CHAPTER 2

LITERATURE REVIEW

This chapter describes concepts and main topics to solve the research problem, basic theories to support the description of the upcoming research and previous research that related to this research.

2.1 EMPIRICAL REVIEW

Some researches were discussed about electromyograph involvement towards new muscle problems in some activities.

The research of cardiometabolic disease risk in children. The objective is children aged 10-14 years old. The research is about to analyze whether 8 hours prolonged sitting will impact much to their cardiometabolic disease risk. It also combined by another session with a short walk intensity. The results is there is not significant difference with no effect of glucose changes (Saunders et al., 2013).

The comparison of three methods can be used in processing amplitude signal in EMG. The study was conducted on 6 men and 6 women with levels between 18-25 years old. Each respondent performs seven levels while running at his own chosen pace. The muscles studied were gastrocnemius (MG), anterior tibialis (TA) and fibularis longus (FL). The three methods used in the EMG signal process are peak RMS (pRMS), mean RMS (mRMS) and integrated RMS (iEMG). From the data processing using ANOVA analysis, it was found that pRMS method has significantly lower significance value compared to mRMS and iRMS. The resulting value of mRMS and iRMS is

almost the same, but based on some other studies the mRMS method is a better method for doing EMG processing (Renshaw, et. al., 2010)

Identification of the relationship of sex and age to the occurrence of gaps in electromyography during a discrete task. The study was conducted by 14 adolescents consisting of 7 males and 7 females and 15 adults consisting of 8 males and 7 females. The result of this study indicate that gap activity is sensitive to occupational activity and the duration of this is seen that the activities of women and adults show a more stable or silent EMG signal compared with the activities of men and adolescents (Harwood, et. al., 2011)

The study of determining the psychological fatigue and analyze muscle activity of production workers who are performing processes jobs while standing for prolonged time periods. The experiment is involved metal stamping workers using electromyograph in erector spinae, tibialis anterior, and gastrocnemius muscle. The result is prolonged standing was contributed to psychological fatigue and to muscle fatigue among the production workers (Halim, et. al., 2012)

Balasubramanian et al. (2014) in his study, described the physical fatigue detection due to motorcycle riding for an hour using electromyography and seat insensor pressure pad. Twenty healthy male respondents performed 60 min of motorcycle riding in a low traffic density environment. Muscle activity was recorded bilaterally from extensor carpi radialis (ECR), biceps brachii (BB), trapezius medial (TM), sternocleldomastoid (S) latissimus dorsi (LD) and erector spinae (ES) muscle groups. Interface seat pressure distribution was monitored using a pressure mapping system. Results showed that respondents have significant ($p < 0.05$) physical fatigue in TM, LD and ES muscle groups during 60 min of motorcycle riding. Seat pressure distribution was found to be non-uniform during the course of motorcycling. Results suggested that the impact on local physical fatigue and seat discomfort are probably due to static seating demand and prolonged sitting posture balance required to ride the motorcycle for an hour.

The research of evaluating the hand muscle activities when it is interacted with the computer using mouse, keyboard and joystick is done by Soewardi, Anugraheni, & Shabrina, (2015). These muscles that investigated are *flexor pollicis brevis*, *flexor digitorium superficiallis* and *abductor pollicis brevis*. Average of Root Mean Square (mRMS) signal was used as parameter and tested with 8 females and 7 males respondents for 15 minutes. The result of this study shows that use of mouse is better.

2.2 THEORITICAL REVIEW

2.2.1 Ergonomics

Ergonomics can be defined simply as a study of work. For a more basic understanding, ergonomics is the science that designs a job to fit the worker. Ergonomic applications such as designing tasks, work stations, tools and work equipment to be adjusted with workers so as to reduce the physical burden on workers and eliminate some potential injuries such as musculoskeletal disorders (OSHA, 2000)

Another definition according to the International Ergonomics Association, among others, states ergonomics as an applied science of human biology and its relationship with machineering science for workers and their work environment, in order to obtain maximum job satisfaction in addition to increasing productivity. Ergonomics can be divided into sections according to their scope (OSHA, 2000):

1. Physical Ergonomics: related to the anatomy of the human body, anthropometry, physiological characteristics and biomechanics related to physical activity. Matters relating to work posture, material handling, repetitive movements, work related to musculoskeletal disorders, workplace layout, safety and health.

