driver. Bovenzi.M (2005) stated that, Vibration-induced bone and joint disorders are a controversial matter. Various authors consider that disorders of bones and joints in the upper extremities of workers using hand-held vibrating tools are not specific in character and similar to those due to the ageing process and to heavy manual work.

Environmental noise is linked to sleep degradation effects such as difficulty in obtaining sleep, sleep duration, reduction in REM stages of sleep, induced physiological effects such as increased blood pressure and heart rate and secondary effects such as fatigue, increased stress, reduced mood and alertness. Sift workers and those sleeping in temporary accommodation are among the most sensitive to environmental noise.

Noise is a physical and social problem with several undesirable effects:

a) It can cause hearing loss if of sufficient effect (physical effect).

b) Causes annoyance (a physical effect), which can result in sleep disturbance, stress, tension and loss of performance.
c) Interferes with activities, such as speed communication, which in turn can cause annoyance and all of its associated effects.
d) Causes structural response (mechanical effect) which can cause structural failures, injury, and product liability.

2.6 Ways to reduce Whole Body Vibration (WBV) Exposure.

In order to reduce whole body vibration in our daily life especially in driving, the drivers should undergo training. Training in order to avoid potentially harmful vibration could prove useful and cost-effective. Awareness among the driver itself about whole body vibration is important in order to reduce accident.

Drivers' need to be aware of the conditions that cause rough rides and what constitutes damaging vibration. They also need the driving skills to avoid or reduce exposure and be given feedback on what constitutes an optimum speed for safety. A driver needs training because:

a) imparting skills and knowledge that can be tested (competencies)
b) raising awareness of the link between health and safety and workplace and equipment design
c) reinforcing safe procedures
d) informing employees of changes to policies
e) obtaining feedback from employees on problems and issues
f) teaching people how to identify and solve problems
g) ensuring that operators adjust their seats correctly so that they are comfortable and that they report any problems with seats
h) Informing employees of the importance of safety and the general principles of risk reduction.

Training on vibration should be used to raise awareness of the constitutes harmful vibration and its effects to their body or even to their driving. Also, to improve driver competencies and skills when they are working in rough conditions in a way that will not unnecessarily increase vibration exposure.

Design that minimizes the contact between the drivers and the seat will reduce whole body vibration. One study showed that a new car seat that tilted back of the seat down to minimize seat contact and included a padded protruding cushion for increased lumbar support decreased the amplitude of whole body vibration by about 30 5 (Makhsous et al. 2005). This kind of seating could possibly reduce the risk of musculokeletal disorders for drivers of trucks, cars and other vehicles. The important points to consider are:

a) Well-designed seats are important in reducing exposures to damaging vibration. Problems with seats can be rectified with a systematic and informed program of seat purchasing, installation, maintenance and repair. Training of drivers in the importance of seat adjustment is essential.
b) Features of a well-designed seat include suspension systems that do not magnify exposures and do not bottom out; and seat profiles that support the back and legs but do not restrict movement. Seats for drivers and passengers must have a well-shaped seat pad and backrest (particularly the lumbar support), as these are important in reducing vibration transmitted to the operator.
c) Different sized operators and drivers need to be able to adjust the seat height and distance from the controls. Often this is limited by the cab size. Seat suspension must be separate to seat height adjustment. This allows short and taller drivers to adjust both independently regardless of their weight.
d) Seats need to be maintained to the manufacturers' specifications and maintenance periods and hours of use need to be specified and logged. Major overhaul or replacement schedules should be nominated and specified by the manufacturer. If mining personnel are to carry out the maintenance they will need specific competency training by the manufacturer.

2.7 Standard for Whole Body Vibration.

2.7.1 Australian Standard (AS 2670.1, 1990)

The Australian Standard (AS 2670.1, 1990) was published in 1990. Stated in the Australian Standard (AS 2670.1, 1990), there are three criteria for exposure limits. They are;

a) Comfort - It is the concerned about the preservation comfort.
b) Fatigue - Relating to impaired working efficiency due to fatigue.
c) Health – Exposure limits. The exposure limit is set at approximately half the level considered.

2.7.2 International Standard (ISO 2631-1, 1997)

The International Standard (ISO 2631-1, 1997) is the mechanical vibration and shock evaluation of human exposure to Whole Body Vibration is mostly different to the Australian Standard (AS 2670.1, 1990).

2.7.3 International Standard Health Guidance

Vibration health exposures are classified as either being:

a) in the likely health risk zone - (likely health risk)
b) in the caution zone - (potential health risk)
c) Below the caution zone - (‘acceptable’ level of vibration).

The important point that we have to take note about the International Standard health guidance zones:

a) there are not sufficient data to show a quantitative relationship between vibration exposure and risk of health effects so the recommendations and exposure classifications are intended as guidance rather than strict limits

b) vibration exposure depends on the duration and level of vibration reaching the operator
c) it generally takes many years for the health effects of whole-body vibration to occur with the exception of one-off severe jolts that can cause immediate damage
d) the recommended exposure times do not predict possible immediate damage caused by a one-off jolt
e) in some cases prolonged sitting may be more of a problem than vibration and this could be overlooked when using the Standard
f) vibration is assessed in the worst axis, which is usually the z-axis (up and down). When vibration is high in all axes, (e.g. some dozer rides) the contribution from each axis is added to give the final exposure level.

2.8 Studies on Whole Body Vibration (WBV) Exposure for bus.

Okunribido O.O et al. (2006) had done a study of the exposures to posture demands, manual materials handling and whole-body vibration on city bus driving. According to Okunribido O.O et al. (2006) study's, 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.

The study is actually to investigate worker exposure to posture demands, manual materials handling (MMH) and whole body vibration as risks for low back pain (LBP). Their study has involving about 80 bus driver to answer a set of questionnaire survey form. They used three different models of bus which is a mini bus, a single-decker bus, a double decker bus. 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).

Szeto.G.P.Y et al. (2007) had done research on work related musculoskeletal disorders in urban bus Drivers of Hong Kong. This study aim to at investigating the prevalence and characteristics of WMSD in male and female bus drivers who operate double-deck buses in Hong Kong. In this study, the subjects are 481 bus drivers. 404 are males and the others 77 are females.

A set of questionnaire survey were distributed for them to answer. Questionnaire included questions on work, musculoskeletal complaints and perceived occupational risk factors associated with each discomfort. From Szeto.G.P.Y et al. (2007) studied, they get the result that male drivers had longer years of work experience according to the female. Neck, back, shoulder and knee/thigh areas had the highest 12-month prevalence rates ranging from 35% to 60%, and about 90% of the discomfort was related to bus-driving.

Another previous study is effects of seated whole boy vibration on seated postural sway. The objective of this study is to measure the acute effect of seated whole body vibrationon the postural control of the trunk during unstable seated balance. Slota.P.G. et al. (2007) stated that spinal stability is maintained through contributions from passive tissue stiffness, active muscular stiffness, and neuromuscular reflexes.

From previous study about bus driver's exposure to mechanical shocks due to speed done, Granlund.J and Brandt.A (2005) stated that, Many bus drivers are at risk for back diseases due to repeated shock exposure during their daily trips over traffic calming speed bumps. The studies objective is to investigate the vibration imposed on the driver from some twenty speed bumps in the Stockholm area (Sweden). It uses peak vibration shock values to predict compression stress in the spine, and reports equivalent daily static compression. The most impact and effect due to whole body vibration is the back pain or also known as back disorder.

The whole body vibration exposure is related to the road roughness, vehicle type and condition as well as with driving behaviour and speed. According to Granlund.J and Brandt.A (2005) 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.

2.9 Previous studies on whole body vibration for other transportation.

Ismail A.R et al. (2010) studied the effect of whole body exposure to train passenger. Their objective is to identify the account of daily exposure to vibration A(8) and Vibration Dose Value (VDV) exposed to the passengers travelling in the train and the effects produced by the exposure towards human body. They had used the national train travelled from East Coast to the South. The time to measure the whole body vibration is 8 hour which is equal to the work time for the worker daily. According to their research, the whole-body vibration absorbed by human body enhanced when the duration of vibration exposure and the total of the trips that has been passed by the passengers increased. This can be proved by the increasing of the value of daily exposure to vibration A(8) and Vibration Dose Value (VDV) calculated in the study.

A questionnaire survey was carried out 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. The likelihood that professional drivers are at high risk for MSP is strongly supported by epidemiological evidence. Driving larger vehicles for a significant part of the day is related to MSP in numerous studies (Anderson, 1992; Boshuizen et al., 1992; Burdorf and Zondervan, 1990; Krause et al., 1997b, 1998, 2004; Magnusson et al., 1996), basically explained by the high intensity of whole-body vibration induced by heavy vehicles.

The seat is another important thing in the bus. The design of the seat should provide the most suitable seat to the user. Seat comfort is the most important especially to the driver. The commercial driver such as heavy trucks will have to go through a long journey daily. According to Fai T.C et al, In America, the driving limit for truck drivers, as defined by the Federal Highway Administration Hours of Service (HOS) regulations, is 10 hours. Almost 20% of drivers, however, reported that they “always or often” exceed that limit. Therefore, the improvement for the seat design should be done. The improvement must include bolster design to increase stability, and adjustments for backrest angle, contouring, and seat height to promote good posture. Also, the development of air suspension system has made the seat better capable of absorbing vibration transferred from the road surface to the driver.

Raanaas R.K. and Anderson.D (2007) have studied about the prevalence of musculoskeletal pain and also to identify work-related factors that are likely to increase the risk of neck, shoulder or lower back pain. The subject for their research is almost 1500 taxi drivers were choose randomly to answer a set of questionnaire form. As the result, they also find that sleeping in the car seat during a rest break and having exposed to violence or threats were found to be risk factors for neck, shoulder and low back pain. Age was not related to pain prevalence. Marital status was not a risk factor for neck, shoulder or low back pain. The amount for driving in terms of hour per shift remained as a risk factor for neck and shoulder pain but not for low back pain, whereas the number of hours driving per week is the factor for low back pain.

Tiemessen I.J.H et al. (2008) studied on low back pain in drivers exposed to whole body vibration: analysis of a dose–response pattern. From this studied, his focus on to analyse a dose–response pattern between exposure to whole body vibration (WBV) and low back pain (LBP) in a group of drivers. Data was collected by using a set of questionnaire and actual field measurements according to ISO 2631-1.

The magnitude and duration of vibration exposure and a variety of daily and cumulative WBV-exposure measures were calculated for each driver. 229 drivers answered all the set of the questionnaire. Tiemessen I.J.H et al. (2008) conclude that No indication of a dose–response pattern was found between WBV exposure and 12-month LBP. Although this dose–response pattern is only an indication, these findings imply that WBV exposure might contribute to the onset of driving-related LBP.

Nastac.S and Picu.M (2010) studied about the evaluating methods of whole body vibration exposure in trains. Their objectives to study are the whole-body vibration in trains which constitutes one aspect of the physical environment that can cause discomfort to passengers. The measurement for this study included accelerometers. Usually, the accelerometer was mounted on the seat pan, the backrest and floor (although occasionally it is necessary to measure solely on the floor for standing passengers). Depending on the location, direction and standard to be used, a different method of signal processing and scaling is used for each accelerometer. Nastac.S and Picu.M (2010) indicated that the vibration in trains is not severe, but could occasionally cause some discomfort.

Funakoshi.M et al. (2004) studied about the measurement of whole body vibration in taxi drivers. Once they get their data, it was compare to the ISO Standard 2631-1:1997. According to Funakoshi.M et al. (2004) because many taxi driver work 18h every day, the shortening of working hours and taking of rest breaks while working should be considered. WBV was measured on the driver seat pan of the taxis under actual working conditions, according to the Standard ISO 2631-1. The three working condition (driving, idling and engine-off) were identified by using both the WBV results and the driving records from the tachometers. As the result for their studied, most of the frequency-weighted r.m.s accelerations of the taxis were within the potential health risk zone according to ISO 2631-1:1997. It was clear that taxi driver were exposed to serious magnitude to WBV. Frequency-weighted r.m.s acceleration of the axis had a tendency to decrease as total mileage increased.

2.10 Previous studies about whole body vibration on human

Another study is about the power absorbed during whole body vertical vibration. The objective is to investigate the effects of support for the feet and back and the magnitude of vibration on the power absorbed during whole body vertical vibration. There are twelve subjects with four different magnitude of random vertical vibration while sitting on a rigid body while sitting on a rigid four posture.

Nawayseh et al. (2010) conclude that during whole-body vertical vibration, the use of a footrest to support the feet reduces the total absorbed power at the seat, with greater reductions with higher footrests. The use of a backrest reduces the absorbed power at the seat at low frequencies but increases the absorbed power at the seat at high frequencies. The total absorbed power at the seat, the feet, and the backrest increase approximately quadratically with increasing vibration magnitude.

Referring to Hinz.B et al. (2001) have done the research about effects related to random whole body vibration and posture on a suspended seat with and without backrest. According to their research, no quantitative data are available to describe the exposure relationships for different conditions of seating, posture, and the biological variability of workers.

There are about 39 male subjects sitting on a suspension seat with or without backrest contact. A two-dimensional finite element model was used for the calculation of the interval spinal load. According to Hinz.B et al. (2001), emission value as a result of standardized test procedures can provide only an orientation for the exposure values to be expected under real conditions with various subjects, different postures and a variable use of the backrest.

Ljungberg. J.k et al. (2007) studied about cognitive after-effects of vibration and noise exposure role of subjective noise sensitivity. Her objective by doing this studied is to investigate the effect on attention performance after exposure to noise and whole body vibration after exposure to noise and whole body vibration in relation to subjective noise sensitivity. The participants for this studied were sixteen high and sixteen low sensitivity male students. They were chosen to answer a set of questionnaire. The time taken to undergo the vibration phase is 44min. after exposure; participants completed an attention task and made subjective ratings of alertness. According to Ljungberg. J.k et al. (2007), the combination of vibration and noise does not produce any additional effects. Participants on average had an error rate of around 1.5%, thus even small differences may be of interest.

According to previous studies, Bovenzi.M (2005), whole body vibration occur when the human body is supported on a surface which is vibrating in all forms of transport and when working near some industrial machinery. Hand transmitted vibration occurs when the vibration enters the body through the hands. By referring to Bovenzi.M study, the complex of this disorder is called hand arm vibration syndrome.

Another cross sectional study is conducted by Okunribido.O.O et al. (2006). It is to study the relative role of whole-body vibration (WBV), posture and manual materials handling (MMH) as risk factors for low back pain (LBP). Same as the most studies in vibration field, a set of questionnaire is used to collect the cumulative data. 394 data were collected from the workers.

Based on the questionnaire responses and direct measurements of vibration exposure, personal aggregate measures of exposure were computed for each of the respondents, i.e., total vibration dose (TVD), posture score (PS) and manual handling score (MHS). Okunribido.O.O et al. (2006) find that combined exposure' due to posture and one or both of vibration and MMH, rather than the individual exposure to one of the three factors (WBV, posture, MMH) is the main contributor of the increased prevalence of LBP.

Paradisis.G and Zacharogiannis.E studied about the effect of whole-body vibration training on sprint running kinematics and explosive strength performance. The aim of this study was to investigate the effect of 6 week of whole body vibration (WBV) training on sprint running kinematics and explosive strength performance. Twenty-four volunteers (12 women and 12 men) participated in the study and were randomised (n = 12) into the experimental and control groups. The control group did not participate in any training. Tests were performed Pre and post the training period. Explosive strength performance was measured during a counter movement jump (CMJ) test, where jump height and total number of jumps performed in a period of 30 s (30CVJT).

