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Journal of Occupational Safety and Health

The Journal

- Aims to serve as a forum for sharing research findings and information across broad areas in occupational safety and health.
- Publishes original research reports, topical article reviews, book reviews, case reports, short communications, invited editorial and letter to editor.
- Welcomes articles in occupational safety and health related fields.

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Contents

Introducing the Journal of Occupational Safety and Health

The National Institute of Occupational Safety and Health (NIOSH), Malaysia is delighted to announce the publication of Journal of Occupational Safety and Health (JOSH).

JOSH is devoted to enhancing the knowledge and practice of occupational safety and health by widely disseminating research articles and applied studies of highest quality.

JOSH provides a solid base to bridge the issues and concerns related to occupational safety and health. JOSH offers scholarly, peer-reviewed articles, including correspondence, regular papers, articles and short reports, announcements and etc.

It is intended that this journal should serve the OSH community, practitioners, students and public while providing vital information for the promotion of workplace health and safety.

Apart from that JOSH aims:

• To promote debate and discussion on practical and theoretical aspects of OSH

• To encourage authors to comment critically on current OSH practices and discuss new concepts and emerging theories in OSH

• To inform OSH practitioners and students of current issues

JOSH is poised to become an essential resource in our efforts to promote and protect the safety and health of workers.

From the Chief Executive Editor

Workplace safety is a priority. There is still more to be done in fostering the safety culture and awareness among us at the workplace. The imperative focus is our commitment to take action; and make the necessary changes to ensure that safety is viewed as the "Top of Mind Awareness" for everyone. NIOSH are engaging with the commitment through an authentic way of dissemination on research and development output by our Journal of Occupational Safety and Health (JOSH).

For this edition, I would like to highlight the article titled "Perception about Drone Application among Safety Officers at Building Construction Sites in Malaysia". A new drone application was proposed as a new inspection tool for a small-scale aerial drone that will give advantages to Environmental, Health and Safety (EHS) practitioners at the construction site. A fundamental research was conducted to study the Perception of Drone Application and Practicality among EHS practitioners at building construction sites in Malaysia. A self-administered questionnaire was distributed to safety practitioners in Malaysia through an online survey using Google form. The relationship between the attitudes of the users towards the drone and the practicality of the drone was analysed using a multivariate statistical method known as Multi Linear Regression (MLR).

There is generally a significantly good attitude of future users towards drone usage in the construction industry and the respondents show a good expectation and this is also supported by previous studies.

It is our hope that the contents of the journal will be referred and reviewed by a wider audience, allowing for a vast academic base, while there should also be an increased cumulative experience to draw on for debate and comment within the journal.

We aspire that the journal will be advantageous to all readers, as our objective is to serve the interest of everyone across all industries. The primary focus will be on issues that are of direct importance to our everyday practices.

I would like to take this opportunity to personally welcome all our readers and contributors to JOSH (Vol 18, No. 1). I am eager to receive more contributions from the Malaysian OSH community for our upcoming issues.

Haji Ayop Salleh
Chief Executive Editor

Original Article

Evaluation of Occupational Health and Safety Management System (OHSMS) Performance and Awareness among the Employees in the Faculty of Engineering, Universiti Putra Malaysia (UPM)

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ABSTRACT: *Managing safety, health and environment in the workplace is very important to prevent any injuries and associated illnesses. However, the implementation of the Occupational Health and Safety Management System (OHSMS) in the educational sector is still inadequate as compared to the industrial sector. Therefore, this study investigates the current implementation of the OHSMS in the educational sector based on the seven key elements derived from the OSHA Program Management Guideline 2015. The Faculty of Engineering, University Putra Malaysia, was selected as a sample of the educational sector in this study. The study was conducted upon reviewing related literature of previous case studies using questionnaires and interviews to determine the awareness level and perception of employees on OHSMS implementation at the faculty. It was discovered that the current OHSMS performance of the faculty against seven key elements is at a satisfactory level but there is room for improvement. Several recommendations were raised based on the seven key elements during the evaluation done on collected data on the faculty. Overall, this study can be used as a new set of findings to improve the OHSMS performance in the education sector complying with the required standards.*

Keywords: *Educational Sector, Occupational Safety and Health Management System (OHSMS), OSHA Program Management Guideline 2015, Recommendations, Seven Key Elements*

1.0 INTRODUCTION

Occupational Health and Safety Management System (OHSMS) is a systematic approach to manage safety and health in the workplace by reducing and preventing work-related accidents. Although there is no specific definition for OHSMS since it has a broad meaning. OSHA Safety and Health Program Management Manual and ILO-OSH (2001) defined the Occupational Health and Safety Management System as “A set of interrelated or interacting elements to establish and implement OSH policy and objectives, and to achieve those objectives.” Meanwhile, the Occupational Health and Safety Assessment Series (OHSAS) 18001 (2007), defines OHSMS as a “part of an organization’s management system used to develop and implement its Occupational Health & Safety policy and manage its Occupational Health & Safety risks.”

The Faculty of Engineering, Universiti Putra Malaysia (UPM) raised the idea of this study and expressed the utmost concern on the current operational level of OHSMS and the employees' awareness within the university. According to Wu et al. (2007), there are various causes of injuries and deaths at universities that involve students, staff, and instructors. Therefore, effective implementation of OHSMS in universities is essential to reduce and prevent occupational accidents that are likely to weaken the university's objectives and in delivering a safer environment for the communities. This study is based on the Malaysian Standard Occupational Safety and Health Management Systems - Requirements MS 1722: 2011, ICS: 13.100, OSHA Safety and Health Program Management Guide and ILO-OSH's key guidelines to ensure that the standard key elements are compliant.

This study relates to the relationship between occupational safety management and firm performance by Fernandez Muniz et al. (2009) in discovering traits and features for implementing the OHSMS in the workplace. These features include the development of Safety Policy in the workplace, incentives for the employees' participation in any kind of health and safety activities, providing training, improving employees' competency and skills, enhancing communication skills at the workplace, planning for all kinds of emergency and also controlling and reviewing all the activities that were carried out within the organization.

In this study, data collected from the OHS Committees Office were measured and analysed based on the seven elements of the OSHA Program Management Guideline (2015). The seven key elements mentioned in the guideline are management, leadership, worker participation, hazard identification and assessment, hazard prevention and control, education and training, program evaluation and improvement, and coordination and communication with multi-employer worksites. Two research instruments were used to obtain reliable findings, questionnaires designed to evaluate the awareness of the employees from the faculty and interview sessions served to assess OHSMS performances.

2.0 METHOD

The details of the methodology and instruments used to assess the performances and awareness among the employees of the Faculty of Engineering, Universiti Putra Malaysia (UPM) is prescribed in this section. Instruments used include OHSMS' performance face-to-face interviews with selected representatives of OSH committees, and OHSMS questionnaires were also distributed to all Faculty employees. The interview and survey questionnaires were designed based on the seven key elements set out in the OSHA Program Management Guideline 2015. Fig. 1 shows the seven major key elements derived from the mentioned guideline.

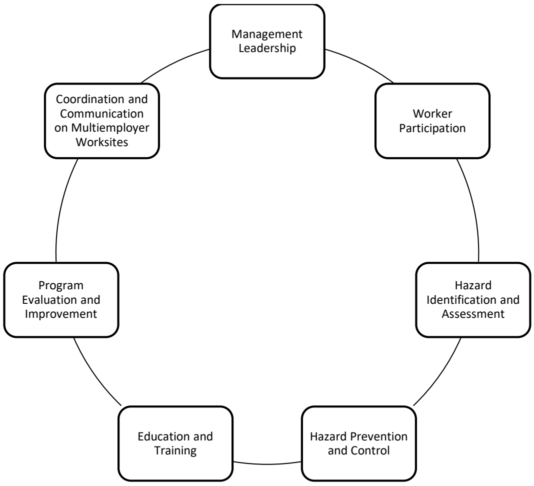

Figure 1 Seven Main Key Elements Derived from OSHA Program Management Guideline 2015

2.1 Questionnaire

The questionnaire was used as the main tool to assess the perception and attitude of employees towards OSH practices within the faculty. There are a total of four sections in the questionnaire and the first section started with the demographics of respondents. This section aimed to gain more insights into the employee's background and related information. The second section was designed to evaluate employees' awareness of OSHMS practices within the engineering faculty. The third section dealt with employees' participation in any activity organized by the OSH committee. The final section of the questionnaires was designed to gain a better understanding of the views and attitudes of employees where these respondents can raise individual recommendations to further improve on OHS practices.

Table 1 Questionnaires for Evaluation of OHSMS' Performance and Awareness among the Employees in the Faculty of Engineering, UPM

Part	Elements	Questions Item
A	Respondent's Information	2
B	Employees' Awareness	4
C	Employees' Participation	2
D	Employees' View and Perception	7

2.2 Interview

The interview is designed for the Faculty of Engineering, UPM OHS management committee. The interviews targeted to learn more about the committees' perceptions, views, knowledge and experiences, especially about the Occupational Health and Safety Management System at the university. Interview questions are designed based on key elements taken from the OSHA Health and Safety Program Management Guidelines 2015. Three interviewees were selected to answer the interview questions due to time constraints. There are six parts with 21 questions developed in the questionnaire, and all participants received the same questions.

3.0 RESULTS AND DISCUSSION

This section discusses the findings on performance and awareness level for Occupational Health and Safety Management System (OHSMS) among the Faculty of Engineering employees at Universiti Putra Malaysia (UPM) based on the distributed questionnaires.

3.1 Demographics

Respondents came from eight engineering departments; chemical, civil, mechanical, electrical, food, computer and aerospace. A total of 70 respondents was involved in the survey. Fig. 2 shows the respondents who participated in the survey. 69.57% of the total respondents are lecturers, 8.7% are assistant engineers and laboratory technicians respectively, 4.7% are engineers and 8.7% are in the “Other” category. The “Other” category refers to the participants representing faculty members, e.g., executive officer, research officer who responded to the survey. Among all respondents, only 13.04% are faculty OSH committees, while 86.96% are ordinary employees.

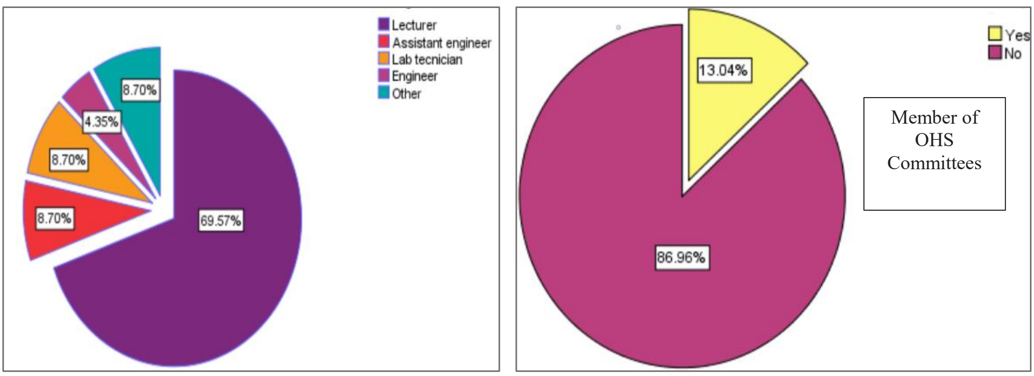

Figure 2 Respondent’s Demographic Information

3.2 Employees' Awareness

The findings for employees' awareness level for OSH-related activities and individual OSH responsibility are presented in Fig. 3. 86.96% of employees who participated in the survey are aware of OSH. Conversely, 13.04% are not aware of any of the OSH activities and individual responsibilities for health and safety at work. The percentage reflects that most faculty, employees were well-informed on safety and health-related programs because the OHS committees constantly disseminate the information to them via email. This encourages employees to actively participate in OSH-related activities.

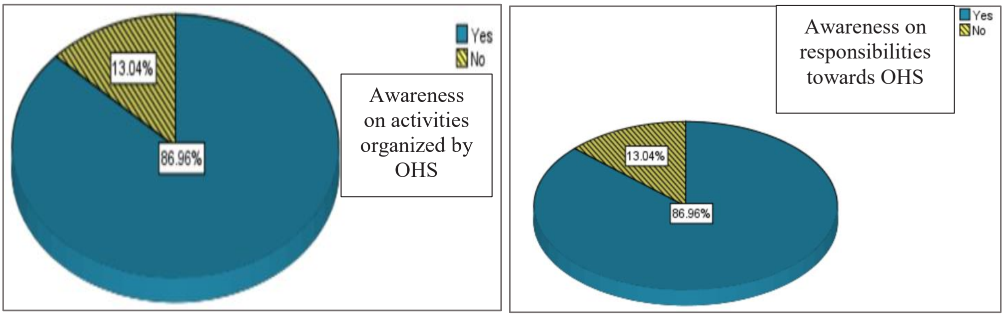

Figure 3 Awareness of the Employees on Activities Organized by OHS Committees and Responsibilities towards OHS

Employees were evaluated on the awareness of hazards in their workplace. Based on Fig. 4, 95.65% of the employees were fully aware of the hazards in their workplace and 4.35% were unaware of the hazards, this is probably due to the fewest hazards encountered in the respective area. Fig. 5 displays the type of common hazards encountered in the faculty, for example, a falling object, slippery ground, contact with chemicals, burns, falls from height, machine hazard, electric shock, injury from moving parts and other hazards such as collapsing ceiling.

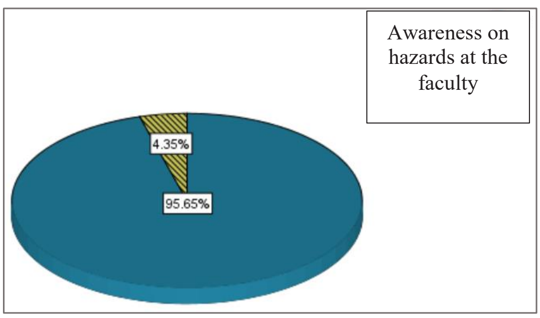

Figure 4 Awareness of the Employees on Hazards Encountered at the Faculty of Engineering, UPM

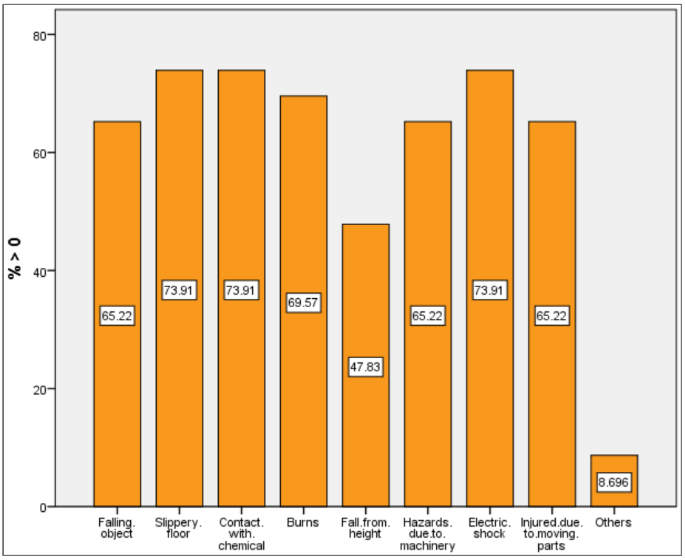

Figure 5 Type of Common Hazards Acknowledged by the Employees in the Faculty of Engineering, UPM

73.91% of the total survey respondents selected slippery floors, contact with chemicals and electric shock as the most common hazards in the faculty. 69.57% voted for Burns and 65.22% voted for falling objects and moving parts injury, both are considered common hazards. In contrast, falls from height and other types of hazards scored the least percentage with 47.83% and 8.696%, respectively. This is because most of the activities in the department are carried out in the laboratory.

3.3 Employees' Participation

The employees' participation in any activity organized by the OHS committees of the faculty was evaluated in the survey. According to Fig. 6, 65.2% of the employees attended the seminar and training related to safety, such as Fire Safety Seminar, Electrical Safety Seminar and Safety and Stress Management Seminar the most preferred among other activities. The second-highest employee participation by 43.5% comes from two main activities: job hazard analysis and employees that contribute to the development of safe work procedures and guidelines. While 30.4% of the respondents assist with accident investigation and 26.1% participated in the safety inspection at the faculty. Only 8.7% of the respondents have the least participation in the development and implementation of the OHS program.

