International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075, Volume-8 Issue-7, May, 2019

Risk Factors of Low Back Pain Amongst Port Crane Operator in Malaysia

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Abstract: Low back pain was reported as the main case for the musculoskeletal disorder among port crane operators. This paper investigated the risk factors of LBP and identified the root causes of low back pain amongst port crane operator in Malaysia. Modified Nordic questionnaire, structured interviews with four quay crane operators, direct vibration measurement were used to collect the data. Then, the data were analysed using SPSS version 14 and ergonomics assessment named Rapid Upper Limb Assessment (RULA). From the results, univariate analysis indicated that there was significant association between duration of exposure with low back pain ($p < 0.001$). Binomial logistic regression showed that those operators who were exposed to current working conditions of more than 5 years were 7 times more likely to stop work due to low back pain. However, there was no significant association found between characteristics and low back pain. Combination effect of long term exposure to whole-body vibration and postural stress might increase the risk of low back pain. In conclusion, operators of quay crane are at risk of having low back pain due to the exposure of working conditions. The findings may help port crane operators to improve their awareness on risk of low back pain.

Index Terms*: *Musculoskeletal Disorder (MSD), Low back pain (LBP), port crane operator, Whole-Body Vibration (WBV)

I. INTRODUCTION

Ergonomics or Human Factors is a field of discipline in designing or arranging workstations or equipment so that they match or fit the workers with the objective of improving the performance of systems by improving human machine interaction [1]. Thus, ergonomics is used to reduce or eliminate work related injuries such as musculoskeletal disorder (MSD) which affected many workers in various sectors. According to Social Security Organization (SOCSO) of Malaysia [2], there were only 161 cases related to MSD that were reported in 2009. The reported cases increased to 238 in 2010 [3], 268 in 2011 [4], 449 in 2012 [5], 517 in 2013 [6] and 675 in 2014 [7] respectively. In 2015 [8], there were 708 cases reported to them which indicate an increase of 340% from 2009 to 2015.

Revised Manuscript Received on April 10, 2019.

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The trend of increased cases each year triggers an alarm not only to SOCSO but also to the industries involved where in 2016 [9], 1006 cases reported while in 2017, 1354 cases reported that indicate more than 8 times increase since 2009. This condition is indicated that the problem of MSD is become serious among workers. Even though quay cranes have long been used in logistic operations in ports in Malaysia, there is a lack of attention given to how to improve MSD issues especially LBP among the operators. This study can demonstrate the right method in order to assess the problem and find the root causes. Furthermore, the findings will provide the industries with information to improve LBP and address the key risk factors in maintaining a safe work environment.

II. METHODOLOGY

A. General methodology

Methodology can be divided into three steps; data collection and data analysis and triangulation of data. Data was collected using a set of questionnaires, interviews, ergonomics measurement and vibration measurement. All the information from the questionnaire were analysed using Statistical Package for the Social Sciences (SPSS). At first, demographic data was established to give an overview of the population. Then, to find the association between risk factor and symptoms, Pearson chi-square was used. At last, binomial logistic regression test was applied to find the prevalence of factors toward symptoms. This study used a modified Nordic questionnaire in order to find the root cause of these ergonomic issues for the crane operator, which was then distributed to all quay crane operators in ports of Southern Malaysia. Detailed interviews were completed to select operators to enhance the result of the questionnaire. Then, ergonomics during operation was assessed using the established Rapid Upper Limb Assessment (RULA) checklist. Vibrations were measured to find the actual whole-body vibration inside the cabin during operation.

B. Questionnaire

Prior to designing the questionnaire, information related to the study needs to be gathered. The gathered information is crucial to ensure that this study will produce a reliable result. Modification was done to the Nordic questionnaire to suit the purpose of this study. The questionnaire was translated into the Malay language as most of the operators are local and have better literacy in Malay. The modified Nordic Questionnaire consists of

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35 questions in four sections including demography, MSD of each part of the body, assessment of low back pain as well as working conditions and environment. In order to address the problem of MSD correctly, some input was gathered from experts from DOSH, NIOSH and an Occupational Health Doctor. Pilot test was done to 10% of total respondents and feedback received was used to improve the questionnaire. A total of 143 respondents participated in the full survey.

