WORK FATIGUE AND PHYSIOLOGICAL SYMPTOMS IN DIFFERENT OCCUPATIONS OF HIGH-ELEVATION CONSTRUCTION WORKERS

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FACULTY OF ENGINEERING UNIVERSITY MALAYA KUALA LUMPUR

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RESEARCH REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER SAFETY, HEALTH AND ENVIRONMENT ENGINEERING

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ABSTRACT

The objectives of this study are to evaluate common work fatigue symptoms and also evaluate differences of physiological strain among construction workers. Total of 60 workers are divided into two groups which are high elevated construction workers and ground level construction workers. Questionnaires consisting demographic data and subjective work fatigue symptoms were distributed and there are also physiological measurement such as heart rate have been collected. Workers required to wear Vivosmart 3 on their wrist for heart rate measurements. Prior to performing measurements, a study found that most of the construction workers have enough sleep time between 7 hours to 9 hours. This could be explained by eliminating those ftigue workers before performing the experimental measurements. For subjective work fatigue symptoms, feel pain in the waist is the most common work fatigue symptoms with prevalence rate for high elevated construction workers and ground level construction workers are 80% and 100% respectively. It can lead to work musculoskeletal disorder that can affect productivity and performance of the workers. The high level construction workers have higher heart rate readings compared with those among ground level construction workers. This indicates that high elevation construction workers have higher physiological strain. This study shows that the subjective fatigue symptoms questionnaires can be used to measure fatigue prevalence and heart rate is a suitable physiological measurement to evaluate physiological strain that construction workers encounter.

ABSTRAK

Objektif kajian ini adalah untuk menilai gejala biasa keletihan tempat bekerja dan juga menilai perbezaan ketegangan fisiologi di kalangan pekerja tapak bina. Sebanyak 60 orang pekerja tapak bina dibahagikan kepada dua kumpulan pekerja iaitu bekerja di aras biasa dan bekerja di tempat tinggi. Soalan kaji selidik yang mengandungi data demografi dan gejala subjektif keletihan tempat kerja telah diedarkan dan terdapat juga perkiraan fisiologi seperti kadar denyutan jantung telah dikumpulkan. Pekerja dikehendaki memakai Vivosmart 3 pada pergelangan tangan mereka untuk pengukuran kadar jantung. Hasil kajian terdahulu mendapati kebanyakan pekerja tapak bina mempunyai masa tidur yang cukup antara 7 jam hingga 9 jam. Oleh itu, pekerja yang keletihan tidak termasuk didalam kajian ini. Untuk gejala subjektif keletihan tempat kerja, rasa sakit di pinggang adalah simptom keletihan tempat kerja yang paling biasa dengan kadar kelaziman untuk pekerja tapak bina bekerja di aras biasa dan pekerja tapak bina bekerja di tempat tinggi masing-masing adalah 80% dan 100%. Ia boleh menyebabkan gangguan muskuloskeletal yang boleh menjejaskan produktiviti dan prestasi pekerja. Pekerja tapak bina yang bekerja di tempat tinggi mempunyai bacaan denyutan jantung yang lebih tinggi berbanding dengan pekerja tapak bina bekerja di aras biasa. Ini menunjukkan bahawa pekerja tapak bina bekerja di tempat tinggi mempunyai tahap ketegangan fisiologi yang lebih tinggi. Kajian ini menunjukkan bahawa soalan kaji selidik berkenaan dengan gejala subjektif keletihan di tempat kerja boleh digunakan untuk mengukur kejadian keletihan dan kadar degupan jantung adalah ukuran fisiologi yang sesuai untuk menilai ketegangan fisiologi yang dihadapi pekerja pembinaan.

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LIST OF ABBREVIATIONS

Non-WAH	Non-Working at Height
WAH	Working at Height
BMI	Body Mass Index
CO_2	Carbon Dioxide
OSHA	Occupational Safety and Health Act
FMA	Factories Machinery Acts
DOSH	Department of Occupational Safety and Health
TN50	Transformasi Nasional 50
SPSS	Statistical Package for Social Sciences
HRV	Heart Rate Variability
SD	Standard Deviation

CHAPTER 1

INTRODUCTION

Construction is a very complex industry which involves many physically demanding tasks. Example tasks in construction industry are scaffold erection, steel fixers and foamworkers. This heavy workload tasks requires workers to do extra exertion of their bodies which lead to physical and mental fatigues. Eventually, it will cause decreases to safety and productivity performances and create accident at workplace. This study is to assess the common work fatigue symptoms and difference of physiological strain between ground level construction workers known as Non-Working at Height (Non-WAH) group with high elevation construction workers known as Working at Height (WAH) group. By understanding the fatigue symptoms and characteristic of physiological strain based on different height elevation, it can help us to construct proper mitigation plan to prevent from accident happen. This section is briefly explained about the background study, problem statement, research objectives, research questions, research hypothesis, scope of study, significance of study and operational definition of the study.

1.1 BACKGROUND STUDY

Malaysia is a developing country, which currently have many mega projects undergoing construction in progress. There are several contributing factors that help in the increasing number of workplace accidents such as heavy workload and hot workplace environment. Besides that, most of the workers come from third world countries which have low education background and awareness in safety. They have difficulties to apply safety at workplace and plus with poor management that didn't take safety matters seriously.

Construction industries possess different systems compared to the manufacturing industries, oil and gas industries and etc. Workers have to work minimum 8 hours per day at workplaces and sometimes it took 24 hours if there is an important work that needs to be finishing that times example like concreting work. Even though they have 3 times rest period for normal hours and 6 times rest period for overtime hours, but due heavy physical works and long period of working time, it can increase the exposure to hazards and can lead to work-related accidents or diseases.

This study will be focusing to discuss about the prevalence of fatigue for highelevation construction workers by subjective fatigue symptoms and physiological strain between ground level construction workers known as Non-Working at Height (Non-WAH) group and high elevation construction workers known as Working at Height (WAH) group. Swustea et al., (2012) stated that construction has always been regarded as one of most hazardous industries. Construction workers are involved with high risks job such as excavation work, working at high and heavy lifting which can cause major accident impact. With proper study about the hazards in construction industry, mitigation measure can be conducts to make a safe and healthy workplace environment.