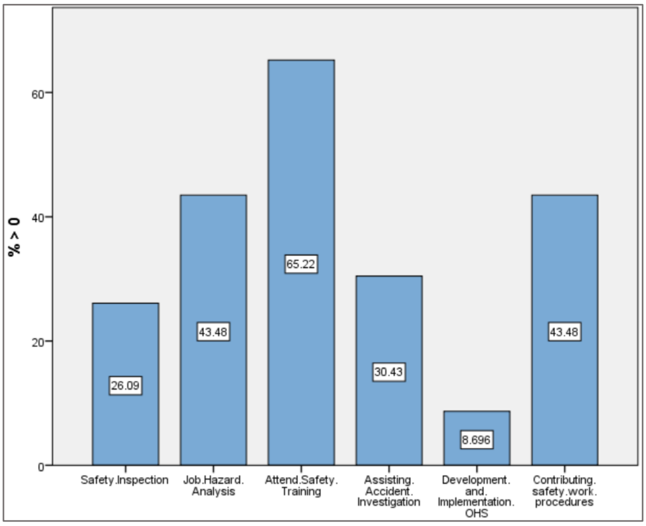

Figure 6 Participation of Employees in OHS Activities in the Faculty of Engineering, UPM

3.4 Employees' Views and Perceptions

3.4.1 Employees' Understanding of UPM OHS Policy

Table 2 summarizes the employees' level of understanding of UPM's OSH policy as part of the survey. Based on the OSH policy, respondents acknowledge that the management shall be responsible for protecting the safety and health of workers in the workplace and it is mandatory to comply with safety standards. 82.6% of the respondent agreed with these statements. Concerning the other two aspects of workers' safety and health issues which is one of the main priorities and the responsibility of management to provide the necessary safety training and supervision, both these two have the same and a lower percentage of 69.6%.

Table 2 Employees' Understanding of UPM OHS Policy

	Aspect of OHS Policy	Percentage
i	Management is responsible for protecting worker's safety and health at the workplace	82.6%
ii	Comply with the standard safety regulations	82.6%
iii	Safety and health issues of the workers are the top priority	69.6%
iv	Management provides necessary safety training and supervision	69.6%

The employees' levels of understanding are highly dependent on the policy. However, the percentage for the aspect of taking "Safety and health issues of the workers is the top priority" was considered low. This is probably related to the OHS Policy content, which is not directly applicable in this case. There might be other factors that limit the employees' level of understanding for example communication barrier that provoked the management to deliver a clear policy content. According to International Labor Organization-OSHA (2001), the OHS Policy should be communicated to all people in the workplace. It shall convey the key principles of protecting the safety and health of all members at the workplace by preventing any kind of work-related injuries and illness.

3.4.2 Employees' Perception of OHS Responsibilities

Table 3 illustrates the findings on the respondent's perception towards the management of OSH responsibilities. 82.6 %, of the respondents presumed that both the employer and employees shall be responsible for Safe Management Measures at the workplace, while 17.4 % perceived that only the employer shall be fully responsible for managing employees' safety and health at the workplace.

Table 3 Perception of OHS Managing Responsibilities

OHS Managing Responsibilities	Percentage
Both Employer and Employees	82.6%
Employer	17.4%

According to Malaysian Standard on Occupational Health and Safety Management System (2011) and International Labour Organization: OSH (2001), the responsibilities of OHS primarily fall under the employer, but the employees should also understand the individual roles in managing safety and health at the workplace and comply with the safe work procedures. Furthermore, the employer should prioritize the worker's safety through regular monitoring so that undesirable events can be prevented.

4.0 CONCLUSION

This study aims to evaluate employees' performance and perceptions towards OHSMS implementation at the Faculty of Engineering, UPM. Overall, the OHS management system's performance in the faculty has achieved a satisfying level, yet not fully complied with the seven key elements derived from the OSHA Program Management Guideline 2015. The OHS committees should be fully aware of this situation and appropriate measures shall be applied to ensure the OHSMS implementation in the faculty is on the right track and well-conducted based on the standard key elements, especially in terms of hazard identification and control aspect.

In summary, the level of awareness among employees on the OHSMS in the faculty is acceptable based on the evaluation and findings gathered from the questionnaire. All the employees (the respondents) shall be aware of the OHSMS function, but OHS policy needs to be kept or placed in a safe corner at the faculty. This is to ensure the awareness level of the safety policy could be increased among the employees as well as the students.

The implementation of the OHSMS in the education sector could be improved through developing a specific design cater for universities that differs from the industries. The adoption of OSHMS alone will be insufficient as if there is no continual improvement to ensure that the system is fully capable to enhance safety and health in the workplace. Beyond that, UPM has taken initiatives to enhance the OSH management system at the Faculty of Engineering and the university also serves as a starting point to strengthen OHSMS performance in the education sector in Malaysia, adhering to the required standard.

ACKNOWLEDGEMENT

Special thanks are owed to all the participants who made this project possible, especially the employees at the Faculty of Engineering, Universiti Putra Malaysia (UPM), Malaysia.

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Original Article

A Study on Respirable Dust and Crystalline Silica among Construction Workers

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ABSTRACT: *This study aims to determine the Respirable Dust (RD) and Respirable Crystalline Silica (RCS) exposure level for different activities at construction sites. The samples were collected throughout the 8H TWA working day, inclusive 36 personal activities, periodic samples for mixing, cutting and plastering and compliance status among workers in construction sites. Samples were retrieved from the Klang Valley area (Kuala Lumpur and Selangor). In this research, the NIOSH Manual of Analytical Methods (NMAM) 0600 had been used for RD and NMAM 7500 for Respirable Crystalline Silica analysis (RCS-quartz). A quick survey on silica dust monitoring and Personal Protective Equipment (PPE) was done concurrently during data collection. The results indicated around 39.5 % of workers in mixing activity were slightly exposed to RCS-quartz level above the Permissible Exposure Limit (PEL) based on Occupational Safety and Health (Use and Standard of Exposure to Chemical Hazardous to Health) Regulations 2000 (USECHH Regulations). Activity with the highest exposure were mixing, followed by plastering and the lowest was cutting activity.*

Keywords: *Gravimetric Analysis, Respirable Crystalline Silica-Quartz, Respirable Dust, X-ray Diffraction (XRD)*

1.0 INTRODUCTION

Silica is a mineral compound that is composed of one silicon atom and two oxygen atoms (SiO2) (ACGIH, 2001). Silica exists in several forms, whereby the most common form is crystalline silica, which makes up to 12% of the earth's crust (NIOSH, 2002). The three major forms of crystalline silica are quartz, cristobalite and tridymite. Quartz is the most common form of silica, and it is reasonable to use quartz as the standard because the other forms of silica are usually not present with a significant amount in industrial hygiene samples (Ashley & O'Connor, 2016). This natural substance can be found in rocks, sand, clay and products such as bricks and concrete. Silica was reported as a Group 1 carcinogenic compound by the International Agency for Research on Cancer (IARC, 2008).

Silica dust particles are small enough to penetrate deeply into the lungs when breathed in and are known as Respirable Crystalline Silica (RCS). RCS dust particles are too small to be seen under normal lighting. RCS particle size range of 10 µm or less is harmful to health because particles inhaled are penetrated deeply into the lungs (IARC, 1997). RCS will trap forever in the lung, and its deposition will trigger a chronic inflammatory response and be replaced with scar tissue (fibrosis). The scar will decrease the percentage of oxygen gas exchange known as silicosis disease, and when exposed to a large amount, it will increase the risk of lung cancer in humans (Sato, Shimosato & Klinman, 2018). As crystalline silica has been used in many industries such as cement manufacturing, glass and concrete mixing product manufacturer, sandblasting, ceramic, clay and many construction activities, silica dust is considered an inhalation risk (Omidianidost et al., 2016). Especially the work processes in the construction industry such as cutting, sanding, grinding, blasting or polishing materials is highly exposed and can generate RCS easily.

Malaysia has a lack of information on crystalline silica exposure. This study aims to determine exposure levels of dust and RCS for different activities at the construction site. Furthermore, the difficulty of implementing a control system in the workplace due to constant change of construction activities and work location makes it crucial for this study to determine eligibility and compliance status among exposed workers in construction sites.

The experiment in this study had been carried out based on NMAM 7500 using XRD's machine. It was a versatile and non-destructive analytical technique that reveals detailed structural and chemical information about the crystallography of materials. XRD looks at a crystalline material's characteristic X-ray scattering, or diffraction pattern, which reveals the material's atomic structure. Activities among construction workers were selected in this study, including mixing, plastering and cutting tiles.

2.0 METHOD

2.1 Total Respirable Dust

The respirable dust analysis was measured by using the NIOSH Manual of Analytical Methods (NMAM) 0600. The filters were weighed before and after sampling on a Mettler Microbalance (XP26; Mettler-Toledo, Greifensee, Switzerland) to collect dust weight. Filters with the holders were stored in an environmentally controlled area (20 ± 1 0C and 50 ± 5% relative humidity) for at least 2 hours for stabilization before tare and weighing the post – weight. (2) 3 readings of the pre-weight and post-weight were performed. The difference between the averages of pre-weight and post-weight was the result of the analysis of respirable dust.

2.2 Crystalline Silica-Quartz Measurement (XRD)

NMAM 7500 were used to determine Respirable Crystalline Silica (RCS) exposure, (NIOSH, 2003). The filters were treated and analysed using XRD (Rigaku, Multiflek, Tokyo, Japan) to obtain the RCS-quartz values (NIOSH, 2003). The filters were digested with hydrochloric acid and then ashes in a muffle furnace at 600°C for 2 hours. The ash was then dissolved in 15ml 2-propanol and then filtered on 25mm silver membranes to make them compatible with the 25mm X-ray diffraction auto sampler. Analytical procedures were subjected to quality assurance requirement under MS ISO17025 accreditation program.

2.3 Statistical Analysis

American Industrial Hygiene Association (AIHA) suggested collected data shall be analysed by using IHSTAT - Statistical Analysis of Health & Safety Data.

3.0 RESULTS

3.1 Demographic Data among Constructions Sites Workers

The epidemiological characteristics of the subjects studied are presented in Table 1. The majority of workers were male compared to female and the age range was between 20 and 40 years old. The PPE compliance survey reflected 83.3% of workers wearing a safety helmet and 69.4% wearing safety shoes during working hours. Perhaps surprisingly, only 16.7% of workers did not wear the appropriate mask (surgical mask) and 5.6% wore a glove with the lowest PPE compliance.

Table 1 Demographic Data of Construction Sites Workers

No.	Sample Id	Gender	Work Area	PPE Compliances			
				Safety Helmet	Safety Shoes	Dust Mask	Glove
1	Mixing 1	M	Mixing	/	/	/	No
2	Mixing 2	M	Mixing	/	No	Surgical Mask	No
3	Mixing 3	M	Mixing	/	/	Surgical Mask	No
4	Mixing 4	F	Mixing	/	/	Surgical Mask	/
5	Mixing 5	F	Mixing	/	/	No	No
6	Mixing 6	F	Mixing	/	/	No	No
7	Plastering 1	M	Plastering	/	No	No	No
8	Plastering 2	M	Plastering	/	No	No	No
9	Mixing 7	M	Mixing	No	/	Surgical Mask	/
10	Cutting 1	M	Cutting	/	No	No	No
11	Plastering 3	M	Plastering	/	/	No	No
12	Plastering 4	M	Plastering	/	No	Surgical Mask	No
13	Plastering 5	M	Plastering	/	/	No	No
14	Plastering 6	M	Plastering	/	/	No	No
15	Plastering 7	M	Plastering	/	/	No	No
16	Cutting 2	M	Cutting	/	/	No	No
17	Cutting 3	M	Cutting	/	/	No	No
18	Mixing 8	F	Mixing	/	/	No	No
19	Mixing 9	F	Mixing	/	/	No	No
20	Plastering 8	M	Plastering	/	No	No	No
21	Plastering 9	M	Plastering	/	No	No	No
22	Mixing 10	M	Mixing	/	/	No	No
23	Mixing 11	M	Mixing	/	/	No	No
24	Cutting 4	M	Cutting	No	No	No	No
25	Cutting 5	M	Cutting	/	No	No	No
26	Plastering 10	M	Plastering	/	/	No	No
27	Plastering 11	M	Plastering	/	/	No	No
28	Plastering 12	M	Plastering	/	/	No	No
29	Plastering 13	M	Plastering	No	/	No	No
30	Plastering 14	M	Plastering	/	/	No	No
31	Plastering 15	F	Plastering	No	/	No	No
32	Mixing 12	M	Mixing	/	/	No	No
33	Mixing 13	M	Mixing	/	/	No	No
34	Cutting 6	M	Cutting	No	No	No	No
35	Cutting 7	M	Cutting	No	No	No	No
36	Cutting 8	M	Cutting	/	/	No	No

M = Male, F = Female, PPE = Personal Protective Equipment

3.2 Respirable Dust Exposure Level

The overall results indicated that the exposure levels of respirable dust in all activities were ranged between 0.060-2.419 mg/m3 which is below the Permissible Exposure Limit (PEL) 3.0 mg/m3 as stated in the Occupational Safety and Health (Use and Standard of Exposure Chemical Hazardous to Health) Regulations 2000 (USECHH Regulations). The top range was mixing activity with a minimum of 0.102 and a maximum of 2.419 (Table 2). The higher Arithmetic Means (AM) is shown in the mixing activity at value 0.641 mg/m3 followed by cutting at value 0.471 mg/m3. Meanwhile, the plastering activity was recorded with the lowest AM with a value of 0.306 mg/m3. This study also shows that the mixing activity is ranked as the highest occupational exposure on respirable dust, where the geometric mean GM value is 0.411 mg/m3 (2.696 mg/m3) followed by cutting activities at 0.361 mg/m3 and plastering at 0.249 mg/m3. Detailed results for respirable dust personal exposure of activity are indicated in Table 2.

Table 2 Respirable Dust Personal Exposure by Activity

Activity	N	Range (mg/m^3)		AM	GM	GSD	% ≥ OEL
		Min	Max				
Plastering	14	0.060	0.821	0.306	0.249	1.951	0.000
Mixing	14	0.102	2.419	0.641	0.411	2.696	0.056
Cutting	8	0.101	1.159	0.471	0.361	2.240	0.000

AM: Arithmetic Mean; GM: Geometric Mean; SD: Standard Deviation; GSD: Geometric Standard Deviation

3.3 Respirable Crystalline Silica-Quartz Exposure Level

The finding has shown that the range of silica exposure levels reported was between 0.004 to 0.237 mg/m3. The highest range appears to be mixing activity with a minimum of 0.005 and a maximum of 2.419 (Table 3). The highest AM was reported by mixing activity at the mean value of 0.084mg/m3, followed by plastering at 0.030 mg/m3 and cutting at 0.029 mg/m3. All of these AM values were slightly below PEL 0.1mg/m3. The highest occupational exposure activity to silica was indicated by the mixing activity where the GM value at 0.040 mg/m3 was followed by the cutting activity at 0.026 mg/m3 and the plastering activity with the value 0.016 mg/m3. From Table 3, presuming a similar approach is practised at a different time interval, we may conclude that 39.5% of workers from mixing activity were more likely to be exposed to silica and exceeding the PEL.

Table 3 Respirable Crystalline Silica - Quartz Personal Exposure by Activity

Activity	N	Range (mg/m³)		AM	GM	GSD	% ≥ OEL
		Min	Max				
Plastering	14	0.004	0.126	0.030	0.016	3.338	4.907
Mixing	14	0.005	0.237	0.084	0.040	3.667	39.483
Cutting	8	0.011	0.037	0.029	0.026	1.580	0.000

3.4 Compliance Status on RD and RCS-Quartz by Activity

Table 2 and Table 3 show descriptive and inferential statistics on 8H TWA personal exposure to respirable dust and RCS-quartz among workers at construction sites. In summary, AM and GM for respirable dust were not significant and far below 3.0 mg/m3 Malaysia's PEL, but for RCS-quartz, the exposure levels were significant as mixing and plastering reporting a results above the PEL (0.1 mg/m3).

By referring to Fig. 1 through Fig. 4, the respirable dust and RCS-quartz exposure level were compared among construction workers and plotted against the log probability, least squares best-fit line and log-normal distribution. In this study, the percentage of Occupational Exposure Limit (OEL) for respirable dust was not significant because only 0.056% of the exposure were likely. With an AM value of 0.641 mg/m3, the amount is much lower compared to 3.0 mg/m3 PEL (Fig. 2). However, the study also shows that approximately 39.483% (Fig. 3) were exposed to an RCS-quartz exposure level of 0.084 mg/m3, which is slightly lower than the PEL of RCS-quartz at 0.1 mg/m3 (Fig.4).

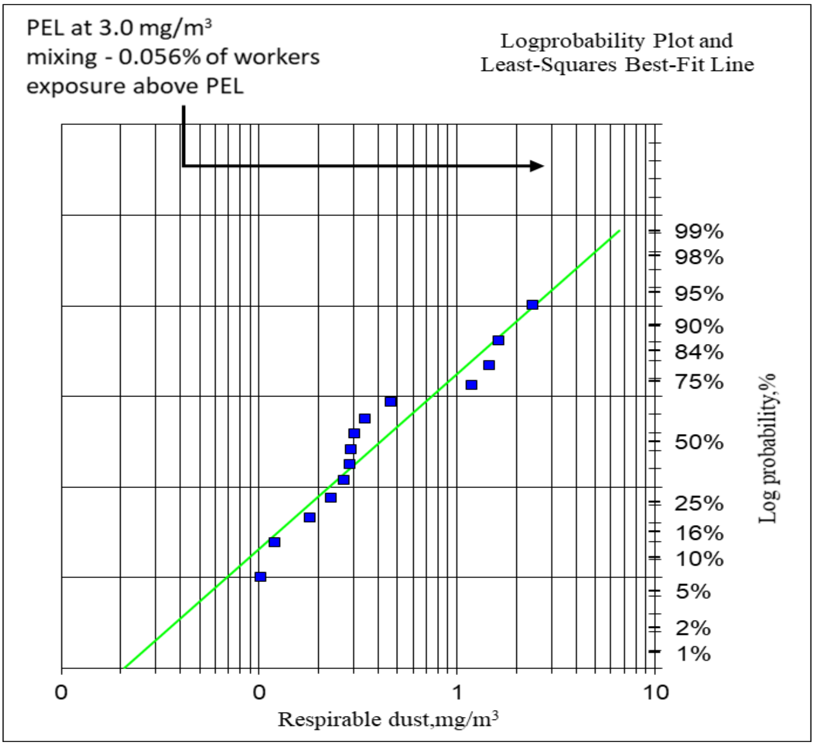

Figure 1 Graph Log Normal Probability Plot and Least-Squares Best-Fit Line for Respirable Dust Exposure Level. PEL by Malaysia USECHH Regulations 2000 is at 3.0 mg/m^3 for Respirable Dust.

