ORIGINAL ARTICLE

ERGONOMICS RISK ASSESSMENT AMONG INFRASTRUCTURE CONSTRUCTION WORKERS IN KUALA LUMPUR

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ABSTRACT

Increased number of injuries due to repetitive movements, excessive force and awkward postures makes ergonomics an important factor in safety and health at workplace. Statistics showed that musculoskeletal disorders are the main cause of loss of productivity in many countries. This study aims to identify ergonomics risk factors that causes work-related musculoskeletal disorders to workers at X infrastructure construction site located in Bukit Bintang, Kuala Lumpur. First objective of this study was to identify workers' body part with highest pain and discomfort complaints. The second objective was to explore the relationship between ergonomics risk factors in construction with the pain or discomfort and finally to investigate the relationship between workers' socio-demographics with the pain and discomfort scores. The investigations were based on the recent guidelines on Ergonomic Risk Assessment issued by DOSH Malaysia. Discomfort survey forms were filled by conducting interview sessions with the selected respondents from three types of work activity which included bar benders, carpenters and general workers. As there were numerous complaints from respondents based on the Self-Assessment Musculoskeletal Pain forms, Initial Ergonomic Risk Assessment was done by observing the three types of work activity where checklists were filled based on the observation. Referring to results of initial assessment of ergonomic risk, Advanced Ergonomic Risk Assessment was carried out on bar benders as this group of respondents had the highest score in the summary rating checklist of Initial Ergonomic Risk Assessment. Further assessment of ergonomic risk should be carried out for bar benders as REBA score was 9 where this work process required monitoring and improvement. Study found that there was a significant relationship ($p < 0.05$) between ergonomic risk factors and body pain where upper and lower backs were significantly higher with ergonomic risk factors. Body pain had significant relationships ($p < 0.05$) with socio-demographic factors such as citizenship, working hours and rest hours. Control measures to reduce or eliminate ergonomic risk factors, contractor or employer may adopt and practice control measures by following hierarchy of risk control such as implementing administrative controls which practices job rotation for employees

Keywords: *WRMSDs, ergonomic risk assessment, REBA, construction*

INTRODUCTION

Work-related musculoskeletal disorders (WRMSD) is a major health challenge for construction workers and general population (Lop et al., 2017). Additionally, MSD is one of the major problems faced by ergonomics experts in various workplaces around the world. According to Christopher & Undoing (2014), MSD costs associated with direct employee compensation were high. The direct cost of compensation for MSDs is much higher than the indirect costs associated with interruption in productivity and quality, employee replacement cost, training and absenteeism costs. Many organizations are aware that non-presence and lower productivity will have higher long-term costs (Knox, 2010). In Malaysia, risk management and investigations on musculoskeletal disorder are still new, and so many of the previously identified risk factors may not have been addressed comprehensively as in other countries (Maakip et al. 2015). The construction industry has gained a reputation as a very dangerous industry due to high incidence of mortality and mortality (Ahmadon et al., 2006).

In this study, three techniques based on Guidelines on Ergonomic Risk Assessment issued by the Department of Occupational Safety and Health (DOSH, 2017) were used to estimate the level of workers' discomfort and to assess their ergonomic risks exposure by using observational techniques and instruments such as Discomfort survey form, Modified Nordic Questionnaire (MNQ) (Kuorinka et al., 1987) and last but not least the Rapid Entire Body Assessment (REBA) (Hignet & McAtamney, 2000). The objectives of this study are in threefolds; identifying the highest level of pain and discomfort complaint on the construction worker body, determining the relationship between the socio-demographic factors and the injury score of the construction workers and determining the relationship between ergonomic risk factors in the construction site with the body pain on workers.

METHODS

This study was conducted at a construction site located in Bukit Bintang, Kuala Lumpur with approval of the main contractor, W, to undertake the study. The survey form for this study will only be provided to legally-employed workers under main contractor, W which is under the Contract 2 Package as this project consists of several infrastructure packages. This study focuses on three types of employees that have been selected for this research study which consisted of bar benders, carpenters and general workers.

Participants

There are various ways to determine the sample size of a study, i.e. by looking at sample size from previous studies, census, referring to available tables and by calculation method. Yamane (1967) has provided a simple formula for calculating the sample size as below. Assumed confidence level is 95% and p = 0.05.