1.2 PROBLEM STATEMENT

According to Figure 1.1 accident statistic at workplace from Department Of Safety and Health (DOSH, 2017) stated that there are more than 50 fatalities accidents in construction industries recorded. Which are the highest compared with other sectors. Even though, there are several acts and guidelines such as Occupational Safety and Health Act (OSHA) 1994 and Factories and Machineries Act (FMA) 1967 which help to improves the safety in Malaysia, workplace accidents still occurs especially that involves fatality.



Figure 1.1: Statistic of Occupational Accidents By Sector in Malaysia

Source: DOSH, 2017

There are less study of construction safety in Malaysia especially work fatigues and physiological symptoms for construction workers despite that the statistic have clearly shown that this sector requires special attention. Heavy workloads lead to work fatigue which causes workplace accidents. Because of that, by identifying most common work fatigue symptoms such as waist pain and eye strain that could occurs to the workers thru questionnaires, we can encounter the problems to create safer workplace environment.

According to Factory Machinery Act (Safety, Health Welfare) 1970, Regulation 12 stated any person that work more than 3 meters above shall be provide with fall protection systems. This indicates that workers that work in higher work level possess more hazards compared to those that work on the ground level. Most of us have fear of height including those construction workers, which it will give effect towards their job performances. High elevated workers will feel more intimidated and uneasy to work when they know there are falling from height hazards if they are not careful enough during work process.

By physiological measurements of the construction workers we can assess the physiological strain that construction workers are exposed and difference between Non-WAH group and WAH group. Heart rate measurement will be used as many previous studies also used this method for fatigue prevalence. Not only because it is convenient, it also given an accurate data for physiological measurements. Heart rate measurements during conducting work process will be collected. With this data, we can study the difference of heart rate readings for the two groups. Does working at height workers which have more hazards will feel more physiological strain compared to the ground level workers. Eventually, it can reveal the importance of study in construction safety that can help other peoples to see it.

1.3 RESEARCH OBJECTIVES

The aim of this study was to understand the most common fatigue symptoms and differences of heart rate measurement between Non-WAH group and WAH group in construction industries. The specific objectives are as following:

- i. To evaluate common work fatigue symptoms for construction workers.
- ii. To evaluate differences of physiological strain between construction workers.

1.4 RESEARCH QUESTIONS

Research question for this study are as following:

- i. What are the most common fatigue symptoms for construction workers?
- ii. Does different height level of work area gives different physiological strain for construction workers?

1.5 HYPOTHESIS

Hypothesis for this study are as following:

- i. H_{A1} : Feel pain in the waist is the most common fatigue symptoms for construction workers.
- H_{A2}: Working at Height (WAH) group have higher physiological strain compared with Non-WAH group.

1.6 SCOPE OF STUDY

The scope of this study is explained by specification of information that will be studied throughout this thesis content. Focusing on the working at height and nonworking at height workers in construction industries, it aims to study the most common fatigue symptoms for construction workers and also difference heart rate measurements for workers that work with different height elevation.

This study will involve 60 construction workers from different types of job tasks. Then it will be divided into two groups which are Non-Working at Height group with Working at Height group. Non-Working at Height group will be those that work on ground level that no work using any ladder and stairs. Examples of work activities at ground level are bar bending and bar cutting work, formwork task and concreting work. On the other hand, WAH group will be those that work 15 meters above ground level. This workers need to wear fall protection systems such as body harness to prevent fall from height. Types of job task for this group are scaffold erector, launching gantry workers and formwork workers.

These workers need to wear heart rate measurement device for one complete cycle of works or usually five minutes time period. It will help to get accurate heart rate reading to understand the prevalence of physiological strain among those two groups. Besides that, they also need to fill up several questionnaires which consist of demographic data and work fatigue symptoms to study the most common work fatigue symptoms that construction workers are exposed especially between these 2 groups. With this work fatigue symptoms, we can identify the fatigue symptoms that indirectly can lower workers work performance and increase incident probability at site.

1.7 SIGNIFICANCE OF STUDY

Malaysia seems to be developing very rapidly. Many tall buildings are made with good infrastructures and accommodations near them. Tranformasi Nasional 2050 (TN50 consist of development plan have made construction industries as major activities that will bring benefits to the people. In Malaysia, one of the biggest contributor for fatality in workplace are recorded by construction industries, (DOSH,2017). Because of that, this construction industry need special attention especially for those workers that working at height.

Employees are every organizations most valuable asset. Because of that, taking care of the safety and health of every worker are important factors that they must be taken into their account. With blooming of construction industries, risk of injuries and fatalities will increases because of construction hazards. By conducting this study, it will help the government especially Malaysian to have a better understanding the nature of this construction industries especially for high elevation project and effect of fatigue towards construction workers.

It will help to determine the safety issues that will rise for the construction workers and finally come up with good mitigation plan to reduces the fatalities in construction industries and make a Malaysia as a safe nation in term of construction industries. This study also can be used as a baseline to planning for safety programmes to encounter the effect of work fatigue and physiological strain hazards or as a baseline for further studies later on. Thus, it can reduces the accidents at workplace, creates better and safer workplace environment and also give benefits to all parties especially for those that work in construction industries.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, it will explain about the relevant topic that will be further discussed. Analysis and comparison of previous research journal and related books will be included to give a better view on the topic. The topic that will be discussed are construction industry, height elevated working area, work fatigue, symptoms of work fatigue, physiological strain, heart rate, OSHA 1994, law and regulation related with working at height.

2.2 CONSTRUCTION INDUSTRY

To make a good study, we need to study first the history of the topics. Identify the previous research finding related with fatigue in construction industries, understand their work and nature of the construction activities and eventually we can improvise and make a very good research study that can help to plan mitigation measures to reduces accident and fatalities in construction industries. Jorge (2008) stated that variation in construction sector and its activities have great impact on all aspect of human life. By having construction industries, a country can be developed and their people can have more facilities of their life. A country can build many building that make opportunities for their peoples to find proper job to support their life because there is a strong correlation between construction sector and economic growth (Reza et al., 2013). However, to get such rewards, construction industries possess many risks towards their workers. According to Adeeba and Jimmie in 2014, Construction workers are often exposed to the inherent risks associated with working conditions on construction sites. With all this hazards from unsafe act and unsafe condition, construction workers have higher tendency to be involves with major accidents and fatalities.

