

# Ergonomics Awareness on Construction Site

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**Abstract.** Ergonomics is known as a science of designing the job to fit the workers which makes the job easier, safer and more pleasant for them and also leads to save money. However, ergonomics so far has had little impact in Malaysia. The purpose of the study is to find method to enhance the ergonomics awareness on construction site. The study was conducted in the Johor Bahru district. The respondent involved were professionals working with construction related company. The questionnaire data was analysed using frequency analysis method and average index method. The finding shows that the awareness of the ergonomics among the workers is in satisfactory level but there is still lack on implementation. Therefore, some improvements and recommendations should be considered. All parties involved in the construction should take action to increase the ergonomics awareness together with educational training effort.

## Introduction

Ergonomics is the science and practice of designing jobs and workplace to match the capabilities and limitations of the human body. It can be simply define as to fit the job to the worker. The goal of ergonomics is to create jobs, tools, equipment and workplace that fit people rather than making people adapt to them.

Ergonomics term is derived from the Greek words, ‘ergon’ and ‘nomos’ which refers to consideration of laws into the work. It is one of the strategies to make the job easier for the workers. In addition, ergonomics can also reduce the pain which is related to the job that can degrade the work performance and quality [1].

The profession has two major branches with considerable overlap. The first branch sometimes referred to as industrial ergonomics or occupational biomechanics, concentrates on the physical aspects of work and human capabilities such as force, posture and repetition. While the second branch sometimes referred to as human factors is oriented to the psychological aspects of work such as mental loading and decision making [2].

The construction is defined as the building of something, typically a large structure where the nature of the work imposes a lot of ergonomically hazards to the workers [3]. It is considered as a demanding job where a large number of workers are working in and often classified as a high risk industry since it has historically been plagued with much higher and unacceptable injuries such as strains, sprains, Musculoskeletal Disorder (MSDs) and etc. when compared to other industries [1].

Construction industry is a dynamic and hazardous industry, making it challenging for ergonomic aspects to be implemented on site. Thus, there are lots of controlling factors that can be taken into consideration in implementing ergonomics and controlling ergonomics risk factors in the construction site. The implementation of ergonomics at the workplace can be improve through a few steps or approaches such as communication, management control, ergonomic design factors, training and education as well as written ergonomics program [2]. These steps are very important to increase the awareness of the ergonomics among the workers.

**Problem Statement** The construction industry is a challenging place to work as its physical processes can causes various ergonomic-related problems. The industry stands out from other industries as having the highest worker injury and fatality rates, which makes it the highest risk

sector in regard to WMSDs. Every construction worker is likely to be temporarily unfit to work at some time as a result of moderately serious injuries or health problems after working on a construction site.

MSDs or musculoskeletal disorders are injuries and disorders of the soft tissue in the body and nervous system. Soft tissues include the muscles, tendons, ligaments, joints and cartilage. MSDs can effects the nerves, tendon sheaths and most frequently it will attack arms and back [4].

According to [5], there were 365 580 cases of musculoskeletal disorders (MSDs) such as sprains or strains resulting from exertion in lifting. The MSDs incidence rate per 10 000 full time worker for construction industry recorded in 2014 is 32.7 reducing from 41.9 incident rate which is recorded in 2013 (Figure 1). The incidence rates represent the number of injuries and illnesses per 10,000 full-time workers and were calculated as  $(N/EH) \times 20,000,000$ , where:

N = number of injuries and illnesses

EH = total hours worked by all employees during the calendar year

20,000,000 = base for 10,000 equivalent full-time workers

(working 40 hours per week, 50 weeks per year).

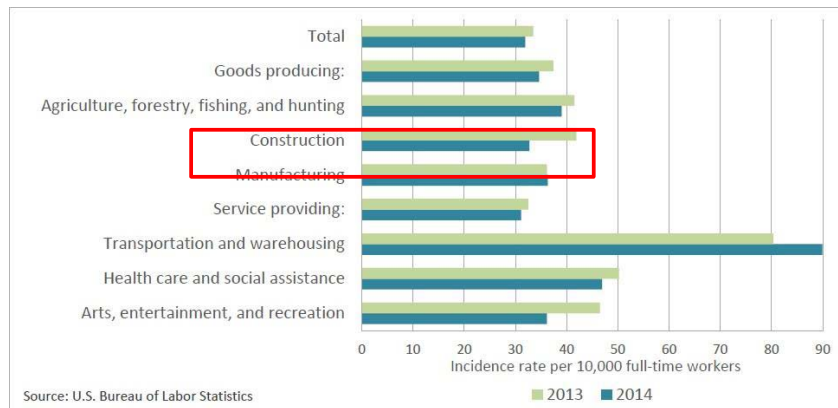


Figure 1: Musculoskeletal disorder incidence rates for selected private sector industries, 2013-2014