Performance in 10 m, 20 m, 40 m, 50 m and 60 m improved significantly after 6 week of WBV training with an overall improvement of 2.7%. The step is length and running speed improved by 5.1% and 3.6%, and the step rate decreased by 3.4%. The countermovement jump height increased by 3.3%, and the explosive strength endurance improved overall by 7.8%. The WBV training period of 6 week produced significant changes in sprint running kinematics and explosive strength performance. As the result from this study, WBV training period of 6 week, through the muscle contractions it provokes, produced significant positive changes is selected kinematical characteristics of sprint running (step length, step rate and running velocity) and selected explosive strength characteristics (jump height, total number of jumps performed in a period of 30 s) in non-experienced sprinters. (G. Paradisis et al. 2007)

2.11 Evaluation whole body vibration exposure in building.

This is another aspect of whole body vibration, for which different criteria applied. The weighing curves in the range 1 to 8 Hz are similar in shape to the ISO curve. The interpretation is a somewhat different. Building vibrations may be classified as impulsive, intermittent or continuous. Impulsive is a rapid build up to a peak, followed by decay and may involve several cycles or can consist of a sudden application of several cycles lasting less than 2 seconds. Intermittent is a string of vibration incidents separated by much lower magnitude and continuous vibrations are uninterrupted for a period of 16 hours. (G. Paradisis et al. 2007)

Table 2.11: Summarize from Previous Journal on Whole Body Vibration and Noise

No.	Author(s)	Research Title	Purpose of Study
1.	Ruth K. Raanaas & Donald Anderson	A questionnaire survey of Norwegian taxi drivers' musculoskeletal health, and work-related risk factors.	To determine the prevalence of musculoskeletal pain. To identify work-related factors that is likely to increase the risk of neck, shoulder or lower back pain.
2	Olanrewaju O. Okunribido, Steven J. Shimbles, Marianne Magnusson & Malcolm Pope.	City bus driving and low back pain: A study of the exposures to posture demands, manual materials handling and whole-body vibration.	To investigate worker exposure to posture demands, manual materials handling (MMH) and whole body vibration as risks for low back pain (LBP).
3	A.R. Ismail, M.Z. Nuawi, C.W. How, N.F. Kamaruddin, M.J.M. Nor & N.K. Makhtar	Whole Body Vibration Exposure to Train Passenger	Will give an account of daily exposure to vibration A(8) and Vibration Dose Value (VDV) exposed to the passengers travelling in the train and the effects produced by the exposure towards human body.
4	D.J. Oborne	Vibration and passenger comfort.	To examine both the qualitative and quantitative effects of vibration.
5	T.C Fai, F. Delbressine1 & M. Rauterberg	Vehicle seat design: state of the art and recent development	To review the state of the art of vehicle seat design.
6	Duarte, Maria Lúcia Machado, Pereira, Matheus de Brito, Misael, Marcos Roberto & 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?	To evaluate the comfort levels obtained for whole-body human vibration both for the threshold limit as well as for the maximum acceptable vibration at dwellings.
7	I J H Tiemessen, C T J Hulshof & M H W Frings-Dresen	Vibration: Analysis of a dose_response pattern Low back pain in drivers exposed to whole body.	To analysis of a dose–response pattern between exposure to whole body vibration (WBV) and low back pain (LBP) in a group of drivers.

Table 2.11: Continued

No	Author(s)	Research Title	Purpose of study
8	Yu Mingjiu, Ye Jun, Zhang Quan & Lu Changde	Ergonomics Analysis for sitting posture and chair.	To analyze human's physical structure and pressure in sitting posture, and designs chair in the point of ergonomics.
9	Ronnie Lundstro, Patrik Holmlund & Lennart Lindberg	Absorption of energy during vertical whole-body vibration exposure.	To measure absorbed power during exposure to vertical whole-body vibration in a sitting posture
10	Naser Nawayseh & Michael J.Griffin	Power absorbed during whole-body vertical vibration: Effects of sitting posture, backrest, and footrest	To investigate the effects of support for the feet and back and the magnitude of vibration on the power absorbed during whole-body vertical vibration.
11	G.H.M.J. Subashia, N.Nawaysehb, Y.Matsumotoa & M.J.Griffinc.	Nonlinear subjective and dynamic responses of seated subjects exposed to horizontal whole-body vibration	To investigate the effect of the magnitude of fore-and-aft and lateral vibration on the subjective and mechanical responses of seated subjects
12	Bosco C., M. Cardinale, R. Colli, J. Tihanyi, S.P. von Duvillard & A. Viru.	The influence of whole body vibration on the mechanical behavior of skeletal muscle	To investigate the effects of whole body vibrations on the mechanical behavior of human skeletal muscles
13	P.-E¨ Boileau & S. Rakheja"	Whole-body vertical biodynamic response characteristics of the seated vehicle driver measurement and model development.	To investigate the influence of variations in the seated posture, backrest angle, and nature and amplitude of the vibration excitation are introduced within a prescribed range on the driving-point mechanical impedance of seated vehicle drivers
14	Danielle Noorloos, Linda Tersteeg, Ivo J.H. Tiemessen_, Carel T.J. Hulshof &Monique H.W. Frings-Dresen	Does body mass index increase the risk of low back pain in a population exposed to whole body vibration?	To determine whether body mass index (BMI) influences the risk of low back pain (LBP) in a population exposed to Whole body vibration (WBV

Table 2.11: Continued

No	Author(s)	Research Title	Purpose of study
15	Salam Rahmatalla & JonathanDeShaw	Effective seat-to-head transmissibility in whole-body vibration: Effects of posture and arm position.	To evaluate seat dynamics and human response to vibration by using a biomechanical measure (seat-to-head). To presents a novel approach to use transmissibility effectively for single- and multiple-input and multiple-output whole-body vibrations. In this regard, the full transmissibility matrix is transformed into a single graph, such as those for single-input and single-output motions.
16	R. Lundstrom & P.Holmlund	Absorption of energy during whole-body vibration exposure	To investigate the absorbed power during exposure to vertical and horizontal whole body vibration in sitting posture was measured using 04 male and 04 female subjects.
17	Darren M. Joubert & Leslie London	A cross-sectional study of back belt use and low back pain amongst forklift drivers	To determine the association between back belt usage and back pain amongst forklift drivers exposed to whole-body vibration (WBV).
18	B. Hinz, H. Seidel, G. Menzel & R. Bluthner.	Effects related to random whole-body vibration and posture on a suspended seat with and without backrest.	Experiments and subsequent predictions of forces acting within the spine during WBV can help to improve the assessment of the health risk. The model simulates the human response on a suspension driver seat.

Table 2.11: Continued

No	Author(s)	Research Title	Purpose of study
19	Antonio Fratini , Antonio La Gatta, Mario Cesarelli & Paolo Bifulco	Whole Body Vibration training: analysis and characterization	To contribute to the analysis and characterization of training with whole body vibration (WBV) and the resultant neuromuscular response
20	Grace P. Y. Szeto & Peggo Lam	Work-related Musculoskeletal Disorders in Urban Bus drivers of Hong Kong	To investigating the prevalence and characteristics of WMSD in male and female bus drivers who operate double-deck buses in Hong Kong.
21	Gregory P. Slota, Kevin P. Granata & Michael L. Madigan	Effects of seated whole-body vibration on postural control of the trunk during unstable seated balance	The purpose of this study was to measure the acute effect of seated whole-body vibration on the postural control of the trunk during unstable seated balance.
22	Gregory P. Slota, Kevin P. Granata & Michael L. Madigan	Effects of seated whole-body vibration on seated postural sway	To measure the acute effect of seated WBV on the postural control of the trunk during unstable seated balance. Measures of seated postural sway during unstable seated balance have been used as surrogate measures of trunk postural control and have been related to spinal stability.
23	Zheng Ke, Ming Zhang, Cheng Tan，Wei Su，Chao Ma, Zhili Li，Huijuan Wan & Wenjuan Chen.	Effects of Whole Body Vibration on prevention of bone loss in 8-week tail suspended male rats	To investigate the effects of low frequency whole body vibration on preventing the bone loss of rats’ lower limbs induced by tail suspended.
24	Jessica K.Ljungberg & Gregory Neely.	Cognitive After-effects of Vibration and Noise Exposure and the Role of Subjective Noise Sensitivity.	To investigated the effects on attention performance after exposure to noise and whole body vibration in relation to subjective noise sensitivity

Table 2.11: Continued

No	Author(s)	Research Title	Purpose of study
25	M. Bovenzi	Health effects of mechanical vibration.	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.
26	Johan Granlund, & Anders Brandt.	Bus Drivers' Exposure To Mechanical Shocks Due To Speed Bumps	To investigate of vibrations imposed on the driver from some twenty speed bumps in the Stockholm area (Sweden). The vibrations have been evaluated in accordance with the new standard ISO 2631-5. It defines a method of quantifying whole-body vibration containing multiple shocks (such as bumpy rides) in relation to human health.
27	Silviu NASTAC & Mihaela PICU	Evaluating methods of Whole-body-vibration exposure in trains.	To studies the whole-body vibration in trains which constitutes one aspect of the physical environment that can cause discomfort to passengers. Modern methods of assessment use digital techniques.
28	O.O. Okunribido, M. Magnusson & M.H. Pope.	Low back pain in drivers: The relative role of whole-body vibration, posture and manual materials handling	To investigate the relative role of whole-body vibration (WBV), posture and manual materials handling (MMH) as risk factors for low back pain (LBP).

Table 2.11: Continued

No	Author(s)	Research Title	Purpose of study
29	Mitsuhiko Funakoshi, Kazushi Taoda, Hiroji Tsujimura & Katsuo Nishiyama.	Measurement of Whole-Body Vibration in Taxi Drivers.	To measure whole body vibration (WBV) on the driver's seat pan of 12 taxis operating under actual working conditions. The results were evaluated according to the health guidelines in International Standard ISO 2631-1:1997.
30	Hassan Nahvi, Mohammad Hosseini Fouladi & Mohd Jailani Mohd Nor.	Evaluation of whole-body vibration and ride comfort in a passenger car	To evaluate of vehicle comfort characteristics based on standard mathematical formulae and frequency analysis. A variety type of road types was selected and quantified by from the International Roughness Index (IRI).
31	Olivier Bruyere, Marc-Antoine Wuidart, Elio Di Palma & Jean-Yves Reginster.	Controlled Whole Body Vibrations Improve Health Related Quality Of Life In Elderly Patients	To investigate the effects of controlled whole body vibrations (CWBV) exercises on global health in elderly patients.
32	Daniëlle A W M van der Windt, Elaine Thomas, Daniel P Pope, Andrea F de Winter, Gary J Macfarlane, Lex M Bouter & Alan J Silman.	Occupational risk factors for shoulder pain: a systematic review	To systematically evaluate the available evidence on occupational risk factors of shoulder pain.
33	S. Rahmatalla, T. Xia, M. Contratto, G. Kopp, D. Wilder, L. Frey Law & James Ankrum	Three-dimensional motion captures protocol for seated operator in whole body vibration.	To measure the response of seated people to whole body vibration (WBV). Simulated ride files containing both complex vibration and mild impact signals were played back through a man-rated 6 d.f. motion platform.

Table 2.11: Continued

No	Author(s)	Research Title	Purpose of study
34	Giorgos Paradisis & Elias Zacharogiannis	Effects of whole-body vibration training on sprint running kinematics and explosive strength performance.	To investigate the effect of 6 wk of whole body vibration (WBV) training on sprint running kinematics and explosive strength performance.
35	Bourje Rehn, Tohr Nilsson, Bodil Olofsson & Ronnie Lundstroum.	Whole-Body Vibration Exposure and Non-neutral Neck Postures During Occupational Use of All-terrain Vehicles.	To characterize whole-body vibration (WBV) exposure from various all-terrain vehicles (ATVs) like snow groomers, snowmobiles and forwarders. To investigate how frequently the drivers' cervical spine is positioned in a non-neutral rotational position during operation.
36	M. H. Pope, D. G. Wilder & M. Magnusson	Possible Mechanisms Of Low Back Pain Due To Whole-Body Vibration.	To study the relationship between whole body vibration and low back pain.
37	K T Palmer, M J Griffin, H E Syddall, B Pannett, C Cooper & D Coggon.	The relative importance of whole body vibration and occupational lifting as risk factors for low-back pain.	To explore the impact of occupational exposure to whole body vibration (WBV) on low back pain (LBP) in the general population and to estimate the burden of LBP attributable to occupational WBV in comparison with that due to occupational lifting.
38	Stephan Milosavljevic, Frida Bergman, Borje Rehn & Allan B.Carman	All-terrain vehicle use in agriculture: Exposure to whole body vibration and mechanical shock	To investigate the most effect of whole body vibration among the farmer.
39	Shyamal Koley, Lalit Sharma and Sukhpal Kaur	Effects of Occupational Exposure to Whole-Body Vibration in Tractor Drivers with Low Back Pain in Punjab	To assess the severity of pain, the modified Oswestry Pain Questionnaire was used. To investigate the relationship between

Table 2.11: Continued

No	Author(s)	Research Title	Purpose of study
			whole body vibration exposure to the effects of back pain. To investigate if age also can be a factor to whole body vibration exposure and back pain
40	Scott Haynes & Karen Williams.	Impact of seating posture on user comfort and typing performance for people with chronic low back pain.	To study the impact of sitting upright posture and lying down alternate postures on typing performance and user comfort. To investigate either sitting posture can cause significant differences in typing speed and user comfort in supine postures when compared to traditional upright typing postures.
41	Geraldine S. Newell & Neil J. Mansfield.	Evaluation of reaction time performance and subjective workload during whole-body vibration exposure while seated in upright and twisted postures with and without armrests.	To investigate the influence of sitting in different working postures on the reaction time and perceived workload of subjects exposed to whole-body vibration.
42	W. Wang, S. Rakheja & P.-E´. Boileau.	The role of seat geometry and posture on the mechanical energy absorption characteristic of seated occupants under vertical vibration.	To study the effects of sitting posture on the biodynamic response under whole-body vertical vibration.
43	J. Hoy, N. Mubarak, S. Nelson, M. Sweerts de Landas, M. Magnusson, O. Okunribid & M. Pope.	Whole body vibration and posture as risk factors for low back pain among forklift truck drivers.	To investigate the risks from whole-body vibration and posture demands for low back pain (LBP) among forklift truck (forklift) drivers.

Table 2.11: Continued

No	Author(s)	Research Title	Purpose of study
44	W. Wanga, S. Rakhejaa & P.-E Boileaub	Effects of sitting postures on biodynamic response of seated occupants under vertical vibration.	To study the effects of sitting posture on the biodynamic response under whole-body vertical vibration. A higher seat height yields higher peak magnitude response which is attributed to relatively larger portion of the body mass supported by the seat, while the influence of seat pan inclination is observed to be negligible for range of inclination investigated.
45	Brenda R. Santos, Christian Larivie`re, Alain Delisle, Andre´ Plamondon, Paul-E´ mile Boileau & Daniel Imbeau.	A laboratory study to quantify the biomechanical responses to whole-body vibration: The influence on balance, reflex response, muscular activity and fatigue	To determine the acute effects of whole-body vibration (WBV) on the sensor motor system and potentially on the stability of the spine, different biomechanical responses were tested before and after 60 min of sitting, with and without vertical WBV, on four different days.
46	Olanrewaju O. Okunribidoa, Marianne Magnusson & Malcolm Pope.	Delivery drivers and low-back pain: A study of the exposures to posture demands, manual materials handling and whole-body vibration.	To investigate the exposures of drivers to posture demands, manual materials handling (MMH) and vibration as risk factors for LBP.
47	Geraldine S. Newell, Neil J. Mansfield & Luca Notini	Inter-cycle variation in whole-body vibration exposures of operators driving track-type loader machines.	To study the variation inherent to WBV exposure to help understand how this variation will affect health risk assessments. A large array of variables affect the outcome of a vibration measurement and its extrapolation to a daily dose measure: e.g.

Table 2.11: Continued

No	Author(s)	Research Title	Purpose of study
			variability in driving style, road surface roughness, loading
48	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.	An epidemiological study of low back pain in professional drivers.	To confirm that professional driving in industry is associated with an increased risk of work-related LBP. Exposure to WBV and physical loading factors at work are important components of the multifactorial origin of LBP in professional drivers.
49	H. Issever, L. Onen, H. H. Sabuncu & O. Altunkaynak.	Personality characteristics, psychological symptoms and anxiety levels of drivers in charge of urban transportation in Istanbul.	The purpose of the study was to examine whether poor working conditions influenced drivers' psychological health, and to identify drivers' personality characteristics. The subjects were 208 bus drivers working in the European sector in Istanbul.
50	Laura Punnett & David H. Wegman	Work-related musculoskeletal disorders: the epidemiologic evidence and the debate.	The debate about work-relatedness of musculoskeletal disorders (MSDs) reflects both confusion about epidemiologic principles and gaps in the scientific literature. The physical ergonomic features of work frequently cited as risk factors for MSDs include rapid work pace and repetitive motion, forceful exertions, non-neutral body postures, and vibration. However, some still.