Early study in 2007 by Hsu et al., they found that construction workers such as riggers, steel fixers, form workers, electrician–plumbers, concreters and miscellaneous workers need to be studied due to their unsafe work activities at site. Its shows some job activities that have high exposure towards work fatigue. The latest study in year 2015, a researcher known as Sang D. C. stated that the four trade/occupation groups with the highest injury rates were laborers, carpenters, iron workers, and operators. Based on the previous study, there are target group that need to be study due to their high risks categories.



Figure 2.1: Construction hazards

Source: SOTECH, 2016

2.3 HIGH ELEVATED WORKING AREA

High elevated working area also knows as working at height. It can be define as working in any place where, if precautions are not taken, a person could fall and injure themselves. This includes places above, at or below ground level. Factories and Machineries Act 1967 stated that any person that work above 10 feet shall used fall protection system. It indicates that workers that working at height level need extra precautions or means to protect them fall from height.

As mentioned by Steven and Mohamed (1979) said that some easy ground-level tasks become more difficult when performing at high-elevation workplace. Normal ground level job such as erect scaffold and carpenters required more focus and energy when doing it on height level work area. When unfit worker working at height level area, the exposed with high risk of injury and accidents. According to Department of Occupational Safety and Health, 2018 statistics shown that there are 14 peoples died due to falling from height. This is a serious number and proper procedure must be implements.

Construction workers that involved in working at height, they exposed with many risks. Usual risk that associated with working at height is people falling from height, material falling from height and also several external factors. For falling from height, people can easily fall if they are not wearing proper fall protection equipment such as full body harness. Besides that, if their work platform also unsafe, it can collapse and cause people to fall to the ground. For material fall from height, even a tiny bolt falling down can cause big accident when hit workers head. It can happen due to untidy workplace and no toe board. Lastly, external factors such as strong wind and heat stress can cause people fall from height. Because, high elevated workers are exposed to hot weather and more windy area.

Because of that, Department of Safety and Health (DOSH) 2018, have introduce a hierarchy of fall protection. First is hazard elimination, which we need to eliminate the hazards from the workplace. Second, is physical restrain system which install hard barricade. Third is used passive fall protection such as ppe to limit workers movements. Fourth is fall arrest system that catches us when we fall. Lastly is an administrative control such as proper procedures to working at height.

2.4 WORK FATIGUE

Hartman and Fleischer (2005) stated that construction personnel have higher exposure to fatigue because of their heavy workload nature. Fatigue have significant characteristics or symptoms such as awkward postures (Mattila et al., 1993) and prolong work hours (Dong, 2005). Which both of this happens due to job demand at site even though it is not the same between types of activities they done. Furthermore, personal characteristics and job stress had a direct effect on self-perceived fatigue (Chang et al., 2015). This means that, even the behavior of the workers and work load stress can cause fatigue physically and emotionally towards someone life.

Each worker has their own capability and limitations. Because of that, it is very important to be observant about the workers conditions. Abdelhamid and Everett (1999) stated that excessive work physiological demands can negatively affect safety and productivity due to a decrease in workers' well-being, attentiveness, motivation, and capacity to perform muscular work. When they are forces to do beyond their limit, they are expose to several health symptoms such as back pain, muscle pain and musculoskeletal disorders. In 2011, Powell and Copping also found that fatigue caused by inadequate sleep might results in decrements in performance and a higher risk of accident. If the workers did not get a proper sleep, then they have higher rate to involves with accident due to lack of stamina and focus.

In addition, latest study by Aryal et al., in 2017 said that fatigue is one of the factors leading to reduction in productivity, poor quality of work and increased risk of accidents in construction. This seems to be true because if the workers are tired, eventually they will be less productive at work site compared to those who have enough rest at home. The best practice is to work only 9 hours and rest at least 6 hours, if not then they will expose to adverse health effect (Dongping et al., 2014). Workers will feel

more burden if the job need to finish as fast as possible, and they get lesser time to recover. During this time, they are tired and fatigue and will be more prone to accidents and injuries (Swaen et al., 2003).

2.5 SYMPTOMS OF WORK FATIGUE

Due to dangerous or hazards because of the fatigue, it is very important for us to detect the prevalence of fatigue among our construction workers. To detect the presence of fatigue at workplace, many researchers have using work fatigue symptoms to help them discover fatigue characteristics. There are several of fatigue symptoms that available and have been established from previous researchers. Every work fatigue symptoms scheme has their own pro and cont and suitability towards certain work area.

In this study, it is more focus on the fatigue symptoms that have been design by Research Committee on Industrial Fatigue of Japan Society for Occupational Health, called RCIF scale (Research Committee on Industrial Fatigue, 1969). Table 2.1 shows a checklist of subjective symptoms of fatigue which in the RCIF scale. It consist of 30 questionnaires divided into three categories that is Drowsiness and Dullness, Difficulty in Concentration and Projection of Physical Impairement. The prevalence rate of a particular fatigue symptom (T) is determined based on the ratio of the number of "yes" to the total number of samples.

Drowsiness And Dullness			Difficulty In		Projection Of Physical	
			Concentration		Impairment	
1	Head feel heavy	11	Find difficulty in	21	Have a headache	
			thinking			
2	Whole body feel tired	12	Become weary while	22	Feel shoulder stiffness	
			talking			
3	Legs feel tired	13	Become nervous	23	Feel pain in the waist	
4	Yawning	14	Unable to concentrate	24	Breathing feel	
					constrained	
5	Head feel hot or	15	Disinterested	25	Feel thirsty	
	muddled					
6	Become drowsy	16	Become forgetful	26	Have a husky voice	
7	Eye feel strained	17	Lack of self-confidence	27	Have dizziness	
8	Become rigid or clumsy	18	Anxiety	28	Have a spasm of the	
	in motion				eyelids	
9	Feel unsteady while	19	Unable to straighten up	29	Have a tremor in the	
	standing				limbs	
10	Want to lie down	20	Lack patience	30	Feel ill	

 Table 2.1: Checklist of Subjective Fatigue Symptoms (RCIF, 1969)

2.6 PHYSIOLOGYCAL STRAIN

Physiological stress can be defined as how our body reaction or response towards some stress. Brains will give signal towards our body how to react with the undesired condition and cause physiological changes to happen such as heart rate increases, sweating increases also breathing gets shallow and faster supplying oxygen to the body. Thus, stress will happen because of a cascade of hormones from the brains towards the whole body. This situation happens frequently with construction workers especially those who involved with working at height. Wen et al., in 2016 said that high-elevation workers might encounter some difficulties in physiological adjustment when performing heavy duties or delicate tasks and Tower construction workers perceived an increased level of mental stress as working surface height increased. This indicates that physiological stress really happens to those workers that work at higher area than normal.