2. Cognitive Ergonomics: related to human mental processes, such as perception, memory and reaction. Relevant points include mental workload, decision making, skilled performance, human-computer interaction, human reliability, job stress and training.

3. Organizational Ergonomics: deals with organizational structures, policies and processes. Relevant matters include communication, resource management, job design, work time design, teamwork, participatory design, community ergonomics and quality management (www.iea.cc, 2011)

4. Environmental Ergonomics: related to lighting, temperature, noise and vibration. In ergonomics involves three interacting components including human, machine and environment. The interaction is known as a work system which means a work system that cannot be separated from one to another (Birdger, 2003). Here is a basic interaction table in the work system:

Table 2.1 Basic interaction and evaluation in worksystem

Interaction	Evaluation
H > M **:** Basic control measures by humans in the use of tools or machines, the application of: maintenance, material handling, use of work tools.	**Anatomy:** Posture and movement, magnitude of strength, duration, frequency, muscle fatigue. **Fisiologi** : *work rate* (oxygen consumption, heart rate), *fitness of workforce*, physical fatigue.
H > E **:** The effects of humans on the environment. Humans emit carbon dioxide, body heat, air population, etc. M > H **:** Feedback and display information. The machine can affect the pressure on humans, in the form of vibration, acceleration and others. The surface of the machine can be either hot or cold **can be** a health threat to humans.	**Physic** : The objective measurement of the work environment, the implications of compliance with applicable standards. **Anatomy** : Controls and Tools design **Physic** : Measurement of vibration, machine strength, noise and surface temperature of the machine.
M > E **:** The machine can change the working environment due to noise, heat, and hazardous gas emissions. E > H **:** Vice versa, the environment can affect the human ability to work, for	**Physiology** : the sensor reaction feedback exceeds the physiological limit or not. Generally handled by industrial and machineering practitioners and industrial hygienist. **Physical Physiology** : Noise, lighting and temperature surveys.

Interaction	Evaluation
example because of noise, heat temperature, etc.	
E > M **:** The environment may affect the function of the machine for example to freeze components at low temperatures.	Handled by industrial machineering practitioners, maintenance officers, facility management and others.

H **:** ***Human,*** M**:** ***Machine,*** E**:** ***Environment,*** >**:** ***causal direction***

Prolonged sitting in the workplace can cause discomfort and muscle fatigue especially in the lower extremities of workers by the end of the workday. Discomfort or subjective fatigue can be linked to psychological fatigue and it has been recognized as a factor in the decline of alertness, mental concentration, and motivation (Halim, et al., 2012). The Hamstring muscle is one of muscle that would involve to discomfort muscle group during prolonged sitting. It is located between the hip and knee behind the thigh area. It is composed by three muscle bellies of Bicep Femoris, Semitendinosus and Semimembranosus muscle. The muscle location which from medial hamstring and lateral hamstring is Semimembranosus, Semitendinosus and Biceps Femoris muscle (Onishi et al., 2002).