Table 2.11: Continued

No	Author(s)	Research Title	Purpose of study
			dispute the importance of these factors, especially relative to non-occupational causes
51	G.H.M.J. Subashi, Y. Matsumoto & M.J. Griffin	Modelling resonances of the standing body exposed to vertical whole-body vibration: Effects of posture	To study the lumped parameter mathematical models representing anatomical parts of the human body have been developed to represent body motions associated with resonances of the vertical apparent mass. To study the fore-and-aft cross-axis apparent mass of the human body standing in five different postures: 'upright', 'lordotic', 'anterior lean', 'knees bent', and 'knees more bent'.
52	Lenka Gallais & Michael J. Griffin.	Low back pain in car drivers: A review of studies published 1975 to 2005.	To investigate whether there is evidence of an association between car driving and low back pain, and evidence that whole-body vibration contributes to low back pain in car drivers. The evidence of an association between various physical, psychosocial and individual factors and low back pain in car drivers was also investigated
53	Z. Milic, M. Demicd & J. Lukicd.	Some Aspects Of The Investigation Of Random Vibration Influence On Ride Comfort.	To develop criteria for ride comfort improvement. The highest loading levels have been found to be in the vertical direction and the lowest in lateral

Table 2.11: Continued

No	Author(s)	Research Title	Purpose of study
			direction in passenger cars and trucks.
54	Mats Hagberg, Lage Burstro¨m, Anna Ekman & Rebecka Vilhelmsson.	The association between whole body vibration exposure and musculoskeletal disorders in the Swedish work force is confounded by lifting and posture.	To investigate the association between whole body vibration exposure and musculoskeletal disorders in the Swedish work force is confounded by lifting and posture.
55	Eduard Alentorn-Geli, M.D., M.S., Jaume Padilla, M.S., Gerard Moras, Cristina Lázaro Haro, B.S. & Joaquim Fernández-Solà, M.D.	Six Weeks of Whole-Body Vibration Exercise Improves Pain and Fatigue in Women with Fibromyalgia.	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.
56	Ivo JH Tiemessen, Carel TJ Hulshof & Monique HW Frings-Dresen.	The development of an intervention programme to reduce whole-body vibration exposure at work induced by a change in behavior: a study protocol.	To developed an intervention programme to reduce WBV exposure in a population of drivers with the emphasis on a change in behavior of driver and employer. The hypothesis is that an effective reduction in WBV exposure, in time, will lead to a reduction in LBP as WBV exposure is a proxy for an increased risk of LBP.
57	Hsieh-Ching Chen, Wei-Chyuan Chen, Yung-Ping Liu, Chih-Yong Chen & Yi-Tsong Pan.	Whole-body vibration exposure experienced by motorcycle riders – An evaluation according to ISO 2631-1 and ISO 2631-5 standards	To investigate Whole-body vibration exposure experienced by motorcycle riders. This study compares the predicted health risks of motorcycle riders according to ISO 2631-1 and ISO 2631-5 standards.

Table 2.11: Continued

No	Author(s)	Research Title	Purpose of study
58	Paulo Henrique Trombetta Zannin.	Occupational noise in urban buses.	To investigate the noise level environment for Brazilian urban bus drivers (city of Curitiba) Noise levels were measured in 3 types of buses: (1) bi-articulated, (2) speedy, and (3) feeder, 20 buses of each type. The evaluation of noise levels in the workplace of bus drivers (that is, inside buses) was performed according to ISO 1999.
59	Erik W. Gregory	Whole-Body Vibration and the Lower Back: The Effect of Whole-Body Vibration on Pain in the Lower Back.	To study the exposure to whole-body vibrations where it will be measured and reported as root mean squared (r.m.s.) values in accordance with ISO standard 2631. It was expected that the individuals subjected to the highest vibration levels would tend to report LBP, with severity of pain increasing with the intensity of exposure.
60	Paulo H.T. Zannin, Fabiano B. Diniz, Clifton Giovanini& Jose A.C. Ferreira	Interior noise profiles of buses in Curitiba.	To evaluates the noise level exposure of noise levels to which the bus drivers in Curitiba. Two measurements were taken inside 25 buses, the first close to the driver and the second at the back of the bus
61	TarynE.Hill, Geoffrey T.Desmoulin & Christopher J.Hunter	Is vibration truly an injurious stimulus in the human spine?	To study about epidemiological data tone time was taken to suggest that chronic vibrations — for example operating vehicles with low quality

Table 2.11: Continued

No	Author(s)	Research Title	Purpose of study
			seats—contributed to intervertebral disc degeneration and lower back pain. More recent discussions, based in part upon extended twin studies, have cast doubt up on this interpretation, and question how much of the vibration is actually transmitted to the spine during loading.
62	Ali ElHafidi, BrunoMartin, AlexandreLoredo & EricJego.	Vibration reduction on city buses: Determination of optimal position of engine mounts.	To study about whole body vibration in three different phrases. The first part describes an indirect semi-experimental method which is used to reconstruct the excitation force of an operating diesel engine from the acceleration data measure data the mounting points. The second part deals with prevention of low frequency vibration of the power train from spreading to the rest of the vehicle. Three uncoupling techniques are used to minimize these vibrations. The first technique reduces the non-diagonal elements of stiffness matrix. This technique uses the elastic axes decoupling criterion. The third technique uncouples the torque roll axis (TRA) by using the previously determined excitation

		Table 2.11: Continued	
No	**Author(s)**	**Research Title**	**Purpose of study**
			efforts. In the third part, numerical and experimental results are discussed. The solicitations deducted and the position soft mounts. Allowing decoupling of the power train is presented.
63	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.	Despite the expanding use of Whole Body Vibration training among athletes, it is not known whether adding Whole Body Vibration training to the conventional training of sprint-trained athletes will improve speed-strength performance.
64	Prue Cormie, Russell S. Deane, N. Travis Triplett, & Jeffrey M. Mcbride	Acute effects of whole-body vibration on muscle activity, strength, and power.	To determine the acute impact of a bout of whole-body vibration on athletic performance. To investigate the effects of a single bout of whole-body vibration on isometric squat (IS) and countermovement jump (CMJ) performance. Nine moderately resistance-trained men were tested for peak force (PF) during the IS and jump height (JH) and peak power (PP) during the CMJ.
65	Ren Dong, Kristine Krajnak, Oliver Wirth & John Wu.	Proceedings of the First American Conference on Human Vibration.	To provided us with a historic opportunity to exchange information regarding this critical occupational health issue. To understand the

Table 2.11: Continued

No	Author(s)	Research Title	Purpose of study
			exposure risk factors and adverse health effects of occupational vibration exposure have waxed and waned over the years. To produce the knowledge about recent technological advances that may improve vibration measurement, tool and vehicle seat designs and tests, personal protection devices, and clinical diagnosis and assessment methods. To summarize what we know that we know, what it is sometimes claimed that we know, and what we know that we do not know about the relation between exposures to vibration and our health.
66	Lenka Justinova.	Back Problems Among Car Drivers: A Summary Of Studies During The Last 30 Years.	To summarize studies of low back problems among car drivers published during the last three decades. The study populations were mostly tractor drivers, truck drivers, bus drivers, drivers of heavy machinery and helicopter pilots. To review epidemiological studies of car drivers published during the past thirty years and consider evidence for low back problems associated with vehicular vibration.

Table 2.11: Continued

No	Author(s)	Research Title	Purpose of study
67	N. Kumar Kittusamy & Bryan Buchholz.	Whole-body vibration and postural stress among operators of construction equipment: A literature review	This review evaluates selected papers that have studied exposure to whole-body vibration and awkward posture among operators of mobile equipment. A few of the health hazards among operators of construction equipment are whole-body vibration, awkward postural requirements (including static sitting), dust, noise, temperature extremes, and shift work.
68	J. Rittweger, G. Beller & D. Felsenberg.	Acute physiological effects of exhaustive whole-body vibration exercise in man.	Vibration exercise (VE) is a new neuromuscular training method which is applied in athletes as well as in prevention and therapy of osteoporosis. Vibration exercise (VE) is a type of exercise that has recently been developed for the prevention and treatment of osteoporosis.
69	Anthony D.Woolf & Bruce Pfleger	Burden of major musculoskeletal conditions.	To describes the burden of four major musculoskeletal conditions: osteoarthritis, rheumatoid arthritis, osteoporosis, and low back pain. Musculoskeletal conditions are a major burden on individuals, health systems, and social care systems, with indirect costs being predominant.
70	Dian Darina Indah Daruis, Mohd Jailani Mohd Nor, Baba Md	Whole-body Vibration and Sound Quality of Malaysian Cars.	To study about the whole body vibration and sounds quality of Malaysian cars.

Table 2.11: Continued

No	Author(s)	Research Title	Purpose of study
	Deros, & Mohammad Hosseini Fouladi.		Consequently, interior noise and vibration of two different Malaysian cars representing a premium sedan and a compact car were investigated
71	N. Kumar Kittusamy & Bryan Buchholz	Whole-body vibration and postural stress among operators of construction equipment: A literature review.	To study about the 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.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Chapter 3 will be discussing about all the method and the measurement equipment used in order to collect the data for whole body vibration in a bus. Also, the subject studies and the flow chart to get a good result also will be discussed here.

3.2 Study design.

The study includes two parts. Which are self-assessments by a questionnaire and direct observation. Self-assessments are where a set of questionnaire form will be required, while the direct observation is during the journey. While in the bus, everything that happened will be noted.

The population for these studies is the bus driver from Kuantan to Johor Bharu. To contact with transport or health and safety management staff of commercial telephone was used. Both methods to know about the population data very well were held at the Terminal Kuantan.

3.3 Types of vehicle

Types of the vehicle that will be measure the vibration for the driver with are the bus. In Kuantan, there are about three buses which have the route from Kuantan to Johor Bharu. They are, Transnasional, Plusliner and Mara liner. But, for this study, only the transnasional bus will be choosen.

3.4 Study group

A sample of 20 bus drivers at Terminal Kuantan was chosen randomly to answer a set of questionnaire. Transnasional bus was chosen because its main office is the most nearest among all. The company management was informed about the nature of the research. Company management also will be provided with a final report after all the research is finish. All of the drivers are men. Their age is between 30-45 years old. Their average experience are 5 years most of them.

3.5 The Routes

The routes for the bus to take are from the terminal Kuantan to Johor Bharu. Actually, there are two ways for the bus to take. But for this study, the bus will go through the route from Kuantan to Pekan, Pekan to Mersing and then Mersing to Johor Bharu.

Figure 3.5: The routes from Kuantan to Johor Bharu.

3.6 Questionnaire Assessment.

There are about 20 respondents for the questionnaire and all 20 are being chosen to discuss in the result and discussion. The questionnaire survey consists of section A until section G. For this section, only section a required to analyse to know all the population especially about the driver itself and about their field of work.

Section A is the question based on respondent background. Under this section, roughly the information about the age and the status can be collected. For section B, it focuses on more about the work information. Section C discuss about respondent problem involving their skeletal muscle. Section D focuses more on low back pain while section E focus on disability of the arm, shoulder and hand (dash). Section F focuses more on overall health information and last but not least, section G discussed about other factor that may contribute to health.

The questionnaire was distributed randomly among the bus driver in Kuantan. The aimed group is the bus driver in Kuantan area in order to get the information about the bus driver population in Kuantan area.

3.7 Materials and method

The driver will sit on the accelerometer as in Figure 3.7. The location for measuring the whole body vibration is from Kuantan to Johor Bharu. The measurement equipment for the whole body vibration is the accelerometer sensor while for measuring the noise, the measuring equipment is known as dosimeter.

The accelerometer used in this study is the VI-400Pro. This equipment consists of 9 keys. All the 9 keys are having contact to the other keys. Every data can be displays on its screen but for more appropriate data, the software Quest Suite professional II is much easier. Because, the software simplifies all the task starting from the first main point which is setting the unit, retrieving the data and also reviewing all the data.

Figure 3.7: Accelerometer sensor and dosimeter used for measuring the vibration.

Dosimeter is the equipment to measure the excessive of noise during the bus driver working hour. All the collected data can be used as information to make sure the compliance with regulatory bodies to ensure if hearing program is needed. The Dosimeter is quite similar to the accelerometer sensor because the data collected can be seen only through its screen. But still the software Quest Suite professional II is used because it is much easier. Before use any of the dosimeter, all of them have to calibrate until its reach 114dB exactly.

Whole-body vibration and noise measurement explored by the bus driver was done along the journey from Kuantan to Johor Bharu. Excessive exposure of whole body vibration usually occurred at working area which involved long duration of exposure and high-level of vibration magnitude. Bus is one of the most public transportations that produced high magnitude of vibration.

3.8 Observation study

While on the bus, the driver was observed while they are driving in their assigned duty route for at least one complete round which is from Kuantan to Johor Bharu. The driver will be observed according to how many times will he stop, how long does he stop and as well as their driving style. Usually to undergo a long journey, a bus driver will stop at their usual pit stop to have a rest. Therefore, it is essential for the bus driver to stop at a pit stop before the bus driver itself experience the excessive whole body vibration and excessive noise. This is important to reduce the accident especially during the peak hour like Chinese New Year and else.

Also, the surface of the road also will be observed. Either the road is in good condition or not. The posture for the driver along the journey also will be observed. The most important is posture for their sitting especially. Every observation will be noted and recorded.

3.9 Flow chart

To ensure that each step is omitted, a flow chart was prepared. Flow chart in Figure 3.9 is to facilitate the work. When there are errors that occur, are directly able to know the proper steps are taken.

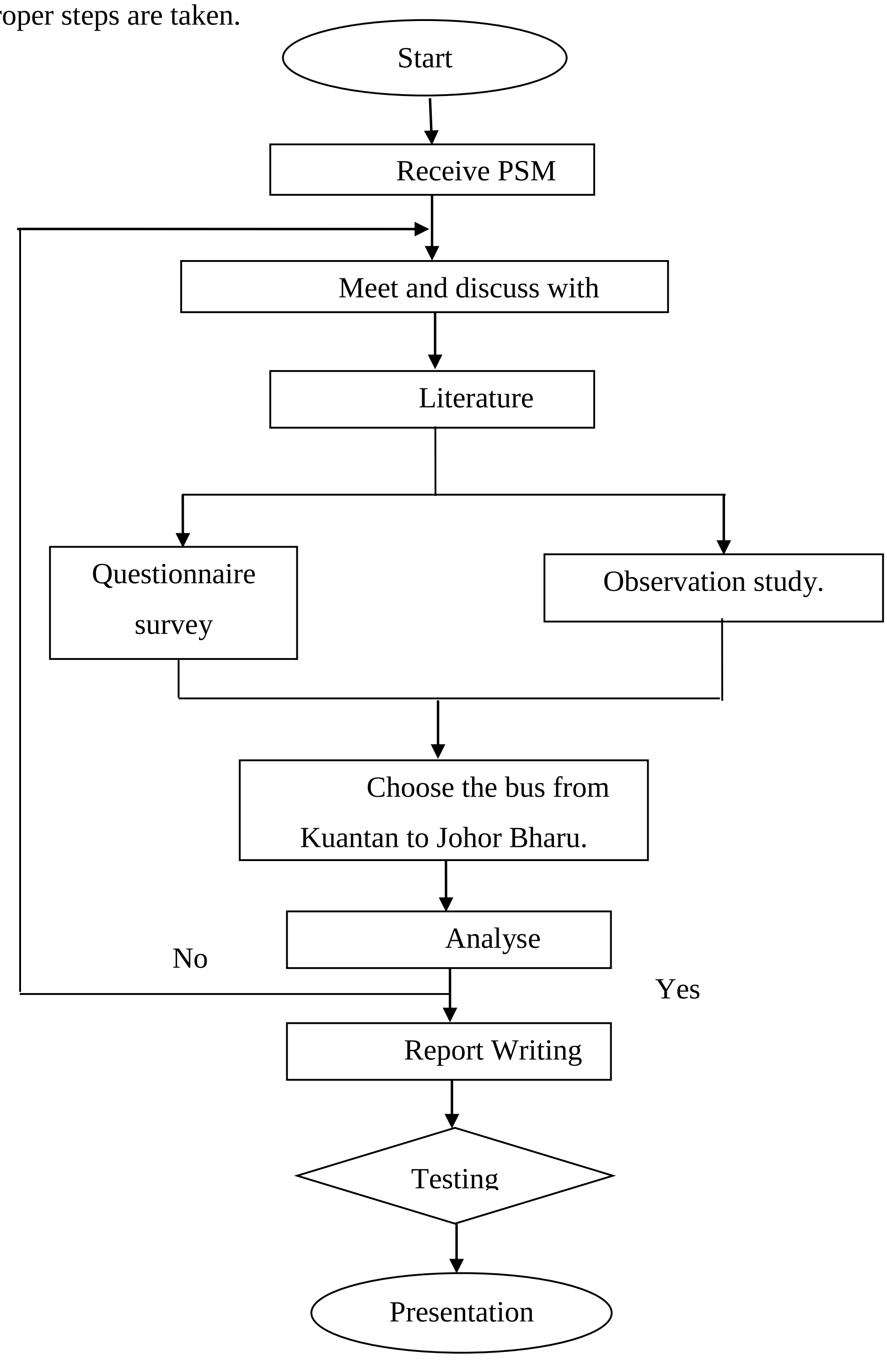

Figure 3.9: Flow chart

Testing is a process for obtaining data. In this study in order to get data, the bus driver will sit on equipment called the acceleration sensor. Acceleration sensor is to measure the whole body vibration. While for the noise is the dosimeter. Along the way for five hours, the bus driver would sit on the device itself. For each stop, the time taken to stop will be recorded. This is to facilitate the process to result and discussion later.