Malaysia as a developing country has experienced quick development for the last decades. Therefore, the construction industry is also experiencing the same problem with the increases of musculoskeletal disorders among the workers. Based on the statistical report from Social Security Organization (2104), the number of cases for MSDs has risen continuously from 10 cases in 2005 to 675 cases in 2014 (Figure 2). The increase number of cases in the MSDs shows the lack of ergonomics awareness among the workers. Therefore, a proper understanding and efficient management program need to improve to increase the ergonomics awareness and reduce the total illness in construction industry.

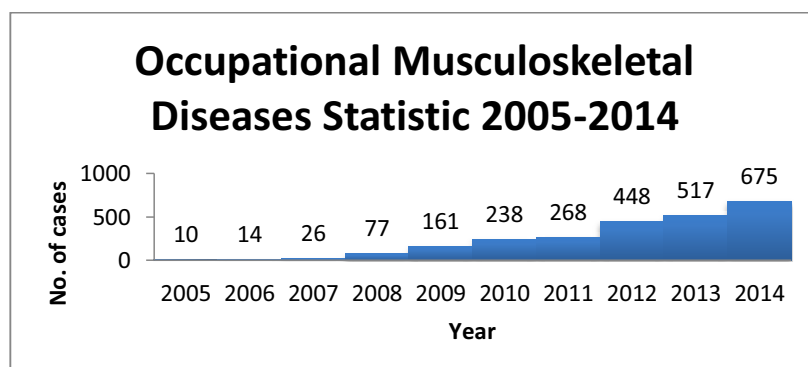


Figure 2: Occupational Musculoskeletal Diseases Statistic. (SOC SO, 2014)

**Research Aim and Objectives** The aim of the study is to find method to enhance the ergonomics awareness in construction site. To achieve the aim, the following objectives have been identified:

1. To study ergonomics programs on construction site.
2. To determine the level of ergonomics awareness among the worker in construction site.
3. To propose improvement of ergonomics awareness on construction site.

**Scope of Study** The research involved the construction industry in Malaysia and focused in the Johor Bahru area only. Respondent for the research are selected among the individual that have a basic knowledge about the practical of the ergonomics on site such as project manager, resident engineer, safety officer and supervisor. The most important, the study will cover the assessment for implementation of ergonomic awareness.

**Significance of Study** The significant of the study is to have a better understanding on the implementation of ergonomics programs at construction industry. This study also identifies the level of ergonomics awareness among construction players. The result of the analysis is expected to contribute to the construction industry to enhance the ergonomics programs that have been implemented at the site.

**Previous Studies**

**Ergonomics Definition** There are many definitions of the ergonomics from various parties from different industry. However, the concept of the ergonomics is almost the same. The origin of the term ergonomics is derived from the Greek word ‘ergon’ and ‘nomos’ which means work and natural laws or study of respectively [2]. These words brings the definition of consideration of laws into the work. Below are the definition of ergonomics from various authors.

Table 1: Definition of Ergonomics

Authors	Definition of Ergonomics
U.S Department of Labour Occupational Safety and Health Administration (4)	Simply as study of work. More specifically, ergonomics is the science of designing the job to fit the worker, rather than physically forcing the worker’s body to fit the job.
International Ergonomics Association (6)	Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.

**Scopes of Ergonomics** There exist scopes of specialization within the discipline of ergonomics, which represent deeper competencies in specific human attributes or characteristics of human interaction. Scopes of specialization within the discipline of ergonomics are broadly the following:  
(6)

Table 2: Scope of Ergonomics

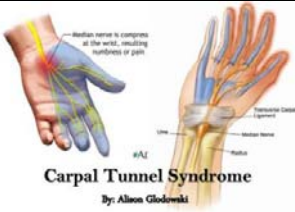
Scope	Details
Physical Ergonomics	Concerned with human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to physical activity.
Cognitive Ergonomics:	Concerned with mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system.
Organizational Ergonomics:	Concerned with the optimization of sociotechnical systems, including their organizational structures, policies, and processes.