2.2.2 Musculoskeletal Disorders

Musculoskeletal disorders (MSDs) are a complaint of the muscular parts found by someone who is sick. If anything, it will take a long time to produce damage to joints, ligaments and tendons (Grandjean, 1988)

Musculoskeletal disorders are also known as repetitive motions that are continuous and are also used for the incorporation of various tissue conditions and joint inflammation. Some diseases are included in repetitive injuries such as tendonitis, tenosynovitis, neurological syndrome (eg radial, ulnar, etc.), muscle sprain, carpal tunnel syndrome and bursitis (Phillips, 1999)

Some of the factors that cause musculoskeletal disorders are occupational, environmental and human factors (Oborne, 1995; Pheasant, 1991) and psychosocial factors

1. Job Factor
    a. Work Posture

    Unnatural work attitude or work attitude that causes the body to move away from its natural position.

    b. Frequency

    Frequencies that are too often will encourage tendon changes and tension muscles.

    c. Duration

    The duration of time is guided by risk factors. Definitions of duration if <1 hour per day, moderate duration: 1-2 hours per day, duration> 2 hours per day. While the duration of awkward posture is at risk when the posture is more than 10 seconds (Humantech, 2003)

    d. Load

    The recommended weight is 23-25 kg or according to the Ministry of Health (2009) for adult men 15-20 kg and women of 12-15 kg.

    e. Tool Handling / Grip

    When the hand has to waver the tool or welfare button, then the network will receive directly from the tool handler (Tarwaka, 2004)

2. Environmental Factors
    a. Vibration

    Vibration with high frequency will cause muscle contraction increases. Contractions that are static will cause the blood circulation is not smooth, accumulation of lactic acid increased and multifunctional muscle pain (NIOSH, 1997)

b. Microlimat

Exposure to cold temperatures that can be used to change the agility, sensitivity and strength of workers into slow, difficult movements that move the decrease in muscle strength (NIOSH, 1997)

c. Lighting

Eye are tired because spies will try to see by opening their eyes wide.

3. Worker Factor

a. Age

According to (Oborne, 1995), Skeletal muscle examination is usually carried out on the workers in the age of 24-65 years. While (NIOSH, 1997) says there is no relationship between MSDs and workers, the things that are discussed in older workers.

b. Gender

Female workers have bigger risk of MSD if compared to men (Michael, 2001)

c. Working time

In the work measurement, work time required and optimum which is according to the type of work.

d. Habit

Smoking habits are divided into 4 categories: heavy smoking (> 20b / day), moderate (10-20 cigarettes / day), mild (<10 cigarettes / day) and no smoking (Bustan, 2000)

e. Physical Freshness

Muscle complaints will increase as a result of muscle cramps along with increased physical activity without physical fitness (Mitchell, 2008)

f. Physical Strength

Workers who have low muscle strength are three times as likely to be bigger than they are compared to workers with high muscle strength (Don B. Chaffin, Gunnar B. J. Andersson, 1999)

g. Years of service

The degree of increasing MSDs attention is longer than the work of older people (Ohlsson K, et. al., 1989)

h. Body Period Index

The bigger body, the greater risk for MSDS to dig. This is carried out with a heavy load that will be attempted to move the body from front side by contracting the lower back muscles (Tan HC & Horn SE., 1998)

According to (WHO, 2005), the formula of BMI is BB / TB2 (Weight / Height2) with a lean (<18.5), normal (18.5-25), obese (25-30) and obese (> 30).

4. Psychosocial Factors

Unfavorable social aspects can change the state of MSDs such as overwork, complex tasks, time function, low work control, lack of motivation and poor social environment. (European Agency for Safety and Healt at Work, 2003)

Muscle fatigue could related to MSDs which caused by physiological impairment which leads to a decline in the maximal force or power capacity of muscle, which means that submaximal contractions can be sustained after the onset of muscle fatigue. It is gradually decreasing in the force capacity of muscle or the endpoint of a sustained activity, and it can be measured as a reduction inmuscle force, a change in electromyographic activity or an exhaustion of contractile function (Enoka & Duchateau, 2008). Muscle fatigue on the other hand can be identified technically by observing the changes in amplitude and frequency of electromyogram (EMG) signals over time

2.2.3 Electromyograph (EMG)

A. Definition of Electromyography

Saulia, (2001) mentioned that one ways to measure local muscle work is to use electromyography. It measures the local muscle workload and muscle fatigue that occurs. Electromyography (EMG) is an experimental technique focused on the analysis of myoelectric muscle signal recording. Myoelectric signals are formed from physiological changes in the muscle fiber membrane (Konrad, 2005). According to Konrad (2005) most of the electromyograph techniques are used for various studies.