Aryal et al., (2017) found that physical fatigue can be monitored using wearable sensors. Which this can lead to get good measurement and data collection about physiological stress. Two types of monitoring are available which by skin temperature and heart rate. But if we used both monitoring in the study, it will give the best data compared to other methods. However, to use wearable sensors it requires high budget in the study. It is not suitable to be used due to budget limitation. Furthermore, it requires complex equipment that need to be handle with extra care. Due to that, it is more practical to conduct heart rate monitoring at site.

Besides that, there are other elements that can contribute to the physiological stress. Recent study in 2017 by Yuting et al., found that safety climate not only affected construction workers' safety performance but also indirectly affected their psychological stress. Safety climate is the perceived value placed on safety in an organization at a

point in time. These perceptions and beliefs can be influenced by the attitudes, values, opinions and actions of other workers in an organization, and can change with time and circumstance. Besides that, there are also studies that have shown that employees with such adverse health conditions are absent more often, lose more work hours, and are less productive (Singh et al., 2010). Because of the negative environment at workplace, they will be demotivated to performs their job properly. Not only that, heat stress also having physiological effects on workers, it can lead to reduction of work enthusiasm and productivity, increased incident rate, heat illness, and death (Wen, 2012).

2.7 HEART RATE

Heart rate is the amount of cardiac cycle that pumps the blood throughout the whole human body. It carries oxygenated blood to human body cells while the deoxygenated blood will carry Carbon Dioxide (CO₂). It is one of the most relevant variables to be used as a physiological measurement. Mao et al., (2000) stated that work postures as well as physiological responses, such as heart rates, differed between high-elevation and ground-level workers. It supported this study that heart rates gives significant data for fatigue prevalence for construction workers.

Table 2.2 shows the normal target heart rate zone based on the age of the person. Target heart rate zone is the best heart rate readings for a person to have during active period. It helps to indicates that the person have a good heart and enough oxygen supply to all parts of the body. Besides that, maximum heart rate zone is the highest heart rate readings that a person should have when they are performing their work activity. Higher heart rate readings than the maximum heart rate zone, it can cause a high blood pressure thus heart attack. There are other factors that can affect heart rate readings. American Health Association, 2015 also stated that when body temperature increases, heart rate also increases because it needs to pump blood throughout the body for cooling process. Because of that, we also need to identify other factors affecting heart rate readings so that it will not disturb our results.

Age	Target Heart Rate Zone	Maximum Heart Rate Zone
(years)	(bpm)	(bpm)
20	100 - 170	200
30	95 – 165	190
35	93 – 157	185
40	90 – 153	180
45	88 – 149	175
50	85 - 145	170

Table 2: Target Heart Rate (AHA, 2015)

2.8 OCCUPATIONAL SAFETY AND HEALTH ACT 1994 (ACT 514)

Occupational Safety and Health Act 1994 is the regulation used to ensure the safety and health of the workers in the workplaces. It ensuring all types of occupation will be covered under this Acts so that accident can be prevented. Because of that, in this act also have the duties of the employers and the employees. Besides that, they also must understand what their roles are when accidents occur (OSHA, 1994).

2.8.1 General Duties Of Employers And Self-Employed Persons.

In section 15 (1) stated that every employer or self-employed person must ensure as far as practicable the safety, health and welfare of his entire employee in the workplace. It means that, employer have the duty to take care their workers safety during they are working in the workplaces.

Besides that, in section 17 (1), it said that every employer or self-employed person also have responsible to ensure as far as practicable the safety and health of the persons that enter their premises other than their employees. It means that, outside persons such as students or normal persons that enter the premise due to some sort of events also will be the responsibilities of the workplace owner to ensure their safety.

For the terms of 'as far as practicable' here, it refers to the practicable ways or conditions to ensure that safety of all the employer, employees and other persons are in good condition. Practicable are concerns with the severity of the hazards in question, the state of knowledge about the hazards, the availability to mitigate the hazards and lastly the cost to mitigate the hazards.

Furthermore, it is also the duty of employer or self-employed person to formulate safety and health policy under section (16). They needs to prepare a written

statement of his general policy with respect to the safety and health at work of their employees and bring the statement and any revision of it to the notice of all of his employees.

If they can't comply with the section 15 to 18 under Parental Acts 514, they can be charge guilty and be liable to a fine not exceeding fifty thousand ringgit or to imprisonment for a term not exceeding two years or both.

2.8.2 General Duties Of Employees.

In section 24 (1), it is the duty of every employee at work to take reasonable care of their safety and health or other persons who may be affected by their acts at work. Besides that, they need to co-operate with their employer in the discharge of any duty imposed on the employer. They also need to wear protective equipment provided during their work and follow with any instruction or policies in safety and health.

However, in section 24 (2) it is more to the penalties that will be charge towards them if they failed to comply with this regulation. They can be charge guilty and be liable to a fine not exceeding one thousand ringgit or to imprisonment for a term not exceeding three months or both.

2.8.3 Notification Of Accidents, Dangerous Occurrence, Occupational Poisoning And Occupational Diseases, And Inquiry.

In section 32 (1), it stated that every employer or self-employed person needs to notify the nearest occupational safety and health office of any accident, dangerous occurrence, occupational poisoning or occupational disease which has occurred or is likely to occur at the workplace.

In section 33 (1) to section 33 (3), Director General may has direct inquiry to be held. This is to help the nature and cause of the accident, dangerous occurrence, occupational poisoning and occupational disease. This inquiry will be conducted by occupational safety officer and under section 34, safety officer have the power to compelling the attendance of witness and the relevant alibies.