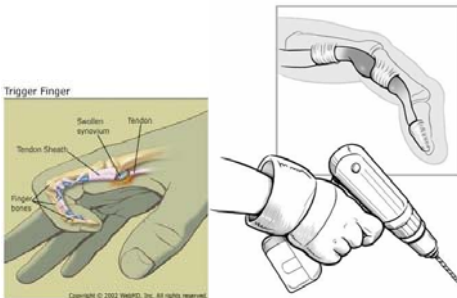
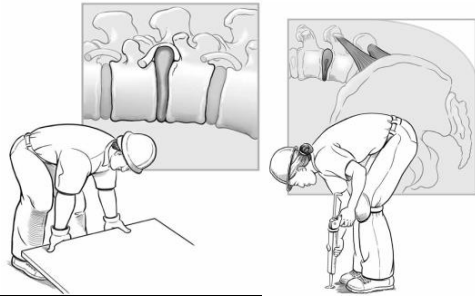
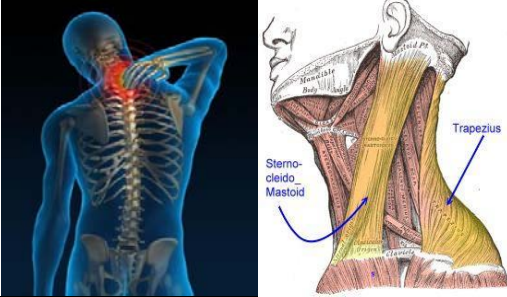
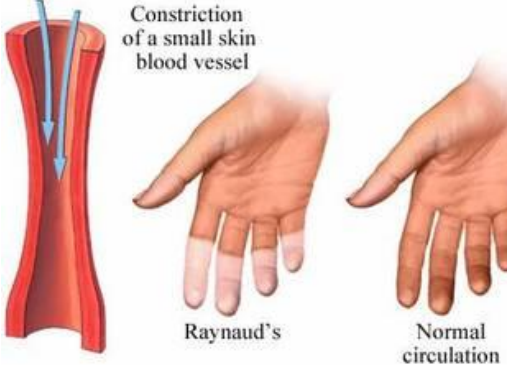
**Ergonomics Risk Factor** Ergonomic risk factors are characteristics of a job that facilitate ergonomics stress on the body. Risk factors occur at different jobs and tasks. The greater exposed to these risk factors the greater probability of ergonomics. According to [1], ergonomics risk factors can be divided into seven categories as follows:

- Forceful strains
- Awkward and static postures
- Vibration
- Repetition
- Duration
- Excessive pressure on nerve or soft tissue
- Extreme temperature

**Musculoskeletal Disorder (MSDs)** MSDs or musculoskeletal disorders are injuries and disorders of the soft tissue in the body and nervous system. Soft tissues include the muscles, tendons, ligaments, joints and cartilage. MSDs can effects the nerves, tendon sheaths and most frequently it will attack arms and back [4]; [7]. According to [3], MSDs are the most prevalent disease that normally occurs to the construction workers. A dramatic increase in MSDs began in 1970s when these disorders increasingly appeared on companies’ injury and illness logs. OSHA cited companies for hazardous workplace conditions that caused problem such as tendinitis, carpal tunnel syndrome and back injuries [4].

Table 3: Type of Ergonomics Diseases

	Disease	Description
	Carpal Tunnel Syndrome	Nerve entrapment results from the build-up of pressure on the median nerve for the construction workers due to carrying of loads and gripping for long time.

	Tendinitis	Tendon inflammation occurring when a muscle or tendon is repeatedly tensed from overuse or unaccustomed use of the wrist, shoulder or knees.
	Trigger Finger	Type of tenosynovitis arises due to flexing of finger frequently against resistance.
	Disc Injuries	Damage that occurs to the disc on the spinal cord due to frequent bending of back. Spine runs from the top of neck down to your lower back.
	Tension Neck Syndrome	Muscles strain that result from long periods of looking up. It can cause neck stiffness, muscle spasms, and pain in the neck or radiating from the neck.
	Raynaud's Syndrome	Blood vessel of the hand is damaged from repeated exposure to vibration long period of time. The skin and muscle do not get the necessary oxygen from the blood and eventually die.

**Ergonomics Program Management** A recent study conducted by [9] showed that most programs organized were less effective and does not give an impact towards the workers. Therefore, the

workers were lack of knowledge and awareness in regards of ergonomics and are exposed to the ergonomics injuries.