1. Medical research
2. Rehabilitation
3. Ergonomics
4. Sport

The surface of electromyograph (sEMG) or so-called electromyograph surface is a device affixed to the skin to determine muscle activity. The use of surface electromyographs is often for safe use (no need to penetrate the skin), easy to use and can determine the energy released from the muscles, but the skin of electromyograph use also has the disadvantage of not being able to measure complex muscle activity because the tool can only be used for 4 observations (Criswell, 2011)

According (Konrad, 2005) there are several advantages of using electromyograph in analyzing muscle activity, among others:

1. Discovering and observing direct muscle activity
2. Measuring muscle performance
3. Assist in decision-making process before and after operation
4. Assist patients in finding and training their muscles
5. Analyzing in order to improve sports activities
6. Detecting muscle activity in research in the field of ergonomics

B. Electrode Installation

In the electrode installation process there are several steps in using electromyograph (Rash, 1999)

1. Preparation
    a. Removes dirt, oil and dead skin using alcohol
    b. Shaves the skin if needed
    c. Gel electrodes will be applied on the dry skin as adhesive
    d. Antiperspirant will be sprayed on sweaty skin after cleaning using alcohol

2. Placement of electrodes

- **a.** There are several references in determining the laid electrode
- **b.** Place the electrodes in the area of the cable with the red and green leads. They need to be placed on electrodes that are attached to the muscle of interest. The two leads are interchangeable for EMGs. Place these leads along the length of the muscle. The black lead serves as a ground. It should not be placed on the muscle of interest (Www.vernier.com, n.d.).

3. Implementation

- **a.** Put on the skin
- **b.** Avoid attachments assisted by adhesive or masking tape
- **c.** Avoid the emphasis on making sure the current electrode cable is still in place
- **d.** Avoid putting electrodes on the wound

4. Test results

- **a.** Performing manual testing to ensure the signal is obtained and place the desired muscle
- **b.** Conducting tests to check signals and ensures the experimental execution known by the subject

According to (Criswell, 2011) there are 3 types of mounting electrodes on the surface electromyograph.

1. General placement

The placement of the electrodes is placed on the outline area of the muscle for examination, and no specific muscles to place.

2. Certain placements

The placement of electrodes in specific groups of muscles. It is usually used for muscles close to the skin and easy to find.

3. Quasi-specific placement

The placement of electrodes that need accuracy due to placement must be known to a certain muscle that will be tested.

C. Signal Electromyograph (EMG)

An unfiltered signal and no process to the signal obtained directly from the recorded muscle is also called the EMG raw signal (Konrad, 2005). The EMG raw signal also corrected by EMG as shown on Figure 2.1 below:

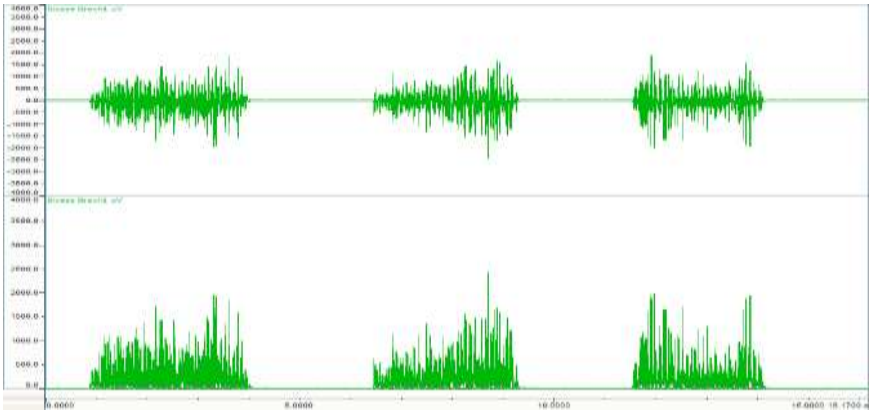

Figure 2.1 EMG Raw signal corrected by EMG

The first step in analyzing the result of raw signal is to convert a negative amplitude into a positive one or by reflecting it (Konrad, 2005)