Sample size, n= N / 1 + N (e) 2
where,
N = population survey,
e = permissible error value (%)

The total number of workers at the construction site is 935. However, in this study, only three types of jobs were selected to be used as a sample of the study. The three types of work that have been selected for this study are bar benders, carpenters and general workers. The number of bar benders in the construction sites are 161 while the number of carpenters and general workers are 143 and 48 respectively. By applying the permissible error value of 0.10%, the sample value of this study is 61 persons for bar benders, 58 persons for carpenters and 32 for general workers. Based on the number of samples, a total of 19 bar benders, 15 carpenters and 10 general workers were selected as the respondents.

Instrumentations

An employee may report to the management, safety and health officer or safety and health committee on any complaints relating to work caused by ergonomic risk factors. In this case, a trained person needs to perform the initial ergonomics sick assessment (DOSH, 2017). One of the forms suggested is the Body Part Symptom Survey (BPSS), to identify the pain of the body parts of the employees from different work due to their respective work activity. This is one step of the initial ergonomics risk assessment. The form has two parts to be filled; Part A (I experience pain / discomfort in the following parts of the body) and Section B (I think pain discomfort comes from work activity) which are based on each part of the body.

Nordic Musculoskeletal Questionnaire (NMQ) was introduced by (Kuorinka et al., 1987). This tool was not developed for clinical diagnosis but can be used as a questionnaire or as a structured interview for measuring the workers postures at the workplace. This questionnaire consisted of several parts: Part A, Part B and Part C. Part A consists of questions on respondents' demographics such as age, gender, occupation, occupation type, dominant hand used, duration of work in the field, comfortably working at work, working hours a day, rest hours for a day, temperature at work in the workplace, adequate workplace lighting, pain in any part of the body during the last 6 months and injuries ever experienced. Questions in Section B where each respondent will mark the work posture involved and the frequency of each posture when carrying out their daily work activity. Respondents were given several options to indicate the frequency of body posture for each work; never, seldom, low, moderate or high. Questions in this section have been adapted and modified from the Rapid Entire Body Assessment (REBA). In Section C, respondents were asked to mark the discomfort / pain section for the past one month. The question on this Musculoskeletal disorder leads to 8 parts of the human body, namely neck, shoulders, upper and lower body parts, elbows, wrists, hips, knees and ankles.

Rapid Entire Body Assessment (REBA)

REBA is a postural targeting method that can be used to estimate the overall risk associated with occupational risk (Hignett & McAtamney, 2000). The REBA worksheet is divided into two parts of the body segment where it consists of segment A and B. DOSH (2017) suggested if the awkward postures score is more than half, tools like REBA should be used.

RESULTS

The demographic information includes age, gender, nationality and the type of work are presented in Table 1.

Table 1 Demographic information (n=151)

Characteristics	Frequency	%
Age		
<20 years	3	2
21-30 years	59	39.1
31-40 years	61	40.4
41-50 years	23	15.2
>51 years	5	3.3
Gender		
Male	151	100
Female	0	0
Citizenship		
Malaysian	1	0.7
Non-Malaysian	150	99.3
Type of Work		
Carpenter	58	38.4
Bar bender	61	40.4
General worker	32	21.2
Hours Standing		
1 hour	6	4
1 hr 30 mins	5	3.3
2 hours	116	76.8
2 hr 30 mins	19	12.6
3 hours	5	3.3
Hot Temperature Work Surrounding		
Yes	147	97.4
No	4	2.6
Sufficient Lighting at Work		
Yes	147	99.3
No	4	0.7
Pain in the body (within 6 months)		
Yes	150	66.2
No	1	33.8
Injuries Ever Experienced		

Yes	12	7.9
No	139	92.1
Injured Body Part		
Neck	0	0
Arm	3	2
Knee	0	0
Back	1	0.7
Hips	3	2
Legs	5	3.3
None	139	92

DISCOMFORT SURVEY

The form distribution was conducted for 3 consecutive days. Prior to the distribution of the forms, respondents were described and briefed on the purpose of the study. All selected respondents were from Bangladesh and Indonesia where some of them have difficulty in understanding and responding to questions in the form. Therefore, the authors helped respondents by conducting interview sessions. After each selected respondent had answered the form, the data were extracted using the SPSS software to determine the employee of the type of occupation which has the highest complaints for a body part.

Figure 1 shows result obtained for Part A and B of the form. The bar benders suffered from pain or discomfort in the neck and that pain discomfort comes from their daily work activities.

