WHOLE BODY VIBRATION ON TAXI DRIVER

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ABSTRACT

This thesis is entitled about the Whole Body Vibration on Taxi Driver at two highways which is South-North Highway and Kuala Lumpur-Karak Highway. Usually, taxi driver are sitting on the seat while they are driving for the whole working times. Additionally, long duration of exposure to whole body vibration while driving may lead them to have diseases and adverse health especially lower back pain. The objective of this study is to measure and record, vibration exposures in the x, y, z axis directions to which occupational taxi drivers are exposed measured. Vibration will be reported as root mean square (r.m.s) unit of m/s^2. All the respondents which is taxi drivers had given a questionnaire in order to indicate the prevalence, severity and the human sensation that would lead to musculoskeletal disorders and lower back pain, thus all collected data will be compared to the exposure limit standard which ISO 2631.. . From the measurement, it has found that the taxi driver that through Kuala Lumpur-Karak Highway daily exposure to vibration A(8) and Vibration Dose Value (VDV) were 0.4166 m sec^{-2} and 7.5871 m $sec^{-1.75}$, while for the taxi driver that through North-South Highway were 0.3917 m sec^{-2} and 7.1438 m $sec^{-1.75}$ respectively. It can be concluded that whole body vibration absorbed by the taxi driver has not been exceeding RMS minimum exposure value that could lead adverse health to taxi driver in term of long duration.

ABSTRAK

Tesis ini adalah kajian tentang Getaran Badan Seluruh Pemandu Teksi di dua buah lebuh raya iaitu Lebuh Raya Selatan-Utara dan Kuala Lumpur-Karak. Pada kebiasaanya, pemandu teksi duduk di kerusi sepanjang waktu bekerja mereka. Oleh disebabkan itu, mereka telah terdedah kepada getaran seluruh badan semasa memandu yang boleh menyebabkan penyakit dan kesihatan yang terjejas seperti sakit belakang. Objektif kajian ini adalah untuk mengukur dan merekod, pendedahan getaran keseluruh badan pada arah paksi x, y, z. Getaran akan direkodkan sebagai punca kuasa dua (rms) $msec^{-2}$. Semua responden yang merupakan pemandu teksi telah diberi soalan soal selidik untuk menilai persepsi berdasarkan kecenderungan, tahap masalah dan kesan yang dialami yang akan membawa kepada masalah sakit belakang, maka semua data yang telah dikumpul akan dibandingkan dengan had piawai pendedahan gegaran iaitu ISO 2631. Daripada pengukuran, ia telah mendapati bahawa pemandu teksi yang melalui Kuala Lumpur-Karak Highway untuk pendedahan gegaran seharian A (8) dan nilai dos gegaran (VDV) ialah 0.4166 $msaat^{-2}$ dan 7.5871 $msaat^{-1.75}$. Manakala bagi pemandu teksi yang melalui Lebuhraya Utara-Selatan adalah 0,3917 $msaat^{-2}$ dan 7,1438 $msaat^{-1.75}$. hasil daripada kajian ini dapat disimpulkan bahawa getaran pada keseluruhan badan yang diserap oleh pemandu teksi tidak melebihi nilai rms minimum iaitu 0.5 ms^{-2} yang boleh menyebabkan kesihatan terjejas terhadap pemandu teksi untuk satu tempoh yang lama..

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LIST OF SYMBOLS

%	Percent
mm	Milimeter
kg	Kilogram
dB	Desibel
m	Meter
SD	Standard deviation
s	seconds
min	Minutes
m/s^{-2}	Meter per seconds power of two
h	Hour
$msec^{-1.75}$	Meter per seconds power of 1.75
a(t)	Frequency weighted acceleration
T	The total period of the day during which vibration may occur
Hz	Hertz

LIST OF ABBREVIATION

r.m.s	Root Mean Square
WBV	Whole Body Vibration
VDV	Vibration Dose Value
LBP	Low back pain
EAV	Exposure action value time
MTVV	Maximum transient vibration
ELV	Exposure limit value time
ISO	International Standard Organization
EU	European Union
OSHA	Occupational Safety and Health Administration

BMI	Body Mass Index

CHAPTER 1

INTRODUCTION

1.0 Introduction

Ergonomics is the application of scientific principles, methods and data drawn from a variety of disciplines to the development of engineering system in which people play a significant role (A. R Ismail et al, 2010).