The ergonomics programs that have been implemented on site will be less effective and worse, it will never give impact towards the ergonomics concern if there is no proper management. Effective ergonomics program should include the following elements:

Table 4: Key Elements of Ergonomics Program

<b>Key Elements</b>	<b>Successful ergonomic program</b>
Purpose and objective of ergonomics program	Describe the purpose and the goals of conducting the ergonomics program
Ergonomics program overview	Introducing and explaining the important consideration in managing ergonomics on construction site
Management leadership	Focusing the employer’s belief on necessity of ergonomics program Appointing persons in charge for ergonomic program execution Establishing goals
Employee participation	Enhancing job satisfaction Creating team Improving communication
Job hazard analysis	Ergonomic hazards identification Controlling development to mitigate hazards
Controlling ergonomic risks	Engineering control – work station, tools, equipment Work practice controls – proper lifting techniques, keeping work areas clean PPE ( Personal Protective Equipment) Administrative controls - worker rotation, more task variety, rest breaks
Musculoskeletal Disorders (MSDs) management	Injury and illness record keeping Early recognition and reporting of MSDs symptoms Systematic evaluation and referral to a qualified health care provider Conservative treatment, such as restricted duty jobs, when necessary
Training and education	Increasing knowledge of ergonomic Improving skills & abilities in reducing ergonomic hazards
Program evaluation	Auditing of targeted performance Evaluating of program efficiency

**Methodology**

To assess and evaluate the ergonomics awareness among the workers, some construction company are chosen randomly in the Johor Bahru area. In general, the research methodology began with a literature review on the related topic. It was followed by the collection of data through a questionnaire. The data collected is then analysed using a specific method.

**Data Collection**

- A questionnaire is developed to assess the perceptions of the respondent on the ergonomics awareness in construction site.
- A total of 30 sets questionnaires have been distributed and only 26 were returned with valid answer.

- The questionnaires were distributed manually by hand to the person that is related to the construction such as project manager, engineer, safety officer and supervisor.

**Data Analysis** The following statistical methods have been used for data analysis:

- Frequency Analysis
- Average Index (AI)

In analysing the data on the program importance and implementation or respondent level of awareness, the following assumed values have been considered for responses based 5 point Likert Scales.

*Frequency Analysis.* The data collected through questionnaire were analysed using frequency rate technique (also known as point estimate or mean) to describe the background information of respondents. The method simply calculates the number of respondents and its correspondent's percentage to the relevant group required by questionnaire. The following simple equation has been applied:

$$\text{Frequency Rate } (p') = (n / N) \times 100$$

Where, n = Number of response frequency for preferred criteria and N= total number of respondents.

*Average Index (AI).* The data collected from the questionnaire was tabulated based on the number of response for each category of degree of awareness or agreement. Based on the frequency analyses the average index was then calculated to determine the ranking of each factor being considered. The average index is calculated as follow:

$$AI = \frac{\sum a_i \cdot x_i}{x_i}$$

Where,  $a_i$  = constant expressing the weight given to  $i$ ,  
 $x$  = variable expressing the frequency of response for  $i = 1, 2, 3, 4, 5$ .

In order to determine the degree of program importance and implementation and the ergonomics awareness in this studies the classification of the rating scales proposed by [9] have been used. The classifications of the rating scales are as follows:

Table 5: Average Index Classification

Average Index (AI)	Classification
$1.0 \leq AI \leq 1.5$	Not Important
$1.5 < AI \leq 2.5$	Less Important
$2.5 < AI \leq 3.5$	Moderately Important
$3.5 < AI \leq 4.5$	Important
$4.5 < AI \leq 5.0$	Very Important

## Data Analysis

Section A of the questionnaire form captures some basic demographic of the respondents as shown in Figure 3 to 5. Majority of the respondents are from main contractor while others are from

sub-contractor, consultant and client. Most of them are an engineer while others are project manager, safety officer and supervisor. The respondents have been actively involved in construction site and mostly have an experience more than 5 years.