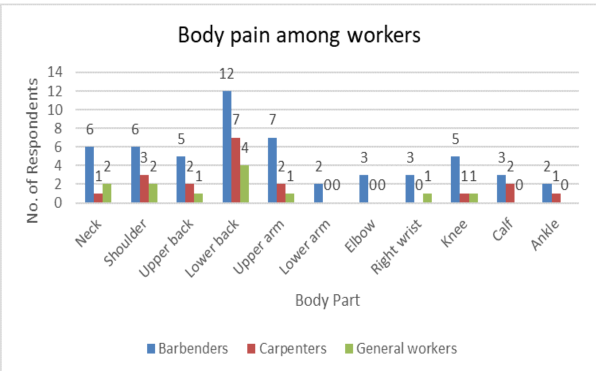

Fig. 1. Self-reported Body Pain by the Workers

It is shown that bar benders have the highest number of complaints and feels pain in some parts of the body compared to carpenters and general workers. Figure 1 indicated that workers at construction sites especially bar benders felt pain or discomfort in certain body parts due to their daily work such as repetitive movements and lifting heavy loads. Therefore, initial ergonomic risk assessment must be done as pain and discomfort was identified from this self-assessment report.

In Part B of the questionnaire, the respondents were required to respond to the posture of the body that they were involved as well as the frequency of each body posture. Table 2 shows the summary of physical risk exposure among the respondents which consisted of all the three types of jobs, bar benders, carpenters and general workers. From Table 2 items 3, 4 and 10 received more than 50% complaints on moderate occurrence of the working postures.

Body Parts Experiencing Discomfort / Pain for the Last One Month

In Section C of the questionnaire, respondents are required to answer the frequency and the pain on certain parts of their body. Table 3 describes the summary of physical symptoms among the respondents from all the three types of jobs.

According to the results obtained, most of the respondents confessed that they felt pain on a certain body part and at which most of them felt something on the body part sometimes at a time. Thus, it can be concluded that the respondents working at the construction site are exposed to ergonomic risk factors which had caused their body parts to feel pain.

Initial Ergonomic Risk Assessment (ERA)

Based on the checklists that were completed during a walkthrough (refer Fig. 2), it was observed and recorded that most of the bar benders were exposed to awkward postures compared to carpenters and general workers. From the nine risk factors (DOSH 2017), bar benders had scored 7 out of 13 scores whereas carpenters had only obtained a score of 4 out of 13 scores. The second ergonomic risk factor was static posture where bar benders had again earned a high score of 2 out of 3 scores that have been identified. This was because most of them works in a standing position with minimal foot movement while carrying out bar bending or during tying reinforcement bars. The third ergonomic risk factor was forceful exertion. Bar benders earned a score of one because of the characteristics of their work activities which requires them to lift and place the reinforcement bars repeatedly with twisted posture. The other reason on how bar benders earned a score of one for the said risk factor was also due to dry floor surfaces but in poor condition and uneven or sometimes wet.

The fourth risk factor was repetitive movement by bar benders where they had earned a score of 2 out of 5 which was higher than the carpenters and general workers. This was due to the activity of a bar bender involving intensive use of hands and wrists which also involves shoulder and arm movements repeatedly with several pauses. Their exposure period is usually more than 3 hours on normal working days. Of the total scores for all ergonomic risk factors, the Advanced Ergonomic Risk Assessment must be carried out for bar benders to assess the risk factors listed above. For temperature and noise risk factors, both bar benders and carpenters both had earned a score of one. Based on the observational walkthrough on these two types of workers, each of these workers are exposed under the sun and the noise from the machine around the site.

Table 2. Body Part Discomfort

No.	Explanation	Frequency (Percentage)				
		Never	Seldom	Low	Moderate	High
1	Working with the neck position is slightly forward (chin is not close to the chest)	69 (45.7)	56 (37.1)	26 (17.2)	0	0
2	Working with neck position bowed forward (chin close to chest)	2 (1.3)	5 (3.3)	132 (87.4)	12 (7.9)	0
3	Working with forward body position (20-60 degrees)	0	8 (5.3)	51 (33.8)	85 (56.3	7 (4.6)
4	Working with forward body position (more than 60 degrees)	0	21 (13.9)	29 (19.2)	95 (62.9)	6 (4)
5	Work with the position of the back arm	151 (100)	0	0	0	0
6	Work with elbow position in shoulder level	1 (0.7)	14 (9.3)	132 (87.4)	4 (2.6)	0
7	Work with arms position on / above shoulder / head level	107 (70.9)	26 (17.2)	16 (10.6)	2 (1.3)	0
8	Work with elbow position at / above shoulder level	0	7 (4.6)	130 (86.1)	13 (8.6)	1 (0.7)
9	Work with position in the body line or outside to the left / right	6 (4)	4 (2.6)	105 (69.5)	35 (23.2)	1 (0.7)
10	The position of the wrist up or down	0	3 (2)	36 (23.8)	112 (74.2)	0
11	Working with positioning legs is unbalanced and supported	14 (9.3)	51 (33.8)	48 (31.8)	38 (25.2)	0
12	Working with legs bending	4 (2.6)	35 (23.2)	91 (60.3)	21 (13.9)	0
13	Manually lifting heavy material	3 (2)	52 (34.4)	36 (23.8)	45 (29.8)	15 (9.9)