It has been estimated that 4% to 7% all drivers in some European countries, the USA and Canada are exposed to potentially harmful whole body vibration. Long term occupational exposure to whole body vibration is associated with an increased risk of orders of the lumbar spine and the connected nervous system (Tiemessen et al, 2007). In whole body vibration, such that encountered in aircraft, ships, automobiles, farming, machinery, construction equipment, army vehicles and other moving environment, the problem become more acute as operator are subjected to a complex form of vibration which may include low amplitude sudden impact signals (Rahmatalla et al, 2007). According to Hagberg et al, (2006) whole body vibration is a mechanical energy oscillation which are transferred to the human body as a whole and it occurs usually through a supporting system such as a seat or platform. The various effects of vibration on the human body, and the interactions of the human body with supporting structures, are influenced by the dynamic responses of the body (Subashi et al, 2008).

Musculoskeletal conditions are prevalent and their impact is persuasive. They are the most common cause of severe long term pain and physical ability and they affect hundreds of millions of people around the world (Anthony, 2003). Musculoskeletal condition more functional limitation in the adult population in most welfare states than any other group disorders

Taxis are the one of the important and famous public transportation in the whole world, the magnitude of whole body vibration formed by the vehicle may cause diseases and health problem to the human especially a low back pain. According Laura et al, (2004) there is international near-consensus the musculoskeletal disorders casually related to occupational ergonomic stressors, such as repetitive and stereotype motion, forceful exertions, non-neutral postures, vibration, and combination of these exposures.

1.1 Background of Study

From this topic, it will emphasize more on the aspects of the whole body vibration that experienced by taxi drivers. Taxi drivers are exposed to high magnitude of vibration, the awareness of this phenomena is still low. Driving for a long period of time will result to low back pain, the other risk factor for developing low back pain other than whole body vibration and static posture such as awkward movement, frequent and heavy lifting, obesity, unexpected loading of the back and physical conditioning.

Overall, this project involved to determine at what magnitude that make the driver harm from this exposure. Also, give a recommended solution to reduce these effects, the stiffness of the suspension also give a contribution to the effect of vibration that come from the condition of the vehicle.

1.2 Problem Statement’

Over million working days are lost each days due to back pain caused or made worse by work. Back pain can cause by many work and non-work activities. It can lead to time off work, lost productivity and compensation claims. In this current years there are lots of physiological and psychological pain suffer by employees every year. There are lots of factors contributing to the road accident and one of them is the condition of the car. The whole body vibration is transmitted through the seat or feet of employees who drive mobile machine, or other work vehicles and it may cause a health risk including low back pain. Additionally, the total duration exposure to vibration and the magnitude itself contribute to adverse health to employees.

1.3 Objective:

The purpose of this study is to:

(i) Measure and record, vibration exposures will be in the x, y, z directions to which occupational taxi drivers are exposed measured. The vibration will be reported as root mean square (r.m.s) unit of m/s^2.

(ii) Collected data will be compared to the exposure limit standard as per ISO 2631-1:1997.

(iii) Taxi drivers (respondent) will be asked to complete a questionnaire in order to indicate the prevalence, severity and the human sensation that would lead to lower back pain.

1.4 Scope of Study

The scopes of the project are as stated below:

1. Selection of the area and the subject of an experiment to do the survey
2. Preparing some questionnaires related to the anthropometry, activities and comfort/ discomfort feeling by the taxi drivers.
3. Execute the measurement of the taxi drivers to obtain a result.
4. Analyzing the result based on several criteria such as noise effect, whole body vibration effect and criticize the result.