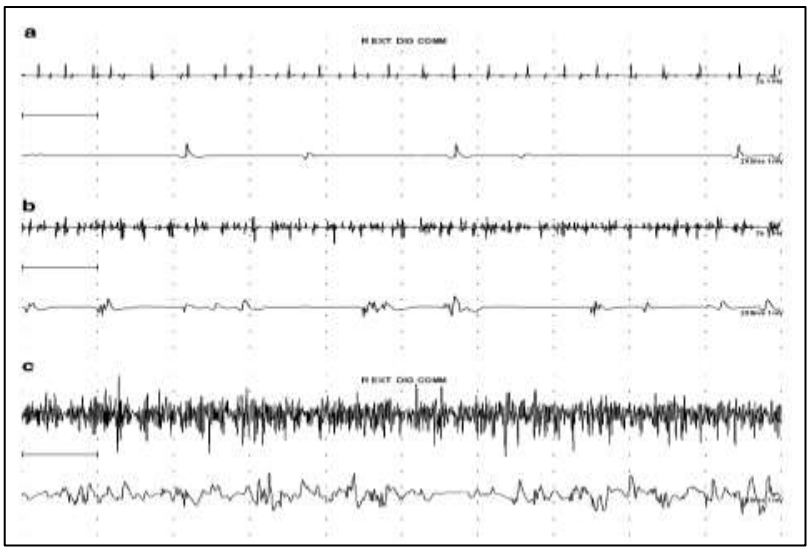

Figure 2.2 EMG signal formed contraction

The Figure 2.2 above is a graph showing several categories of signals that can be captured by EMG. In section A is a weak signal because it detects the pattern with the two units of motors captured. Section B is considered as moderate because it has a

mixed signal pattern. While, C is a signal that included as strong category signal since it experiencing a fluctuating contraction with some motor units that are captured by EMG.

D. Surface EMG electrode Installation

Installation of electrodes is performed on the muscles to be known as activity, in this study the muscles to be known as activity is the brachioradialis muscle. The muscle is a branch of the median nerves and associated with pressure/compression that can lead to the risk of CTD in a person. In the use of EMG, the electrodes will be paired to determine the three muscle activities. Installation of surface EMG electrodes, biceps brachii muscle is performed by (Criswell, 2011)

1. Respondents are asked to reflect the forearm on supine position,
2. The installer palpates on the dorsal portion of the enlarged upper arm,
3. Positioned the two active electrodes in parallel to the muscle fibers and in the middle of the muscle mass,
4. Both electrodes are positioned as far as 2 cm.

E. Signal Filters

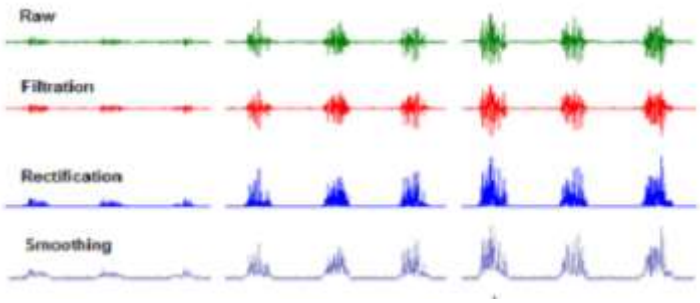

Figure 2.3 Signal Filtering with decay filter (Ricardo et al., 2012)