Therefore, an Advanced Ergonomic Risk Assessment must also be carried out for both these workers to assess temperature and noise risk factors. Based on Table 4 of ERA (DOSH 2017), REBA should be done for bar benders due to high scores in the Initial Ergonomic Risk Assessment.

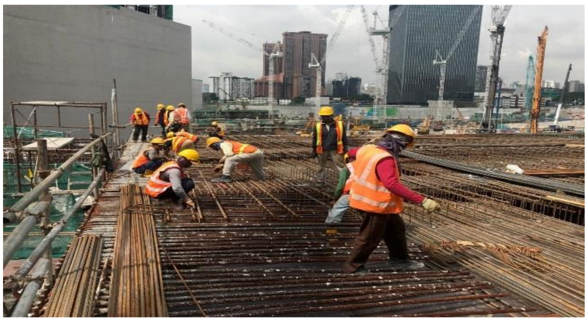

Fig. 2 A Walkthrough Observation during Laying the Reinforcement Bars Activity

Based on the activity involving tying of reinforcement bars carried out by the bar benders, the REBA final score is 9. This indicates that the work is of high risk to bar benders and requires monitoring and improvement in the work process.

Socio Demographic and Physical Symptoms Score of Body Pain

There is a diversity of significance between the socio-demographic variables and physical symptoms score of body pain. Socio demographic considered are, age, gender, citizenship, type of job, working years in construction sector, comfortably working at work, working hours, rest hours, standing hours, hot temperature at work, workplace lighting, experienced pain in the last 6 months and experienced injury.

Physical symptoms are defined as skeletal or skeletal muscles that are at risk in performing work. Respondents were informed of their limbs through the pain they felt and the frequency they felt. The body parts are; neck, upper back, shoulder, elbow/arm, wrist/hand, lower back, knee and ankle.

The correlation between BPSS score and citizenship of each respondents was found to be significant ($p<0.05$). This can be explained by the possibility of respondents' daily living routines.

Majority of respondents are from Bangladesh and followed by respondents from Indonesia. During the walkthrough on a construction site, researcher conducted interviews with several respondents from Bangladesh and Indonesia and some respondents admitted that in order to save money, they did not go to the clinic or hospital when they felt something or felt pain parts of the body. Moore et al. (2013) stated in their study that 27% of the construction worker's samples show that they have failed to report injury during work due to the perception of injury as "small" and taking this injury is "part of the work" and fearing the negative consequences that may be following injury report.

The working hours of each respondent at the construction site was also identified as significantly correlated ($p<0.05$) with the physical symptoms of discomfort or body aches. This can be explained further where respondents working more than 8 hours a day have higher likelihood of being sick. Even when researcher conducted interviews with several respondents, they claim that most respondents will work more than 8 hours a day and this is practiced every day in a week. Due to this, each respondent's body would not have enough rest time from the previous working day.

The rest hours of each respondent were also found as significant ($r = 73.991$, $p<0.05$). Although respondents were given adequate rest time, the body of each respondent still needs enough recovery time. Dembe et al. (2005) stated that working overtime is associated with an injury hazard rate of 61% higher than work without overtime work and also working at least 12 hours a day associated with a 37% increase in hazard rate and work at least 60 hours a week is associated with a 23% increase in danger rates.

Next is temperature at workplace which was also significance ($r = 37.038$, $p<0.05$). Hot temperatures are one of the ergonomic risk factors where hot environment can affect physical abilities. Exposure to hot temperatures over a long period of time, respondents are quicker to become tired and thus it is possible that respondents become more vulnerable to injury. Magnavita et al. (2011) suggested that both 'hot temperatures and cold' temperatures have adverse effects on workers' health, including symptoms of muscle pain disorders and work performance, causing irritation, negligence and tiredness. The next significant socio-demographic factor is pain in the last 6 months ($r = 72.574$, $p<0.05$).