2.9 BUILDING OPERATION AND WORK ENGINEERING CONSTRUCTION, REGULATION 1986 (FMA 1967)

Besides OSHA 1994, other regulation that related with working at height have been enforce in Malaysia. In terms of construction industries, the most related regulation is known as Building Operation and Work Engineering Construction, Regulation 1986. It functions as a guideline to conduct any construction activity safely. There are total of 154 regulations can be refers that covered most work in construction industry.

In terms of working at height, there are several regulation that we must comply. Firstly, when working at height, we need safety belt that can protect us falling from height. Regulation 50 mentioned that every safety belts and related devices that will be attached to the lifeline must be test the strength. It will help to make sure that the fall protection system is function properly. Besides that, working at height also considered when we using ladder to performs our work at site. Regulation 62 stated that every ladder at site shall be of good construction and adequate strength to fit the purpose. Best practice is we used ladder that have been manufactured at factory with proper manual and certificate instead of handmade ladder.

There are more of regulation that helps to protect workers during they performing working at height besides what have been mentioned above. Because of that, before conducting work activities in high-elevated work area, proper fall protection system and training need to be prepared so work can be done safely.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The purpose of this chapter is to give a brief explanation regarding the method that will be applied for the primary data collection that can help to identify the studies that relevant to the topic. It consists of the study area, research design, study sample, sampling strategy, research instruments, data analysis, study ethics and study limitations.

3.2 STUDY AREA

The study area of this research is focused on construction industry that located at Klang Valley area. To be more specifically, the study conducted between ground level construction workers known as Non-Working at Height (Non-WAH) group and high elevation construction workers known as Working at Height (WAH) group which comes from different workplace. Non-WAH group respondents come from construction site at Seri Kembangan, they usually performs their task on the ground level. The activities that have been carried out by Non-WAH group are bore pile work, formwork and rebar work. On the other hand, for WAH group they come from construction site at Kepong and they conduct their task more than 15 meters height level. The activities that have been carried out by WAH group are Launching Girdle work, formwork and rebar work. Both group consist of slightly different scope of work from the others. In addition, construction workers that have been screened and selected as respondents in this study have enough sleep time and are free from any poor medical histories such as heart attack and asthma.

3.3 RESEARCH DESIGN

The study was carried out by using cross sectional study to assess the common work fatigue symptoms and identify the differences of physiological strain between construction workers. In this study, construction workers will be divided into two group categories which are Non-WAH group and WAH group. WAH group have 15 meter higher work area level compared to Non-WAH group. Due to heavy work load, respondent is exposed with work fatigue. Furthermore, workers are more scared to work high level compared to ground level work activities. The data was collected based on personal monitoring approach to assess the most common work fatigue symptoms and also heart rate measurement for one cycle of job activities to detect physiological strain among them. The data was collected between October 2018 and November 2018. During the assessment being conducted, it was under supervision of their respective person in charge.

3.4 STUDY SAMPLE

The total numbers of the study sample are 60 respondents that will be selected as respondents among the construction workers from various job activities. The respondents divided into two groups which are Non-WAH group and WAH group. There are 30 respondents for Non-WAH group and also 30 respondents for WAH group. Both group will come from different types of job activities such as concreter, rebar bender, formworker and scaffold erector.

3.5 SAMPLING STRATEGY

The first steps that conducted in this study was by categorised the construction workers into two group which are Non-WAH group and WAH group. Each group consist of 30 respondents from different job activities. Person in charge and workers from each group were briefed on the purpose and the method to conduct this study. They will be called to assembly at rest area for briefing and question and answer session. Both person in charge and workers must be understand and clear so it will smoothen the data collection.

After every party are good, personal monitoring conducted for each of the workers from both group. The personal monitoring was conducted orderly to assess the individual of total 60 respondents among construction workers. It involves a two types data collection which are heart rate measurements and questionnaires. For heart rate measurements, it will help to analyse the prevalence of physiological strain thus compared between Non-WAH group and WAH group. Workers needed to wear heart rate measurement device for one cycle of work or 5 minutes time period. The data was transferred to mobile phone and average of heart rate reading for the workers can be recorded.

After finish heart rate measurements, questionnaires were given to the workers. This survey was focused on the 60 respondents from both study groups. The questionnaire was conducted to determine the respondents' common work fatigue symptoms that they feel due to their heavy work activities and also their demographic data such as the gender, age, duration of sleep hours, smoking habit and others. For common work fatigue symptoms, it was divided into three categories which are Drowsiness and Dullness, Difficulty in Concentration and Projection of Physical Impairment. It will be used to identify the most common work fatigue symptoms among construction workers and comparison between both study groups.

3.6 **RESEARCH INSTRUMENTS**

In this study, it involves one type of instrument that was used in collection of data. The instrument used is a Vivosmart 3 to collect construction workers heart rate readings.

3.6.1 Vivosmart 3

It is a smart activity tracker with wrist-based heart rate and fitness monitoring tools. Vivosmart 3 tracks heart rate variability (HRV), which is used to calculate and display stress level. The graph of real time is shows on the device anytime throughout the day. Vívosmart 3 activity tracking capabilities include steps, floors climbed, calories burned, intensity minutes and more. It activity tracker automatically syncs to Garmin Connect which can be downloaded in the smartphone.

For the operation of this instrument, it was place on the wrist of the respondents. It should be comfortable to use by respondents, not too tight nor to lose. They need to make sure no disturbance with the device such as long sleeve shirt which can cause error during data collection. Workers need to wear it for minimum five minutes or one cycle of work. After that, data will automatically be tranfered to the mobile phone for record purpose.



Figure 3.1: Vivosmart 3

Source : Garmin International (2018)

3.7 DATA ANALYSIS

They are two types of data analysis which are descriptive analysis and inferential analysis. For inferential analysis it used bivariate analysis analysis to get comparison data of various variables. All the data that collected was analysed using software known as Statistical Package for Social Sciences (SPSS).

3.7.1 Descriptive Analysis

The purpose of descriptive analysis is to provide the characteristics of variables. In this study, it used to describe the subjective fatigue symptoms of construction workers. The data was shown in terms mean, percentage, frequency and standard deviation.