According to this study, measuring will take place according to the day or night. Therefore, there are two readings for each whole body vibration and noise. They are reading for the night and another one is reading for the day. Along the journey to arrive the destination, all happening are recorded.

In analyse the data, Quest Software will be used. All the data collected in the measurement equipment will then download to the software. Afterwards, all the data will be imported to Microsoft Excel to perform a graph. A graph is much easier for a people to understand. The data collected will be compared to actual data from the ISO Standard 2631. Then, we will know either the bus had excessive whole body vibration and noise or not. Just then, the discussion will be discussed based on some different criteria such as the age, the road, and the time taken to arrive the destination and also what type of bus used for hire.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

Under this chapter, all the result that already collected will be discussed here. Every parameter involved during the measurement will be stated. Also, under this topic all the equation used to calculate will be explained. After all the data about vibration exposure and noise to the bus driver done, all the analysis was done using the Quest Professional II. By using the software, the vibration exposure daily can be measured. The measurement was done during the whole one day. Two data's for vibration are collected during the measurement. The measurement takes place along the journey from Kuantan to Johor Bharu. The time is during the day which is the route from Kuantan to Johor Bharu. The second measurement is during the night, from Johor Bharu to Kuantan. When the measurement was conducted, the weather is in good condition. The measurement also included two bus drivers. They are take turn in the whole journey. While the first bus driver drives, the other bus driver will take rest. Until arrived to a place, they will change bus driver.

4.2 Population data

4.2.1 Questionnaire survey

The method to gather the information about the population for the bus driver in Kuantan was questionnaire survey. There are about 20 bus driver was asked to fill a questionnaire survey. The questionnaire survey consists of section A until section G.

For this section, only section a required to analyse to know all the population especially about the driver itself and about their field of work. Section A is the question based on respondent background. Under this section, roughly the information about the age and the status can be collected. For section B, it focuses on more about the work information. (Refer to appendix 1).

4.2.2 The personal information data

Data collection for personal information is important because by doing this way, we are managing to know better the population.

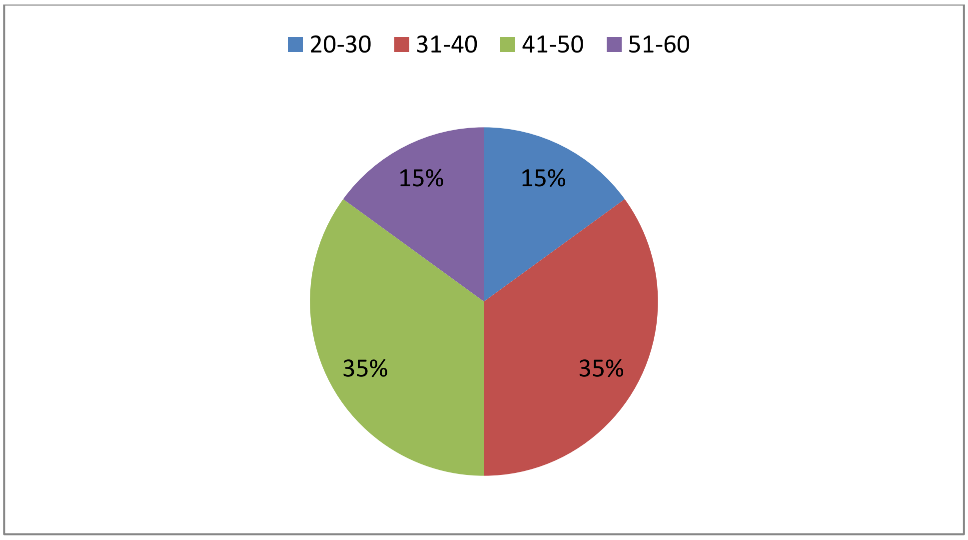

Figure 4.2.2 (a): The percentage for the bus driver in Kuantan.

According to the questionnaire survey that had been done before, Figure 4.2.2 (a) shows about 15 % average are between 20-30 and 51-60 which is equal to three person. The other percentage is 35% which goes to the average age between 31-40 and 41-50. From this, it can be conclude that average age is 31-50. That is the most age noted.

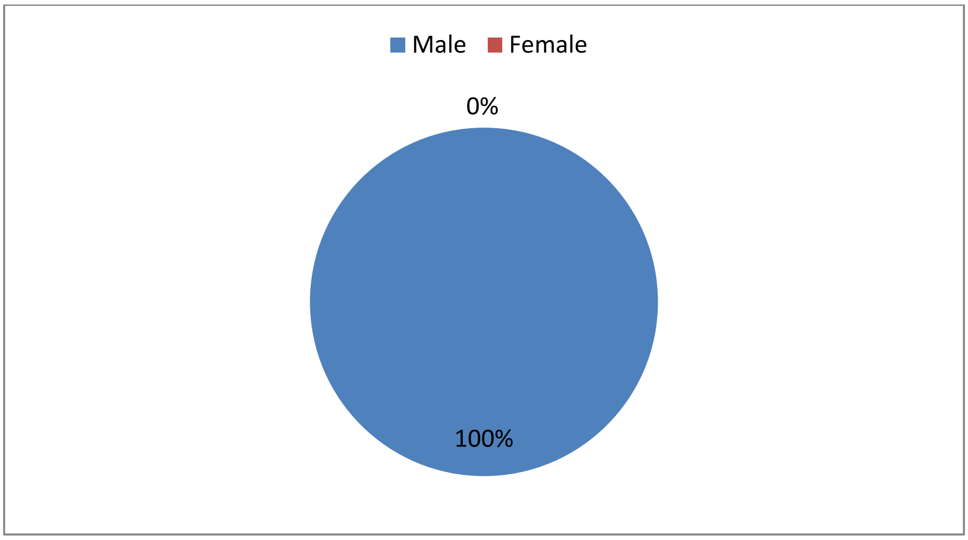

Figure 4.2.2 (b): The percentage of gender for the bus driver in Kuantan.

Figure 4.2.2 (b) shows the percentage of gender for the bus driver in Kuantan. It is clearly showed that almost all the bus driver that has answered the survey is male. 100% stated it is male monopolize the job as the bus driver in Kuantan.

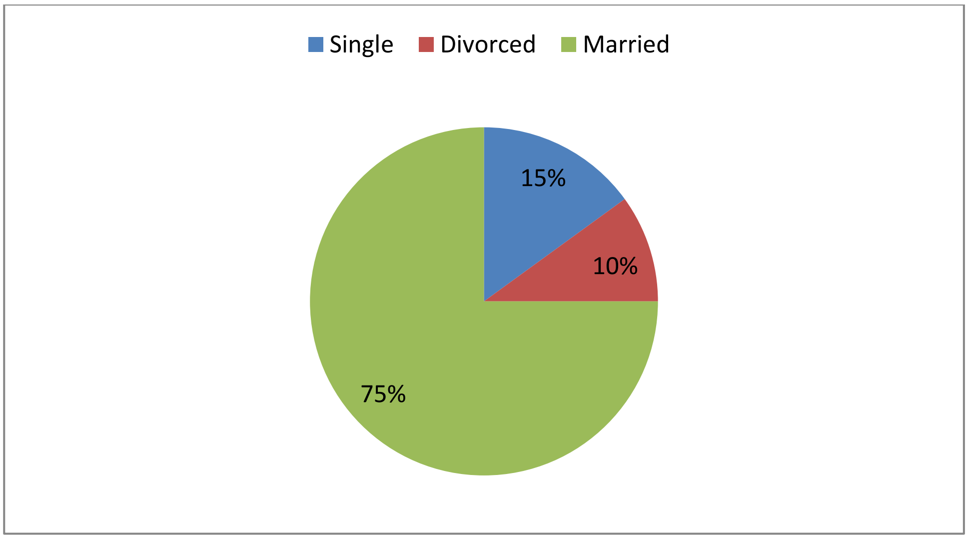

Figure 4.2.2 (c): The percentage for the marital status bus driver in Kuantan.

Figure 4.2.2 (c) shows the percentage for the marital status bus driver in Kuantan. About 75% answered the questionnaire survey with married. While the other 10% answered with already divorced and about 15% answered with single. It is a proved that most of the bus driver in Kuantan area married and have their own family. Only a few remainders have yet to have the responsibility as the head of the family.

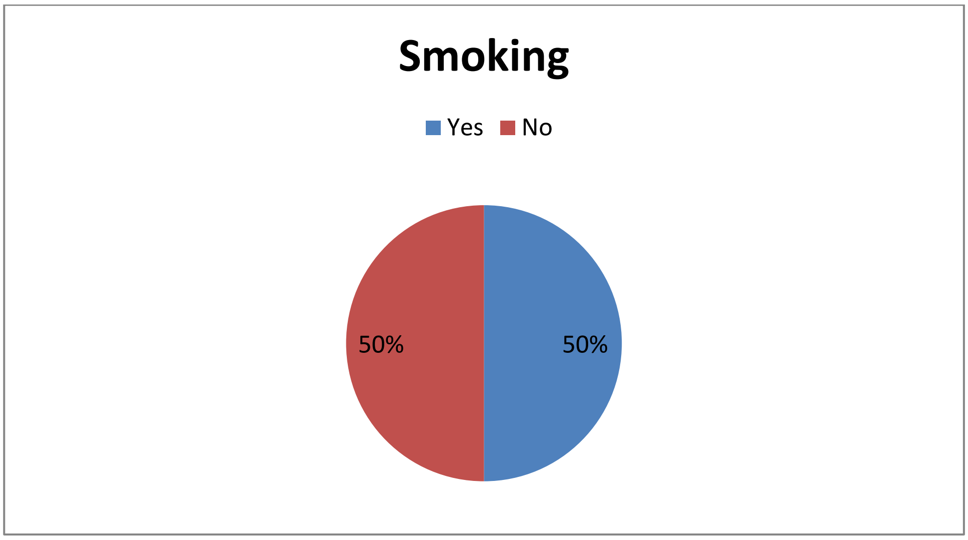

Figure 4.2.2 (d): The percentage for smoking bus driver in Kuantan.

The percentage for the smoking bus driver in Kuantan is show by Figure 4.2.2 (d). The answered was 50-50. Which are about 10 person smoke and the other 10 is not smoking. From this question also, the total cigarettes they smoke everyday also managed to get. Table 4.2.2 (d) will show the result.

Table 4.2.2 (d): The percentage of cigarettes per day.

No.	Total Cigarettes	Percentage (%)
1	6 – 10	30
2	11 – 15	50
3	16 – 20	20

The average cigarettes that they smoke per day are 50% which is about 11 to 15 cigarettes per day. Not that the cigarettes effect the health, it also disturb the way that a driver drive their bus because they are to focus in smoking, not driving. Accordingly, the most of the bus driver take it as a habit to smoke while driving.

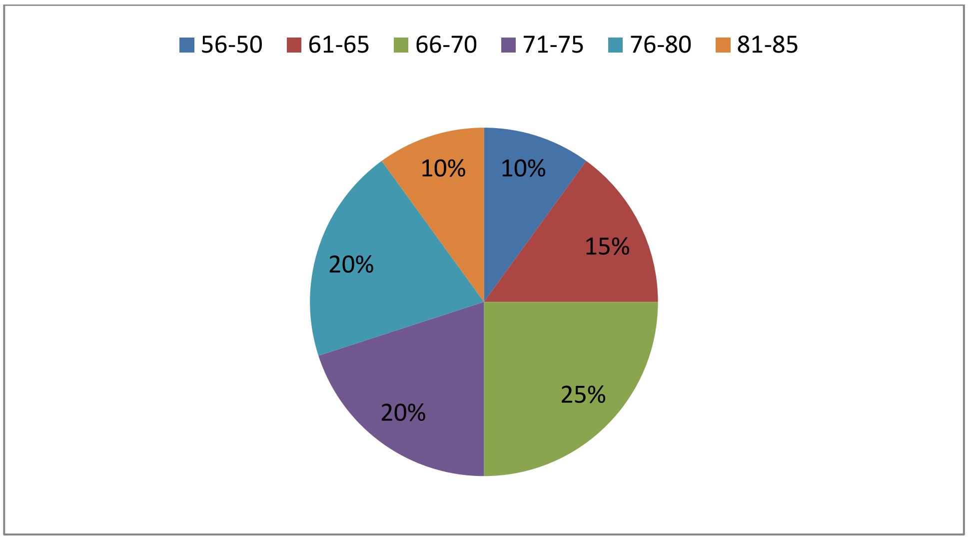

Figure 4.2.2 (f): The percentage of weight (kg) for bus driver in Kuantan.

The next question in the questionnaire survey discussed about the weight (kg) for bus driver in Kuantan (Figure 4.2.2 (f)). It is stated that about 10% average weights are about 81-85 (kg) and 56-50 (kg). About 20% average weights are between 76-80 (kg) and 71-75 (kg). The other 15% goes to average weight in between 61-65 (kg) and 20% average weight is in between 66-70 (kg).

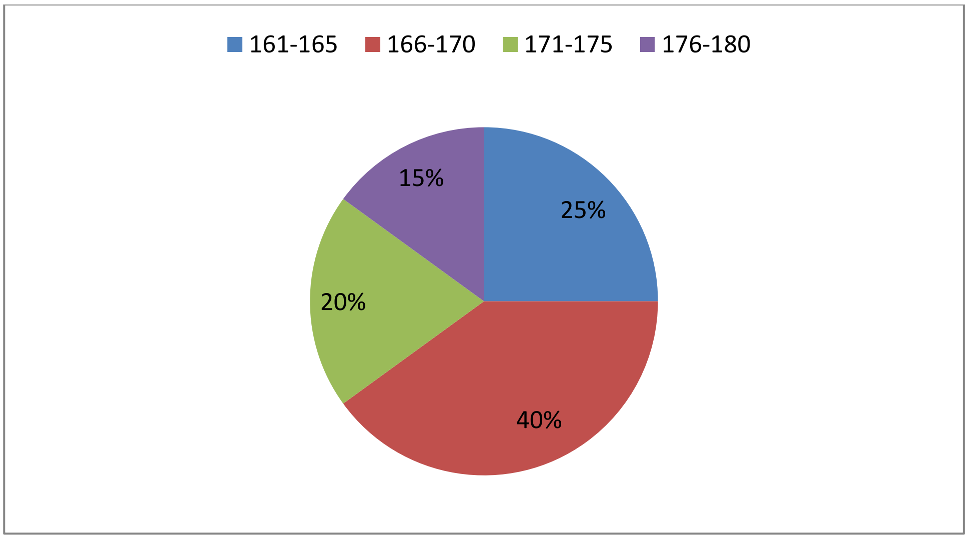

Figure 4.2.2 (g): The percentage of height (cm) for bus driver in Kuantan.

Figure 4.2.2 (g) shows the percentage of height (cm) for bus driver in Kuantan. Only 15% average height (cm) are in between 176-180 (cm). 20% average height is

171-175(cm) and 25% goes to average height in between 161-165 (cm). The most average height percentage is between 166 and 170 (cm).

4.2.3 The population data for the bus in Kuantan.

There a lot of Bus Company that provides services in Kuantan. The most famous one are the Transnasional bus. Transnasional not only provide the service for the journey along in Kuantan but also in other places. Since this study is about the whole body vibration for the bus driver from Kuantan to Johor Bharu, here is the schedule time for the bus.

Table 4.2.3(a): The departures time for Transnasional bus from Kuantan to Johor Bharu.

Bus	Departure time
Transnasional	i. 10.00am
	ii. 11.00am
	iii. 3.00 pm
	iv. 6.30 pm
	v. 8.30 pm
	vi. 10.30pm
	vii. 11.00pm
	viii. 11.59pm

There are also another bus company that provide services from Kuantan to Johor Bharu.