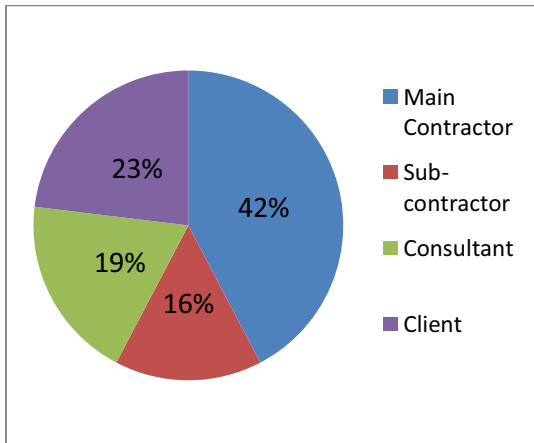


Figure 3: Percentage of respondent based on organisation type

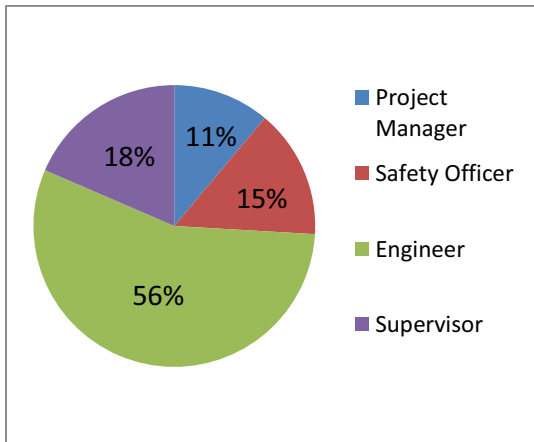


Figure 4: Percentage of respondent based on position

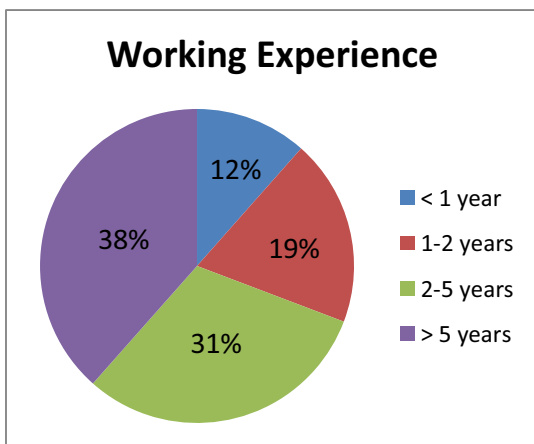


Figure 5: Percentage of respondent based on working experience

**Section B: Ergonomics Program** Figure 6 shows the percentage of respondent attend the ergonomics program based on the period of time. The highest percentage which marks 35% indicates that majority of the respondents attends ergonomics programs more than 5 years ago. Following that are less than one year and 2 to 5 years at 31% and 23% respectively. The lowest percentage comes from 1 to 2 years which marks 11%. This scenario shows that ergonomics have



been exposed to the construction industry for quite a long time. Besides that, we can also conclude that ergonomics awareness is gaining attention in the industry and are still in the phase of acceptance by the practitioners.

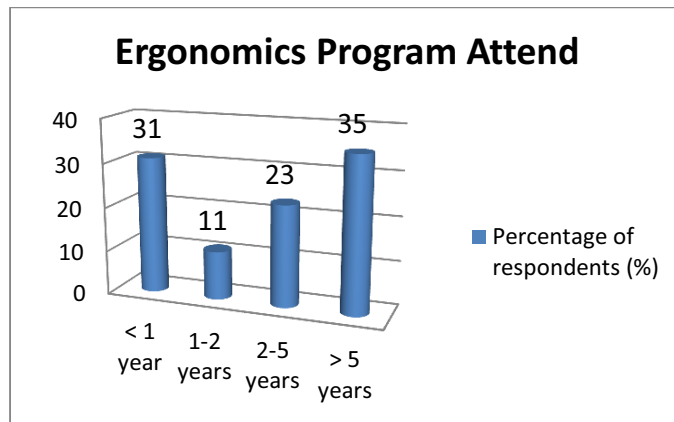


Figure 6: Percentage of respondents attends the ergonomics program based on the period of time

Based on the results on Table 6 below, it was found that majority of the respondent were in the opinion that controlling ergonomic risk was the most important key elements to be considered in ergonomics program. Follow by training and education, job hazard analysis, program overview, management leadership, worker participant, purpose and objective of ergonomics program, program evaluation and lastly is MSDs management. MSDs management was considered as the least important element by the respondents with an average index of 3.42. Therefore, it indicates that the respondents were not well aware on the importance of MSDs management.