1.5 Significant of Study

The significance of this study is to know the condition of driver taxi and take a safety measurement to avoid adverse health effect among taxi driver and to improve taxi drivers' health. From this research, it will help the awareness among taxi community and to develop a healthy lifestyle environment.

1.6 Structure of the Report

The structure of the report consists of chapter 1, 2, 3, 4 and 5. Chapter 1 consists a about an introduction or overview about musculoskeletal, ergonomic and a sneak peak of the prevalence of low back among European community, and also it consists of problem statement, objective, scope of study and also significant of study. It will summarize all the foundation of information about this research that as a boundary to execute this project.

Chapter 2 will consist of theory of vibration, conceptual of whole body vibration. Additionally, the previous study about related topic also puts in this chapter, the objective to do some research from previous studies as a guideline and overview what are the factor and effect from this phenomena. Furthermore, from the previous literature, it also can guide how to execute a measurement of whole body vibration.

Chapter 3 will summarize the flow processes that have been planned as advised by the supervisor. All the methods, procedure and equipment for this project will be described clearly in this chapter.

Chapter 4 consists of characteristic of the population and result that attained from measurement and questionnaire session and lastly continued with criticism of the result. A table is constructed to show the population of characteristic, a graph is plotted to show the prevalence pain among taxi driver, the graph is plotted in each axes (x, y and z) throughout 8 hours working condition, and lastly critic the researcher result with previous literature review.

Chapter 5 consists of a summary of the findings and the contribution of this study to the community. It also contained directly related to the study objectives, there is a recommendation to reduce the adverse health cased by whole body vibration and future study in term of to get more understanding about this disease.

CHAPTER 2

LITERATURE REVIEW

2.1 – Theory

Vibration is usually used to describe the motion of mechanical objects that oscillates or have a potential to oscillate (Gregory, 2000). The vibratory system consists of three elements such as spring or elasticity, mass or inertia and damper and it involve in transfer of potential energy to kinetic energy and vice versa. Vibration is divided between deterministic and stochastic motion (Gregory, 2000). Deterministic vibration is that which can be predicted, stochastic vibration is a random motion (Gregory, 2000).. Both deterministic and stochastic motion can be subdivided further (Gregory, 2000).. The deterministic class of oscillatory motion can be broken down into periodic which is comprised of either sinusoidal or multi-sinusoidal, and non-periodic motion, which is comprised of transient motion and shock (Gregory, 2000).. Vibratory motion is periodic, and is usually expressed in Hertz, the number complete cycles in one second.

Resonance occurs when an object is subjected to vibration, and the natural frequency is same as the object’s frequency which may damage or actually destroy the vibrating object (Gregory, 2000).. When an object is exposed to vibration and resonance occurs, the object experiencing the vibration will amplify or increase the peak signal, or magnitude of the vibration within the object (Gregory, 2000).. The energy of the vibration is related to this peak, therefore a greater peak value indicates higher energy, possibly resulting in damages of the object (Gregory, 2000).. To further illustrate the concept of resonance, one can think of tuning fork. When the tuning fork is brought near a vibrating string, that is not the same key, nothing occurs (Gregory, 2000).. However, when the fork is placed close to a vibrating string in the same key, the fork begins to vibrate and the vibration in the form of sound is actually amplified (Gregory, 2000).. The tuning fork is experiencing resonance. Unfortunately, human beings are not exempt from experiencing this phenomena at certain resonant frequencies (Gregory, 2000).. It is thought that the WBV (Whole Body Vibration) resonance in the vertical direction is 4 to 8 Hz and in horizontal and lateral direction WBV thought to be between 1 to 12 Hz (Gregory, 2000).