Table 4.2.3(b): List of the other bus company that provide the service from Kuantan to Johor Bharu

No.	Bus	Departure time
1	Cepat ekpres	i. 1.00 am
		ii. 10.30 am
		iii. 1.00 pm
		iv. 10.30 pm
2	Mara Liner	i. 11.00am
		ii. 6.00pm

4.3 Data descriptive and data analysis

To understand better about the musculoskeletal disorder, low back pain and also the overall health within the bus driver, a questionnaire approach is used. Still as the previous questionnaire survey, about 20 bus driver an asked to fill a form of survey. They survey is the continuous part from the first part.

4.3.1 Data analysis for musculoskeletal disorder

Musculoskeletal disorder is when a musculoskeletal system is injured over time. The disorder may be cause by the longer of time for a person to sit. Therefore, the range of works is important.

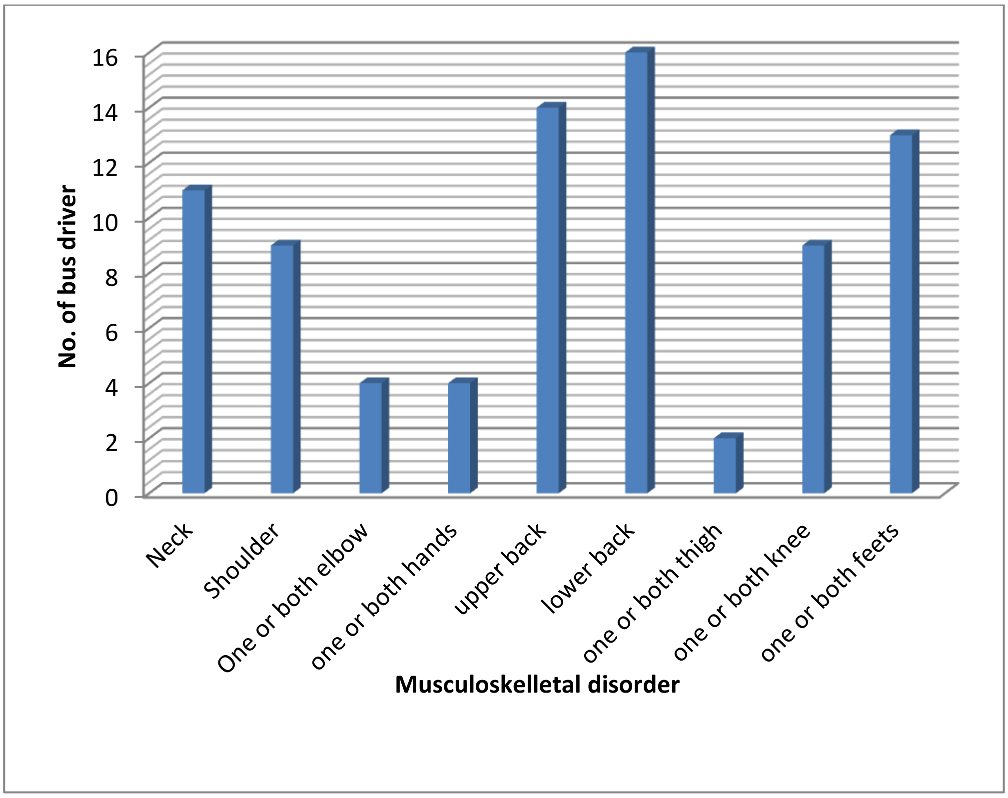

Figure 4.3.1(a): Prevalence for musculoskeletal disorder complaint.

From Figure 4.3.1(a) it is the result from the questionnaire survey for prevalence for musculoskeletal disorder complaint. From figure, it is stated that the most complaint goes to the lower back which is about 16 bus driver answer with yes.

The second highest is the upper back. Simple conclusion is, the most pain that the bus driver felt during their working hours are involving their back. This is because their work needs them to sit on the chair for hours. Just sometimes, they will stop to rest at certain place.

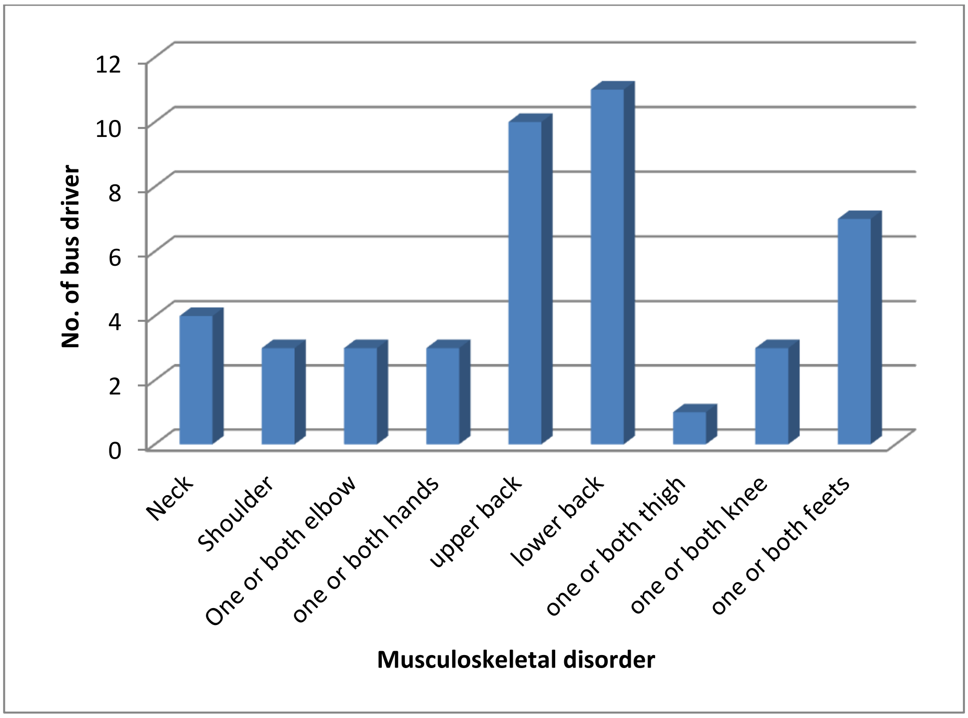

Figure 4.3.1(b): Prevalence for musculoskeletal disorder complaint in 12months.

From Figure 4.3.1(b), it is show the result for prevalence for musculoskeletal disorder complaint in 12moths. Still the same as previous figure 4.3.1(a), the highest are involving the case back pain. This is also due to because of their age average 31-50years which can be consider a quite almost most of them are old. A.D.Woolf et al (2010), osteoarthritis, which is characterized by loss of joint cartilage that leads to pain and loss of function primarily in the knees and hips, affects 9.6% of men and 18% of women aged >60 years.

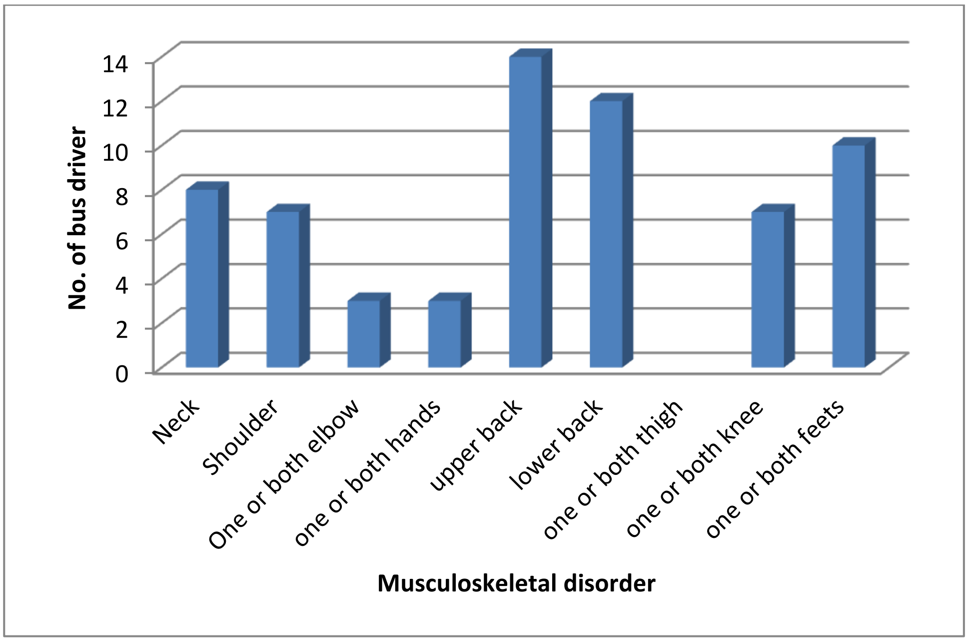

Figure 4.3.1(c): Prevalence for musculoskeletal disorder complaint in 7 days.

From Figure 4.3.1(c), it is show the result for prevalence for musculoskeletal disorder complaint in 7days. Still the same as previous figure 4.3.1(a), the highest are involving the case back pain. A.D.Woolf et al (2010) stated that the musculoskeletal conditions cause more functional limitations in the adult population in most welfare states than any other group of disorders. They are a major cause of years lived with disability in all continents and economies. According to Ontario Health Survey, for example, musculoskeletal conditions caused 40% of all chronic conditions, 54% of all long term disability, and 24% of all restricted activity days.

The musculoskeletal and peripheral nerve tissues are affected by systemic diseases such as rheumatoid arthritis, gout, lupus, and diabetes. Risk varies by age, gender, socioeconomic status, and ethnicity. Other suspected risk factors include obesity, smoking, muscle strength and other aspects of work capacity, L. Punnett et al (2004).

4.3.2 Data analysis for low back pain.

Figure 4.3.2(b) shown the result for the low back complaint that filled by the bus driver. 11 bus drivers said they always felt the low back pain and only about 9 people answered with no.

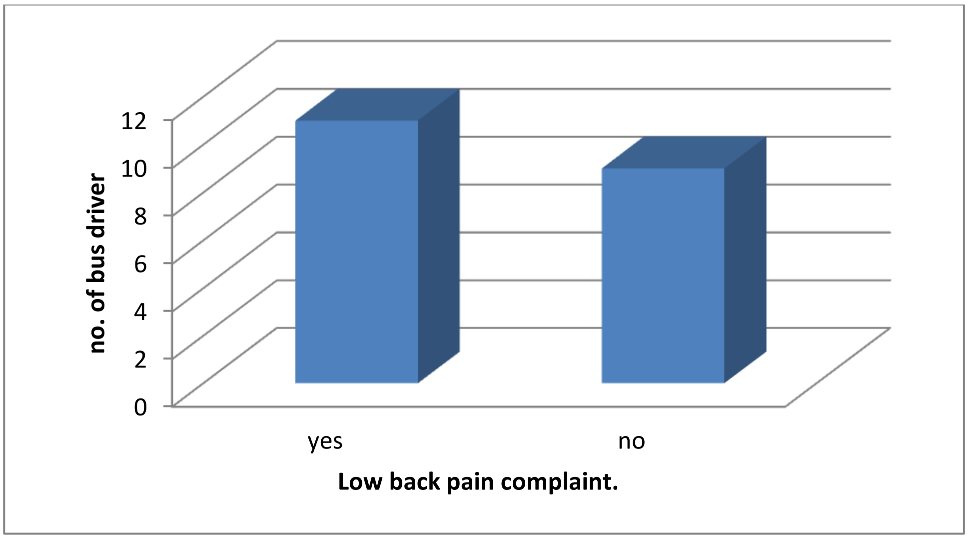

Figure 4.3.2(b): The result for the low back complaint.

According to M.Bovenzi et al (2006), low back pain can be explained as pain or discomfort in the low back area between the twelfth ribs and the gluteal folds, with or without radiating pain in one or both legs, lasting one day or longer in the previous seven days (7-day LBP) or the previous twelve months (12-month LBP).

O.O. Okunribido et al (2006) said that drivers with LBP showed to be significantly lighter in weight and to associate with significantly higher posture scores (on average) than those without LBP. Furthermore, the drivers with LBP showed to lift loads (light and medium) more frequently and associated with higher daily driving hours and years in current job than those without LBP though, these latter differences did not reach significance level. It is reported that some of the bus driver before have been working in other area where they need to lift heavier things. Therefore, it is fulfil what O.O Okunribido said.

4.3.3 Data analysis for overall heath.

Under the questionnaire survey section, there is a section that asks about overall result for their health daily. There are 12 questions that had been asked in this section. Most of the question is about their own heath that happen daily during their work time or even when they are finish with their work for the day.

The first question asks about their focused. The question is the ability to concentrate or focus. This is important because if the bus driver did not focus or unable to give full attention while driving, it might cause accident. Based on survey, the majority of the bus driver answer the question with they always focused while driving.

The second question is about having sleep. Sleep is one of the best ways to relax. Some said that when we sleep, the heart and blood pressure are in very low pressure. The same as that from the first question earlier, most bus drivers say they do not having difficulty to have sleep to rest. Adults are encouraged to sleep for 7 to 9 hours a day.

The third question is based on playing a role in things. This is showing that they are confident in their work. The fourth question is about the ability to make decisions. Third and fourth questions are said to be connected. Both questions involve confidence. If one can solve the problem without a doubt, they can give full attention to their daily jobs. Bus drivers who took part in the survey agreed that their answer could play a role and make decisions wisely.

The fifth question is about the pressure. Pressure occurs when the elements of an urgent or pressing beyond our capacity to deal with them. Based on the survey, half of them also admit that they suffer from stress while driving. This is because due to the weather is hot, the seats are not ergonomics, and the road is too crowded, especially during the festive season and many more. However, the pressure can be a powerful form of encouragement. It can help our body and mind to work well and contribute to mental health. How we handle stress is important in determining the mental and physical health.

The sixth question is about the difficulties you encounter problems. This means that someone is not convinced. The seventh question was about whether they enjoy their daily activities. If they are not fun while doing their work, then they may face pressure.

4.4 Data presentation and data discussion

Under this topic, it is decided to divide it into two parts which is the first one will discuss about the whole body vibration exposure to the bus driver and the second one is about the noise.

4.4.1 Data presentation for whole body vibration exposure

The value for vibration dose value (VDV) is calculated using equation,

$$VDV = \left\{\int_0^T [a_w(t)]^4 \, dt\right\}^{1/4} \qquad \text{.......... (1)}$$

Where:

i. $a_w(t)$ is the instantaneous frequency-weighted acceleration
ii. T is the duration of measurement

Also, the value for daily exposure to vibration A(8) can be calculated using the following equation.

$$A(8) = Vibration\ dose\ value\ \left(\frac{m}{s^2}\right) \times \sqrt{\frac{exposure\ time\ (min)}{480\ min}} \qquad \text{........ (2)}$$

Vibration dose value (VDV) and the Average working hours was calculated by using equation 1 and equation 2. The whole body vibration exposure was recorded for every time from Johor Bharu to Kuantan. Vibration which is transmitted to the body shall be measured on the surface between the body and that surface. The principal areas of contact between the body and a vibrating surface may not always be self-evident. This part of ISO 2631 uses three principal areas for seated person: The supporting seat surface, the seat back and the feet.

According to ISO Standard 2631, whole body vibration can be measured in three position; standing, sitting and lying. Since the case study is the bus driver, it is decided to measure the whole body vibration in sitting position.

From the measurement that was done before, three value of RMS according their axis was obtain. Figure 4.4.1 (b) for x-axis, figure 4.4.1(c) for y-axis and figure 4.4.1(d) for z-axis.