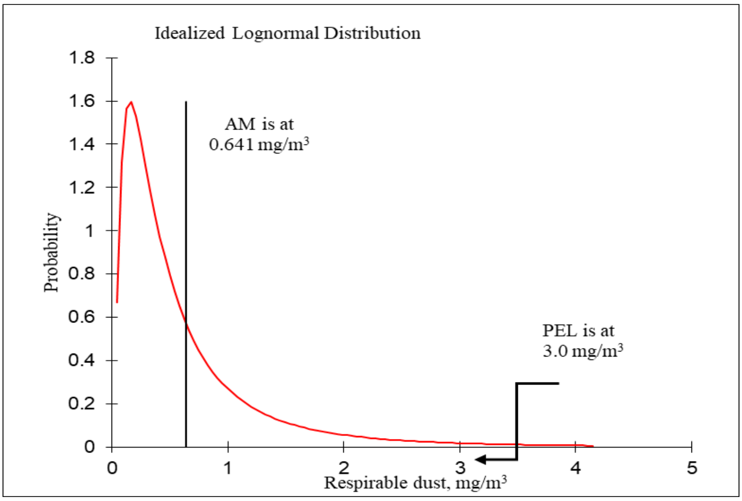

Figure 2 Log Normal Distribution for Respirable Dust Exposure, AM; Estimated Arithmetic Mean. PEL by Malaysia USECHH Regulations 2000 is at 3.0 mg/m^3 for Respirable Dust.

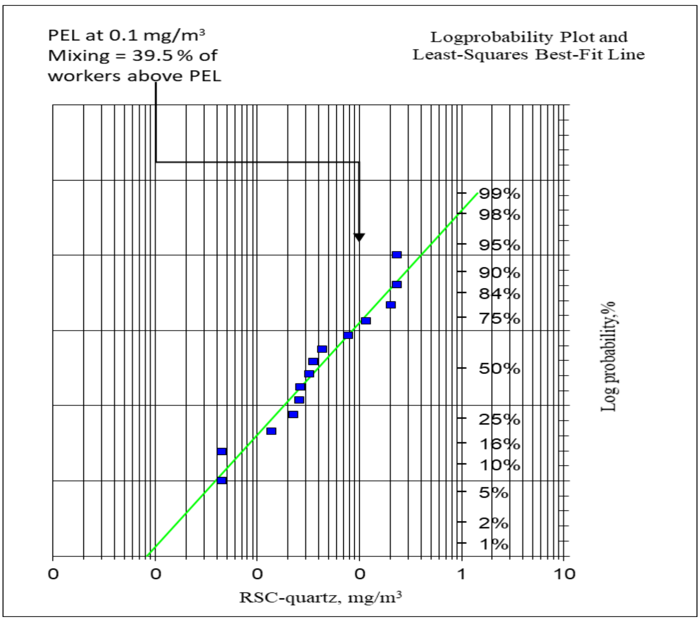

Figure 3 Log Normal Probability Plot and Least-Squares Best-Fit Line for RCS-Quartz Exposure. PEL by Malaysia USECHH Regulations 2000 is at 0.1 mg/m^3 for RSC-Quartz.

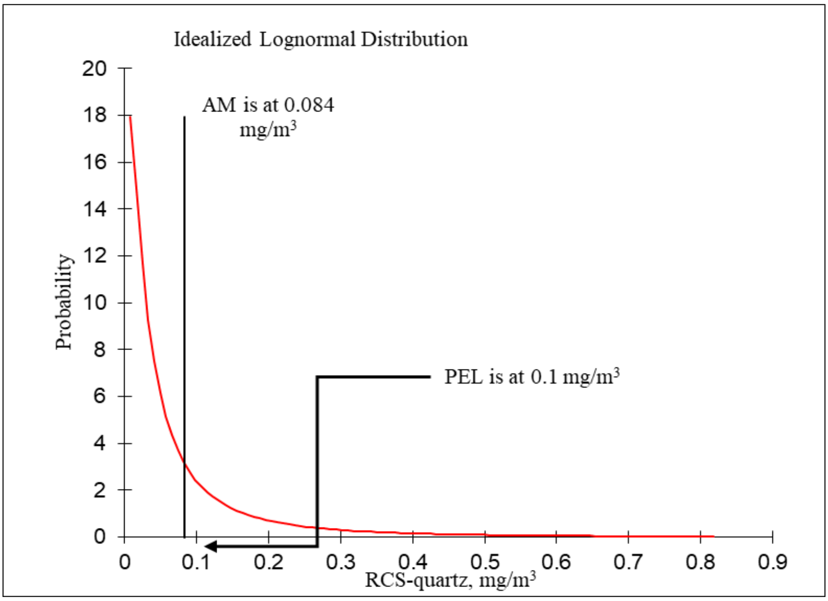

Figure 4 Log Normal Distribution for RCS-Quartz Exposure, AM; Estimated Arithmetic Mean. PEL by Malaysia USECHH Regulations 2000 is at 0.1 mg/m³ for RSC-Quartz.

4.0 DISCUSSION

The samples in this study were collected at construction sites. The samples for dust and silicon-quartz exposure of this group have not been thoroughly investigated in our country. The sampling was done at two construction sites in the Klang Valley area as these areas were developed by many construction projects. Then, the samples were selected among the three most common activities including mixing, plastering and tiles cutting. As reported, the exposure of silica may cause silicosis with increasing cumulative exposure with duration of exposure (odds ratio = 1.37; 95% confidence interval = 1.14 –1.65) (Cassidy et al., 2007). Therefore, researchers are interested in knowing more about the silica exposure level among Malaysian construction workers.

The highest exposure to respirable dust was identified from the mixing activity (0.641 mg/m3). However, there are no significant dust concentrations discovered above the OEL. This is probably because the activity was performed in an open area thus many movements involved could potentially manipulate the materials that produce dust with and without silica.

Even so, this study shows cutting activity with the second-highest dust exposure for the arithmetic mean and geometric mean, but it was not significant. Similar to the high cutting activity results shown by Yassin et al. (2005) from his data on OSHA, Integrated Management Information System. Among the eight industries, the highest GM value comes from cutting stone and stone products (0.091 mg/m3) compared to other activities such as concrete cutting work (0.073 mg/m3), bridge, tunnel construction (0.070 mg/m3) and stone masonry (0.065 mg/m3). Our data should support more evidence in representing a similar exposure pattern in workers.

In this study, plastering work shows the lowest dust concentration (0.306 mg/m3) compared to mixing (0.641 mg/m3) and cutting (0.471 mg/m3) activities. It was noted that the plasterer uses a water jet pump, which could be the main reason for less exposure of dust throughout the plastering activity. The level of exposure to dust can vary and influence of many factors depending on job duties, type of material, equipment and tools used, environmental conditions and skill level of the workforce.

For RCS-quartz, mixing activity (0.084 mg/m3) has the highest exposure level with 39.08% of this group exposed above the OEL. Yassin et al (2005) stated that 4.8 % of workers are likely to be exposed to silica in plastering work, which is very close to these findings (4.907%).

In this study, the lowest exposure of the silica level was recorded by the cutting activity with the AM value of 0.029 mg/m3, but the percentage of exposure is insignificant (0.000%) due to the small sample size. This result contradicts Mohamed SH, et al. (2018) results which indicate a max, mean silica% found in stone cutting at 48.65%.

Although the findings show a low level of exposure to respirable dust and silica (below PEL), the awareness of construction workers wear PPE for protection was still very low. A surgical mask is available for the workers, but as observed only a few workers were using it. For this activity, respiratory protection must be worn and N95 is suitable for reducing exposures or below the occupational exposure limit, especially for the mixing activity. During the work process, mixing activities will produce large amounts of dust containing silica and these exposures can potentially exceed the occupational exposure limits.

5.0 CONCLUSION

Approximately 39.5% of workers in the mixing operation were overexposed to RCS-Quartz above the PEL. OSHA regulatory efforts are needed to further increase industry compliance with occupational exposure limits by enforcing effective engineering controls and to protect workers from overexposure to crystalline silica. Therefore, it is highly recommended that engineering controls should be in place to prevent the recurrence of high silica exposure. For example, in tiles cutting activity, wet cutting is the most effective method for controlling silica dust generated during the cutting process because when the dust is wet, it is less able to become or remain airborne. In addition, other controls must take into consideration, change in work practices (e.g. implementing worker rotation programs for mixing activity) and issues related to Personal Protective Equipment (PPE).

Appropriate respiratory protection should be used when source controls failed to keep exposures below occupational exposure limits. Workers exposed to Silica should participate in a medical surveillance program and undergo periodic respiratory health evaluations.

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Original Article

Development of Normative Data for Grip Strength between Genders of Malaysian Working-Age Population: Preliminary Study

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ABSTRACT: *An increasing number of Musculoskeletal Disorders (MSDs) cases in Malaysia affect work task efficiency. There are many guidelines on the control and prevention of MSDs issues. In this study, the researcher encourages MSDs prevention at an early stage by designing tools or products that ergonomically fit the user to create a comfortable and productive workplace while preventing discomfort. Therefore, this study aims to establish normative data of handgrip strength and pinch grip strength for Malaysian working-age group in both genders. The data is practical to be applied by all designers in developing tools that healthy and ergonomic. For the method, the Baseline Digital Smedley Dynamometer is used to analyze handgrip strength. Baseline Hydraulic Pinch Gauge follows the lateral pinch type method to analyze the pinch grip strength. The result shows that males are significantly stronger than females. Analysis across the age groups found that mean score of female handgrip are equivalent of lower than the lowest 5th percentile value of male handgrip. this study also found that male are at their strongest across the age group, the 5th percentile value of males is greater than the mean score of female handgrip strength, male at their strongest in their thirties while females are strongest at their age below 20 years old. Normative data of grip strength is established in this study.*

Keywords: *Anthropometry, Design, Ergonomics, Gender, Grip Strength, Musculoskeletal Disorder*

1.0 INTRODUCTION

Poor workstation or equipment design may cause musculoskeletal disorders (MSDs) in the area of shoulder, neck, nape, hand, and waist (Kalınkara et al., 2012). According to the Social Security Organization of Malaysia (SOCSO), MSDs cases have increased steadily over the year with 268 cases in 2011, 449 cases in 2012, 517 cases in 2013, and increased to 675 cases year 2011 (Hassan et al., 2015). MSDs are classified into six groups, including 1. Nerve Entrapment Disorders, 2.Occupational Disorders of the Neck and Brachial Plexus, 3.Shoulder disorders, 4.Tendonitis of the Elbow, Forearm, and Wrist, 5.Hand-Arm Vibration Syndrome and 6.Low Back Disorders (Anghel & Lungeanu, 2007). The upper limb was the major part of the body affected primarily involving the hand, wrist, fingers, and shoulder, such as Carpal Tunnel Syndrome (CTS), which has become common work-related injuries to MSDs (Tamrin & Zakaria, 2016). Many of these problems contribute to poor ergonomics. Ergonomics is the science of designing work tasks to fit the worker while considering the human body's capabilities and limitations

(Moriguchi et al., 2013). It is related to the worker's interaction with tools, equipment, environment, jobs, tasks, work methods, work rates and other systems (Bridger et al., 2018; Moriguchi et al., 2013; Bridger, 2009).

The increasing number of MSDs in Malaysia alerted the Department of Occupational Safety and Health (DOSH) and local universities to focus more on MSDs risks (Anwar et al., 2019; SOCSO, 2018). However, many companies still have not considered ergonomics a critical issue (Sirat et al., 2011). Although DOSH has provided some solutions to control hazards, the guidelines were based on industry or task-specific solutions (Sirat et al., 2011), which is not enough to prevent the MSDs issues among workers. Therefore, it is essential to study MSDs risk factors and prevention methods, especially for Malaysians. As suggested by the Occupational Safety and Health Administration (OSHA) ergonomic guideline, a load's weight should be reduced to limit the force exertion to reduce injury chances. Therefore, the tools should be redesigned to fit the workers' ability and encourage a neutral posture to prevent MSDs.

Anthropometry is the science of obtaining systematic measurements of the human body. Ergonomic problems related to fitting the work task or tool to the users can be solved by including the anthropometry element at the design stage to reduce the ergonomic risk factors to the user. Strenuous movements or awkward postures at workplaces are mostly due to incompatible anthropometric data and workstation design (Deros et al., 2011; Seri et al., 2013). Recently in Malaysia, anthropometric studies have become the most significant discussion among ergonomists, anthropometrists, and researchers (Nurul Shahida et al., 2015; Hassan et al., 2015; Hashim & Dawal, 2012; Karmegam et al., 2011; Deros et al., 2011 and Rosnah et al., 2006). Karmegam et al. (2015) conducted a study on anthropometry among adults of different ethnicities in Malaysia. They measured 33 anthropometrical dimensions on 300 respondents for both males and females. They also suggested that designers consider ethnicity when designing for the Malaysian population (Karmegam et al., 2011). Hassan et al. in 2015 developed an anthropometric database for Malaysian workers. They took 23 static anthropometric dimensions of 1134 Malaysian workers and suggested that designers use the database for guidelines in designing for a safer and healthier workplace for Malaysian workers.

Previous studies had included grip strength as one of the anthropometric dimensions (Nikolaos, 2015; Taha and Nazaruddin, 2005). The grip strength data can help the designer to design tools or equipment that will fit the workers. The tools developed by the designer must apply optimum force based on the normative data of the grip strength to prevent overuse injuries. The principle of prevention through design may reduce the risk of MSDs, especially among workers. Taha & Nazaruddin (2005) developed models using an artificial neural network to predict Malaysian industrial workers' grip strength. Their study found that grip strength data is useful to the designer and can be used by the physician to measure the normal grip strength. In 2009, Werle and colleagues conducted a study in an average Swiss population aged 18 to 96 to obtain normative data of grip and pinch strength. They stated that the data could be used for hand assessment parameters to evaluate the hand's functional integrity, determine the effectiveness of different treatment strategies in traumatic hand diseases, and hand strength assessment (Werle et al., 2009). Some studies have endorsed handgrip strength as a tool to measure whole-body strength (Nikolaos, 2015; Taha and Nazaruddin, 2005). Some also used grip strength as a benchmark to evaluate muscle weaknesses.

McCaffrey and LeFebvre (1999) published a protocol on Dynamometer (Grip) and Pinch Gauge use. In the protocol, selected indicators for grip dynamometer include grip weakness and MSDs. Some pinch gauge indicators include suspected weakness of the thumb or fingers and Basilar arthritis of the thumb and ulnar nerve palsy (McCaffrey & LeFebvre, 1999). Anthropometry also considered humans' human mass properties and strength capabilities (Wilson & Desai, 2017). Thus, static strength such as grip strength should be considered essential data to solve the ergonomic issues. Massy-Westropp et al. (2011) conducted a longitudinal cohort study of the Australian population aged 18 and above. Their study aimed to describe normative data for the handgrip. The Australian population showed a lower grip strength in younger participants compared to international hand grip strength norms from the study. The study also reported that the age and gender grip strength values are lower in younger adults than those reported in the international literature (Massy-westropp et al., 2011). It can be concluded that different populations have their normative data for grip strength, and the data also different based on gender and age.

Therefore, this study aims to establish normative data of handgrip strength and pinch grip strength between genders for the Malaysian working-age population. The data might be useful for industrial designers where the MSDs preventions can be done at the design stage. Besides, the data can also be used for the physician for rehabilitation purposes, set realistic treatment goals, and assess the patient's ability to return to work (Gallagher et al., 2000). The previous studies showed that handgrip tests and pinch grip tests are often used to evaluate the hand's physical ability and detect MSDs especially CTS (Maranhao Neto et al., 2017; Dale et al.; Sung et al., 2014). In their study, Dale et al. (2014) found that male and female new workers in high and low intensive handwork have low baseline hand strength compared to normative data of Caucasian adults (Lam et al., 2016). There is no documentation on normative data for grip strength on the Malaysian working age in Malaysia yet. Thus, this preliminary study is significant for ergonomic study in Malaysia.