C. Interview

Interview sessions provide an alternative way of expressing the problem. Participants are far more likely to release important data when they have formed some rapport with the researcher during interview sessions[1]. Number of samples was based on result saturation. Respondents with at least 5 years of experience in that specific job were selected, as the effect of the working environment towards the workers is more significant above this period[2]. A total of 4 respondents participated. They have experience as crane operators in the port industry ranging from 6 to 30 years.

D. Rapid Upper Limb Assessment (RULA)

RULA is an established ergonomic checklist created by McAtamney, and Corlett [20] and since then has been used by many safety practitioners to evaluate ergonomics at the workplace. RULA focuses on upper limbs and provides a simpler observational method. A total of 3 direct observations with different operators were done at workstations during operation. For posture, RULA measured the position of arm, wrist, neck, and trunk which included the angle of those body parts. All those positions were given points accordingly. Aside from posture, RULA also took into account, the muscle used, whether static or repetitive. All those points were then calculated and summarized according to RULA weighting system. Numbers of observations needed were based on result saturation.

E. Vibration Measurement

Vibration measurements at quay cranes were done using a dose meter from Larson Davis model HVM 100. The duration of measurement should be sufficient to ensure reasonable statistical precision[13]. This equipment was calibrated in a vibration lab prior to actual measurement. This HVM 100 comes with various types of accelerometers and a range of applications. For whole body vibration measurement, sensor type SEN027 integrated with a seat adapter was used. HVM 100 calculated weighted r.m.s acceleration and vibration dose value according to ISO 2631-1 requirements. Vibration data collected from dose meter were analysed using Blaze software (version 6.1.1). This enabled us to look into a detail breakdown of the data and to initiate further tasks such as combination or comparison of data. Those data were analysed for their mean and standard deviation. Daily Exposure Value (A(8)) and Value Dose Vibration (VDV) were two methods that were included in this study.

III. ANALYSIS AND RESULTS

This section is explained on the analysis and results based on the methodology described in Section II.

A. Descriptive results

A total of 143 respondents participated in this study which makes the response rate of 51.07% out of total targeted operators of quay crane in Johor. Reliability test using Cronbach's alpha gave value of $\alpha = 0.7$ to 0.9, which indicate that internal consistency was acceptable.

Table 1 shows the characteristic of the respondents. Average age was 36.86 years with the standard deviation (SD) 8.16. Most of the operators were overweight with average Body Mass Index (BMI) 27 and SD 5.2. 62.2 % of them stated that they do sports activities and 67.8% are smokers. Only 27 respondents (18.9%) indicated that they have been involved in an accident related to low back either at work or at home. Genetic issues related to low back was claimed by 6 respondents (4.2). Majority of the operators (79.7 %) have been exposed to this job for more than 5 years.

Table 1: Characteristic of respondent

Characteristic (n = 143)	n or Mean / SD
Age (years)	36.86 (8.16)
Height (cm)	168.76 (10.6)
Weight (Kg)	76.46 (13.7)
Body Mass Index	27 (5.2)
Doing Sports Activities	89 (62.2 %)
Smoking	97 (67.8 %)
Married	118 (80.4 %)
Working hours per week	48.6 (8.07)
Previous Trauma related to LBP	27 (18.9 %)
Genetics of LBP	6 (4.2 %)
Current job years of exposure	
< 5 years	29 (20.3 %)
> 5 years	114 (79.7 %)