2.2 Whole Body Vibration

According to Wasserman, (1996) state that the possible effects of WBV exposure include herniated and degenerative lumbar disc diseases, low back pain, and other musculoskeletal disorders. Also, cases of spontaneous abortion in some female vehicle operator have been recently reported. This makes it clear that the exposure of whole body vibration to occupational drivers is a risk factor for developing low back pain and other medical problems. According to previous reports that made by Helmkamp et al, 1994 found that a typical occupational driver would be exposed to over 40,000 hours of occupational vibration over a 30-year period. This shows that chronic effects of this vibration are important and must be investigated. According to Griffith 1990, the term of whole body vibration is used to describe a situation when the whole environment is undergoing motion and effect of interest is not local to any particular point of contact between the body and environment. It occurs when the body is supported by vibrating surface. And also according to Griffith 1990, there are three main possibilities of WBV which is sitting on a vibrating seat, standing on a vibrating floor, or lying on a vibrating bed

2.3 Seating posture and low back pain

Chao Ma et al, (2010) wrote a journal about Lower Limb Muscle. The aim of this study is to analyze the state of muscle activities and joint forces of the lower limb during whole body vibration of 30 Hz with knee lock and knee under normal standing postures. The three dimensional musculoskeletal of lower limb was set up by using the Anybody Modelling System, the subject was selected based on a healthy male subject with 29 years old, height of 172 cm and weight of 60 kg and the data of length of thigh, shank, foot, width of the pelvis and the percentage of fat, the muscle and bone are recorded. There are 11 key points to obtain the freedom constraints which is calcaneus, lateral malleouls, tibial lateral eondyle, fumer lateral condyle, iliac crest and secrum. The data collected by using Motion Capture System, monitoring system and vibration platform. According to the muscle curve activity, the knee lock standing posture is more active compared to knee lock standing postures, so there is the influences of vibration with the knee lock posture of the human body. From the joint curve, found that with different standing postures and have a different joint force curve. The hip joint with knee lock postures has a greater than the knee normal standing and both of standing posture have similar ankle joint force. It concludes that the knee lock standing posture is the factor that contribute to the bad musculoskeletal system

Bazrgari et al, (2008) evaluated seated whole body vibration with high magnitude acceleration they found that spinal compression and shear forced were influenced to a greater extent by muscle activations than by inertia in the presence of shock content at near to the resonant frequency. The cause of spinal injuries that initiated from unstable or equivalently hypermobile configuration of the spine and to reach a stability of the spine is effective by some low activities in an abdominal muscle. Muscles are also contributing a stability to spinal by their passive intrinsic and reflexive response. They conclude that by flattening the lumbar lordosis from an erect to a flexed posture and antagonistic coactivity in abdominal muscle, both increased the force on the spine while substantially improving trunk stability and there is a significant increase of muscle activity if the high magnitude of vibration combined with at near resonant frequency that exposes to the vertebral column and it lead to the larger risk of injury

Slota et al, (2008) evaluated effects of seated whole body vibration on postural control of the trunk during the unstable seated balance. They found that all measures kinematic variables of unstable seated balance increase ($p<0.05$) after vibration including ellipse area (35.5%), root mean square radial lean angle (17.9%), and path length (12.2%) and for measurement of non-linear stability control also increased ($p<0.05$) including the Lyapunov exponent (8.78%), stability diffusion analysis (1.95%), and Hurst rescaled range analysis (5.2%). All measures of kinematic variance and non-linear stability control during the unstable seated balance increase following whole body vibration and the changes of postural control of trunk during the unstable seated balance it depends on impairment of spinal stability which is it maintained through the contribution of passive tissue stiffness, active muscular stiffness and neuromuscular stiffness. They also found that the effect of whole body vibration on these tissues can contribute to the alteration of postural control of trunk. They conclude that, whole body vibration impaired postural control of the trunk lid to indicate impaired spinal stability.