2.0 METHOD

2.1 Sample Selection

Respondents were voluntarily recruited from all over Malaysia between June 2018 and June 2020. The respondents were given a short briefing before starting the measurements regarding the study's objectives and the measurements. The respondents then fills up the consent form and the demographic data needed for the study. Malaysian with a working-age range between 18 to 69 years old were included in this study. On the day of measurement, respondents must have a healthy body. Respondents were excluded from the study if they are foreigners, out of age range, unhealthy and pregnant. All the respondents were included in this study because had declared that they had no acute pain in their arms, back, and hands, at least six months' post-hospitalization, and can continue to carry on a normal lifestyle without restriction in their activity because of health problem.

2.2 Procedure

2.2.1 Handgrip Strength Test

The Baseline Digital Smedley Dynamometer was used to measure Handgrip strength (Mathiowetz et al., 1985). The handgrip strength test procedure was adapted from the Duke Center for the Study of Aging study (2017). The respondents hold the dynamometer in one hand, standing in an erect position while the same arm extended along the body. The equipment's grip will be adjusted accordingly to ensure that the respondents exerted force by only the last four phalanges to the handle. The respondents perform a maximal strength three times (Dale et al., 2014; Nilsen et al., 2012) for both right and left hand. Both dominant hand and non-dominant hand data will be taken into account for the analysis. The highest strength was recorded.

Figure 1 Respondent Gripping the Baseline Digital Smedley Dynamometer during Hand Grip Strength Test

2.2.2 Pinch Grip Strength Test

For the pinch grip tests, the Baseline Hydraulic Pinch Gauge-Standard-50 lbs (22.6796 kg) Capacity was used using the lateral pinch type to obtain the measurement (Kong et al., 2014). As shown in Fig. 2, the respondents hold the pinch gauge with the thumb, and the index finger's lateral side come into contact. During the test, the researcher would hold the dynamometer's levers so that the respondents's forearm and hand are parallel to the ground (Kong et al., 2014). The test was conducted for both right and left hand for three trials (Dale et al., 2014; Nilsen et al., 2012). Similar to the handgrip strength test, both dominant hand and non-dominant hand data will be taken into account for the analysis. The measurement unit was in kilograms (kg). The highest strength was recorded.

Figure 2 Respondents during Pinch Grip Strength Testing Using Baseline Pinch Gauge Hydraulic Standard 50 lbs

2.2.3 Statistical Test

Independent t-tests were used to determine the statistical differences for weight, height, handgrip strength, and pinch grip strength between male and female respondents. Means and standard deviations were calculated to establish the central tendency and dispersion of all the variables. The 5th and 95th percentile values of the handgrip and pinch grip strength tests were also presented. The study's significance level was set at $\alpha < 0.02$ (Cochran & Wiley, 2017).

3.0 RESULTS

The independent t-tests for age, height, weight, age group, and grip strength for all respondents are shown in Table 1. Height, weight, handgrip strength, and pinch strength were summarized in mean, standard deviation (SD), fif^{th,} and 95th percentile values. A normality test was performed for the data distribution.

Table 1 Normality Test for All Variables

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Gender	0.366	1485	0.000	.633	1485	0.000
Age Group	0.186	1485	0.000	.924	1485	0.000
1. Hand grip Dominant	0.070	1485	0.000	.983	1485	0.000
2. Hand grip Non-dominant	0.073	1485	0.000	.753	1485	0.000
3. Pinch grip Dominant	0.096	1485	0.000	.975	1485	0.000
4. Pinch grip Non-dominant	0.091	1485	0.000	.972	1485	0.000

Table 1 shows the normality test for all variables. From the data, all the variables show significant differences between genders, age groups, and grip strength, which indicates the data was not normally distributed.

Table 2 Statistical Analysis for Hand Grip Strength and Pinch Grip Between Genders and Age Groups

	Gender *P* -value ($p < 0.02$)	Age Group *P* -value ($p < 0.02$)
Hand grip Dominant	0.000	0.000
Hand grip Non-dominant	0.000	0.001
Pinch grip Dominant	0.000	0.000
Pinch grip Non-dominant	0.000	0.037

Handgrip dominant, handgrip non-dominant, pinch grip dominant, and pinch grip non-dominant show significant differences between male and female respondents at p-value < 0.02. Handgrip dominant (0.000), handgrip non-dominant (0.001), pinch grip dominant (0.000), and pinch grip non-dominant (0.037) also show significant differences respectively across age group.

Table 3 Mean Score, SD, 5th Percentile and 95th Percentile Value for Hand Grip Strength (Kg) for Both Dominant and Non-dominant Hand, Between Genders Across Age Group

Gender	Hand	Age Group	≤ 19	20-29	30-39	40-49	50-59	60-69
Male	Dominant	Mean (kg)	37.24	40.19	41.07	39.58	36.26	34.96
		Standard Deviation	6.83	8.60	7.52	8.24	8.25	4.24
		Percentile 05 (kg)	27.50	27.50	28.70	27.30	23.40	27.40
		Percentile 95 (kg)	47.50	56.00	53.20	52.90	49.70	41.00
	Non-dominant	Mean (kg)	36.41	39.50	38.82	36.60	35.11	32.15
		Standard Deviation	6.53	19.78	7.01	7.64	7.66	5.20
		Percentile 05 (kg)	28.00	26.70	26.70	25.10	23.75	20.90
		Percentile 95 (kg)	46.50	52.20	50.00	47.70	50.75	40.50
Female	Dominant	Mean (kg)	24.95	24.55	24.54	24.33	21.66	22.37
		Standard Deviation	4.87	5.48	5.68	5.60	5.82	3.06
		Percentile 05 (kg)	17.20	15.20	15.10	15.45	11.60	16.70
		Percentile 95 (kg)	34.10	33.20	33.70	33.10	30.40	25.60
	Non-dominant	Mean (kg)	23.18	23.48	23.08	22.61	20.59	22.07
		Standard Deviation	5.80	5.00	5.03	5.03	4.98	3.73
		Percentile 05 (kg)	17.20	16.90	15.60	14.35	13.00	17.00
		Percentile 95 (kg)	30.40	32.90	31.20	30.75	28.10	28.70

Table 3 presents the results of handgrip strength between males and females across age groups. For males, the mean score for hand dominant is slightly greater than the mean score of non-dominant hand. Both the 5th percentile value and 95th value of hand dominant are more significant than the non-dominant hand. For the dominant hand, the age group 30-39 years old have the highest mean score (41.07 kg) and 95th percentile value, while the non-dominant hand of age group 20-29 years old have the highest mean score (39.50 kg) and 95th percentile (52.2 kg).

Similarly to males, the females mean score for hand dominant for all age is slightly greater than the mean score of non-dominant hand. For the dominant hand, the age group <19 years old have the highest mean score (24.95 kg), 5th percentile value (17.20 kg) and 95th percentile value (34.10 kg), while the non-dominant hand of age group 20-29 years old have the highest mean score (23.48 kg) and 95th percentile value (32.9 kg).

On average, dominant handgrip strength for females was shown to have the same mean scores across an age group (average =24.0 kg) except for the age group 50-59 years old (21.66 kg) and 60-69 years old (22.37 kg). Females of 18-19 years old have the highest value for the 5th percentile (17.20 kg) and 95th percentile (34.10 kg). In comparing genders, males' fifth percentile value is greater than the mean score of female handgrip strength.

Table 4 Mean Score, SD, 5th Percentile and 95th Percentile Value for Pinch Grip Strength (Kg) for Both Dominant and Non-dominant Hand, between Genders Across Age Group

Gender	Hand	Age Group	≤ 19	20-29	30-39	40-49	50-59	60-69
Male	Dominant	Mean (kg)	8.87	8.99	9.24	9.18	8.05	8.35
		Standard Deviation	1.74	1.93	1.99	2.14	2.06	1.92
		Percentile 05 (kg)	6.50	6.00	6.00	6.00	5.00	6.50
		Percentile 95 (kg)	12.00	12.50	12.50	12.70	12.00	12.50
	Non-dominant	Mean (kg)	8.63	8.85	9.08	9.11	8.29	8.25
		Standard Deviation	1.88	2.00	2.18	2.15	1.98	2.16
		Percentile 05 (kg)	6.40	6.00	6.00	6.00	5.00	5.50
		Percentile 95 (kg)	12.00	12.50	13.00	12.50	12.25	13.00
Female	Dominant	Mean (kg)	6.34	6.16	6.20	6.29	5.78	6.29
		Standard Deviation	1.30	1.60	1.78	1.91	1.51	.91
		Percentile 05 (kg)	5.00	4.00	4.00	3.50	3.50	5.50
		Percentile 95 (kg)	8.00	8.50	9.40	8.75	8.90	8.00
	Non-dominant	Mean (kg)	6.32	5.97	6.01	6.20	5.85	6.03
		Standard Deviation	1.88	1.64	1.80	1.81	1.69	1.22
		Percentile 05 (kg)	4.50	3.50	3.50	3.00	3.50	4.00
		Percentile 95 (kg)	9.50	9.00	8.60	8.60	8.00	7.50

From the data above (Table 4), it is apparent that the pinch grip strength score is higher for males than females across all age groups. The 5th percentile value for males is almost similar to the female mean score. The average 95th percentile value for females is slightly the same as the average mean score of the males across the age group. For males, the dominant hand has a more excellent mean score compared to the non-dominant hand. However, for females, the average mean score for both dominant hand and non-dominant hand almost similar.

4.0 DISCUSSION

Overall, 1496 men (822) and women (674) working-age groups from 18 years to 69 participated in this preliminary study. A total of 90.2% (n= 1349) of the respondents showed right-hand dominance whereas 9.8% (n=147) are left-hand dominant. The number of the respondents are not normally distributed across age group, 88 in the age group less than 20 years old, 361 in the age group 20-29 years old, 492 in the age group 30-39, 345 in the age group 40-49, 193 in the age group 50-59 and only 17 in the aged group 60-69 years old. Table 3 and Table 4 show that all group means to have small Standard Deviations (SD), which shows this data is reasonable to be used. Finding from the present study consistent with the findings of previous studies, in which male has greater grip strength compare to female in all age groups (Nilsen et al., 2012; Massy-westropp et al., 2011, Puh, 2020; Faraone et al., 2008; Kamarul, Ahmad and Loh, 2006).

As shown in Table 3, the mean score for the handgrip strength test for the male population steadily increases starting from a group age 18-19 years old to a 30-39 years old, gradually decreasing. The mean handgrip score for the females are highest at their youngest age group (<19 years old) before gradually decreased. This is similar to a study conducted by Kamarul et al. (2006) on handgrip strength in the adult Malaysian population on 200 men and 212 women. Their study found that the right-hand dominant group's grip strength increased with age peaking in respondents aged 18 to 34 years and decreased steadily after that. The present study also shows that females reduce strength at an earlier age than males. It indicates that females have difficulty sustaining hand function due to reduced strength and endurance in grip strength. It shows that females are more vulnerable than males when maintaining daily functions due to lower hand strength and reduced endurance in the handgrip. This view is supported by Nilsen et al. (2012), who writes that due to lower hand strength and weakened stamina in hand gripping, older women are more vulnerable than men when it comes to sustaining function in everyday activities.

Like handgrip strength, males are stronger than females in their pinch strength across all age groups, and the range of strength is more comprehensive for younger than older respondents. Males are at their strongest in their thirties, while females of the age group less than 20 years old have the strongest pinch grip strength. Both males and females aged 50-59 have the lowest mean score for hand dominance. However, for non-dominant hand female in the age group, 50-59 years old also has the lowest mean score while male in the same age group falls the second-lowest. Males have the strongest pinch grip in their thirties. Compared to Nilsen et al., study (2012) found that their respondents have the strongest pinch grip in their forties. Thus might conclude that different populations have different grip strength levels, varying between gender and age. Table 4 shows that pinch grip strength for dominant hands is more muscular than the non-dominant hand, about 0.2kg only. This might affect from training and conditioning effect (Wilson et al., 2013).

This present study aimed to establish normative data of handgrip strength and pinch grip strength for healthy adults of both genders for the Malaysian working-age population. The data are suggested to be used as guidance to design healthier workplaces. When performing work tasks especially that involve tools, workers need to adjust his or her ability to the intense demands which result whether their hand increase tolerance from training and conditioning effect or weakened their hand capabilities, which may contribute to MSDs (Nurul Shahida et al., 2015; Hashim & Dawal, 2012; Karmegam et al., 2011).

Thus, the anthropometric data obtained can be used by the ergonomists, manufacturers, and designers as an indicator to measure optimum strength in design tools, especially those that involve gripping, pulling, push-button, and machine lever. Thus, the tools, products, or machines fit Malaysian workers' capability (Berth, Garfield, and Daryle, 2019). The data also can be used to measure overall hand strength, physical performance, to test the functional index of nutritional status, rehabilitation purpose, and including to evaluate hand function and overall body strength (Nurul Shahida et al., 2015; Kaur, 2009; Taha and Nazaruddin, 2005; Tsunawake et al., 2003). For example, the 5th percentile can be used as a baseline evaluation for the CTS problem's recovery state. For any individual who went CTS surgery, they must achieve 5th value based on their age group category. If they did not archive the value yet, they must continue the physiotherapy program that design for CTS problem until they achieve the targeted value.

One limitation of this study is the gripping trial. In this present study, the respondents performs three trials, and then the average score will be recorded (Dale et al., 2014; Nilsen et al., 2012). This method may result fatigue and pain. Thus it is not necessary to get an advantage. This may also potentially introduce systematic error as there is a risk that participants are better in the second testing due to the learning effect.

In summary, we found that males are stronger than females in all age groups, the 5^{th} percentile value of males is greater than the mean score of female handgrip strength, male at their strongest in their thirties while females are strongest at their age below 20 years old.

5.0 CONCLUSION

The normative data is practical to be applied by all the designers in developing a healthy and ergonomic product, tools, and workstation. In this study, the researcher encourages prevention at an early stage by designing tools or products that ergonomically fit the user. Thus, it can create a comfortable and productive workplace and prevent discomfort and reduce fatigue, resulting in MSDs prevention. Therefore, a good design of the product is the first step in preventing the ergonomic risk problem, which can reduce the employee's medical expenses.

It is recommended for further research to consider the ethnicity and type of work of the respondents. The data quality can also be improved by adding the number of respondents to represent the entire Malaysian working-age population. Finally, this data can be used as a reference for the designer to design hand tools to create a safe working environment and prevent MSDs at an early stage.

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Original Article

A Case Study on Biomechanical Analysis of Kneeling and Squatting Methods while Manual Lifting Using Motion Capture Analysis

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ABSTRACT: *Weight lifting techniques had been long discussed and debated between squatting and semi-squatting (kneeling) techniques. Using motion analysis and force plates, the weight lifting tasks were measured for comparison. Participant was required to lift different weights of 5kg, 10kg and 15kg using squat and semi-squat techniques. The tasks were randomized and the performance was measured using Cortex 7.0 and Mokka 6.0. Then kneeling technique was indeed a more efficient and safe posture as compare to the squatting technique that would expose an acute onset of spinal injury. The case study illustrated that kneeling technique was the better technique in protecting the spinal health from any chronic musculoskeletal disorders. Therefore, the study recommended that weight lifting training exercises to be promoted for kneeling postures and provide core muscle in strengthening exercises as an important intervention and training program at workplace.*

Keywords: *Force, Intervertebral Angles, Motion Capture, Technique, Weight Lifting*

1.0 INTRODUCTION

Supervisors need to be cautious when managing his co- workers' physical activities. Training had always been limited with regards to multitasking. In many instances, proper engineering innovation and controls could not be allocated due to various financial and commitment constraints. Therefore, the cost- efficient control strategies would be adopting hazard isolation and administration control strategies. In the service sector, (e.g.: nurses, stewardess or receptionists) workers would be exposed to various multitasking including lifting objects at various degrees and frequencies in a day. The musculoskeletal system would be chronically affected if the job task required high repetitive movement (even contact stress). Night shifts, improper sleeping posture, inadequate recovery time and poor quality of sleep were all indirectly associated with low back pain with time. Procedures such as venipunctures, dialysis, dressing and nursing care were commonly done under non-ergonomic conditions (Theodora et al., 2010).

Papi et al. (2017) and Tam et al. (2019) correctly pointed out that there were ergonomic and psychological factors related to low back pain especially at work. Numerous efforts have been spent on developing tools to prevent chronic back pain, which include questionnaires (Traeger et al., 2014) and simple field- assessments especially addressing sports related injuries. Surprisingly, objective and standardized anthropometric and ergonomic assessments at workplace settings were not easy to come by. Most physical assessment of the human body catered for human efficiency enhancement for development of sports. Studies have shown that the intervertebral discs of running athletes were reported to be healthier than individuals who were not active in sports (Belavy et al., 2017) while Yoo & An (2009) correlated musculoskeletal pain with poor physical posture. Therefore, the human posture and anthropometric knowledge could answer the chronic presentations of musculoskeletal diseases.

Other sports that emphasized on the technique would be the weight lifting category. Weight lifting techniques were catered for competitive performances and prevention of long-term injuries and disabilities. It would be interesting to assess the movement of the human body when challenge with weight lifting under working environment or requirements. Pourahmadi et al. (2019) concluded that kinematic/ motion analyses were very different assessments that medical science assessments and that there were not many motions analysis reviews (even assessments among healthy population were limited) in the literature. Meanwhile, Yamamoto et al. (2017) and van der Have et al. (2019) mentioned of low back pain association with forward bending or stooping posture movements. Besides the movement and forces, the angle movement could also be observed using the motion analysis (Suter et al., 2019); squatting compared with kneeling (semi-squat) techniques. Nevertheless, there are limited documented visuals or figures on how the vertebrae, typically the lumbar angles changes and its relationship to low back exposures pain while lifting in squatting versus kneeling (semi-squatting) positions.