3.7.2 Bivariate Analysis

Bivariate analysis usually involves correlation test. In this study, Independent ttest were used. It was used to determine the difference of heart rate measurements between two study groups. By determine it, we can observed the differences of Non-WAH group and WAH group of construction workers average heart rate and which group more exposed to physiological strain at workplace.

3.8 STUDY ETHICS

The study is conducted under a good relationship between researcher, respondents and construction companies. All the collection of data were managed properly and scheduled so that the study can be conducted smoothly until it finish. All respondents were treated equally and fairly so that no bias towards them. Furthermore, the respondents were given a briefing so they can understand the purposes of this study, understanding the proper used of the instrument that will be used in this study and their roles as the respondents. During the data collection, they were treated in a good manner and the instruments were being used will not disturb their work which can cause discomfort to them. The questions that were asked also will not touch any sensitive issues of the respondents. Besides that, their personal details also will be kept secret from the outsider as this is for study purposes only and because of privacy concern.

3.9 STUDY LIMITATIONS

For the study limitations, there are some factors that can give affect towards the quality and accuracy of this study. Because of these factors, the results of this study may be differs from the other researched paper that have been done by the other researcher.

Firstly, it is involving the limited number of samples. It is not easy to get approval from industries to disturb their work progress. Because of that, the number of workers that they approved is still in small quantity. With bigger number of samples, it can increase the data and result of the study.

Secondly, there is limited time for the collection of data. This situation can happen because the duration of heart rate measurements differs from each group. Person in charge of the workers cannot give fix period of time for the workers to wear the heart rate measurement device. This study collects minimum five minutes or one cycle of job task for every respondent. With proper time collection, it can help to consistent reading for this study.

Thirdly, the data was a one shot collection. Construction workers in this study are collected their data just one time only. There are no follow up data collection to make it pre and post study. by conducting pre and post data collection after certain period of time, we can truly identify the workers fatigue symptoms and their physiological strain based on their work task and difference level of work area.

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

This chapter consisting result and discussion after the collected data being analysed by using direct reading from the instruments and statistical analysis using Statistical Package for the Social Sciences (SPSS) version 25. The topic that will be discussed are demographic data of respondents, subjective fatigue symptoms and heart rate measurements for ground level construction workers known as Non-Working at Height (Non-WAH) group and high elevation construction workers known as Working at Height (WAH) group.

4.2 DEMOGRAPHIC DATA OF RESPONDENTS

Demographic data of 60 respondents comes from construction workers were recorded. The data have been collected for two categories with 30 respondents respectively which are Non-WAH group and WAH group. There are three elements that being studied in this thesis which are age, experiences and sleep hour. The three elements were compared between two groups. All these elements can be one of various factors that can contribute to work fatigue in the body of construction workers. 4.2.1 Age

Based on the Figure 4.1, there are three main categories of Ages. WAH group has highest workers in the age of 20 years – 30 years and also 31 years to 40 years with both have 12 workers respectively. On the other hand, Non-WAH group has highest workers in the age of 41 years and above with 13 workers. The difference between these two groups in terms of age of workers, WAH group need more fit personnel due to high elevation level that requires the workers to used stairs and etc. While Non-WAH group no work in high level needed so they no need to be physically fit as compared to the other group.



Figure 4.1: Race of Construction workers

4.2.2 Experiences

Based on the Figure 4.2, there are three main categories of work experiences. WAH group highest data for work experiences is from 2 years to 10 years with 18 workers. Besides that, Non-WAH group highest workers work experiences is also from 2 years to 10 years with 22 workers. Both groups have the same highest number of respondents work experiences. However there are no workers below 2 years work experiences for Non-WAH group. While 6 workers from WAH group, have work experiences below 2 years. This condition can happen because of WAH group of workers need to be young and fit enough to work high elevation level compared to Non-WAH group that have 8 workers that work experiences above 11 years.



Figure 4.2: Work Experiences of Construction workers

4.2.3 Sleep Hour

Based on the Figure 4.3, there are two main categories of Sleep Hour. WAH group highest data for sleep hour is from 7 hours to 9 hours with total number of 20 workers. On the other hand, Non-WAH group have similar result as in the respondents with 15 workers for both sleep time which are 4 hours to 6 hours and also 7 hours to 9 hours. Both groups do not have workers that sleep more than 10 hours a day. It can happen because of the busy work schedule at workplace. However, compared with two groups, most of WAH group workers have sleep time 7 hours to 9 hours. This is because, WAH workers feel more tired due to heavy job task compared to the Non-WAH group thus they need more rest time.



Figure 4.3: Sleep Hour of Construction work

4.3 SUBJECTIVE FATIGUE SYMPTOMS

Subjective fatigue symptoms can indicate the workers are fatigue due to their daily work routine. Workers perform their own work activities that some of them requires heavy exertion of their muscle body. There are total of 30 types of subjective fatigue symptoms that have been divided into three categories which are Drowsiness and Dullness, Difficulty in Concentration and Projection of Physical Impairment (Hsu et al., 2007). The questionnaires were being asked to the total of 60 construction workers in the workplaces which divided into two groups that is Non-WAH group and WAH group. The data was collected by using questionnaires. The results of the questionnaires was analysed and discussed to identify the most common fatigue symptoms reported by the construction worker.

4.3.1 Drowsiness & Dullness

The first category of fatigue symptoms is drowsiness and dullnes. Based on the Figure 4.4, there are ten work fatigue symptoms in this category. Both categories have highest fatigue symptoms differ from each others. For Non-WAH group, the most common work fatigue symptom is **eye feel strained** with 83.33% prevalence rate. It is followed by whole body feel tired, legs feel tired and want to lie down with prevalence rate are 70% respectively. Besides that, for WAH group, the highest prevalence rate is **whole body feel tired** with 83.33% and followed by want to lie down with 73.33%. Basically there is no significant difference between both groups, this can happens due their nature of work that needs them to exert their energy to the limits.