Table 6: Importance of Key Elements of Ergonomics Program

Key Element	AI	Rank	Indication
Controlling ergonomic risk	4.23	1	IMPORTANT
Training and education	4.15	2	
Job hazard analysis	4.08	3	
Ergonomics program overview	3.96	4	
Management leadership	3.96	5	
Worker participant	3.81	6	
Purpose and objective of ergonomics program	3.77	7	
Program evaluation	3.73	8	
Musculoskeletal Disorder (MSDs) management	3.42	9	MODERATELY IMPORTANT

The result of implementation of the key element was presented in Table 7 below. Controlling ergonomic risk is ranked first with an average index of 3.35. Place second in the ranking is ergonomics program overview. Follow by job hazard analysis and management leadership in third and fourth place respectively. Next is training and education. The last bottoms three are purpose and objective, program evaluation and MSDs management. These three elements have an average index lower than 3 which are considered low. From the table, it can be seen that all the key elements have been moderately implemented.

Table 7: Implementation of Key Elements of Ergonomics Program

Key Element	AI	Rank	Indication
Controlling ergonomic risk	3.35	1	<b>MODERATELY IMPLEMENTED</b>
Ergonomics program overview	3.27	2	
Job hazard analysis	3.23	3	
Management leadership	3.19	4	
Training and education	3.08	5	
Worker participant	3.00	6	
Purpose and objective of ergonomics program	2.92	7	
Program evaluation	2.88	8	
Musculoskeletal Disorder (MSDs) management	2.65	9	

The discussion above was then presented in the Figure 7 below. Figure 7 below shown clearly the difference in average index for every key elements considered in ergonomics program. From the figure, we can see that the importance of the key elements have a higher average index compared to the implementation. Thus, we can conclude that even though the respondents were all aware on the importance but they do not implement it. The lack in implementation maybe cause there were no suppression from the management and the authorities.

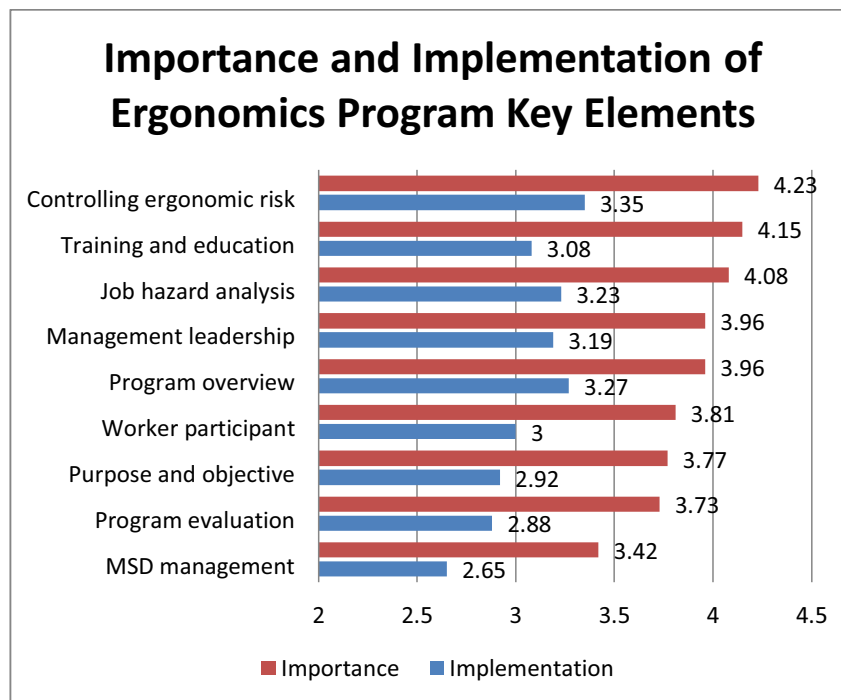


Figure 7: Importance and Implementation of Ergonomics Program Key Elements

Table 8 below shows the result of methods of ergonomics program implementation. From the result, it was clearly shown that the preference was affected greatly by the cost. Ranked first is send representative to ergonomics program and deliver info onsite after the program followed by develop a program for workers and invite ergonomist as consultant and deliver info onsite. These two methods have the most favour by the respondents because it is viewed as the most economical method.

Next is hands-on exercise followed by send workers to an appropriate ergonomics programs. Hands-on exercise is a method that can be practised with a low cost but will have effect greatly on the educational and understanding of the workers about ergonomics. Finally, the method that has have the lowest votes is distributes brochure based on content of ergonomics program. This is because the methods do not gives a significant impact as it involves self-learning process and the workers do not have any intention to do so.