This case study aims to present the relationship of forces created via different lifting postures (kneeling versus squat postures) while lifting various different weights from the ground to the standing posture. The study would identify the movement of the thoracolumbar spine (thoracic kyphosis) and lumbosacral spine (lumbar lordosis) with the spinal angle changes in relation to the forces during lifting. By comparing the two postures, the benefits and limitations on the two lifting postures can provide preventive knowledge for ergonomic health purposes.

2.0 METHOD

This study was approved by the Ethics Committee of the Faculty of Design at Kyushu University, Japan. A male participant (35 years old, 178cm, 78.3kg and BMI of 24.62kgm^{-2}) had volunteered and consented to participate in this study. The participant's kinematic data were collected using a 3D motion- capture system (Cortex 7.0; Motion Analysis Corporation, Santa Rosa, CA, USA) while two force platforms (9286A; Kistler, Winterthur, Switzerland) were sampled at 1000 Hz in sync with the kinematic data through the 3D motion- capture systems. There were 11 infrareds high- speed cameras that would be recording movements with a sampling rate of 120 Hz.

The task conditions were box lifting at weight 5kg, 10kg, and 15kg with kneeling or squatting method in randomized order. The weight was based from the Ergonomic Risk Assessment at Workplace 2017 of Malaysia (DOSH, 2017). Subsequently, the participant was asked to rate his perceived exertion based on the Borg's Rating of Perceived Exertion (RPE) scale (Borg, 1990) after every trial. The kneeling method in this study refers to a singular kneeling of either side of the human body while the task was randomized as with the weighs mentioned above and as shown in Fig. 1. The squatting method was referred as crouch posture with his knees bent and the heels were adjacent to the hamstring muscles. At force plates, the measured forces were identified as X (left to right), Y (back to forward) and Z (top to bottom) vectors. Finally, the total resultant forces (in Newton- N) were used in this report.

A total 22 reflective markers were placed on the participant's body surfaces to collect the kinematic data; from the anterior trageus, distal acronium process to the 5th little toe, 8 markers over the box and 8 markers were placed on the two tables placed above one another. Each dot on Fig. 1 represents the refractory markers. Before the initiation of the study, the participant was allowed to change and prepare himself. Pre-assessment medical screening such as weight and height was also taken. The 22 markers were placed on the anatomical surfaces of the important structures of the body off-lined and the movements of the markers were recorded and calculated by the Cortex 7.0. The participant was told to begin the trial by standing at rest. Then, the participant would have to pick up the weighted box and finally to stand straight (Fig. 1) with the weighted box either using kneeling or squatting according to the randomized protocol. The task conditions (two postures and three weights) were randomized for the participant, and each condition was repeated for three repetitions. Randomization is needed to prevent the participants to be able to prepare himself on the various different trials that would need to be performed.

A single task would take 30 seconds (maximum). In between each task, the participant was allowed 60 seconds of recovery time. The entire motion capture would require approximately an hour to complete. For the purpose of the study, the focus was on the spinal movements of C7, T6, T12, L5 and S1 vertebraes in relation to each other as they move on their respective vertebral planes. The lumbar lordosis angle was calculated from the thoracolumbar and thoracosacral segments. The thoracic kyphosis angle was calculated from the upper thoracic segments (the C7-T6-T12 vertebral angle changes) and the lumbosacral segments (the T12-L5-S1 vertebral angle changes) were also measured. For each task, the participant would have to repeat the task 3 times. All the randomization effect, data, weight, movement, graphic videos and forces produced and captured by the cameras and force plates were recorded into the Cortex 7.0 software.

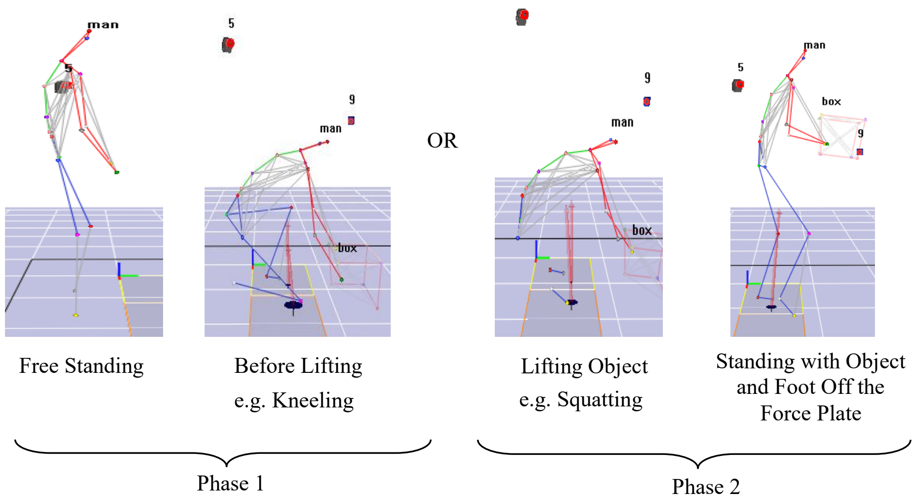


Figure 1 Difference Postures and Phases during Lifting

In this case study, the single lifting motion cycle was divided into Stand to Lift (Phase 1) and Box Lifting (Phase 2) (Fig. 1). The measured forces were identified as X (left to right), Y (back to forward) and Z (top to bottom) vectors. Lastly, the total resultant forces were used in this report. The maximal forces produced over the left foot during the movements were recorded as the right knee would be used during the kneeling posture that would be less consistent compared to the left foot. The Borg's RPE was also obtained from the participant after each task was performed. Besides the experimental movement of the tasks that were captured, the changes in the management of the thoracic and the lumbar curvatures were also observed and measured. Finally, the reporting method of Institute of Biomechanic Standards were used as reference (Wu et al., 2005 and Hasegawa et al., 2018) when the angle changes were recorded by the Cortex 7.0 and Mokka 6.0 system.

3.0 RESULTS & DISCUSSIONS

Fig. 2 showed the difference values of the Borg's Rapid Perceived Exertion (RPE) between kneeling (semi-squatting) and squatting postures with increased weight. Using Borg's RPE, we could conclude that the tasks were not too physically strenuous and should not increase the cardiovascular demand (Max RPE: 6 units) on both occasions. Findings suggested that the participant felt less amount of effort was needed when lifting objects above 10kg when kneeling as compared to squatting postures. Although very efficient, the squatting technique did increase perceived exertion to the participant as compared to kneeling technique.

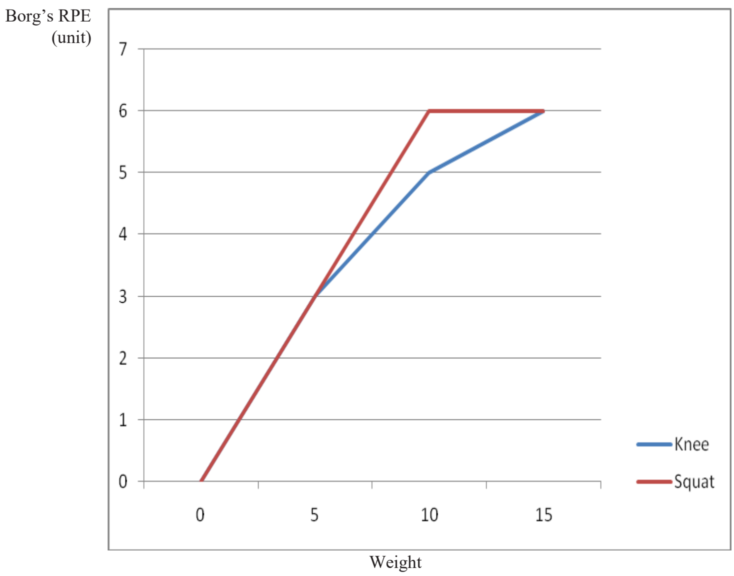
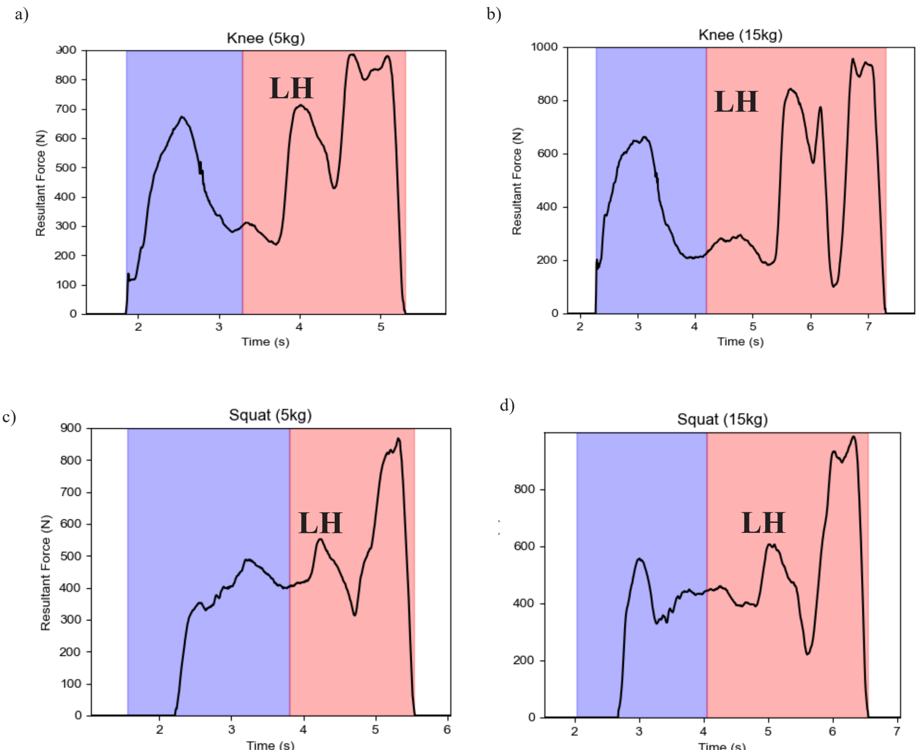


Figure 2 Documented RPE when Kneeling or Squatting

However, the study managed to record higher forces that were generated when the participant was adopting the squatting technique as compared to kneeling technique to lift the similar 5kg and 15kg from the ground (Fig. 3). Phase 1 (Blue Segment) referred to the participant standing to box lifting position. In phase 1, the participant would need to bend his body and move nearer to the box. Phase 2 (Red Segment) referred to the position from lifting the box to standing position with more movement and force generated. The squatting technique produced a localised movement force (Fm) as compared to the kneeling techniques (Lifting hump-LH). The squatting technique would expose a smaller number of muscles in a short period of time as compared to the kneeling technique. Therefore, the intensity of the ergonomic risk would be much higher in the squatting technique as compared to kneeling technique. The kneeling posture with 15kg object was noted to be using larger number of muscles of the body as they body adjust, prepare and accommodate to the increased physical activity that needed to be performed. With additional energy or force generated, the angle range on both kneeling and squatting was relatively similar.



LH- Lifting Hump

a) Kneeling Posture with 5kg box
b) Kneeling Posture with 15kg box
c) Squatting Posture with 5kg box
d) Squatting Posture with 15kg box.

Figure 3 Forces Generated with Various Posture and Weighted Box

Table 1 Resultant Force Measured

Level	Rest	Standing with empty box (95% CI)	Standing with box plus 5kg (95%CI)	Standing with box plus 10kg (95%CI)	Standing with box plus 15kg (95%CI)
Force (N)	781.02 ±7.37	808.31 (805.53 to 811.10)	853.43 (849.95 to 856.91)	877.50 (874.71 to 877.52)	927.93 (923.78 to 930.03)

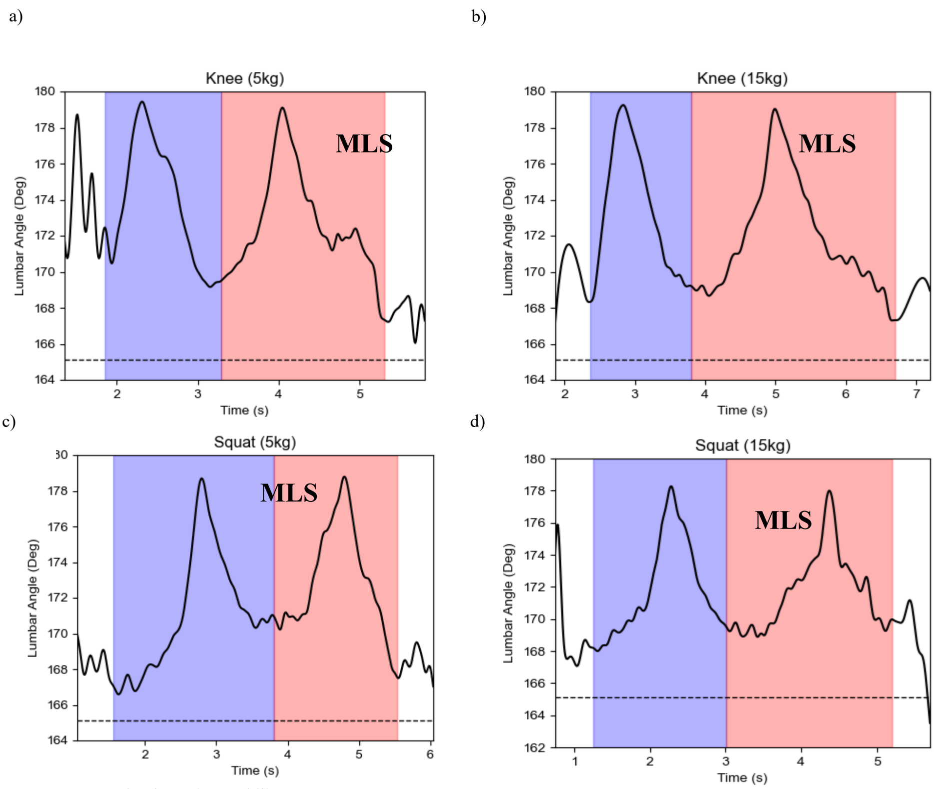
Table 2 Maximal Forces during Lifting Objects from Floor

Weight (kg)	Stand-to-Lift (Phase 1)		Box Lifting (Phase 2)	
	Knee	Squat	Knee	Squat
5	665.57 ± 26.59	510.17 ± 71.0	878.84 ± 14.42	862.64 ± 5.53
10	662.03 ± 14.05	521.66 ± 75.40	869.17 ± 48.10	918.00 ± 6.24
15	672.60 ± 9.15	522.39 ± 38.61	955.60 ± 0.85	959.31 ± 22.32

Table 3 Angle Changes from Neutral Positions

Weight	Posture	Stand to Lift (Phase 1)		Box Lifting (Phase 2)	
		Thoracic	Lumbar	Thoracic	Lumbar
5kg	Knee	4.57 ± 0.96	14.72 ± 0.07	4.01 ± 0.48	14.04 ± 0.51
	Squat	10.70 ± 1.10	12.95 ± 0.22	6.89 ± 0.91	13.34 ± 0.44
10kg	Knee	6.47 ± 2.19	13.67 ± 0.19	5.33 ± 2.31	13.46 ± 0.13
	Squat	7.62 ± 0.93	14.37 ± 0.41	6.44 ± 0.77	13.90 ± 0.36
15kg	Knee	8.29 ± 1.00	14.16 ± 0.32	8.31 ± 1.30	14.39 ± 0.37
	Squat	10.70 ± 6.81	13.00 ± 1.29	6.89 ± 0.38	13.34 ± 0.38

The results are presented in mean±SD, unless otherwise specified. Table 1 showed the resultant forces at rest from no object to exposure when lifting objects with 15kg. During the participant's movement from standing to kneeling or squatting to pick up the object that was on the floor, the force plates recorded forces that were changing during movements (Table 2). Table 3 illustrated the forces that were documented during the initiation stages as the participant kneeled or squatted to lift an object during Phase 1 to Phase 2. The forces along with the movements were dynamic and similar forces were generated between both postures in Phase 2.



MLS- Maximal Lumbar Stability

a) Kneeling Posture with 5kg box
b) Kneeling Posture with 15kg box
c) Squatting Posture with 5kg box
d) Squatting Posture with 15kg box.