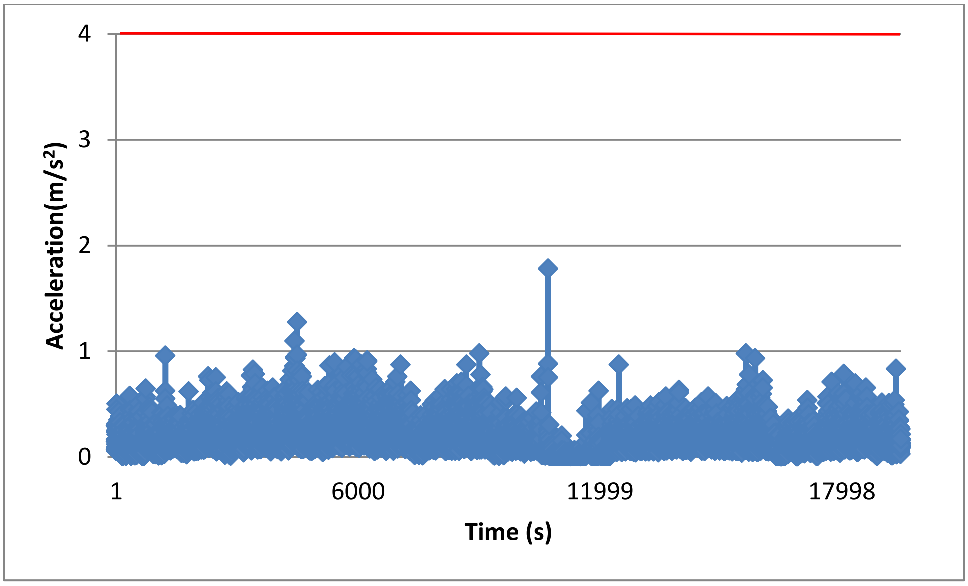

Figure 4.4.1(a): Profiling for whole body vibration exposure for x-axis

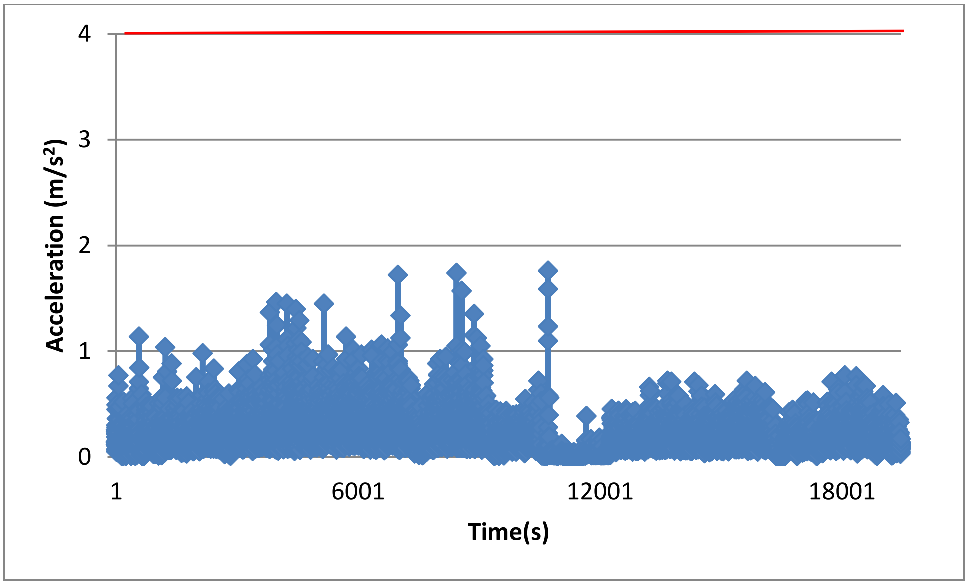

Figure 4.4.1(b): Profiling for whole body vibration exposure for y-axis

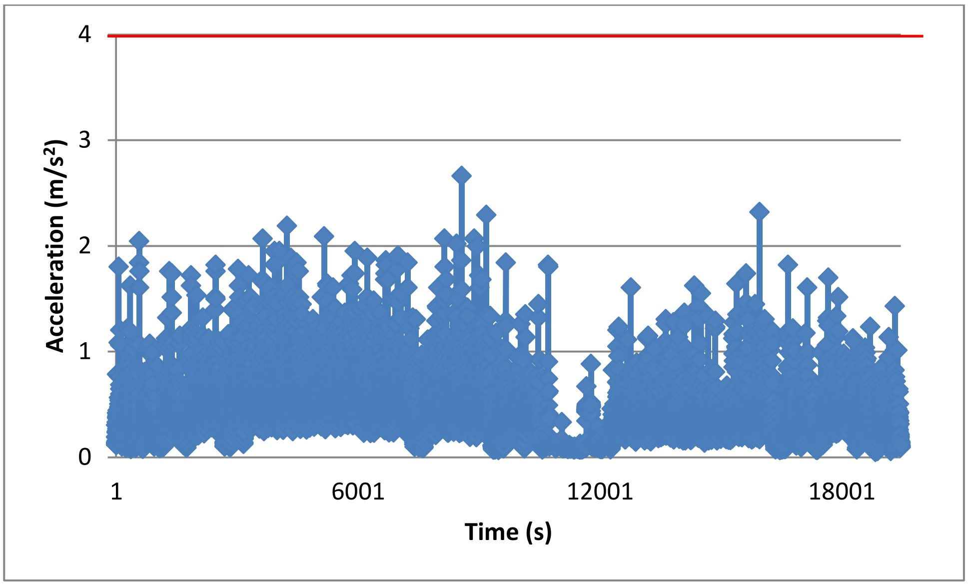

Figure 4.4.1(c): Profiling for whole body vibration exposure for z-axis

Note: The red line is referring to the Permissible Exposure Level (PEL).

4.5 Data presentation for noise

Noise profiling data was collected using the measurement devices known as The Edge. There are 5 devices. Therefore, the data that manage to get is 5. Since the devices are quite a lot, so, some of the devices are attach to the passenger in order to measure the noise in the bus along the journey.

By referring to OSHA permissible noise exposure, the result either the noise in the bus is fail or not can be known. Since the journey from Kuantan to Johor Bharu is taken about 5 to 6 hours, so the collected data should be compared to 6 hours in OSHA permissible noise exposure. According to the table below, for the 8 hours duration of works per day, the sound level should not be greater than 90dB.

Table 4.5: 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
1	105
1/2	110
1/4 or less	115

4.5.1 From Kuantan to Johor Bharu

There are two datas collected. One is from Kuantan to Johor Bharu. The second one is from Johor Bharu to Kuantan.

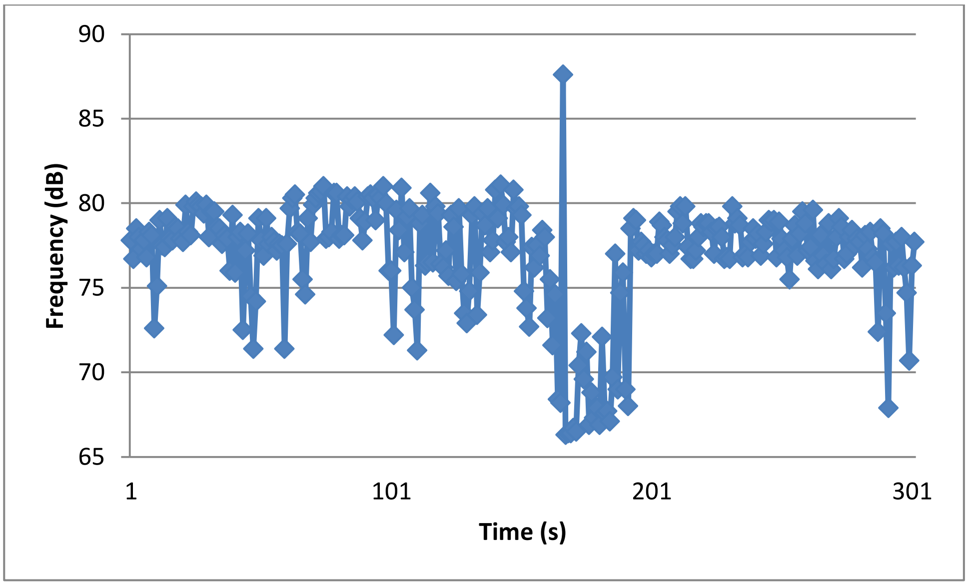

Figure 4.5.1(a): Noise profiling for sample 1

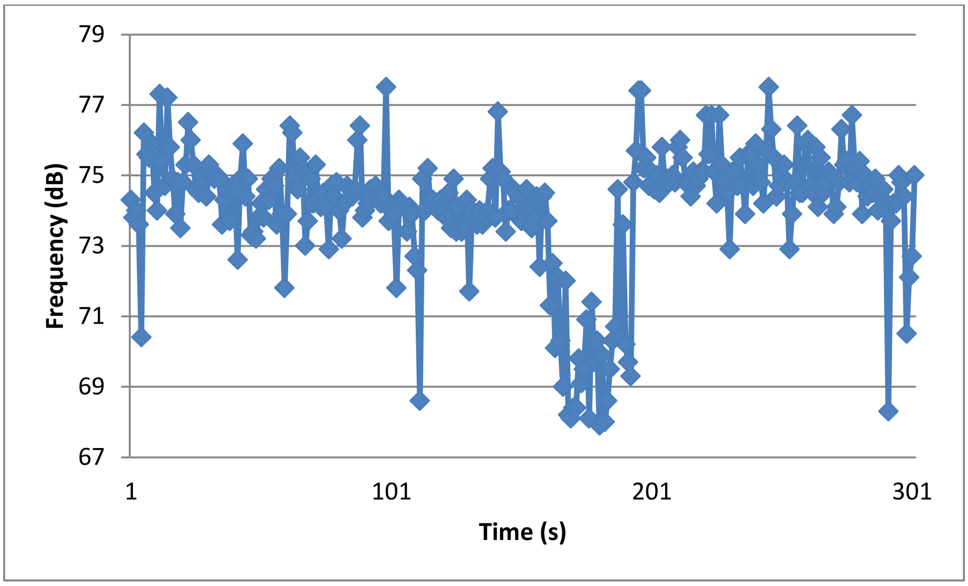

Figure 4.5.1(b): Noise profiling for sample 2.

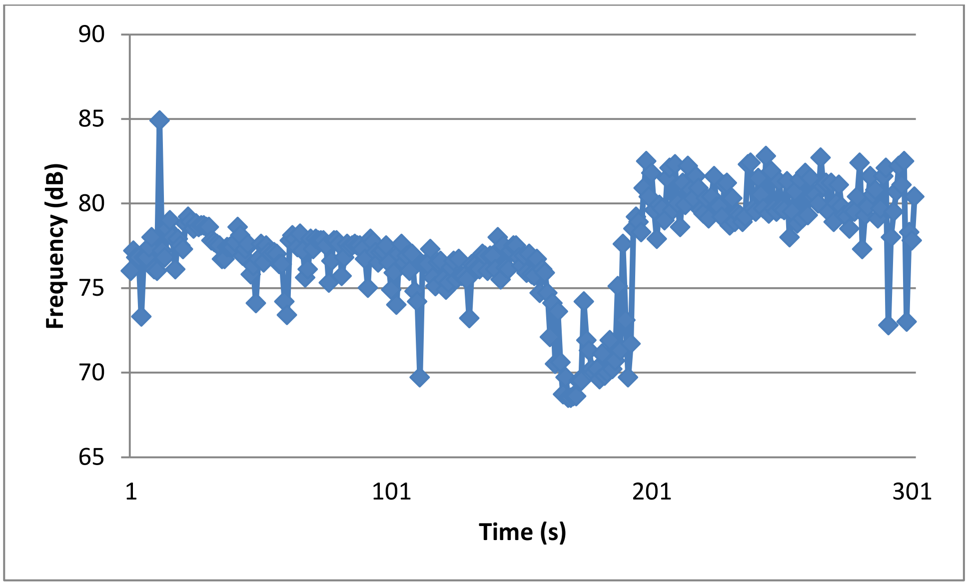

Figure 4.5.1(c): Noise profiling for sample 3

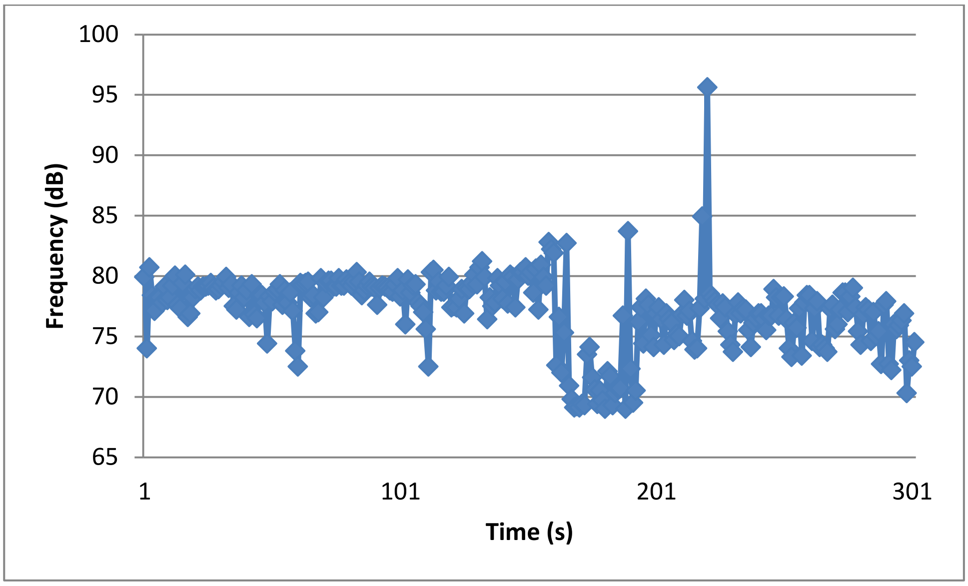

Figure 4.5.1(d): Noise profiling for sample 4

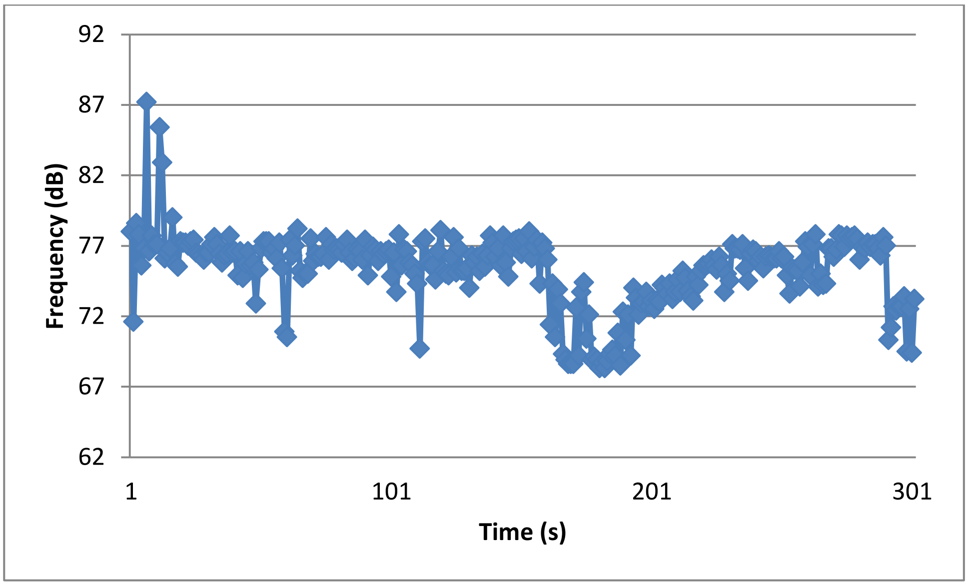

Figure 4.5.1(e): Noise profiling for sample 5

Table 4.5.1 : The overall result for noise profiling from Kuantan to Johor Bharu.

Sample	Sound level, dB(A)
1	87.6
2	77.5
3	84.9
4	95.6
5	87.2

Table 4.5.1 are the overall result for noise profiling from Kuantan to Johor Bharu above, the highest value is 95.6dB which is exceeded the value given by OSHA. Accorindg to OSHA, for slow respon noise, the value should be lower than 92dB. So, it can be concluded that it is a fail since one of the measurement devices for noise measured a very high noise frequency.

Figure 4.5.1(a) shows noise profiling for sample 1 shows that the higher value for the noise collected during the measurement are 87.6dB. Figure 4.5.1(b) shows the noise profiling for sample 2 show that the highest value is 77.5dB. For this profiling, the value for data collected look almost similar. There are 2 points for highest value of noise in this data collected. Figure 4.5.1(c) show that the highest value for the noise profiling for sample 3 is 84.9dB. While the lowest value for the noise are between 67-70dB. Figure 4.5.1(d) is for noise profiling for sample 4. It is clearly shown that the highest value is 95.6dB. Which is no doubt exceed the value given by the OSHA. For the last Figure 4.5.1(e) for the journey from Kuantan to Johor Bharu, the highest value for noise profiling for sample 5 is 87.2dB.

4.5.2 From Johor Bharu to Kuantan

Here are the collected data for noise in a bus from Johor bharu to Kuantan. There are 5 data. The first one is for the bus driver. The other four are for the passengers.