Table 8: Methods of Ergonomics Program Implementation

<b>Ergonomic Program Implementation</b>	<b>AI</b>	<b>Rank</b>	<b>Indication</b>
Send representative to ergonomics program and deliver info onsite after the program	3.19	1	<b>MODERATELY IMPLEMENTED</b>
Develop a program for workers and invite ergonomist as consultant	3.15	2	
Hands-on exercise	3.12	3	
Send workers to an appropriate ergonomics program	2.96	4	
Distribute brochure based on content of ergonomics program	2.77	5	

**Section C: Ergonomics Awareness** Referring to the Table 9 and Figure 8 below, the health aspects were ranked the highest with average index of 4.31 and 4.23. It shows the respondents were aware that occupational disease can cause disability, paralysis and decrease of the quality of life. Besides that, rate of injuries, accidents and occupational disease will increase if ergonomics is not implemented. Following with an average index more than 4 were safety, complaint and comfort.

The education aspect and cost aspect have taken the lowest ranking with an average index of less than 4. This shows that the respondent is less aware that enhancements of training, knowledge and ergonomics programs are needed in the organisation and provision of ergonomics must be followed to avoid penalty. In term of cost aspect, respondent are still less aware that medical cost and compensation will increase the organisation cost if ergonomics is not implemented. Besides that, they are also less aware to the fact that cost of implementing ergonomics on site is lower than the cost of compensation payment to worker.

Table 9: Ergonomics Awareness among Construction Players

<b>Awareness</b>	<b>Aspect</b>	<b>AI</b>	<b>Rank</b>	<b>Indication</b>
Occupational disease can cause disability, paralysis and decrease of the quality of life.	Health	4.31	1	<b>AWARE</b>
Rate of injuries, accidents and occupational disease will increase if ergonomics is not implemented.	Health	4.23	2	
Unhealthy and insecure working environment will increase employee turnover and termination.	Safety	4.19	3	
Employee will lost focus and get pressure when working environment is not safe and secure.	Safety	4.15	4	

Equipment, furniture and workstation need to fit the worker to achieve job satisfaction.	Comfort	4.15	5
Appropriate action need to be taken if there are complaint on safety and health at site.	Complaint	4.08	6
Ergonomics helps to create a safe and healthy working environment.	Comfort	4.04	7
Medical cost and compensation will increase the organisation cost if ergonomics is not implemented.	Cost	3.92	8
Employee satisfaction, commitment and productivity will reduce if the complaint made is not taken seriously.	Complaint	3.85	9
Provision of ergonomics must be followed to avoid penalty.	Education	3.85	10
Enhancements of training, knowledge and ergonomics programs are needed in the organisation.	Education	3.81	11
Cost of implementing ergonomics on site is lower than the cost of compensation payment to worker.	Cost	3.69	12

AWARE

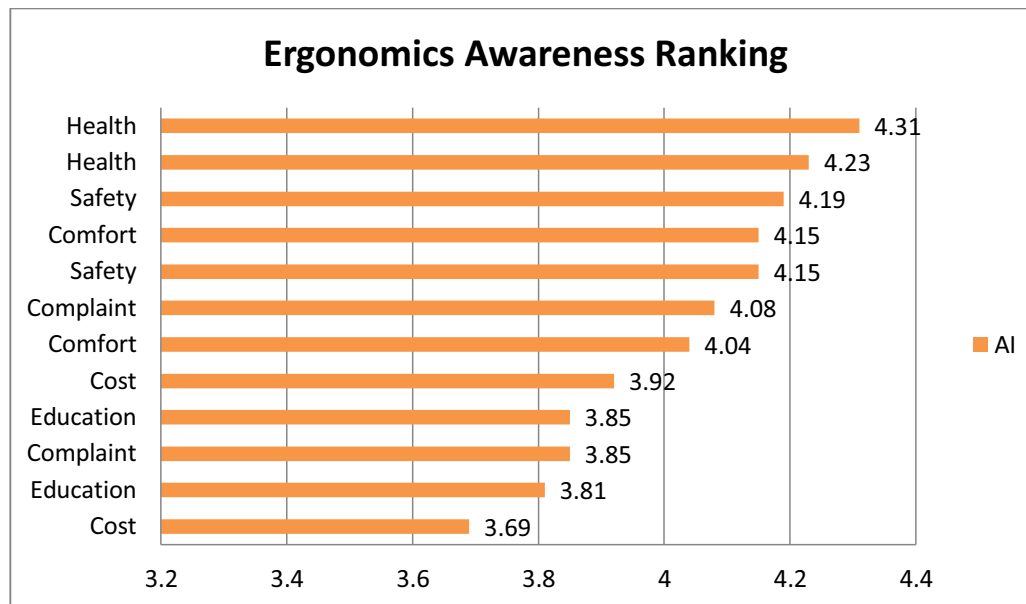


Figure 8: Ergonomics Awareness among the Construction Players

### Conclusion

**Achievement of Objective 1: To study ergonomics programs on construction site.** Based on analysis, the study of importance of key elements shows that all of the key elements are considered important except for MSDs management. This shows that the respondents are still lack awareness on the importance of the MSDs management. As for the implementation, it can be conclude that it

still in the unfavourable stage. Even though the respondents are aware on the importance but it is not being well implemented. This is maybe because there were no suppression from the management and the authorities.