To find the association between risk factors and symptoms, Pearson chi-square was used. Based on the findings, there were significant association found between years of exposure, BMI, marital status, previous trauma, ergonomics knowledge and posture with symptoms. Those who were exposed for more than 5 years were significantly associated with lower back pain ($p < 0.001$). Upper back pain was significantly related to BMI ($p < 0.001$) and marital status. ($p < 0.017$). Those who had previously been involved in an accident related to low back suffered from thigh ($p < 0.026$) and ankle/feet ($p < 0.038$) pain. Aside from years of exposure, lower back pain was also significantly associated with knowledge of ergonomics ($p < 0.035$), long hours of sitting ($p < 0.001$) and trunk bending ($p < 0.001$). Upper back pain was also significantly related to long hours of sitting ($p < 0.027$) and trunk bending ($p < 0.004$). The shoulder part was strongly associated with long hours of sitting ($p < 0.01$) and trunk bending ($p < 0.043$), while the neck was

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significantly associated with trunk bending ($p < 0.027$) and trunk twisting ($p < 0.008$). To find the prevalence of factors toward symptoms, the binomial logistic regression test was applied. Table 2 summarized the result of the probability test.

Table 2: Prevalence ratio of LBP

[a] Chi-square test: ($p < 0.001$)

Operators who were above 40 years old were less likely to suffer from low back pain when compared to younger age operators. Those who have worked for more than 5 years were 7 times ($p < 0.001$) more likely to stop work due to LBP and around 6 times more likely ($p < 0.001$) to suffer LBP within 7 days if compared to operators who have worked less than 5 years. The 12 months and 7 days LBP prevalence tended to decrease with increase of body mass index (BMI). Operators who did

Factor	12 months LBP prevalence 7 days LBP prevalence (work stop)			
	PR	95%CI	PR	95%CI
Age				
<30	1		1	
31-40	3.123	0.257-38.01	0.95	0.045-20.21
>40	0.775	0.162-3.7	0.28	0.029-2.654
Years of Exposure				
1-5	1[a]		1[a]	
>5	7.197	1.592-32.536	5.818	1.126-30.072
BMI				
<25	1		1	
25-30	0.757	0.179-3.208	0.614	0.122-3.096
>30	0.483	0.093-2.5	0.455	0.069-3.010
Sports Activity				
No	1		1	
Yes	0.884	0.259-3.015	0.383	0.082-1.785
Smoking				
No	1		1	
Yes	3.221	0.883-11.744	3.34	0.74-15.07
Marital				
No	1		1	
Yes	0.619	0.098-3.919	0.542	0.078-3.788
Previous Trauma				
No	1		1	
Yes	0.550	0.062-4.829	0.451	0.0531-3.980

sport activities suffered lower LBP during last 12 months and 7 days. High prevalence ratios for LBP during last 12 months (*PR*: 3.221; 95% *CI*: 0.883-11.744) and 7 days (*PR*: 3.34; 95% *CI*: 0.74-15.07) were observed in those operators who smoke.

B. Whole Body Vibration

WBV was measured at 4 quay cranes according to ISO 2631-1 (1997) requirements. Daily Exposure Vibration (A(8)) was calculated according to EU Good Practices Guide for WBV. Tables 3.1 and 3.2 summarize the vibration results.

Table 3.1: Weighted acceleration value, mean (SD)

Quay Crane	a_x (m/s^2)	a_y (m/s^2)	a_z (m/s^2)	a_v (m/s^2)	Remark
QC-5	0.21 (0.07)	0.12 (0.03)	0.25 (0.1)	0.38 (0.07)	Double boom
QC-4	0.35 (0.05)	0.16 (0.05)	0.21 (0.07)	0.50 (0.08)	Single boom
QC-8	0.28 (0.03)	0.20 (0.04)	0.30 (0.04)	0.51 (0.05)	Single boom
QC-1	0.20 (0.04)	0.09 (0.03)	0.18 (0.05)	0.32 (0.07)	Double boom

Table 3.2: Daily exposure A(8)

Quay Crane	$A_x(8)$ (m/s^2)	$A_y(8)$ m/s^2)	$A_z(8)$ (m/s^2)	A(8) (m/s^2)
QC-5	0.25	0.15	0.22	0.25
QC-4	0.42	0.19	0.18	0.42
QC-8	0.34	0.24	0.26	0.34
QC-1	0.24	0.11	0.16	0.24