Figure 4.4: Drowsiness & Dullness

4.3.2 Difficulties in Concentration

The second category of fatigue symptoms is difficulties in concentration. Based on the Figure 4.5, there are ten work fatigue symptoms in this category. For Non-WAH group, **disinterested** recorded as the most common work fatigue symptoms with prevalence rate 46.66% and followed by Unable To Concentrate (43.33%) and Lack Patience (43.33%). On the other hand, for WAH group, the workers feel more **lack of patience** during conducting their work with prevalence rate 66.67% and followed by Disinterested (53.33%). WAH group of workers may feel lack of patience more because of the high elevation work area makes them uneasy and want to finish their work faster so they can take rest earlier. While Non-WAH group feel Disinterested with their work, many reasons can be the cause of this condition even though they are work on safer ground level compared to WAH group.



Figure 4.5: Difficulties in Concentration

4.3.3 Projection of Physical Impairment

The third category of subjective fatigue symptoms is projection of physical impairment. Based on the Figure 4.6, there are ten work fatigue symptoms in this category. The most common work fatigue for Non-WAH group is the workers **feel thirsty** with prevalence rate 90% and it is followed by feel shoulder stiffness (86.67%). Non-WAH group of workers feel thirstier due to nature of construction which works under direct sunlight. Besides that, for WAH group of workers, they more to **feel pain in the waist** with 100% of prevalence rate and followed by also the same as Non-WAH group that is feel shoulder stiffness (86.66%). The statistic of 100% prevalence rate for feels pain in the waist indicates that WAH group of workers requires more exertion of their body while performing their work task. They not feel too thirsty may be due to work not direct under sunlight because usually high elevation work area have upper slab.



Figure 4.6: Projection of Physical Impairment

4.3.4 Assessment of Most Common Fatigue Symptoms

There are three categories of subjective fatigue symptoms that is Drowsiness and Dullness, Difficulty in Concentration and Projection of Physical Impairment for a total of thiry questionnaires. From these work fatigue symptoms, we can identify and assess the most common work fatigue symptoms for construction workers that can later on effect with their work performances.

All the subjective fatigue symptoms questionnaires have been analysed in Figure 4.4, Figure 4.5, and Figure 4.6. From the three figures, it can be concluded that the hypothesis H_{A1} was accepted: Feel Pain in The Waist is the common most common work fatigue symptoms among construction workers. With WAH group prevalence rate 100% and Non-WAH group prevalence rate 80%, it is the most fatigue symptoms reported by the workers compared to the others fatigue symptoms. Feel Pain in The Waist can be the main symptoms in this workplace due to the heavy duty task that need to be completed by them when doing their construction works such as erect scaffolding, install rebar into the formwork and concrete slab.

From the analysis, it found that construction workers also more exposed to the Projection of Physical Impairment categories, then followed by Drowsiness and Dullness, then lastly Difficulty in Concentration. Between these three subjective fatigue symptoms categories, there are different fatigue symptoms recorded for Non-WAH group and WAH group among construction workers. Even though both groups are from construction industries, but different of fatigue symptoms can happen because of different work level area and also job task between them. However, there is no significant difference of work fatigue symptoms because both groups have similar work fatigue symptoms and slightly difference in terms of prevalence rate.

4.4 HEART RATE ASSESSMENT

According to American Health Association (2015), there are target heart rates for each individual based on their age factor. With the standard that has been introduced by them, the study can compare with the heart rate among construction workers between Non-WAH group and WAH group. The heart rate readings that have been collected was analysed to find which group that have the highest heart rate readings. The group that have highest heart rate readings is indicates that they are more exposed with physiological strain at workplace.

4.4.1 Average Heart Rate for Non-WAH group and WAH group

Average heart rate for Non-WAH group and WAH group among construction workers are recorded as per Table 3. There are thirty respondents from each group collected.

Respondents	Average Heart Rate (bpm)				
—	Non-WAH	WAH			
1	63	73			
2	66	80			
3	77	80			
4	79	83			
5	80	86			
6	81	88			
7	81	88			
8	82	89			
9	83	89			
10	84	90			
11	87	90			
12	87	91			
13	87	93			
14	88	96			
15	90	98			
16	90	98			
17	91	99			
18	92	100			
19	95	101			
20	9 5	101			
21	97	101			
22	98	102			
23	98	103			
24	99	107			
25	101	108			
26	101	109			
27	103	109			
28	104	111			
29	106	116			
30	106	123			

Table 4.1: Average Heart Rate (bpm)

Average heart rate recorded from Table 4.1 then further analysed into Figure 4.7. This figure shows that the trend is directly proportional for both Non-WAH group and WAH group. However, WAH group have higher average heart rate readings compared to Non-WAH group. From Table 3, for WAH group, the highest average heart rate recorded are 123bpm while only 106bpm for Non-WAH group. The lowest average heart rate readings also differs between both groups, WAH group with average 76bpm and Non-WAH group with average 63bpm. The different of average heart rate measurements between Non-WAH and WAH group shows that construction workers among them exposed to different physiological strains.



Figure 4.7: Average Heart Rate (bpm)

4.4.2 Comparison Of Heart Rate Measurement Between Non-WAH Group With WAH Group

Table 4.2 shows the comparison of heart rate measurement between Non-WAH group and WAH group. This data is important to identify the difference of physiological strain that occurs for both groups. By understanding which group exposed more to physiological strain, proper control measure can be plan to protect them from danger at workplace. In this study, the test that being used is Independent t-test. This test used in non-parametric test study the difference between two group of data.

From the table, it stated that there is significant difference of heart rate measurements between Non-WAH group and WAH group of construction workers (p< 0.05). For WAH group, the Mean (96.73) and SD (11.41) are higher than Non-WAH group Mean (89.70) and SD (10.93). It shows that there are WAH group have higher heart rate measurements compared with Non-WAH group. It can be concluded that the hypothesis H_{A2} was accepted: WAH group workers have higher physiological strain than Non-WAH group. Construction workers that work at high elevated area feel more uncomfortable to work because it affects their mental stress and fear of height can lead to dangerous occurrences at workplace.

Table 4.2: Comparison of heart rate measurement between Non-WAH group

Heart Rate Group	Ν	Mean	SD	p-value
Non-Working at Height	30	89.70	10.93	0.018
Working at Height	30	96.73	11.41	
Note. Independent t-test	t			

and WAH group

CHAPTER 5

DISCUSSION

5.1 Discussion of Results Compared With Previous Studies

This study conducted based on two main journals from previous research. Firstly, Hsu et al., (2007) conduct a study about the effect of elevation change on work fatigue and physiological symptoms for high-rise building construction workers. Secondly, Chang et al., (2008) study more about work fatigue and physiological symptoms in different occupations of high-elevation construction workers. With many similar studies, it gives greater comparison and validity for this study.