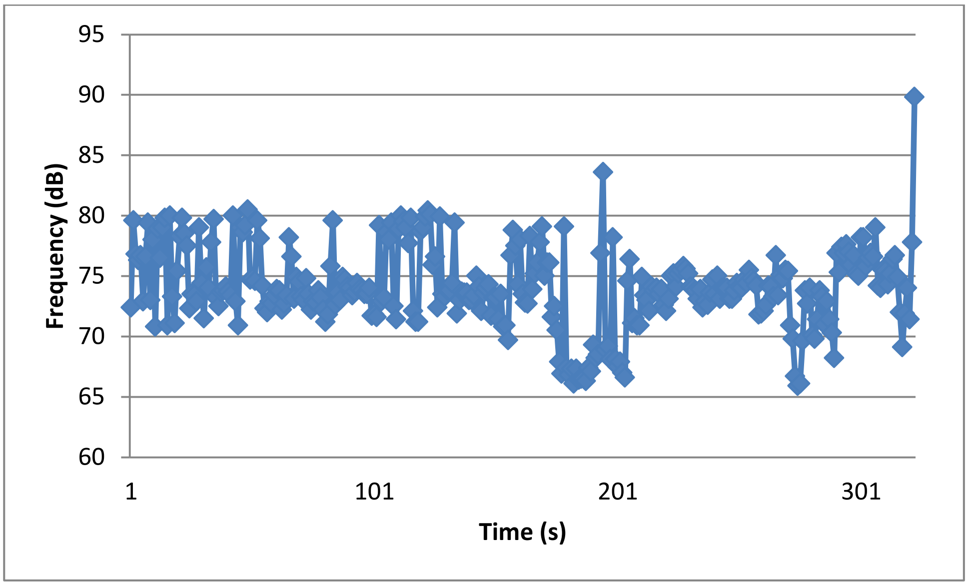

Figure 4.5.2(a): Noise profiling for sample 1

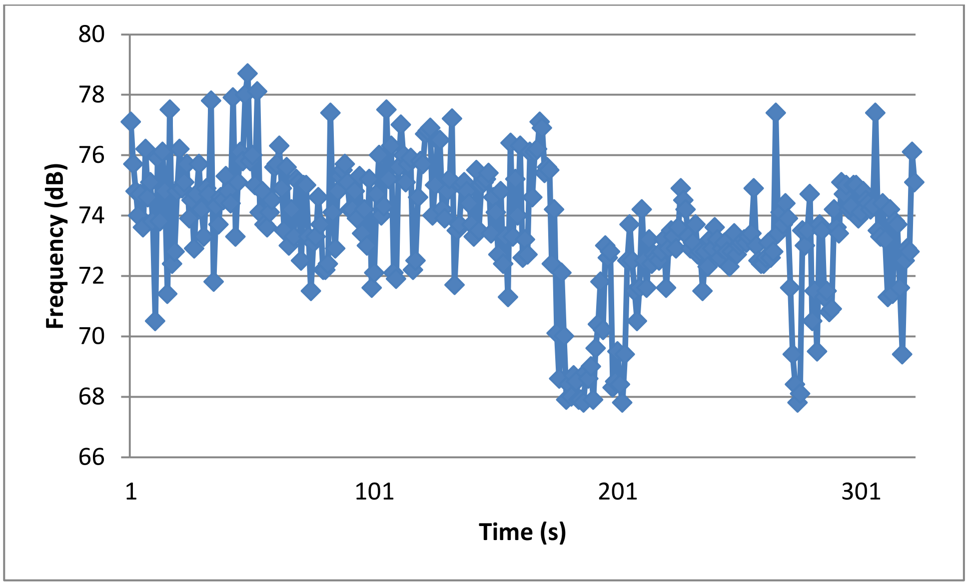

Figure 4.5.2(b): Noise profiling for sample 2

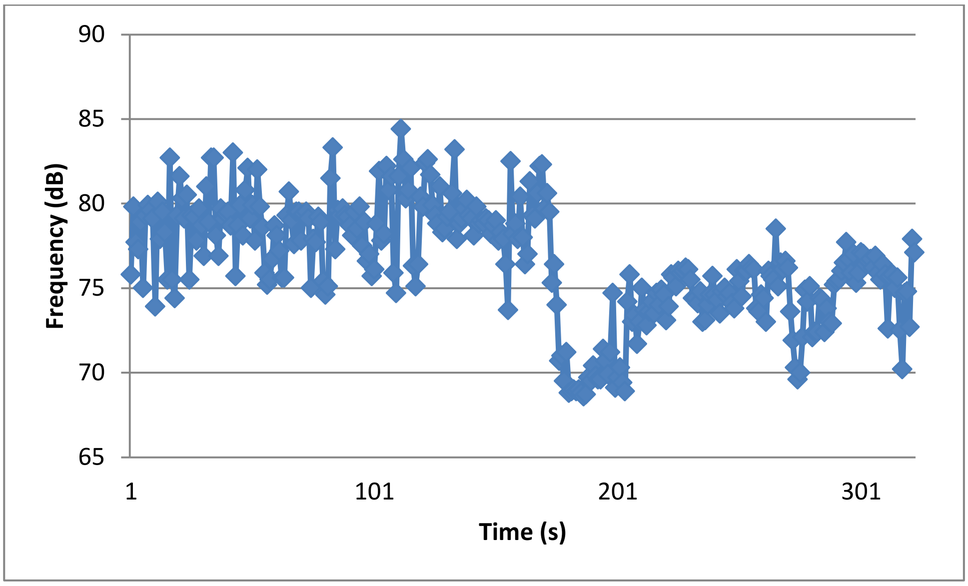

Figure 4.5.2(c): Noise profiling for sample 3

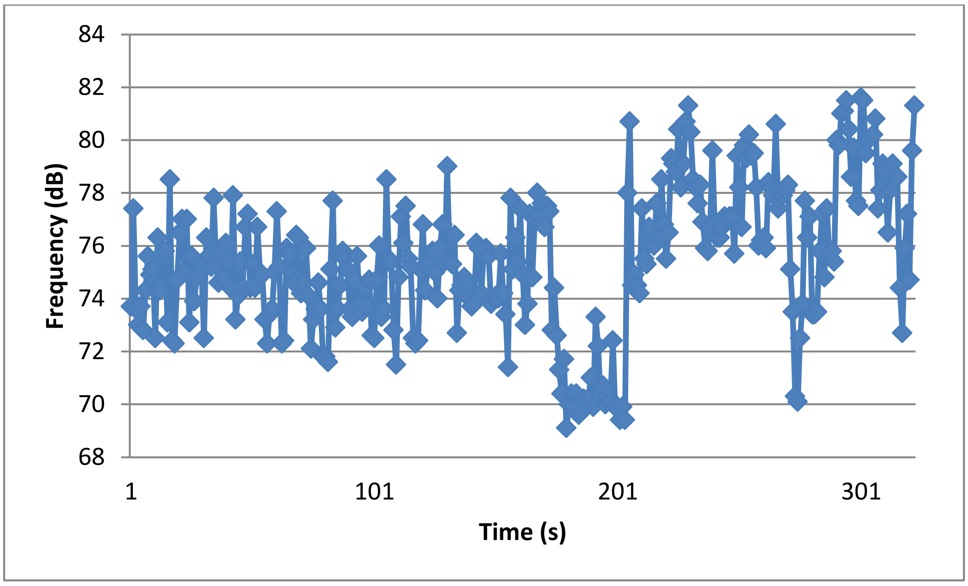

Figure 4.5.2(d): Noise profiling for sample 4

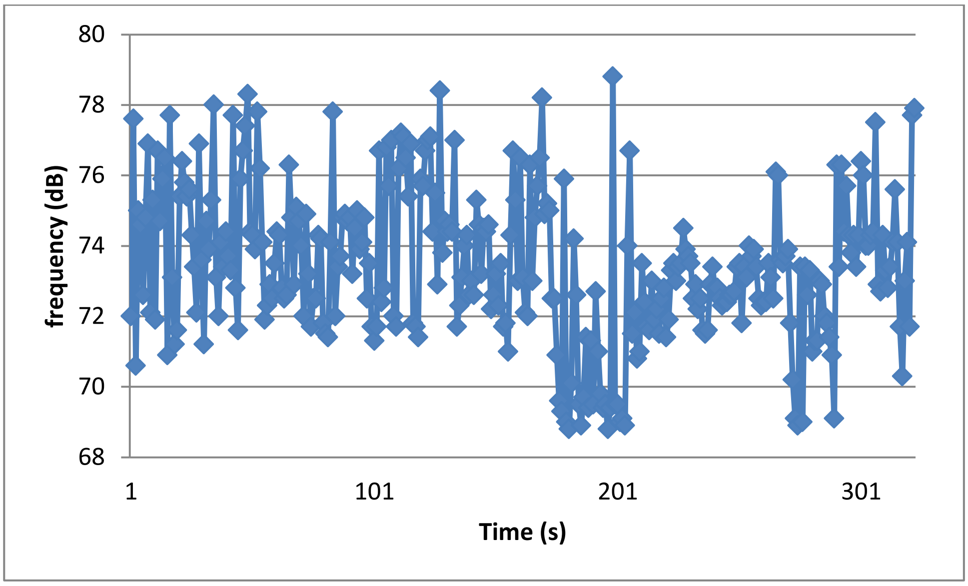

Figure 4.5.2(e): Noise profiling for sample 5

Table 4.5.2: The overall result for noise profiling from Johor Bharu to Kuantan.

Sample	Sound level, dB(A)
1	89.8
2	78.7
3	84.4
4	81.5
5	78.7

For the first sample of noise profiling, the value that managed to collect was 89.8dB which is much closed to the value of noise permissible for 6 hours which is 92dB. This is because, during the measurement, the first sample is a passenger who seat really far in the bus. Usually, at the very end of every bus designed, there is an engine.

From the Figure 4.5.2(a), it shows that the noise profiling for sample 1 is not exceed the value of 90dB. The highest value for the noise profiling is 89.8dB. From Figure 4.5.2(b), it is clearly stated that the value for the noise not even exceed the 80dB. So, the highest value for the noise profiling is 78.7dB. Figure 4.5.2(c) also showed that the noise did not exceed the 92dB value. The highest noise value that measured from sample no 3 is 84.4dB. Figure 4.5.2(d) also showed that the noise profiling for sample four is not a failed because the higher value for noise are 81.5dB. Still the same as the

Figure 4.5.2(e), the noise profiling did not exceed the value of 92dB. The highest value is 78.7dB which is not even closed to 92dB.

So, the noise from the engine is also one of the causes to a higher value of noise profiling for sample 1. However, since every noise profiling for every sample still did not exceed the value of 92dB, therefore it can be concluded that the noise in the bus during the long journey from Johor Bharu to Kuantan is not a fail.

4.6 Data discussion

According to ISO Standard 2631, they are actually a table to refer the standard value of RMS acceleration and also the standard value of comfort reaction to vibration environment.

Table 4.6(a): Standard value of RMS acceleration

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}

The first reference must be the exposure limit. The easier words to describe exposure limit are the total of time for a bus driver to finish their work. Therefore, they are interpreting in hours. Since the route from Johor Bharu to Kuantan takes about 5 to 6 hours every journey, the RMS acceleration that should be refer is 8hours of exposure limit. Therefore the value of RMS acceleration that should be measure is 2.8 m sec^{-2}.

The overall result that manages to get is 0.5467m sec^{2}. Therefore, by comparing the value of the RMS acceleration which is 2.8m sec^{-2}, the result did not exceed the standard value of RMS acceleration given.

A.R Ismail (2010) stated that, the basic method (frequency weighted R.M.S. method) in ISO 2631-1 is primarily applicable to assessment of health risks from stationary vibrations not containing severe multiple or single event shocks. Single event shocks can be analyzed with the additional method running R.M.S. in 2631-1, although there is no information on health risk levels. The additional method VDV (frequency weighted fourth power vibration dose value) is more sensitive to shocks than the basic method, but it will still underestimate the health risk of vibration containing severe shocks in comparison to the health risk of vibration not containing severe shocks. The EU Physical Agents Directive uses the basic method for assessment of health risk with VDV as an alternative.

The root-mean-square (R.M.S) vibration magnitude is expressed in terms of the frequency weighted acceleration at the seat of a seated person or the feet of a standing person, it is expressed in units of meters per second squared (m sec^2). The R.M.S vibration magnitude represents the average acceleration over a measurement period. It is the highest of three orthogonal axes values (1.4awx, 1.4awy or awz) that are used for the exposure assessment.

For knowledge, the frequency weighted acceleration value which less than 0.45 m sec^2 showed that there was no negative health effect expected. Whilst the frequency weighted value in between 0.45 and 0.90 m sec^2 explained that the negative health effects still can be accepted. But, the frequency weighted acceleration value greater than 0.90 m sec^2; high risks of bad health problems were anticipated.

Table 4.6(b): 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

Still, there are ranges to know either the condition is comfortable enough or not comfortable. For the value of RMS less than 0.315m sec^2, the condition is stated as not uncomfortable. The value of RMS acceleration in between 0.315 m sec^{-2} to 0.63 m sec^2, it is stated as a little uncomfortable. For the extreme uncomfortable is when the value of RMS acceleration is greater than 2m sec^{-2}.

Therefore, according to result obtain the value for RMS acceleration that manages to collect during the measurement is 0.567m sec^{-2}. By refereeing to table 4.4.3(b), it says that the value in between 0.5 m sec^{-2} to 1 m sec^{-2} the condition is fairy uncomfortable. There are a lot of reasons to contribute to this condition. According to T.C.Fai et al (2007), seats are one of the most important components of vehicles and they are the place where professional drive spend most of their time on the seat while working. M.J.Yu et al (2002), comfortable chair means that posture on body is the most close to natural state in it.

The lumbar in lying on the side under relaxation is considered as the natural waist state, when the spinal column presents its natural curve and the space among vertebra doesn't change, the press on intervertebral disks is distributed well-proportioned, which is called the best state. The distance among vertebra will be changed, intervertebral disks become jaundiced and ligaments tensioned when spinal column bends, which raises waist discomfort even intervertebral disks are extruded under press.

Other reasons that may lead to this uncomfortable condition are the condition of the road. Theoretically the best way to reduce most vibration is to control it at source by ensuring that all roads and work surfaces are smooth. This should be the aim especially for transport vehicles such as trucks and light vehicles. Road construction needs to be done correctly and according to established procedures. There are important points to consider when involving the road maintenance. The first one is professional road construction methods especially for main roads. The second important points are planned and systematic road maintenance programs that are not regarded as secondary to production demands. Last but not least are dedicated vehicles and drivers for road maintenance.

The high magnitude of vibration which is comes from the vehicle may contribute to low back pain, musculoskeletal and psychological bad effect to the driver.

The words low back pain refers to pain felt in the lower back and it sometimes lasts for a few days to a few weeks. While musculoskeletal is a condition where a part of musculoskeletal system is injured over time. The disorder occur when the body part is called on to work harder, stretch farther, impact more directly or otherwise functions at a greater level then it is prepared for. The immediate impact may be minute, but when it occurs repeatedly the constant trauma cause damage.

According to ISO Standard 2631, the relevant literature on the effects of long term high intensity whole body vibration indicates an increased health risk to lumbar spine and the connected nervous system of the segments affected. This may be due to the biodynamic behaviour of the spine. Whole body vibration may also worsen certain endogenous pathologic disturbances of the spine. Although a dose-effect relationship is generally assumed, there is at present no quantitative relationship available. With a lower probability, the digestive system and the female reproductive organs are also assumed to be affected. It generally takes several years for health changes caused by whole body vibration to occur. It is therefore important that exposure measurements are representative of the whole body vibration exposure.

A.R Ismail et al (2010), said that experimental studies have found that resonance frequencies of most of the organs or other parts of the body lie between 1 and 10 Hz, which are in the range of frequencies found in occupational machines and vehicles. 6 million workers are exposed to WBV typically while in a seated position including delivery vehicles drivers, forklift operators, helicopters pilots and construction equipment operators (Griffin, 2006).

A study from Noorloos.D et al (2006) stated that BMI does not influence the risk of low back pain complaints in a population of occupational participants already exposed to whole body vibration exposure. According to O.O. Okunribido studied et al (2006), one hundred and thirty-three persons (55.7%) reported previous LBP (pain in past 12 months), in which regards, pilots associated with the highest prevalence (80.6% reporting), tractor drivers (43.3%) with lowest prevalence and prevalence for the other groups ranged from 44.1% (works drivers) to 63.3% (taxi drivers).

One hundred and twenty-six persons (30.1%) reported current LBP (pain in last 7 days), in which regards, taxi drivers associated with highest prevalence (44.1%), though prevalence for pilots was only slightly lower (41.9%). Tractor drivers associated with the lowest prevalence (16.7%) and the prevalence for the other groups ranged from 19.0% (police drivers) to 36.7% (controls), O.O. Okunribido et al (2006).