Figure 4 Lumbar Angle Changes

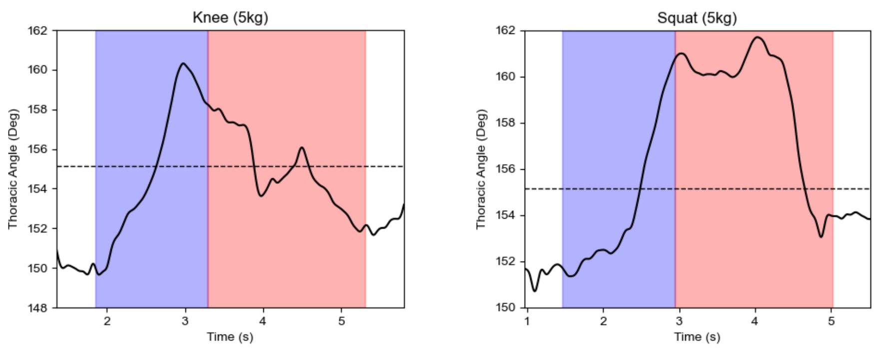


Figure 5 Thoracic Angles Lifting 5kg Objects (Kneeling and Squatting Postures)

However, the squatting technique exhibited relatively erratic and unstable angle movements to recovery as compared to kneeling technique (Fig. 4). In fact, the squatting technique transfers some of the physical force to the upper back (thoracic region) as the body entered Phase 2. Such thoracic angles were relatively protected when using the kneeling technique as compared to the squatting technique (Fig. 5). Therefore, there would be stronger and forceful impact of the vertebral during the squatting technique as compared to kneeling technique even at 5kg.

Fig. 4 illustrated in detail the different physical (muscle) hazards that the body was exposed when different techniques were used. As similar angles were required, the final postures of lifting were similar (Maximal Lumbar Stability- MLS). Our motion findings were consistent with van der Have et al. (2019). The kneeling technique provided a much stable and gradual spinal angle changes. Once MLS was achieved, the core muscles would enter the predominant isometric phase which would allow the lumbar spine to return to its anatomical angle to reduce injury.

There were several advantages in using motion capture to document spinal movements during object lifting. Although, motion capture along with force plates would be able to document movements and the forces that interplay during the physical activities, it should be important to note that other modalities could be added or incorporate to increase the precision and to detail out other important parameters such as muscle contractility, muscle strength, oxygen- ventilation perfusion, neural impulses, spinal kinematics (Papi et al., 2017) and many others anthropometric assessments. This study was designed to document inter-vertebral movements during object lifting. With surface markers, the angle movements of the vital skeletal and muscle points were objectively reported and represented (Stinton, 2011).

From literatures, kneeling technique was ergonomically efficient and would prevent back injuries (Vecchio, 2017), but relatively less power. Both techniques had similar loss of lumbar lordosis giving added pressure and compression to the disc. However, the stability of the kneeling posture was affected when the objects were 15kg. Our findings were consistent with Wang et al. (2012). Without adequate recovery and rest, chronic fatigue would further injure the affected workers (Vecchio 2017 and Patel 2020). Therefore, untrained or unprepared workers should be allowed to decline such tasks if the activity was done without supervision by a trained senior colleague or health professionals (e.g., fitness trainer or physiotherapists). In the study, the untrained participant had consistently described difficulty in lifting objects via squatting compared to kneeling (semi-squat) technique. As a case study, this participant was a healthy, a 30-year-old Asian male that reported healthy lumbosacral or lumbar lordosis angles. The participant was a teaching staff of the university as all students in Japan was told to return home due to the Covid-19 pandemic. It was intended to have more than 20 participants form the university (majority Asians) to participate in this study. With large number of participants and data, we could compare and measure the range of muscle movement among the individuals. Therefore, the level of Asian referential and representation of this study is limited.

The lumbar angle changes increased with additional weight during both squatting and semi- squatting (kneeling) techniques. Caglayan et al. (2014) managed to report that an increased lumbar lordosis angle was associated with onset of low back pain. A key important discussion that squatting lifts (trained appropriately especially in sport performance) generate more efficient and effective competitive heavy lifting, particularly with a straightened back and training (Wang et al., 2012, Kim 2014 and Cho et al., 2017). The motion capture had successfully provided that insight and would recommend the importance of training and physiotherapy and core exercises for workers to build a strong back.

Postures of lifting in competitive weight lifting sports applied weights to be supported on shoulders/ upper trunk in order to exceed daily lifting capacity (Myer et al., 2014 and Kushner et al., 2015). Although acceptable and practiced in the past among sea-farers unloading shipments at seaports or docks, these techniques had not been commonly used in this modern era. Kneeling technique would be a rather appropriate and safer technique of lifting objects less than 10kg. Even procured tools to assist lifting had to be introduced and taught to all workers effectively, especially in the service industries like banking, corporate business and the healthcare industry. Secondly, perhaps a paradigm shifts especially for nursing staff or discipline to incorporate a healthier practice to work on standing computer designs along with serving of medication and attending to patients. This would allow nurses to really enjoy their rest and breaks sitting down as compared to repetitive or prolonged sitting with limited movement which would be less healthy to the human body.

As recommendation, this study proposes the need for employers to designate dedicated trained personnel to be in- charge of the back care treatments aimed to prevent musculoskeletal injuries with proper lifting technique training, nutrition and medical care to strengthen the back muscles typically the multifidus muscle. Interestingly, most literatures suggested that body- building squatting exercises were good core exercises to strengthen the back structures (Al-Otaibi, 2015, Cho et al., 2017 and Lorenzetti et al., 2018). The multifidus muscle thickness was noted to have a very close relationship with low back pain (Wallwork et al., 2009). 'BackCare' in the form of preventive back strengthening programmes and workplace ergonomic investments would delay or prevent an early onset of degenerative changes to the spine of all workers at work. Medical screening recommendation such as the Unilateral Hip Bridge Endurance Test (UHBET) would be a good physical assessment of the strength a worker's core muscles (Butowicz et al., 2016). The idea would be to prevent occurrence of micro-injuries over the vertebral disc that would be dehydrated and replaced by fibrous tissues (Ract et al., 2015). Such un-prevented pathogenesis would promote back pain and prolapsed or herniated intervertebral discs. As such, core muscle strengthening and squatting exercises (Lorenzetti et al., 2018) would improve performance and reduce dependency on the spine/ back to lift objects from the ground (Patel, 2020).

Besides that, this study also proposes that employers from all sectors to designate a 'Team Lifting' personnel who has knowledge in ergonomics awareness and weight lifting training at work particularly in the service and administrative industries (Theodora et al., 2010). These individuals should be upskilled further with the knowledge on muscle strengthening and fitness benefits, covered in the scheduled nutritionist and physiotherapist sessions. Our study clearly showed that structured physical training activities would be required to be implemented for manufacturing workers or industries that involved extensive manual lifting work (Cho et al., 2017 and Patel, 2020).

However, there are limitations in this study. While testing out the kneeling posture, the knee was used to balance the human body to lift the box. Therefore, the recording or motion captured between the lower limbs were relatively inconsistent. Although the systemic bias had been addressed, the quality of knee posture information would be limited as compared to the squat posture data. On the other hand, the participant successfully demonstrated that the squat technique provided a powerful and sustained force during lifting (Fig. 3). It is advised that it would be important to maintain a straight posture of the back to prevent possible injuries during the squat posture (Kim, 2014).

At the muscle level, Hemming et al. (2018) studied the kinematics movement of the spine among individuals with non- specific chronic low back pain. These people specifically had more markers (13 markers) along the spine as compared to our study (6 markers). As the spine moved, the spinal changes involved flexion and all active extension pattern motor control impairment should be captured accurately. The benefits of this study would be enhanced further with a larger recruitment of participants in safer conditions, post pandemic.

5.0 CONCLUSION

Both techniques of kneeling and squatting while lifting had different advantages with regards to lifting the objects. Lifting heavy objects using the kneeling technique may have illustrated lower ergonomic risk as compared to the squatting technique. Based on the law of energy conversion, additional pressure/ force would receive or be absorbed by the joints, discs and soft tissues of the human body during the squatting technique. Although the squatting technique could achieve a lifting task faster and easier, the squatting could promote more micro- injuries to the spine as compared to the kneeling technique. Therefore, all manual workers and relevant stakeholders need to be trained with Back Care awareness and prevention programme to prevent prolapsed intervertebral disc at work.

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Original Article

Perception of Drone Application and Practicality among Environmental, Health and Safety Practitioners at Building Construction Sites in Malaysia

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ABSTRACT: *Safety management in the construction sector is still lagging in terms of technological involvement. A new drone application was proposed as a new inspection tool for a small-scale aerial drone that will give advantages to Environmental, Health and Safety (EHS) practitioners at the construction site. A fundamental research was conducted to study the Perception of Drone Application and Practicality among Environmental, Health and Safety Practitioners at Building Construction Sites in Malaysia. A self-administered questionnaire was distributed to safety practitioners in Malaysia through an online survey using Google form. The relationship between the attitudes of the users towards the drone and the practicality of the drone was analysed using a multivariate statistical method known as Multi Linear Regression (MLR). From the result, the respondents show significant positive attitude towards the practicality of the drone system for the inspection of safety, security, fire, and environmental monitoring (R^2=0.76; p-value=0.01). There is generally a significantly good attitude of future users towards drone usage in the construction industry and the respondents show a good expectation and this is also supported by previous studies.*

Keywords: *Construction, Drone, Environmental, Health and Safety (EHS), Malaysia, Multi Linear Regression (MLR)*

1.0 INTRODUCTION

The construction sector remains to be one of the vital industries, strengthening its value and producing job opportunities to approximately 1.33 million people in Malaysia (Hamid et al., 2019). Despite the fact that this sector has had a significant impact on economic development, construction has been regarded as one of the most dangerous and hazardous sectors (Rahman, 2015). According to Azhar (2017), the construction sector registered the highest accident rate in comparison to other sectors. Those accidents led to many cases of major and minor injuries as well as work-related fatalities among construction workers. Therefore, all safety measures should be prioritized in order to avoid the high number of accident occurrences (Tam et al., 2004). Good identification of the hazard was one of the main factors that can prevent accidents at construction sites.

The hazard monitoring method could effectively reduce the management cost and thus improve safety systems (Hamid et al., 2008). The hazard monitoring method could be more effective when there is involvement in cutting edge technologies. Drone application is one of the best technologies that could be implemented to monitor the hazards at the construction sites. A new drone application was proposed as a new inspection tool for a small-scale aerial drone that will support Environmental, Health and Safety (EHS) practitioners on the construction site. The drone is an aerial quadricopter that uses smartphone, tablet device or a computer that is remotely controlled by an authorized practitioner. A drone is an Unmanned Aerial Vehicle (UAV) that involves humans to control its operation without any pilot on board. The involvement of these EHS would be able to prove the features of an ideal, practical and efficient application at the jobsite.

This alternative also could help safety managers to reveal undiscovered hazards and various unforeseen issues specifically on the safety inspection context. The inspection could be faster rather than a walk-in inspection by the SHOs around the construction sites. By having this automated and secured monitoring tools inspection at the construction site, the delivery message between construction workers and the EHS practitioner would be successfully delivered.

A study needs to be conducted before producing and establishing the prototype of the proposed drone. This is very important to identify the needs and opinion of EHS practitioners regarding drone. Hence, this study was conducted to assess the perception of drone application among SHOs at the construction sites in Malaysia. This study was specifically aimed to evaluate the perception of application and practicality of drone technology among safety authorities as a new safety inspection tool at construction sites in Malaysia. Besides, it is also conducted to determine the attitude of future users towards drone utilization as a new safety inspection tool at construction sites in Malaysia. Last but not least, it was carried out to determine the association between the attitude and practicality of drone application among EHS practitioners in Malaysia.

2.0 LITERATURE REVIEW

Drones are Unmanned Aerial Vehicles (UAVs) that use a person to control their operation and do not have a pilot on board. An unmanned aerial vehicle is also known as a drone. Recent technologies have allowed for the development of many different kinds of advanced UAVs used for various purposes. UAVs are designed to be semi-autonomous or fully-autonomous aircrafts that can be equipped with cameras, sensors, communication devices and other components. UAVs mostly rely on human involvement human. The implementations of UAVs are still in the trial phase. Certain researches have been conducted to identify the potential and practicality of drones in construction sites. Several studies comprised of four phases such as scheduling and preparation, data gathering, image processing, video and image analysis (Kaamin et al., 2017).

Nonetheless, several socio-technical issues are inciting public outrage against the technology that is accused of delaying UAVs adoption. Although the literature addresses these concerns extensively, factors influencing public acceptance are rarely and insufficiently examined (Chamata & Winterton, 2018). Thus, several studies need to be conducted to assess the acceptance and perception of people regarding drone application from time to time.

3.0 METHOD

3.1 Study Design

A cross-sectional study was conducted at the construction sites located in Malaysia. In this research, a self-administered questionnaire was distributed among safety and health authorities such as Safety and Health Officer (SHO), Site Safety Supervisor (SSS), Safety Manager, Environmental Officers (EO), and any construction workers who conduct safety practitioner at construction sites in Malaysia.

3.2 Sample Size

Based on the report by the National Institute of Occupational Safety and Health (NIOSH), there were 5,984 registered EHS Practitioners involved in the construction sector in Malaysia. Thus, from that population number, a sample size could be calculated and determined by that number in order to make an observation. For this research, the sample size has been determined and calculated using the sample size formula in Equation 3.1 below as stated by Daniel (2012). The minimum sample that should be collected are 180 samples. The formula by Daniel can be formulated as below:

$$n = \frac{Z^2 \, P(1-P)}{d^2} \tag{3.1}$$

Where:

Z = statistic for a level of confidence. For the confidence level of 95% which is conventional, Z value is 1.96.

P = expected prevalence or proportion. P is considered as 0.5

n = sample size needed.

d = Precision. d is considered as 0.05 to produce good precision and smaller error of estimate

3.3 Data Collection

The questionnaires were distributed through email in the Google Form format and were distributed throughout Malaysia in any kind of construction companies. The distribution of the questionnaire was conducted for three months for the data collection. The data was collected from 6th March 2020 till 6th May 2020.

3.3.1 Research Instrument

IMOSSED-1 is a modified drone which equipped with several sensors and modification. The selection of drone is based on its powerful aerial film making system with class leading agility and speed, redundancy features for maximum reliability, and new, smart features that make capturing complex shots easy. A new airframe was designed together with dual batteries to boost flight time up to approximately 25 minutes.

Furthermore, an additional set of sensors could be installed to enhance the collection of highly localized data and relaying the information to any Android device via Bluetooth. Just like a computer that could run many different applications, this set of sensors able to run multiple of sensor applications as well, including temperature sensor, wireless sensor, light sensor, gas sensor and gas detector, Carbon Monoxide sensor and CO detector, humidity sensor, colour sensor, Bluetooth sensor, networked sensor, environmental sensor, and infrared temperature sensor. A feasibility study was carried out with the main purpose to the application of Intelligent Malaysia Occupational Safety, Security and Environmental Drone (iMOSSED-1) as a new safety inspection tool at a construction site in Malaysia.

A questionnaire was developed to identify the perception of the respondents toward this IMOSSED-1. This questionnaire survey was created based on the Knowledge, Attitude and Practices (KAP) model (Ahmad et al., 2015) and also adapted from several previous studies as well as Acts and Regulations that related to the objectives of this study. The questionnaire consisted of five main sections which are Section A for socio-demographic, Section B for the current safety system, Section C on the attitude towards IMOSSED-1, Section D on the application and practicality of IMOSSED-1, and Section E for IMOSSED-1 investment willingness.

Section B, Section C and Section D had been composed based on the Likert Scale. Those scale need to be answered by the respondents according to the scale provided such as strongly agree, agree, disagree, strongly disagree and neither agree nor disagree.

3.4 Data Analysis

3.4.1 Correlation

Correlation is a statistical technique that can show whether and how strongly a pair of variables are related to each other. A positive correlation is defined as a pair of variables, which increases or decreases in parallel. A negative correlation, on the other hand, indicates an inverse relationship between two variables in which one variable increases as the other variable decreases. The correlation can be divided into two which are Pearson's correlation and Spearman's correlation. In this study, the correlation test was utilized to explore the association between knowledge and practices among construction safety practitioners toward safety requirements on the construction sites. Besides, it also used to determine the relationship between knowledge and attitude of the safety practitioners regarding safety matters.

3.4.2 Multiple Linear Regressions (MLR)

Multiple linear regression (MLR) or known as multiple regression is one of the statistical techniques used to predict the outcome of the response variables. It is the predictive analysis to predict the variability between the dependent and independent variables. In this study, the MLR was used to find the significant correlation between the good attitudes of future users towards drone usage at construction sites. Thus, it could be calculated using the Equation 3.2 below:

$$Y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} \dots . + \beta_{p-1} x_{i,p-1} + \varepsilon_i \tag{3.2}$$

Where:

Y = Response variable

p – 1 = Explanatory variable

$\beta_1, \beta_2 \dots \beta_{p-1}$ = Regression coefficient

β_0 = The intercept

ε = Error associated with the regression

The coefficient of determination (R^2) and Root Mean Square Error (RMSE) are the important mechanisms that must be considered in the performance model. The value of R^2 establishes information on the reliability of fit of a model to the observed all data. Meanwhile, RMSE is applied to calculate the residual error and it will be included in the estimation of the mean difference between the observed and modelled value. All date collected in this study was analysed using the SPSS software.