Enough sleep time is need for us to have good stamina and energy for another day. Results from this study found that for both ground level construction workers and high elevation construction workers, their sleep times are between 7 hours to 9 hours. This result also similar with Hsu et al., (2007) and Chang et al., (2008) which their respondents have 7 hours – 9 hours sleep time. It is then further justified by Max Hirshkowitz (2015), stated that the suitable sleep duration for an adult (26 years – 64 years) is between 7 hours to 9 hours. With enough sleep time, it will not affect construction workers productivity and performances.

The prevalence rate for subjective fatigue symptoms shows that feel pain in the waist is the highest. Non-WAH group have 80% prevalence rate and 100% for WAH group of construction workers. The results of previous study by Hsu et al., (2007) and Chang et al., (2008) also shows similar most common fatigue symptoms that is feel pain in the waist. Both study support the result of this study. In terms of ergonomic

perspective, chronic waist pain among construction workers is likely the results from heavy work task, repetitive workload and spending long-periods in awkward postures due to the nature of construction industry. There are exposed with musculoskeletal disorder disease due to awkward posture can affect their work performances. Therefore, it is very important to give proper training and information to the workers so they can conduct their work safely.

Sakai and Nose (2003) found that heart rate can be considered as good and reliable variables for physiological strain. It is further justified by ISO standard 8996 (2004), the workers metabolic rate help to identify the difference between heart rate readings. Therefore, the heart rates collected were further analyzed to determine the presence of physiological strain among construction workers. This study found that WAH group have a higher physiological strain compared with Non-WAH group (p-value<0.05). Heart rate reading of WAH group is greater than Non-WAH group. Hsu et al., (2007) found that the increasing work floor level, it increases the heart rate readings of the workers. Thus their result supports this study. On the other hand, Chang et al., (2008) study shows that higher heart rate for scaffolders, this indicates that their physiological strain is greater than other workers. This can happen due to the instinctive responses, such as fear, panic and shiver, arising from standing on scaffold. Which also means that working at height workers have higher physiological strain than ground level workers.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

The purpose of this study was to evaluate common work fatigue symptoms and differences of physiological strain between construction workers. It divided into two groups which are ground level construction workers known as Non-Working at Height (Non-WAH) group and high elevation construction workers known as Working at Height (WAH) group with thirty respondents each groups. Subjective fatigue symptoms questionnaires distributed and construction worker's heart rate measurements taken to study the physiological strain. Then, the result was analysed by using simple statistic and also SPSS 25 software.

From the analysis of collected data, both hypothesis of this study are accepted. The first hypothesis stated that feel pain in the waist is the most common work fatigue symptoms among the construction workers. High elevation construction workers have 100% prevalence rate of this work fatigue symptoms, while ground level construction workers have 80% prevalence rate. This indicates that, due to nature of work in construction industry that workers need to carry out heavy duty task, workers are more prone to waist pain. This will disturb their health when they exposed with it for long period of time and not enough rest is given. The second hypothesis that has been accepted is that high elevation construction workers have higher physiological strain compared to the ground level construction workers. By using Independent t-test to analysed the difference of average heart rate for ground level and high elevation construction workers, it found that the p-value is 0.018 (<0.05). This data indicates that construction workers that working at high level of workplace feel more pressure compared to those that working on the ground level. Height elevated level give workers more mix feeling between fear of height and responsibilities to finish their job.

Physiological strain that workers are exposed can lower their work focus and increases the error while performing their job activities. Construction workers will feel easily fatigue due to different body metabolism that heart rate are pumping at higher rate when they working at height. The effect of fatigue can reduces worker's ability to make decision, ability to handle stress, poor reaction time and poor productivity. Thus it can increase the risk of injury and accident at workplace if the workers are not fit to conduct their work.

In conclusion, high elevation construction workers are more exposed to the hazards at workplace due to the subjective fatigue symptoms and physiological strain that they have compared to the ground level construction workers. High elevation construction workers are more prone to accident at workplace, because of that proper action plan need to have so that workers will feel more secured when they work at high elevated work area.

6.2 **RECOMMENDATIONS**

There are several recommendations that can be used for this study in terms of industrial sector and also future study.

6.2.1 Industrial Sector

Industrial sector means that the recommendations that can be applied in the construction industries to reduce the presence of work fatigue and physiological strain for every workers in the workplace. The recommendation can be addressed to the top management and also the workers itself. With the recommendations, it will make safer workplaces area for the construction workers.

Doing construction work use a lot of metabolic energy, cardiovascular system and other human body system. It lead to fatigue and physiological strain, thus workers need enough rest time to get back their normal body systems. By giving construction workers frequent rest time during work hour and enough rest time at home, it can help them to restore back their energy so that they can be more focus, awake and have enough stamina to conduct their job properly.

Finally, workers must undergo a proper training to reduce the impact of unsafe work. Training is always the basic requirements for every work process. With enough training, worker will be more aware about the effect of work fatigue at workplace. They also will be prepared with the job task and skilled to perform their work correctly. With adequate skill and knowledge, workers know how to prevent themselves from fatigue and physiological strain that comes from their scope of work.

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6.2.2 Future Study

The recommendations for future study also needed to make sure the study of work fatigue and physiological symptoms in different occupations of high-elevation construction workers will be more effectives and gives more benefits towards the industries. It also will help to increase the validity of the results and can be used to be referred by others.

For a great and more accurate results, it requires same respondents that doing same scope of work but different high level of work area. By having same respondents will eliminate the difference of physiological characteristics between each individual such as heart rate reading and medical history. However, it is not easy to get same respondents that work at different height, because of that it requires proper planning and communication between researcher and industry.

The needs of more physiological variables used to identify the presence of physiological strain in an individual are crucial. Even though previous study used heart rate, to have a reliable study of physiological strain, more variables such as pinch test and blood pressure measurements can give clear data that can help us understand better how that particular works cause the workers to accumulate unsafe physiological strain at workplace.

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