Next, for the methods of implication of the ergonomics program, the preference is greatly affected by the cost aspect. Respondents always think to reduce the cost in any aspect. This is because they believe that managing safety and health in construction site is costly especially when they need to send workers to attend an ergonomics program. That is why, by sending one workers as representative for all is considerable. Besides that, workers itself less motivated towards self-learning process which contribute the way distribute brochure well implemented.

***Achievement of Objective 2: To determine the level of ergonomics awareness among the worker in construction site.*** Based on analysis, the level of ergonomics awareness among the worker in construction site shows a satisfactory level in most of the aspect considered except for cost and education aspects. However, despite of the high awareness, there were still lacks of implementation. Therefore, the need for improvement is require by propose improvement of implementation ergonomics programs as following subchapter.

***Achievement of Objective 3: To propose improvement of implementation of ergonomics awareness on construction site.*** From the study, the lack of ergonomics implementation on construction site is caused by there is no proper management of the ergonomics. Besides that, there is also lack in term of enforcement by the top management and authorities. Thus, all parties involve should take some action to implement ergonomics on site.

In addition, improvement in ergonomics program itself helps the site personnel apply the content towards the workers on site. Some of the recommendations are:

- i. Include a suitable arrangement of managing equipment and work activity.
- ii. Ergonomics program must be sensitive with the surrounding issue and keep update parallel with technology changes in construction activity.
- iii. Update the content of ergonomics programs regularly.
- iv. Create a team that will be in charge of ergonomics at site to create the sense of responsibility.

Reputation loss is difficult to quantify and commonly neglected in the consequence assessment. It is dependent on time and perceptions. This paper endeavored to identify the factors of stakeholders' perceptions that result in pipeline operator reputation loss. The AHP approach was adopted to prioritize the reputation loss factor. The results show that the factor contributing to the highest priority value is B1 (loss of customer confidence). The AHP method is capable of identifying contributors to reputation loss. Thus, better risk assessment of pipeline damage due to corrosion will be achieved with the inclusion of reputation loss in the consequence assessment. Hence, decision making in pipeline repair, inspection, and maintenance will be improved as well as the company's annual profit margin.

## References

- [1] Shoubi, M. V., *et. al.* (2013). Ergonomics Principles And Utilizing It As A Remedy For Probable Work Related Injuries In Construction Projects. *International Journal of Advances in Engineering & Technology*, 6(1), 232-245.
- [2] Mittal, A. *et.al.* (2013). Ergonomic Risk Controls in Construction Industry- A Literature Review. *International Journal of Emerging Research in Management & Technology*, 2(8), 28-33.

- [3] Manikandan, R., & Sathyanathan, M. (2014). Analysis of the Ergonomic Hazards for the Construction Workers in an Educational Institution. *IJRET: International Journal of Research in Engineering and Technology*, 3(11), 290-292.
- [4] OSHA 3125. (2000). *Ergonomics: The Study of Work*. U.S. Department of Labor Occupational Safety and Health Administration.
- [5] Bureau of Labour. *Nonfatal Occupational Injuries and Illnesses Requiring Days Away From Work, 2014*. US: U.S Department of Labour, 2015.
- [6] IEA. (2016). *What Is Ergonomics: Definition and Domain of Ergonomics*. Retrieved January 7, 2016, from International Ergonomics Association: <Http://www.iea.cc/whats/index.html>
- [7] Jaffar, N., *et. al.* (2011). A Literature Review of Ergonomics Risk Factors in Construction Industry. *Procedia Engineering* 20 , 89-97.
- [8] Derosa, B. M., *et. al.* (2015). A Study on Ergonomic Awareness among Workers Performing. *Procedia - Social and Behavioral Sciences* 195 , 1666-1673.
- [9] Abd. Majid, M. Z. (1997), *Non-excusable Delays in Constructions*, Ph.D. Thesis: Loughbrough University of Technology, UK.