Range of sum Root Mean Square (RMS) measured was 0.32 m/s^2 to 0.51 m/s^2. Daily exposure values measured were 0.24 m/s^2 to 0.42 m/s^2. Single type boom gave higher values, thus vibrates more if compared to double type boom. Vibration Dose Value (VDV) is another method to identify the severity of WBV experienced by the operators. Unlike RMS weighted value, VDV will indicate any shock or jerking during work. Table 4.1 and 4.2 summarizes the VDV measurement.

Table 4.1: Value dose vibration

Quay Crane	VDV_x ($m/s^{1.75}$)	VDV_y ($m/s^{1.75}$)	VDV_z ($m/s^{1.75}$)	VDV_{total} ($m/s^{1.75}$)
QC-5	1.94	1.11	1.95	2.52
QC-4	2.7	1.79	2.06	3.28
QC-8	2.33	1.68	2.4	3.26
QC-1	1.66	1.18	1.78	2.26

Table 4.2: Daily exposure VDV

Quay Crane	VDV_x ($m/s^{1.75}$)	VDV_y ($m/s^{1.75}$)	VDV_z ($m/s^{1.75}$)	Daily VDV_{exp} ($m/s^{1.75}$)
QC-5	5.06	2.89	3.62	5.06
QC-4	7.04	4.66	3.83	7.04
QC-8	6.07	4.38	4.47	6.07
QC-1	4.33	3.07	3.31	4.33

VDV_{total} measured were from 2.26 $m/s^{1.75}$ to 3.28 $m/s^{1.75}$. Highest daily VDV_{exp} was 7.04 $m/s^{1.75}$, measured at QC-4 and the lowest daily VDV was 4.33 $m/s^{1.75}$ at QC-1. QC-4 and QC-8 produced higher daily VDV_{exp}, which indicates that they jerk more during operation.

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C. Interview

Interviews have been done with 4 operators using a set of structured questions. All the operators that were involved in this interview session have been exposed for more than 5 years to their working environment. Standard daily working time is 6 hours with extra 4 hours if they are doing overtime. Typically, overtime is scheduled 3 days per week per operator. The management has set out the target for each operator to process at least 22 containers per hour and if they manage to get more, extra incentive will be given. The operators claimed that they frequently bend their trunk during operation, influenced by their characteristics and surrounding conditions. None of them had been involved in any accident or surgery related to LBP. Only one operator stated that he was doing heavy lifting at home but not frequently. Most of them have weak to little knowledge of ergonomics. All of them were experiencing LBP and one operator stated that he was wearing a back support belt to reduce the pain.

D. Rapid Upper Limb Assessment (RULA)

Assessment using RULA checklist has been done 3 times with different cranes and operators. Assessment gave a Final score of 5 to 6. According to RULA guideline all three operators were in a group (score 5-6) that needs to be further investigated and change.

IV. DISCUSSION

In this study, LBP was the highest reported problem among quay crane operators. Lower back, upper back, shoulder and neck pain accumulated to 65% of total MSD count. Significant association was also found between years of exposure to LBP. Those operators who have been exposed for more than 5 years were more likely to experience LBP ($p < 0.001$). Prevalence ratio also indicated that this group was 7 times more likely to be associated with LBP compared to the operators who have less than 5 years of exposure. This finding is consistent with a study done in Netherlands by Bongers et al., [11] at port crane operator. The study indicated that more disability due to back trouble was observed among crane operators with more than 5 years of exposure to vibration. Bongers et al., [12] also stated that risk ratio for disability pension due to disease of the intervertebral disc for crane operators with more than 5 years of exposure was almost 3 times compared to the control group. A study by Burdorf and Zondervan [13] at crane operator in steel factory showed that 61% workers who were exposed to vibration reported LBP when compared to 27 % in the control group. According to Kadir et al. [14] who did a survey at port crane operator, the association between years of experience towards LBP was significant. Zimmerman et al. [15] in a study related to operating engineer, concluded that long-term exposure to WBV causes morphological changes in the lumbar spine. Many of the researchers [16, 17, 18, 19, 20], however used control groups to observe the differences between those who are exposed to risk factors and those who were not. Aside from duration of exposure, postures which are long hours of sitting ($p < 0.001$) and trunk bending ($p < 0.001$) were also found to be significantly associated with LBP. This is aligned with the study from Courtney and Evans [21] which concluded that static loading of the trunk and neck contributed to the various aches and pains experienced by the drivers. Bovenzi et al. [22] in a study in Italy stated that significant associations were observed between the various time-related LBP and occupation, cumulative vibration exposure, and perceived postural load. Kadir et al. [14] in the same study also concluded that there was a significant influence of awkward job history towards the LBP problem.