Newell and Mansfield, (2008) investigated the influence of sitting in different working posture on the reaction time and perceived workload of subject exposed to whole body vibration. Twenty one subjects were exposed to 1 -20 Hz random vibration in the vertical and fore-and-aft directions. A task was completed while seated in four posture condition, upright or twisted, with and without armrests. Posture combined with whole body vibration exposure had a significant influence on the ability to perform the task. The combined environmental stresses significantly degraded the performance, not only did their reaction times become compromised, the participant workload demand also increases. The most severe decrement in performance and workload was experienced while seated in a twisted posture with no armrest support. They concluded the inclusion of armrest significantly improved the participant's ability to complete the task with a lower workload demand

Okunribido et al, (2006a) evaluated delivery drivers and low back pain that a study of the exposures to posture demands, manual handling and whole body vibration. They found that the delivery driver work relatively long hour each day and the driver showed that to spend 20% of the work time behind the wheel. In terms of manual material handling, there is only low physical effort was involved in manual material handling but at high frequency of lifting and lifting immediately after driving. They also found that, discomfort during driving is not a major problem to them, indeed the torso against the backrest and torso upright where the posture most frequently adopted but they do a twisted posture with and without bending in very short time which is to reverse the vehicle and by eliminating the need to twist can reduce the risk of low back pain in short haul driver. They conclude that low back pain is prevalent among short-haul delivery drivers and likely to transient (lasting less than a week) in nature than permanent and short haul delivery drivers clock up considerable hours of daily work time, but they are not likely to spend more than 30% of the time actually driving. Additionally, avoiding unduly rapid movement of the load during handling, reducing and the need to twisting of the torso during driving and preventing exposure to shock event are the strategies that can control precipitation

Okunribido et al, (2006b) evaluated the relative role of whole body vibration, posture and manual handling in term of low back pain among drivers. From analysis, that three factor of vibration exposure which is uplifting, from seat/seat bottoming out, driving style, and vehicle gearing is associated with the prevalence of low back pain. The adjustable seat and torso straight posture, awkward lifting posture, driving style, backrest, and torso twisted are also associated with the prevalence of low back pain. They conclude that, combined exposure due to posture and one or both of vibration and manual material handling rather than individual exposure to one of the three factors which is a posture, manual material handling and whole body vibration is the main contributor to the prevalence of low back pain

Wang et al, (2006) has been evaluated about the role of seat geometry and posture on the mechanical energy absorption characteristic of seats occupants under vertical vibration. The aim of this study is to investigate the power absorption characteristic of the seated human body under whole body vibration exposure. The seat is adjusted into three different sitting height, measured from the pan to the ground which 510mm(H1), 460mm(H2) and 410mm(H3) and two different inclination of backrest (0^0 and 12^0) and two different pan angles ($0^0$and 7.5^0). The subject of this evaluation is about 27 subjects which are 13 males and 14 females and are considered healthy and no sign of musculoskeletal system disorders, among them the body mass of participant ranged from 47.5 to 110.5 kg with a mean of 70.8kg. The postural variation was also considered for two different hand position condition which is hand in lap representing passenger posture and hand on the steering representing driver posture. The result shows that the body mass, variation in seat geometry, seat height and sitting posture (anthropometry) strongly affect the energy dissipation properties of the vibration exposed body, the maximum amount of energy absorption in the frequency band is around 5-10 Hz for both hand positions. The author also stated that the hand lap in lap posture tends to absorb more energy than those with hand on steering wheel posture with inclined backrest and the back support posture tend to reduce the energy dissipation by the body at low frequencies and increase the absorption at frequencies above resonance, irrespective of the hand position.