The Figure 2.3 shown a record from EMG that directly showed on logger pro software is formed as EMG raw data in exclusion of filtering process. Filtering process is used to reduce the noises in muscle contraction signal that recorded in EMG Raw. Filtered muscle contraction signal of EMG raw is formed as EMG Filtered which has been filtered by the form of High Pass-Filter which reduces the effect of a varying baseline on signals, improving data. EMG Filtered has negative signal which will has mean

value near to zero. This filter already started rejecting the frequency band of 60 Hz once the ambient interferences like pressure appear, arrangement or closer apparatus are appeared in this band. The EMG signal must pass through a pass-band; this passband frequency must be decided by the analyzer, once it can depend on the intentions of the study.

Normally, this frequency is fixed between 20 and 450 Hz, because normally 80% of the muscular energy is concentrated. But, as said before, it is a free choice for the user, once that this frequency can differ from muscle to muscle, so, it is important for the user to know exactly which band of the assessed muscle to make sure that the passband will cut off only the signal that does not belong to that muscle, and at the same time guarantee as precisely as it can to forbid noises get inside the signal. Basically, it limits the signal inside a previous decided range to maintain it inside the muscle activation site. The visual difference between the raw and the filtrated signal can be really hard to notice, especially when the collected process is well cared, however, if we take a rigorous look to both of them, the difference will appear to our eyes, but remembering that the main reason of using those treatments is to obtain the quantitative values of the signal (Ricardo et al., 2012).

EMG Rectify is the absolute value of the EMG filtered graph. It is shown that the EMG rectify graph has shown its trend to the signal. This procedure has the purpose to turn all the signal values integrative, submitting them to the cut of all negative values, that means, to delete the values that are under the baseline, or to turn all this negative values to positive adding the values, making them integrative. The second option is more recommended if the intention is to achieve the total muscle signal, if you cut off the negative part, half of the signal will be lost, so turning all of them positive is a more used and more interesting when it comes to final results. This procedure doesn't affect the signal noises like the filtration and the smoothing, which will be explained in sequence. However it is still recommended and made part of the studies involving this chapter, so it's important for the reader to know how we used and what it means (Ricardo et al., 2012).

EMG with Decay Parameter applies a simple adjustable time constant to the data, smoothing out rapid fluctuations while preserving long-term trends (Vernier.com, 2012). The Smoothing and the filtration have some similar parameters, mostly because both have the intention of taking out the extremes, the parts that are considering noises. Smoothing creates a linear envelope in the signal, leaving only a center part of the signal. The mainly difference between the smoothing and the filtration, is that filtration take in account the muscle activation range, and the smoothing the signal obtained itself. If the filter is strong enough or considered really good, it can even make the smoothing unnecessary. However, it's recommended to use both, especially in cyclic dynamic contractions, that as we already seen, have a bigger chance to have noises interferences. Looking at the Figure again, the smoothed signal is also really easy to realize, it creates visually a much cleaner signal, creating almost a line, which means, it excludes the extremes, leaving only the signal that isconsidered the muscle activation signal (Ricardo et al., 2012).

2.2.4 Blood Pressure

Blood pressure is a measure of the force that the circulating blood exerts on the walls of the main arteries. The pressure wave transmitted along the arteries with each heartbeat is easily felt as the pulse (Dieterle, 2012). The pressure caused by the heart pumping blood to all parts of your body is called blood pressure. This allows blood to circulate throughout the body. Normal BP is an indication of good health. Blood pressure is measured in millimeters of mercury (mmHg), and it has two numbers. The first is the systolic blood pressure, and is the pressure when the heart is contracting. The second is the diastolic blood pressure, and is the pressure when the heart is resting. A person with a normal blood pressure is around 120/80mmHg. Systolic BP (SBP) is measured by an increase in cuff oscillation when blood first passes the deflating cuff indicate the force while the heart pumps. Diastolic BP (DBP) is recognised when oscillations return to baseline indicate the force while the heart pumps (Dieterle, 2012). According to Parsudi in Subagiyo E., 2007 normal blood pressure varies greatly depending on:

1. Sports especially those that use arm muscles
2. The longer workout will decrease progressive systolic pressure so easily tired

3. Older age, then the high systolic pressure is usually associated with arteriosclerosis arise approximately one-tenth and the parents rise above 200 mmHg
4. The condition of women before menopause 5-10 mmHg lower than men his age but after that high blood pressure
5. Severe anemia will cause the blood viscosity decreased 1-2,5 times the normal viscosity 3 times causing increased workload of heart which will increase arterial pressure
6. Feelings of emotion, fear, and anxiety usually rises blood pressure
7. Kidney disease, the hypertensive disease will lead to reduced vascular blood supply or decreased glomerular filtration that will cause hypertension
8. Smoking Although there is no smoking relationship in hypertension, smoking is a major risk factor for cardiovascular disease
9. Consuming alcohol moreover can excessively increase blood pressure and cause resistance to drug and hypertension
10. Caffeine can increase blood pressure acutely but is quickly tolerated by the processor effect
11. The use of certain drugs such as oral contraceptive decongestants of the nose, anti-flu drugs may affect blood pressure to increase
12. Work environment factors that affect blood pressure such as room temperature and noise because it can affect sleep disturbances and autonomic nervous effects

A condition when the inner-thigh pressed and the blood occluded as passenger is in lack of movement then it it leads to insufficient blood pressure which named Transient Paresthesia. Transient Paresthesia is an abnormal sensation of burning, numbness, tingling, itching or prickling caused by the insufficient blood supply to muscle so as inflicting muscle fatigue at the bottom of the thigh (Alhoseini, et al., 2012).

2.2.5 Vibration

Vibration is a physical disturbance that occurs in machines and automobiles. It is an oscillation of the parts of a fluid or an elastic solid whose equilibrium has been

disturbed, or of an electromagnetic wave (Richard Fitzpatrick, 2013). Vibration can be classified based on the target on which it effects as hand arm vibration (HAV) and whole body vibration (WBV). The nature of vibration that is present in a vehicle depends upon the dynamic characteristics of the automobile and road surface characters. Its effect on the human body depends mainly on the frequency, magnitude, direction, area of contact and duration of exposure. Exposure to WBV will result in transmission of vibratory energy to the entire body and leads to localized effects. Exposure to certain frequencies of vibration may have profound effects on specific systems of the body depending upon the natural frequencies of it and acceleration of the vibration at that frequency (Shivakumara BS. and Sridhar V., 2010). Numerous investigations have reported possible discomfort, musculoskeletal problems, muscular fatigue, reduced stability and altered vestibular function caused by WBV exposure (Chen, Chen, Liu, Chen, & Pan, 2009). The table of vibration and its effect to human body is shown on Table 2.2 below:

Table 2.2 Vibration effect to human body

Frequency of vibration	Types of effect
Below 1 Hz	Motion sickness
3.5 - 6 Hz	Allerting effect
4 - 10 Hz	Chest and abdomen pain
5 Hz	Degrades manual actions
7 - 20 Hz	Communication problems
8 - 10 Hz	Back ache
10 - 20 Hz	Intestine and Bladder Pain
10 - 30 Hz	Degrades manual and visual controls
10 - 90 Hz	Degrades visual action

The acceleration depending upon its magnitude and duration of exposure leads to unhealthiness of the human being. The WBV accelerations measured on different roads on different motorcycles shows it is dangerous even considering short duration of riding. The vibrational effects are more hazardous on motorcyclist. As for as possible, measures is to be taken to avoid prolonged exposure to vibration. Also, it is very important to keep the RMS of WBV acceleration within 0.315 m/s2 and total acceleration within 0.8m/s² as safety standard levels of the vibration. If possible it is necessary also to avoid vibrational frequency below 90 hz (Shivakumara BS. and Sridhar V., 2010)