Finally, respondent who suffers an injury in the last 6 months ($r = 37.057$ $p<0.05$). This factor can be related to socio-demographic factors related to citizenship, working hours, rest hours, workplace temperature overheating and pain in the last 6 months where when the mechanical workload of each employee is higher than the physical capacity, the employee will be exposed to repetitive trauma repetitive in the skeletal muscular system especially to those who have been suffering from pain within the last 6 months. The results of this study are similar to the results of the study conducted by (Meo et al, 2013).

Correlation of Pain/Discomforts and Body Parts

Physical risk exposure is identified through the working conditions of the respondents who are perceived to contribute as a risk factor. These factors were listed as, working with the neck position slightly forward (chin is not close to chest), working with neck position bow forward (chin close to chest), working with body position forward (20-60◦), working with forward body position (more than 60◦), work with the position of the back arm, work with elbow position in shoulder level, work with arms position on/above shoulder or head level, work with elbow position at/above shoulder level, work with position in the body line or outside to the left/right, position of wrist up or down, working with positioning legs is unbalanced and supported, working with legs bending and manually lifting heavy material.

Physical symptoms also define body parts that were at risk of developing musculoskeletal disorder when performing daily work. Respondents were asked on their body parts that they felt discomfort / pain and the frequency. The body parts are; neck, upper back, shoulder, elbow/arm, wrist/hand, lower back, knee and ankle. Risk factor of working with forward body position (20-60◦) and working with forward body position (more than 60◦) had significance with upper back pain ($r = 13.398$ and $r = 16.363$, $p<0.05$), lower back pain ($r = 23.564$ and $r = 19.989$ $p<0.05$), left thigh ($r = 8.569$ and $r = 15.27$, $p<0.05$) and right thigh ($r = 14.139$ and $r = 20.586$, $p<0.05$). These two risk factors can be correlated where respondents are exposed to these two risk factors due to their daily activities. During the walkthrough observations on construction sites, it was observed that carpenters often bends their bodies to do their work. Not only are carpenters were exposed with these two risk factors, bar benders were also vulnerable to this risk factor due to their daily activity as often. Risk factor of working with neck position bow forward (chin close to the chest) had significance with pain in the left shoulder (r = 23.4, $p<0.05$), lower back pain (r = 26.905, $p<0.05$) and also pain in both sides of the thighs (r = 20.543 for left thigh and r = 13.373 for right thigh, $p<0.05$).

Just like the risk factor of working with forward body position (20-60◦) and working with forward body position (more than 60◦), respondents sometimes had to bend the neck to carry out their work activities. Exposure to these risk factors is likely to cause pain in the lower back which was caused by frequent bowing down the neck and is followed by bending the body while performing the same work almost throughout the day. Li, et al. (2012) stated that bending the neck or holding the neck in a longer posture for a long time is the most important risk factor causing the lower back pain.

Working with the position in the midline of the body or outside or to the left or right also had significance with pain in the neck (r = 17.549, $p<0.05$), upper back pain (r = 17.549, $p<0.05$) as well as pain in the upper part of the chest (r = 12.92, $p<0.05$).

Based on these results, respondents have the possibility of being exposed to this risk factor due to working frequency to the left side of the body to do their daily work such as for example, transferring building materials that requires respondents to move body to the left and right regularly. Burnett (2008) said that in the construction industry the high volume of spine loading in mid-to-late crooked position was one of the most significant risk factors in the industry. The position of the wrist up or down also had significance with pain in the left arm (r = 22.891, $p<0.05$) and left wrist (r= 16.137, $p<0.05$). As mentioned in Table 1 that most respondents were dominantly right handed in which these respondents are familiar with the use of right hand thus, left hand is not commonly used. This is likely to cause pain in the left arm and left wrists. Helliwell and Taylor (2014) mentioned that that pain in the arm is common among workers in the workplace where pain in the arms is associated with work involving frequent repetition, high strength, and prolonged abnormal posture.

Working with unbalanced and suspended leg position had significance with pain in the left arm (r = 35.762, $p<0.05$) and right arm (r = 28,416, $p<0.05$), pain in the left leg (r = 14.675, $p<0.05$) and right foot (r = 22.234). These results indicated that when respondents are forced to stand with disproportionate foot position and unsupported due to uneven surfaces such as rocky surface or muddy surfaces. Based on an article from Leonard (2018), where people who pronate their feet deeply will cause the outside of the heel to contact to the surface to level up with too much while for those who do not supinate their feet into enough will put pressure on the ankle and cause ankles to rush out, and then cause injury.