4.0 RESULTS

4.1 Demographic Data

The survey questionnaires of the Safety and Health Officer (SHO), Environmental Officer (EO), Site Safety Supervisor (SSS), and other construction safety practitioners resulted in a total of 180 respondents. The age range of respondents collected was from 21 years old to 60 years old. The list of registered SHO, SSS, and safety practitioners were selected from the Department of Occupational Safety and Health (DOSH) website to be respondents in this study. Table 1 shows that the highest percentage of age range among safety practitioners were between 21 to 30 years old with the percentage of 61.10% (n=110), while the lowest percentage was 60 years and above with the percentage of 0.56% (n=1). Next, male gender dominated this sector with the percentage of 71.10% (n=128), while the percentage of female employees was 28.9% (n=52). Lastly, there was approximately 57.20% (n=103) of safety practitioners, who hold Bachelor's degrees as their highest qualification. Meanwhile, there were only 0.6% (n=1) practitioners who obtained LCE/LSA, PhD and others qualification, respectively. Table 1 below shows the overall demographic data for this study.

Table 1 Demographic Background of the Respondents

Variable(s)		(N = 180) n (%)
Age		
	21-30 years	110 (61.10)
	31-40 years	52 (28.8)
	41-50 years	10 (5.56)
	51-60 years	7 (3.89)
	60 years and above	1 (0.56)
Gender		
	Male	128 (71.10)
	Female	52 (28.9)
Academic Qualification		
	LCE/LSA	1 (0.6)
	MCE/SPM	3 (1.7)
	Certificate	5 (2.8)
	Diploma	45 (25)
	Degree	103 (57.2)
	Master	21 (11.7)
	PhD	1 (0.6)
	Others	1 (0.6)

4.2 Relationship between Attitudes and the Practicality Expectation towards the Usage IMOSSED-1

Multiple linear regressions (MLR) test was used to determine the relationship between the attitude of the respondents towards the usage of the IMOSSED-1 at the construction site as a tool for safety inspection, fire inspection, security system and environmental monitoring with the application and practicality of the IMOSSED-1. According to the findings Table 2, there was a significant relationship between the attitudes of the users towards the system IMOSSED-1 as the safety inspection, fire inspection, security system and environmental monitoring at the construction site on the practicality of the IMOSSED-1. This was because the significant value of the finding was p-value=0.01 which is less than 0.05. The findings also show that the variance of the R^2=0.76 which considers that 76% of the variance of the practicality of IMOSSED-1 was explained by the attitude of respondents in using IMOSSED-1 at the construction sites.

Table 2 Multi Linear Regression (MLR) Test between Attitude and Practicality of IMOSSED-1 System at the Construction Site

Variables	R^2	Significant value (p-value)	Significant value (p-value)
Safety Inspection	0.760	0.011**	0.01**
Fire Inspection		0.123	
Security System		0.002**	
Environmental Monitoring		0.001**	

Multiple Linear Regression (MLR) test
**Significant at α<0.001

4.3 The Association between Attitudes and Practices of the Workers toward Safety Requirements at the Construction Sites

For further analysis, the Pearson's correlation test was utilised to determine the relationship between attitudes and practices of the workers towards safety requirements at the sites. As shown in Table 3, there was a significant positive correlation between the attitudes and practices of the workers towards the safety requirements at the sites (r=0.819; p-value=0.001). The correlation coefficient (r) showed a strong positive correlation between variables total attitudes score and total practices score, with the r value was within the range of 0.8 to 1.0.

Table 3 Correlation Test for the Relationship of the Attitudes and Practices of the Workers towards Safety Requirement

	Mean (SD)	r	p-value
Total attitudes score	89.3(17.32)	0.819*	0.001**
Total practice score	88.7(17.21)		

Spearman's Correlation Test
*Correlation is significant at the 0.01 levels (2-tailed)
**Significant at α<0.001.

5.0 DISCUSSION

The knowledge of the respondents towards their current system that is applied at construction sites shows a high level of knowledge and it was proven that the safety practitioners were mostly aware and agreed that their systems were acceptable and efficient for safety inspection. Section 24(1)(a) of Occupational Safety and Health Act 1994 (OSHA 1994) states that it is the responsibility of every employee to take reasonable care for personal safety and health, as well as others who may be affected by his work or omission at works (OSHA, 1994). Please quote the act properly. Therefore, it was meant that every single employee including the safety practitioner has to ensure the safety of him and others.

Besides that, the attitudes of the respondent towards the IMOSSED-1 system mostly showed a satisfactory positive attitude. This could be shown when the respondents agreed that IMOSSED-1 system be utilised at construction site as the inspection tool. But then, a previous study found that there was no significant relationship between the attitudinal variable with the safety outcome variable (McDonald & Hrymak, 2002). This implied that good standards of compliance for safety requirements did not inherently impact workers' attitudes. Therefore, this study suggested that more research must be conducted to have a clear explanation regarding the relationship.

Safety practices could also be affected by the good cultures of the safety committee of the site (Chamata & Winterton, 2018). It can be defined as the good principles and practices on safety values at workplaces. By obeying the act and practicing safety measures. The statement could support the result of the practicality expectation of drone technology. Overall, the respondents mostly agreed and showed good practicality expectations towards the IMOSSED-1system which acted as a safety inspection system, security system, fire inspection system and environmental monitoring. If the drone was applied by the safety practitioner as the safety inspection tool, good safety culture among the employees could be implemented and good and healthy safety practices would be generated.

5.1 Relationship between Attitudes and the Practicality Expectation towards the Usage IMOSSED-1

Based on the objective of this study, the findings showed that there was a significantly good attitude of future users towards drone usage in the construction industry. This was because the respondent of the study had a positive attitude towards the system that would be expected in the IMOSSED-1 as a new safety inspection tools at construction sites in Malaysia. The result also showed that the respondents had a higher percentage in showing a positive attitude towards the system in IMOSSED-1 if it was as a safety inspection tool at construction sites. This could be supported by the study of Irizarry et al. (2012) as they concluded that drone technology had the potential to encourage the awareness of safety assessment and to improve safety industry practices. The drone is also being tested and proven to perform similar and practical roles as a man, but, more efficiently, safely, faster and cost-effective (Ames et al., 2015). The purpose of the application of drones in the construction industry was to ease the job scope of safety practitioners at the construction site since the construction industry was well-known to be listed as dangerous workplaces which required safety awareness among the workers.

Accidents like permanent or temporary disabilities, fatalities and materials or product losses were still liable to all construction employees (Irizarry et al., 2012). The safety manager at the construction site had to inspect their workers, the procedures and the environment site (O'Toole, 2002). Most of the safety practitioner conducted a walk-in inspection which might require longer time, mainly in the bigger construction project. Thus, with the assistance from the system utilised in IMOSSED-1 such as communication tool, real-time video camera, environmental sensor, and RFID system, the regular inspection for daily, weekly or monthly safety inspection on the condition at the construction could be helpful to them.

5.2 The Association between Attitudes and Practices of the Workers toward Safety Requirements at the Sites

In the previous study by Irizarry (2012), the drone applicability had been tested and proven that drones were able to provide good real-time communication between the workers and the safety managers during the inspection and it could observe and monitor the real condition if construction site either comply with safety criteria or not.

As shown in the findings, the percentage of respondents had good practicality expectations towards the IMOSSED-1 system. This study could be supported by previous studies where using drones was beneficial in term of low cost, the ability to move freely, provide safety support, high visual assets, and capability of information transfer (Kim & Irizarry, 2015). Furthermore, Kim and Irizarry (2015) also stated that UAVs could assess the areas which are difficult for human entry, monitor the workflow, logistic and stock counts of the materials, and able to lower the cost of safety monitoring at the construction site.

6.0 CONCLUSION

This study assessed the effectiveness of drone application among safety officers at building construction sites in Malaysia. The findings generally showed that there was a significant good attitude of future users towards drone usage in the construction industry tested by the MLR test and Spearman's Correlation test. Overall, the total attitudes score had a strong positive correlation with total practicality of the system in the drone. This study demonstrated that the safety officers in Malaysia were aware of the current system that their company used, and had good attitudes towards the IMOSSED-1 system. The respondent also showed a good practicality expectation towards the IMOSSED-1 system for safety inspection, fire inspection, security system and environmental monitoring at the construction site in Malaysia.

Moreover, the aim was achieved as there was a significant good attitude of future users towards drone usage in the construction industry. This could be exhibited through the MLR test where the attitudes of the respondents were significant to the practicality of the IMOSSED-1 system. Drone technology usage is applicable and is practical at construction sites. Lastly, the third objective was achieved when most respondents showed a good practicality expectation towards drone usage, and this was also supported by the previous study.

ACKNOWLEGEMENT

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Original Article

Safety Competency on Heavy Machinery: A Comparison Study Between the Importance and Practices from Site Supervisor Perceptions

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ABSTRACT: *There is an increase in awareness of employee competency and relation to accidents that occur during operations and maintenance of heavy machinery. The competence level of operators and supervisors are one of the critical factors related to safety in the workplace. A survey was developed to assess the comparison of perceptions between the practice and the level of importance regarding safety for heavy machinery. Respondents consisted of supervisors and operators of heavy machinery. In this paper, the discussion will focus on the supervisor's perception and practice when managing and maintenance of heavy machinery. The results found that the percentage of the level of 'Importance' more than the percentage of 'Practice' for all elements. These results further indicate that the need for training is very important for improving the competence of handling heavy machinery.*

Keywords: *Competency, Heavy Machinery, Operator, Safety, Supervisor*

1.0 INTRODUCTION

A heavy machinery management system and competent workers are important to ensure the safety of all parties. Work involving the use of heavy machinery requires skills and knowledge in terms of operation and maintenance so that the machinery can operate safely. Employees who operate the machinery must also be competent and skilled in various aspects such as safety and technical problems of the machinery used. They need to attend courses offered by NIOSH or relevant external parties to increase their competence in the use of heavy machinery. However, there are still risks and require monitoring, standards, safe work practices, good training modules, and proper maintenance to prevent accidents.

The construction industry contributes to around 6% of Malaysia's GDP in recent years (Trading Economics, 2020). Heavy machinery is part of the important assets for different land works and material handling activities in the construction industry. Since construction is one of the major industry, accidents often occur, and it will impact the overall project flow and cost. And the root cause of the accident is always related to less precaution regarding safety procedures and the level of competencies of the heavy machinery operators and supervisors. Therefore, a correct safety precaution to minimize the accident occurrence regarding heavy machinery will benefit the industry (Zaini, 2020; Lee, 2020; Bedi, 2021).

The most common type of accident in Malaysia is one involving heavy machinery. Due to physical interaction with powered machinery without proper safeguarding and control, heavy machinery can be a threat and cause serious injuries. Backhoe injuries, rollover accidents, struck-by accidents, faulty machine components, and electrocution are all causes of heavy machinery operator accidents (Cordeiro, 2005; Duarte, 2021; Kazan, 2018).

To minimise workplace accidents, it is proposed that heavy machinery operators need specialised skills (Permana, 2010). To minimise heavy machinery accidents, heavy machinery operators must have a thorough understanding of the necessary competencies. Furthermore, although the majority of those who work with heavy machinery, such as operators and safety supervisors, have completed a competency course, not all of them have put their training into practice while handling the projects (Yin, 2017; Kecojevic, 2004; Md-Nor, 2008).

This paper aims to compare the value of safety and existing safety practices among safety supervisors working on construction sites with heavy machinery. The findings of this study will help to clarify the difference between knowledge and practice for people who work with heavy machinery.

2.0 METHOD

A survey among the construction workers, including project managers, health, safety, and environmental (HSE) officers, site supervisors, training instructors, heavy machinery operators, general workers were conducted to identify and gather data on the safety practices. A total of 63 respondents have answered the survey questions with the site supervisors contributing 38% of the respondent. This paper focuses on the comparison between 'Level of Importance' and 'Current Practice' of safety by the site supervisor based on the collected survey data.

Fig. 1 shows the distribution of respondents in which 38% are working as supervisors who are closely or directly related to users/operators of heavy machinery which represents 25% of the respondents. Other distributions showed 18% as HSE officer, 8% as heavy machinery management, 6% as heavy machinery instructors, 3% as general workers, and 2% as enforcers. Fig. 2 shows 46% of the site supervisors never attend any heavy machinery training.

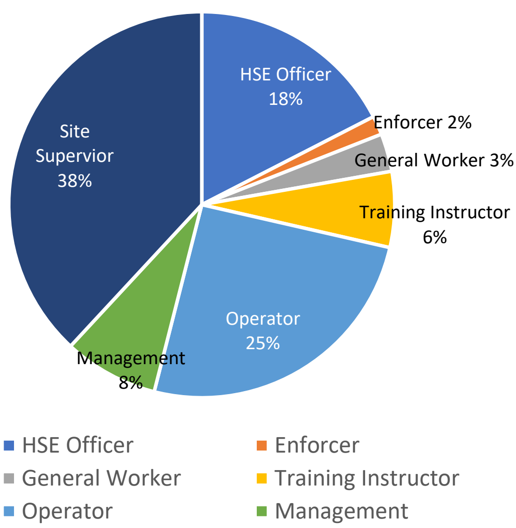

Figure 1 Distribution of Respondents Based on Occupation

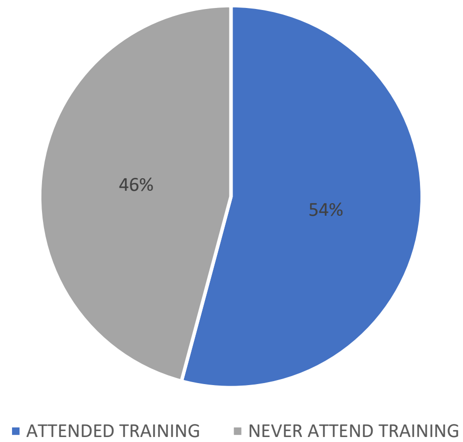

Figure 2 Percentage of Site Supervisor Attended Heavy Machinery Training

The discussion of the findings of this questionnaire is divided into the following order such as the profile of the respondents, operations & monitoring and technical knowledge. The measure for "Level of Importance" and "Current Practice" used in this analysis was the percentage of respondents. This questionnaire requires respondents to answer "Yes" or "No" to a question that requires a yes or no answer. For questions requiring answers on a 5-point Likert scale, respondents were asked to state the level of importance for questions requiring answers "Very Important, Important, Neutral, Not Important, Very Unimportant" and were asked to state the frequency level for questions requiring answers "Always, Very Often, Sometimes, Rarely, Never".

A total of four main types of heavy machinery were classified in this study. Based on the results of the questionnaire, there are six types of lifting machinery, five types of transport machinery, six types of construction machinery, and five types of loading machinery operated or supervised by respondents. This distribution is shown in Fig. 3.

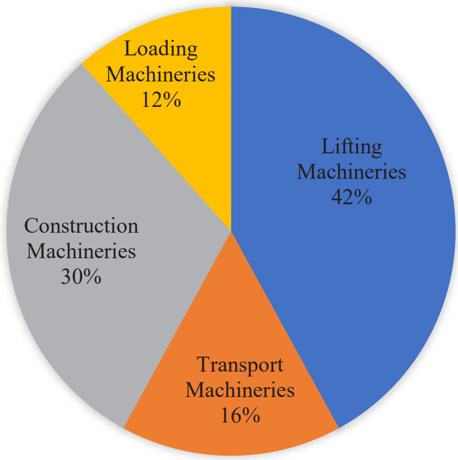

Figure 3 Types of Heavy Machinery Operated or Supervised by Respondent

3.0 RESULTS AND DISCUSSION

Fig. 4 shows the frequency of heavy machinery used or supervised by respondents. A total of 14.7% of respondents have experience in operating or supervising the use of excavators, 11.8% backhoe loader, 9.4% carrier trucks, 6.2% mobile cranes, 5.9% steamroll, 5.6% bulldozers and cement mixer trucks, 5.3% use tractors, 5.0% use front loaders, 4.7% piling machinery, 4.4% tank trucks, 3.8% forklift, 3.5% using drilling rigs, plough machine and garbage trucks, 3.2% grader, 2.9% skid steer loader and tower cranes, 2.4% sky lifts, 0.6% gantry cranes, and finally, 0.3% each represented bored piles, cargo trailers, loaders, log trucks, low loaders, roller compactor, and side loaders.