D.M.Joubert et al (2007) studied about the association between back belt usage and back pain amongst forklift drivers exposed to whole-body vibration (WBV). The conclusion that he mange to get was in a high WBV-exposed group, back belt usage was not associated with decreased risk of LBP. Users appeared to have increased LBP, although the relationship may be due to selection bias due to non-random assignment of back belt condition. Relevance to industry, back belt use for WBV exposed professional drivers should not be considered as a valid control measure to reduce the prevalence and intensity of LBP.

By referring to journal done by A.R. Ismail et al (2010), the methods are almost the same. But in term of software, it is different because they decided to use MATLAB. They conducted the measurement for train passenger in three different routes which is from Kajang to Seremban, from Seremban to Gemas and also from Segamat to Tampin. Compare to researcher, the researcher only mange to get one data from Johor Bharu to Kuantan. The values of daily exposure to vibration A (8) and Vibration Dose Value (VDV) were 0.3749 m sec^{-2} and 1.2513 m $sec^{1.75}$ respectively. This is very different from value that the researcher have.

Their result are slightly different because the journal are measuring the whole body vibration exposure to a passenger and not the driver, while the researcher are actually measuring the whole body vibration exposure to the bus driver which is said to have the highest bad condition in the bus. Furthermore, usually a train is design accordingly to follow the railway that they use to move. But the bus, it is unexpected, because the road can be really bad at certain time especially during rainy days.

M. Fukonashi et al (2004) studied a research about the whole body vibration exposure in taxi drivers. Their objectives in this research are to measure whole body vibration (WBV) on the driver's seat pan of 12 taxis operating under actual working condition. The objectives are exactly similar to researcher objective. Their attained result of health which is by using formula from ISO 2631-1: 1997 0.44 ms^{-2}. The result is different from what the researcher manages to obtain during the measurement. This is due to the difference in time of exposure. As stated in the journal, the time exposure for the taxi drivers is 8 hours. But for the researcher, the time exposure is slightly short which is equal to 5 hour and 30 minutes. Therefore, the time to exposure is longer, the higher value for the whole body vibration. Furthermore, they have quite more sample of driver compared to the researcher which makes their value more accurate.

A journal entitled Whole-body vibration exposure experienced by motorcycle riders – An evaluation according to ISO 2631-1 and ISO 2631-5 standards written by H.C.Chen et al (2009) shows that the WBV values of the sedan vehicle drivers have low RMS, VDV(8) and Sed values (RMS 0.27–0.32 m/s2; VDV(8) 6.3–8.3 m/s1.75; Sed 0.21–0.26MPa). However, over 90% of the motorcycle riders had VDV(8) (mean 23.5 m/s1.75) exceeding the upper boundary of health guidance caution zone (17 m/s1.75) recommended by ISO 2631-1, exceeding the value associated with a high probability of adverse health effects (0.8MPa) recommended by ISO 2631-5. Over 50% of the motorcycle riders reached these boundary values for VDV and Se in less than 2 h. (H.C.Chen et al, 2009)

It is very much different from the researcher studies. This is due to a motorcycle rider are more exposed to its surrounding while the bus driver is in a closed condition. Bus driver measurement will not be effected by wind by the measurement data for the motor cycle riders can be affected by winds. Furthermore, the motorcycle rider cannot lean their back because they are no seat while the bus driver may rest by leaning at the back of the seat. Therefore, the low back pain pressure is much higher to the motorcycle rider.

CHAPTER 5

CONCLUSION

5.1 INTRODUCTION

Under this topic, all the result and discussion before will be concluded under this topic. This chapter is to make it easier to understand the entire objective about the study.

5.2 CONCLUSION

The conclusion from this study are unexpected results are obtained. Even so, the result still can be explained. As stated in the literature review, maximum vibration will result in low back pain and also other pain such as motion sickness. The increasing in whole body vibration exposure will lead to higher low back pain. In other words, LBP due to exposure from WBV should be considered a chronic condition, and should be studied accordingly.

5.3 RECOMMENDATION

For the bus driver, the workplace for the bus driver should be more space. This is because the BMI for the bus driver is almost all different. So, a bigger bus driver will need a bigger space for them to feel comfortable and drive the bus calmly. According to the survey studies that have been held before, they agree that the seat is not suitable. So, they ask to redesign their seat. For the passenger, they agree that the bus should be redesigned so that the inside of the bus can absorb the noise inside the bus along the journey.

For the future research, it is recommended to study for the whole body vibration for passengers especially for those who seat at the very end in the bus along their journey. This is because, they are most exposed to whole body vibration because it is said that, the seat at the very end of the bus was put on top of the tires. So, the whole body vibration exposure will be higher and also increase the low back pain. Also, a study about a lorry driver who was carried their own load just after they are having the whole body exposure while driving.

REFERENCES

Alem, N. M. and Strawn. G. D. (1996) Evaluation of an energy absorbing truck seat for increased protection from landmine blasts. US Army Aeromedical Research Laboratory report no. 96-06.

Alentorn-Geli. E, Padilla. J, Moras. G, Haro. C.L, & Fernández-Solà. J (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.

Anthony D.W & Pfleger.B (2010). Burden of major musculoskeletal conditions. Bulletin of the World Health Organization 2003;81:646-656.

Bruyere. O, Wuidart. M.A, Palma. E.D & Reginster. J.Y. (2003). Controlled Whole Body Vibrations Improve Health Related Quality Of Life In Elderly Patients. OASIS - Online Abstract Submission and Invitation System ©1996-2003.

Brenda R. S, Christian. L, Alain. D, Andre. P, Boileau. P & Imbeau.D (2008). A laboratory study to quantify the biomechanical responses to whole-body vibration: The influence on balance, reflex response, muscular activity and fatigue. International Journal of Industrial Ergonomics 38 (2008) 626–639.

Bovenzi. M, Rui. F, Negro. C, Angotzi .F.D.G, Bianchi. S, Bramanti. L, Festa. G, Gattib. S, Pinto. S.I, Rondina. L & Stacchini. N (2006). An epidemiological study of low back pain in professional drivers. Journal of Sound and Vibration 298 (2006) 514–539.

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

Boileau. P.E & Rakheja.S (1998). Whole-body vertical biodynamic response characteristics of the seated vehicle driver measurement and model development. International Journal of Industrial Ergonomics 22 (1998) 449-472.

Bosco. C, Cardinale. M, Colli. R, Tihanyi. J, Duvillard, S. P & Viru. A.(2005). The influence of whole body vibration on the mechanical behavior of skeletal muscle. Carmelo Bosco Ph.D. C /o Societa Stampa Sportiva.

Chang. S. R, Son. K and Choi Y. S. (1996). Measurement and three-dimensional graphic representations of Korean seatpan and seatback contours. International Journal of Industrial Ergonomics, 18:147-152.

Cho Y. and Yoon Y. S. (2001) Biomechanical model of human on seat with backrest for evaluating ride quality. International Journal of Industrial Ergonomics, 27:331-345.

Chen. H.S, Chen.W.C, Liu.Y.P, Chen.C.Y & Pan.Y.T (2009). Whole-body vibration exposure experienced by motorcycle riders – An evaluation according to ISO 2631-1 and ISO 2631-5 standards. Elsevier B.V

Cormie. P, Deane. R.S, Triplett. N.T, & Mcbride. J.M (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.

Daniëlle. A. W. M, Thomas. E, Pope. D. P, Winter. A. F, Macfarlane. G. J, Bouter. L. M & Silman. A. J (2000). Occupational risk factors for shoulder pain: a systematic review. Occupational Environ Med 2000; 57:433–442).

Delecluse. C, Roelants. M, Diels. R, Koninckx. W & Verschueren. S (2005). Effects of Whole Body Vibration Training on Muscle Strength and Sprint Performance in Sprint-trained Athletes. Faculty of Physical Education and Physiotherapy.

Daruis. D. D. I, Nor. M. J. M, Deros. B. M, & Fouladi. M. H. (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.

Duarte, Machado. M.L, Pereira, Brito. M, Misael, Roberto. M, Filho. F & Assis. L.E. 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.

Dong. R, Krajnak. K, Wirth. O. & Wu. J. (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.

Fratini. A, Gatta. A. L, Cesarelli. M & Bifulco. P (2009). Whole Body Vibration training: analysis and characterization. Proceedings of the 9th International Conference on Information Technology and Applications in Biomedicine, ITAB 2009, Larnaca, Cyprus.

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

Funakoshi. M, Taoda. K, Tsujimura. H & Nishiyama. K (2004). Measurement of Whole-Body Vibration in Taxi Drivers. Journal of Occupational Health.

Granlund. J, & Brandt. A (2005). Bus Drivers' Exposure To Mechanical Shocks Due To Speed Bumps.

Gallais . L & Griffin. M.J (2008). Modelling resonances of the standing body exposed to vertical whole-body vibration: Effects of posture. Journal of Sound and Vibration 317 (2008) 400–418.

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

Hafidi. A. E, Martin. B, Loredo. A & Jego. E (2010). Vibration reduction on city buses: Determination of optimal position of engine mounts. Mechanical Systems and Signal Processing 24 (2010) 2198–2209.

Hinz. B, Seidel. H, Menzel. G & Bluthner.R (2002). Effects related to random whole body vibration and posture on a suspended seat with and without backrest. Journal of Sound and Vibration (2002) 253(1), 265-282.

Haynes. S. & Williams. K. (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.

Hagberg. M, Burstro'm. L, Ekman. A & Vilhelmsson. R (2006). The association between whole body vibration exposure and musculoskeletal disorders in the Swedish work force is confounded by lifting and posture. 2006 Elsevier Ltd.

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

Issever. H, OneN. L, Sabuncu.H.H & Altunkaynak.O (2002). Personality characteristics, psychological symptoms and anxiety levels of drivers in charge of urban transportation in Istanbul. Society of Occupational Medicine.

Justinova. L (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.

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

Koley. S, Sharma. L & Kaur.S (2010). Effects of Occupational Exposure to Whole-Body Vibration in Tractor Drivers with Low Back Pain in Punjab. Department of Sports Medicine and Physiotherapy, Guru Nanak Dev University.

Ljungberg. J.K & Neely.G (2007).Cognitive After-effects of Vibration and Noise Exposure and the Role of Subjective Noise Sensitivity. Journal of Occupational Health.

Lundstrom. R & Holmlund. P (1998). Absorption of energy during whole-body vibration exposure. Journal of Sound and Vibration Darren M. Joubert & 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.

Misael, M.R (2001). "Human Comfort to Vibration Levels" (In Portuguese), M.Sc Dissertation, Mechanical Engineering Department, Federal University of Minas Gerais.

Misael, M.R., Duarte, M.L.M. & Filho, L.E.A (2002). "Experimental Evaluation of Vibration Comfort for a Residential Environment", IMAC XX, CD-ROM, p.1376-1381,2002

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

Mingjiu. Y, Jun. Y, Quan. Z & Changde. L. 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

Milic. Z, Demicd. M. & Lukicd.J (2002). Some Aspects Of The Investigation Of Random Vibration Influence On Ride Comfort. Elsevier Science Ltd.

Noorloos. D, Tersteeg. L, Tiemessen. I. J. H, Hulshof. C. T. J & Monique H. W (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.

Newell. G.S, Mansfield.N.J & Notini.L (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.

Newell. G.S, Mansfield.N.J & Notini.L (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.

Nahvi.H, Fouladi. M.H & Nor. M.J.M (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.

Nawayseh. N. & Griffin. M.J (2010). Power absorbed during whole-body vertical vibration: Effects of sitting posture, backrest, and footrest. Journal of Sound and Vibration329(2010)2928–2938.

Nastac. S & Picu. M (2010). Evaluating methods of Whole-body-vibration exposure in trains. University Of Galatifascicle Xiv Mechanichal Engineering, ISSN 1224-5615.

Oborne D.J. (2005). Vibration and passenger comfort. Department of Psychology, University College of Swansea

Okunribido. O.O, Shimbles. S.J, Magnusson. M & Pope. M (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

Okunribido. O.O, Magnusso. M & Pope. M (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.

Okunribido. O.O, Magnusso. M & Pope. M (2006). Delivery drivers and low-back pain: A study of the exposures to posture demands, manual materials handling and whole-body vibration. International Journal of Industrial Ergonomics 36 (2006) 265–273.

Paradisis. G & Zacharogiannis. E (2007). Effects of whole-body vibration training on sprint running kinematics and explosive strength performance. Track and Field Unit, Department of Sport and Exercise Science, University of Athens, Athens, Greece.

Palmer. K.T, Griffin. M.J, Syddall. H.E, Pannett. B, Cooper. C & Coggon. D (2003). The relative importance of whole body vibration and occupational lifting as risk factors for low-back pain. MRC Environmental Epidemiology Unit, Southampton General Hospital, Southampton SO16 6YD, UK.

Punnett. L & Wegman. D.H (2004). Work-related musculoskeletal disorders the epidemiologic evidence and the debate. Journal of Electromyography and Kinesiology 14 (2004) 13–23.

Pope. M. H., Wilder. D. G. & Magnusson. M (1998). Possible Mechanisms Of Low Back Pain Due To Whole-Body Vibration. Journal of Sound and Vibration.

Rehn. B, Nilsson. T, Olofsson. B & Lundstroum. R (2005). Whole-Body Vibration Exposure and Non-neutral Neck Postures During Occupational Us of All-terrain Vehicles. Oxford University Press.

Raanaas. R.K & Anderson. D (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.

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

Rahmatalla. S & DeShaw. J (2011). Effective seat-to-head transmissibility in Whole body vibration: Effects of posture and arm position. Journal of Sound and Vibration330 (2011)6277–6286.

Rittweger. J, Beller. G & Felsenberg.D (1999). Acute physiological effects of exhaustive whole-body vibration exercise in man. Clinical Physiology.

Szeto. G.P.Y & Lam.P (2007). Work-related Musculoskeletal Disorders in Urban Bus Drivers of Hong Kong. Springer Science+Business Media, LLC.

Slota. G.P, Granata.K.P & Madigan.M.L (2008). Effects of seated whole-body vibration on postural controlof the trunk during unstable seated balance. Clinical Biomechanics 23 (2008) 381–386.

Subashia. G.H.M.J, Nawaysehb. N, Matsumotoa. Y & Griffin. M.J (2008). Nonlinear subjective and dynamic responses of seated subjects exposed to horizontal whole-body vibration. Journal of SoundandVibration321(2009)416–434.

Slota. G.P, Granata.K.P & Madigan.M.L (2008). Effects of seated whole body vibration on seated postural sway. Virginia Polytechnic Institute & StateUniversity. Safework Research Centre, University of Aberdeen, Foresterhill, Aberdeen AB25 2ZP, Scotland.

Tiemessen. I.J.H, Hulshof. C.T.J & Monique. H.W. (2007). The development of an intervention programme to reduce whole-body vibration exposure at work induced by a change in behavior: a study protocol. Coronel Institute of Occupational Health, Academic Medical Centre

Tiemessen. I.J.H, Hulshof. C.T.J & Monique. H.W (2008).Vibration:Analysis of a dose_response pattern Low back pain in drivers exposed to whole body. Coronel Institute of Occupational Health, Academic Medical Center (AMC), University of Amsterdam, Amsterdam, The Netherlands.

Wan. H & Chen.W (2010). Effects of Whole Body Vibration on prevention of bone loss in 8-week tail suspended male rats. 2010 3rd International Conference on Biomedical Engineering and Informatics.

Wang. W, Rakheja. S & Boileau. P.E (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.

Wang. W, Rakheja. S & Boileau. P.E (2005). Whole body vibration and posture as risk factors for low back pain among forklift truck drivers. Journal of Sound and Vibration 284 (2005) 933–946.

Wang. W, Rakheja. S & Boileau. P.E (2004). Effects of sitting postures on biodynamic response of seated occupants under vertical vibration. International Journal ofIndustrial Ergonomics 34 (2004) 289–306.

Zannin. P.H.T (2008). Occupational noise in urban buses. International Journal of Industrial Ergonomics 38 (2008) 232–237. Erik W. Gregory. Whole-Body Vibration and the Lower Back: The Effect of Whole-Body Vibration on Pain in the Lower Back. College of Engineering and Mineral Resources.

Zannin. P.H.T, Diniz. F.B, Giovanini. C & Ferreira. J.A.C (2003). Interior noise profiles of buses in Curitiba. Transportation Research Part D 8 (2003) 243–247. TarynE.Hill, Geoffrey T.Desmoulin & Christopher J.Hunter (2009. Is vibration truly an injurious stimulus in the human spine? Elsevier Ltd.

APPENDICES

APPENDIX A

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