Johanning et al, (2006) evaluated a whole body vibration and ergonomic study of US railroad locomotive. They found that, the mean basic vibration measurement was in the x, y, z axis and vector sum is 0.14, 0.22, 0.28 and 0.49 m/s2, respectively. The SEAT ratio which is floor or seat and transfer function show that the currently used seat is magnified the floor input vibration than reduce it, especially in the horizontal directions. The vibration dose value also exceeds the critical value provided by ISO 2631-1. In terms of questionnaire, it is about 75 % of the railroad engineer experienced low back pain compared 41% of the control whose did not expose to rail bound vehicle vibration. The comfort and adjustment aspect are also contributing the affect for this measurement, most of the railroad engineer said that the cab lay out and seat (49%), followed by vibration (22%) and air conditioning (11%). The role of seating posture, awkward positioning and seat/cab adjustment features in the overall vibration exposure risk assessment generally seem to be really important. They also suggested that for future studies, it should focus on the real time measurement of the locomotive engineer's body posture during a typical work-shift and whole body vibration measurement and compare the results to the other vehicle driver. Additionally, they also propose the idea how to reduce adverse whole body vibration effect on locomotive engineer by customizing vibration attenuation seat and cab design of locomotive and improve task management of locomotive engineer.

Hoy et al, (2005) evaluated whole body vibration and posture as a risk factor for low back pain among forklift truck drivers. They found that there was more prevalent of low back pain in the past 12 months among the driver than the control, the 44% of the driver samples reported severe pain compared to 22% of the control who reported similar level of pain intensity. In terms of body weight for those whose have lower BMI less than 25, low back pain showed to be significantly more prevalent among drivers than among control. They also found the confounding factor among the subjected tested which is smoking habit, exercise habit, job satisfaction, and lifting during work and all of this factor are not lead to the prevalence of low back pain. They conclude that, the low back pain is more prevalent among forklift drivers than non-driving workers and driving postures in which the trunk is twisted or bent forward considerably and the neck extended backward which is associated with low back pain. Additionally, they also concluded that the acceptable level of vibration exposure is lower than the value of EU Physical Agent Directive on vibration which is they recommended action level is 0.5m/s2. But this value is not at z-axis direction but at x and y axis direction by forklift trucks.

Mansfield and Griffin, (2001) evaluated effects of posture and vibration magnitude on apparent mass and pelvis rotation during exposure to whole body vertical vibration. They found that in all postures, resonance frequencies in the whole body vertical vibration apparent mass reduced in frequencies with increases in vibration magnitude, show that this is a non -linear softening effect. The transmissibility is decreased with increasing in vibration magnitude, but between 1.0 and 2.0 m/s^2 RMS with upright, back on and cushion condition is accepted. All condition show more pelvis rotation in frequency ranges from 10 to 18Hz than at lower frequencies. There were only tiny changes in apparent mass and transmissibility with posture, although peaks were lower for the apparent mass in the kyphotic posture and were lower for the transmissibility in the belt posture

In a more study, Toren and Uberg, (2001), investigated whether the exposure to twisted trunk posture was affected when driving an agricultural tractor in the field using freely swivelling saddle chairs. Ten subjected employed as a tractor driver volunteered for this study. The result of this study showed that the exposure to extreme twisted trunk posture was slightly reduced during harrowing using the saddle chair than the conventional chair. But for plowing, the exposure to extreme twisted postures was reduced by about 50% in comparison to conventional chair. Thus, it can be concluded that the use of a freely swivelling mechanism and enough space to swivel would be beneficial in reducing posture stress.

Cornelius et al, (1994) evaluated postural stability after whole body vibration exposure. They found that there is two independent variable, each at two levels consisted vibration and vision. The measured dependent variable were postural sway amplitude and velocity of sway. There is no significant difference between the vibration and no vibration were found. The author said that it cannot conclude that whole body vibration influenced the postural stability. They conclude that it could be more studies to investigate to confirm if the pastoral stability is affected by whole body vibration.

Courtney and Chan, (1999) performed an ergonomic study to evaluate the workplace and workspace design of a cab of grab unloaders for bulk material in ships. Their results demonstrated that the driver adopted poor postures, partially due to the basic geometry of the situation and in part due to using only the central lower front window for downward vision and control boxes that obstructed operator’s vision. All of the drivers complained that they had to maintain and perform their work in an awkward