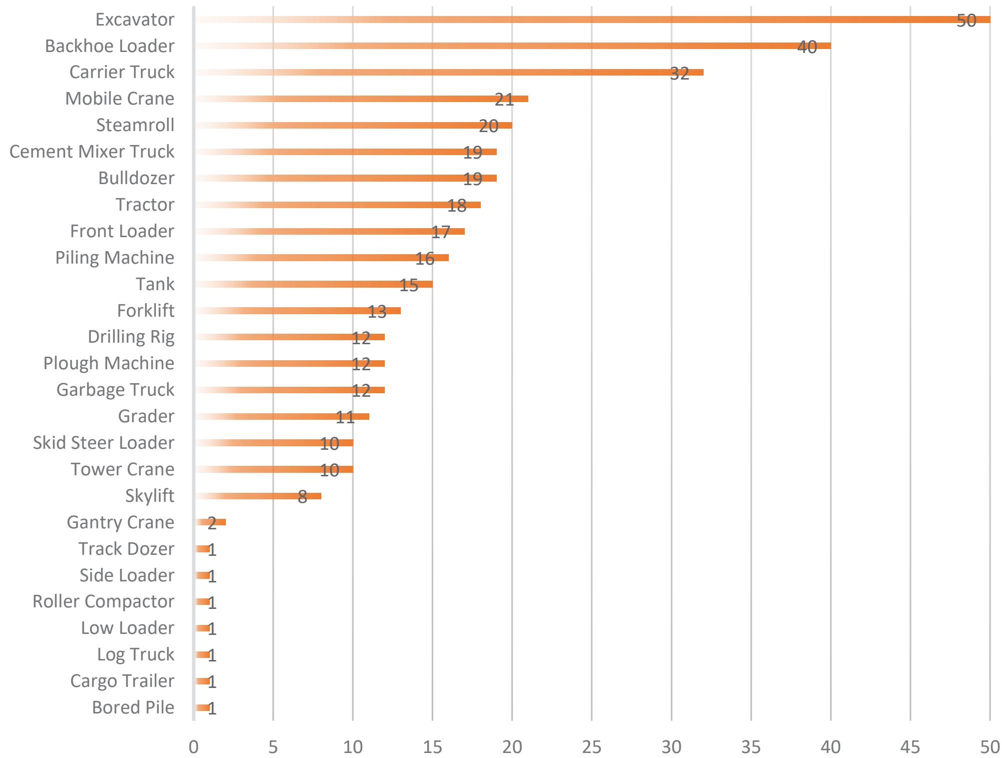

Figure 4 Breakdown of Heavy Machinery Used or Supervised

3.1 Level of Importance and Current Practices Regarding Safety in the Workplace

This section discusses the level of importance and current practices regarding safety in the workplace and it is divided into seven items on the importance and current practices in the workplace such as: Able to identify or detect site hazards and barriers such as power lines, underground cables/pipes, and other hazardous systems (B1), able to identify areas allowed to public access (B2), have current knowledge of safety rules in the workplace (B3), responsibility for safety and health limited to work in the workplace (B4), responsibility for safety and health other than work in the workplace (B5), trained in first aid skills (B6), and able to provide an appropriate response in the event of an emergency or case of an accident at work (B7).

Fig. 5 shows that all respondents response between "very important" and "important" but in terms of current practice, there are many shortcomings, especially for sections "B1: Able to identify or detect site hazards and barriers such as power lines, underground cables/pipes, and other hazardous systems", "B3: Have current knowledge of safety rules in the workplace", "B4: Responsibility to maintain safety and health at the workplace" and "B6:Trained in first aid skills".Overall, for all elements asked, as discovered the percentage of 'Level of Importance' for all questions asked was greater than outcome obtained by the 'Current Practice'. The difference is due to only half of the site supervisors in this survey have attended heavy machinery training as mentioned in Fig. 2. By attending training on heavy machinery, it is convinced that knowledge from questions B1, B3, and B6 can be further enhanced. These results show that the need for training is very important for the improvement of heavy machinery handling and competencies.

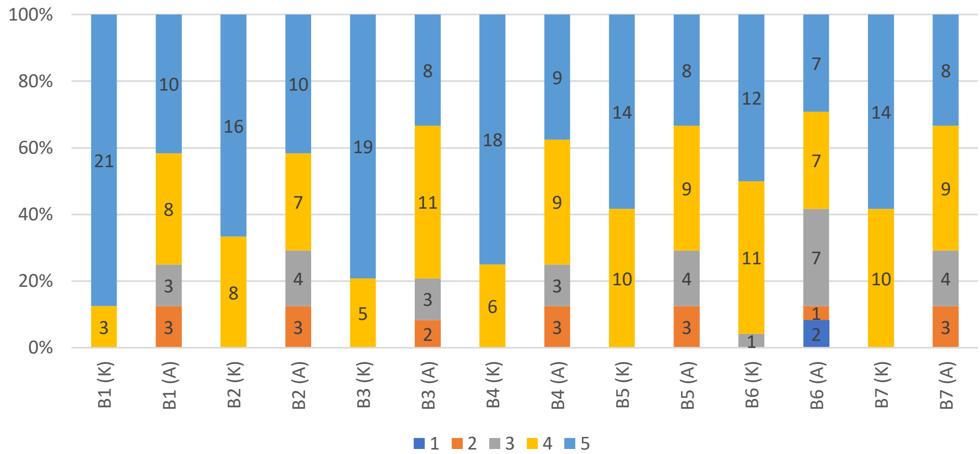

Figure 5 Level of Importance and Current Practices Regarding Safety in the workplace: (K) is a Level of Importance and (A) is Current Practice, with Scale 5 for (K) is Very Important and (A) is Always

3.2 Level of Importance and Current Practices During Operations

This section discusses each nine 'Level of Importance' and 'Current Practices' during the operation of heavy machinery, namely knowing the emergency response procedure in the event of an accident while operating heavy machinery (C1), the emergency response procedure in the event of heavy machinery failure (C2), the emergency response procedure for fire control (C3), emergency response procedures in the event of contact with electrical power sources (C4), how to inspect heavy machinery to ensure machinery is always in the best condition (C5), complete records or forms of handling of heavy machinery (C6), how to safely operate heavy machinery (C7), the appropriate time to communicate with supervisors and management (C8), how best to communicate with supervisors and management (C9).

Based on Fig. 6, almost all respondents make a selection between “very important” and “important” for the ‘Level of Importance’ questionnaires. In terms of current practice, almost all have chosen the lower level answer and some respondents select "Never" for the question "C5: Know how to inspect heavy machinery to ensure the machinery is always in the best condition", "C6: Complete records or forms of operation of heavy machinery”, “C7: Know how to safely operate heavy machinery” and “C8: Know the appropriate time to communicate with supervisors and management”. This information is believed because the respondents have never conducted training but operated heavy machinery on a freelance basis. The appropriate communication time between the operator and the supervisor can also be seen as a key issue and shall be included in the training module at a later stage. Overall, the percentage of ‘Level of Importance’ for all questions asked was greater than what was obtained by the percentage of ‘Current Practice’. The results have shown that the need for training is very important for the improvement of heavy machinery handling competencies.

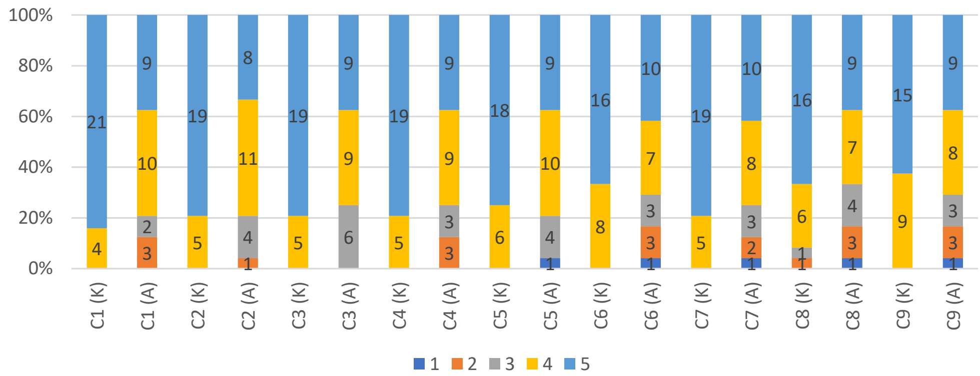

Figure 6 Level of Importance and Current Practice During Heavy Machinery Operation: (K) is a Level of Importance and (A) is Current Practice, with Scale 5 for (K) is Very Important and (A) is Always

3.3 Level of Importance and Current Practices During Monitoring

This section discusses fourteen ‘Level of Importance’ and ‘Current Practices’ during heavy machinery monitoring to assess the knowledge and practice on how: To perform basic heavy machinery maintenance (C11), to stop operation and keep heavy machinery safe when left (C12), to use operator aids and limiting devices for forklifts and skylifts (C13), to operate safely based on recommendations from manufacturers (C14), know the original project schedule (C15), aware of any changes to the project schedule (C16), attend safety training (C17), attend heavy machinery operation training (C18), aware of current weather conditions (C19), aware of site safety conditions (C20), aware standard operating procedures for retrenchment during emergencies (C21), safety is a priority topic at pre-construction and construction meetings (C22), knowing the correct or allowable maximum working day period (C23), and know the working period overtime and the rate of payment (C24).

Fig. 7 shows the respondents chose “very important” and “important” indicating the Level of Importance but in terms of practice, there are many shortcomings. In terms of current practice, almost all chose the low level, especially for questions “C13: Know how to use operator aids and limiting devices for forklifts and skylifts”, “C16: Aware of any changes to the project schedule” and “C23: Know the correct or allowable maximum working day period”. For the question “C13: Knowing how to use operator aids and limiting devices (for forklifts and skylifts)”, a low result in practice was expected because there are respondents who do not operate or supervise this type of heavy machinery compared to others. Overall, for all elements that have been questioned on the percentage of ‘Level of Importance’ for all questionnaires, as discovered, the outcome was greater than what has been obtained from the percentage of ‘Current Practice’.

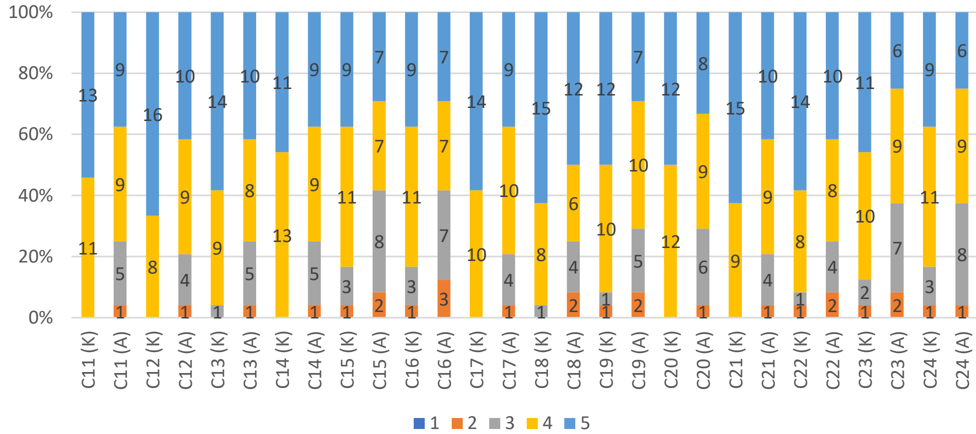

Figure 7 Level of Importance and Current Practice During Heavy Machinery Monitoring: (K) is a Level of Importance and (A) is Current Practice, with Scale 5 for (K) is Very Important and (A) is Always

3.4 Technical Knowledge for Pre-Operational Activities

Based on Fig. 8, all heavy machinery operators and supervisors agreed they need to be alert to heavy machinery accident situations (D1), know the standards, rules, and laws that can be applied in the workplace (D2), know and understand the basic nomenclature of heavy machinery (D3), know the basics of maintenance and inspection criterion for heavy machinery (D4), understand the basic systems of machine power flow of mechanical, electrical, hydraulic and their combination (D5), know how to check structural integrity (D6), know the documents required in the operation of heavy machinery (D7), and understand the safe operating procedures (D8). But in terms of practice, almost 30% felt that they were still at a medium and low level despite feeling the importance of technical knowledge about heavy machinery.

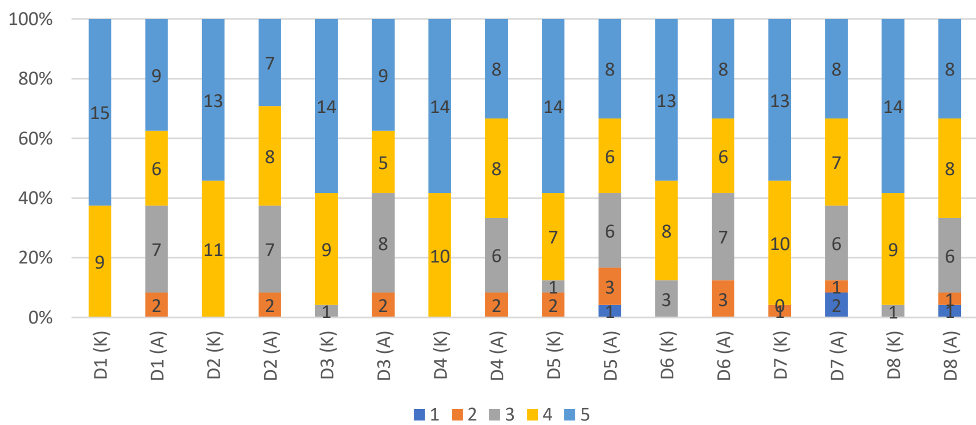

Figure 8 Technical Knowledge of Heavy Machinery Pre-Operational Activities: (K) is a Level of Importance and (A) is Current Practice, with Scale 5 for (K) is Very Important and (A) is Always

3.5 Training and Safety Management Systems Reduce Risk

This section discusses two main issues on the management of safety systems and hazardous incidents and accidents involving heavy machinery. Fig. 9 shows that 20% of the respondents did not undergo specific construction-related training (E2), but almost all companies have safety management systems in their respective companies (E3). Fig. 10 shows that some respondents feel that there is a possibility of accidents based on the existing risk management in their respective workplaces. There were also 48 near-miss accidents and 25 accidents at work when the respondents were operating or supervising the heavy machinery at the workplace. Of these 48 near-miss accident incidents, there are still 6% that were not investigated. As for the accident, 100% of the respondents stated that the accident had been investigated.

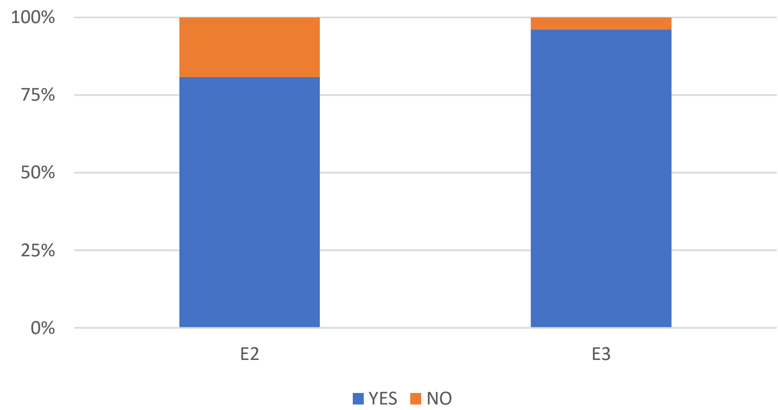

Figure 9 Site-Specific Training and Workplace Management Systems

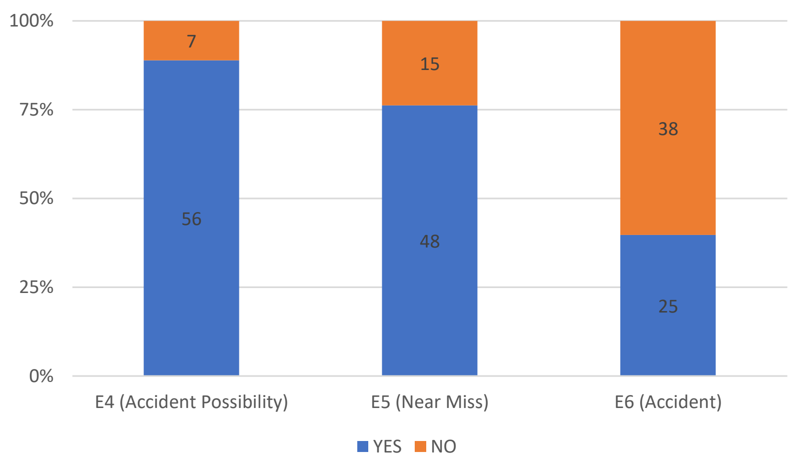

Figure 10 Accidents and Near Misses while Operating Heavy Machinery

4.0 CONCLUSION

Based on the questionnaire of the survey conducted, it can be concluded that the level of importance and practices in the workplace for operations and monitoring; technical knowledge, pre-operation, training, certification, and registration; accidents; needs to be understood and implemented properly by the supervisor and operators of heavy machinery to ensure safe operation of machinery. Overall, for all elements being questioned, the percentage on 'Level of Importance' on responses found was greater than what was obtained by the percentage of 'Current Practice'. According to survey outcome, responses gathered from questions being asked on knowledge, the majority of site supervisors believe knowledge is essential but still lacking in practice. This is because they must expand their knowledge and skills until they can become competent. The finding indicates that the demand for training is very important for improving the level of competence of handling heavy machinery.

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Kindly refer to Appendix A (Author’s Checklist) and Appendix B (Template of the Paper) for more details/further information.

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Original Article: Original Article is report on findings from original unpublished research. The article follows the format provided in the guide to authors. The content includes Abstract, Introduction, Materials and Methods, Results and Discussion, and Conclusion.

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Smith, A.B., Adams, K.D., & Jones, L.J. (1992). The hazards of living in a volcano. Journal of Safety Research, 23(1),81-94.

Book:

Perez, A.K., Little, T.H., & Brown, Y.J. (1999). Safety in numbers. Itasca, IL: National Safety Council.

On-line Publication:

National Institute of Occupational Safety and Health. Sick Building Syndrome. www.niosh.com.my/safetytips.asp?safetyid=1 (accessed October 2004)

Government Publication:

Ministry of Health Malaysia & Academy of Medicine Malaysia (2003). Clinical Practise Guidelines on Management of Obesity 2003.

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