The last risk factor is manually weight lifting. This factor had significance with upper back pain (r = 12.893, $p<0.05$), left shoulder pain (r = 29.128, $p<0.05$), lower back pain (r = 12.752, $p<0.05$) and right back (r = 19.019, $p<0.05$) left (r = 20.382, $p<0.05$) and right foot (r = 26.183, $p<0.05$). This is quite common in the construction industry where respondents are constantly lifting heavy construction materials such as formworks or reinforcement bars. A 32 mm diameter reinforcement bars measuring 3 meters in length has a weight of at least 6 kilograms. Apart from bar benders who often lifts and carry reinforcement bars, it was observed that general workers are also often exposed to manual lifting. Gagne (2011), states the manual handling tasks involves some ergonomic hazards.

Table 3 Summary of physical symptoms

Body Parts	Frequency (Percentage)								
	Uncomfor -table	Pain	Very Painful	None	Rarely	Some-times	Frequen t	Always	None
Neck	4 (2.6)	14 (9.3)	0	133 (88.1)	5 (3.3)	12 (7.9)	0	12 (7.9)	122 (80.8)
Upper back	0	6 (4)	0	145 (96)	0	5 (3.3)	1 (0.7)	0	145 (96)
Left shoulder	1 (0.7)	12 (7.9)	4 (2.6)	134 (88.7)	0	14 (9.3)	3 (2)	0	134 (88.7)
Right shoulder	13 (8.6)	3 (2)	135 (89.4)	0	14 (9.3)	1 (0.7)	0	136 (90.1)	0
Elbow /left arm	3 (2)	6 (4)	2 (1.3)	140 (92.7)	2 (1.3)	8 (5.3)	0	0	141 (93.4)
Elbow/right arm	2 (1.3)	8 (5.3)	1 (0.7)	140 (92.7)	1 (0.7)	9 (6)	1 (0.7)	0	140 (92.7)
Left wrist /hand	3 (2)	10 (6.6)	0	138 (91.4)	1 (0.7)	10 (6.6)	0	0	140 (92.7)
Right wrist /hand	0	11 (7.3)	1 (0.7)	139 (92.1)	0	11 (7.3)	1 (0.7)	0	139 (92.1)
Lower back	2 (1.3)	34 (22.5)	1 (0.7)	114 (75.5)	1 (0.7)	37 (24.5)	3 (2)	0	110 (72.8)
Left hip/ thigh/ buttock	0	8 (5.3)	0	143 (94.7)	2 (1.3)	6 (4)	1 (0.7)	0	142 (94)
Right hip/ thigh/ buttock	0	11 (7.3)	0	140 (92.7)	3 (2)	8 (5.3)	0	0	140 (92.7)
Left knee	2 (1.3)	20 (13.2)	1 (0.7)	128 (84.8)	4 (2.6)	18 (11.9)	1 (0.7)	0	128 (84.8)
Right knee	2 (1.3)	21 (13.9)	0	128 (84.8)	0	22 (14.6)	1 (0.7)	0	128 (84.8)
Left ankle/ leg	4 (2.6)	15 (9.9)	0	132 (87.4)	3 (2)	15 (9.9)	1 (0.7)	0	132 (87.4)
Right ankle/ leg	4 (2.6)	17 (11.3)	0	130 (86.1)	1 (0.7)	19 (12.6)	1 (0.7)	0	130 (86.1)

CONCLUSION

From the study, parts of the construction worker's body which has the highest level of pain and discomfort was the lower back where 34 (22.5%) respondents complained of pain and 37 (24.5%) complained of discomfort. The correlation between socio-demographic factors and physical symptoms score of body pain where factors such as citizenship (r = 29.395, p<0.05), working hours (r = 54.971, p<0.05) and rest hours (r = 73.991, p<0.05), temperature at workplace (r = 37.038, p<0.05) and pain in the last 6 months (r = 72.574, p<0.05) and experienced injury (r = 37.057, p<0.05) had relationship with the body pain on construction workers. The relationship between the ergonomic risk factors in construction site with the employees' body pain, the upper back and lower back had the most significant with physical risk exposures. Hence, appropriate control measures can be implemented in line with the findings of this study.

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COMPETING INTERESTS

There is no conflict of interest.

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