Characteristic factors such as age, BMI, marital status, smoking, sports, genetics or previous trauma were not found to be significantly associated to LBP. This finding is consistent with a previous study done by Bovenzi et al. [22] which stated that there was no clear association between lifetime LBP and age. The period prevalence of LBP was not found to be related to some individual characteristics such as smoking habits, education, marital status and sports activity. This however contradicted with the finding from Kadir et al. [14] which emphasized that age was significantly associated with LBP. Prevalence ratio using binomial logistic regression indicated that those operators who were above 40 years were less likely to have LBP compared to a younger age group. This finding is almost similar to a study in India by Krishna et al. [23] at crane operator in a steel plant, which indicated that the risk of MSD occurrences was the lowest for the workers older than age 45 years. Boshuizen et al. [24] in a study also found that younger drivers (< 35 years) reported higher prevalence of back pain compared to the older drivers. This may, to some extent, be due to older operators being more cautious when doing their job.

Daily vibration exposure value A(8) measured were $0.24\ m/s^2$ to $0.42\ m/s^2$ and daily VDV exposure measured were $4.33\ m/s^{1.75}$ to $7\ m/s^{1.75}$. These values have not yet exceeded the daily exposure action limit set out by EN2002/44/EC which are $A(8) = 0.5\ m/s^2$ and $VDV(daily) = 9.1\ m/s^{1.75}$. However, Bongers et al., [12] concluded that exposure to vibration with acceleration levels ranging from $0.2\ m/s^2$ to $1\ m/s^2$ is at least partly responsible for serious back disorder. Another study by Bovenzi and Betta [25] in a population of 1155 tractor drivers who were exposed to WBV showed that duration of exposure was associated more with LBP compared with the vibration exposure magnitude alone. Due to the nature of this job, prolonged sitting is part of the routine as the operator needs to be at the workstation for 6 hours per shift. Other than that, slight trunk bending is required in order for the operators to clearly see the spreader at the bottom of the quay crane. The combination exposure of both WBV and postural stress could increase the effect of LBP. A review of 45 health studies by Wikstroem et al., [26] concluded that there is a higher risk of injuries in the lower back when WBV is combined with unsuitable postures and prolonged sitting without pauses. Bovenzi et al., [27] concluded that seated WBV exposure combined with non-neutral trunk postures is associated with an increased risk of long term lower back disorder.

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V. CONCLUSION

This study was done to identify risk factors for LBP among quay crane operators in Malaysia. Even though quay crane has long been used, awareness of reducing the LBP among workers and the administration was still low. Aside from finding the risk factors, this paper aims to provide input on managing LBP. This survey was used as a main tool to find the risks, supported by vibration measurement, interviews and ergonomics assessment. It can be concluded that the duration of exposure, prolonged sitting and trunk forward bending were found to be significantly associated with LBP. New retrofitted cabins gave the lowest WBV value and single girder type of crane produced higher WBV value compared to the double girder type. This gives an answer to low back pain issues amongst port/quay crane operators. Therefore, the findings may give insight to port management and operators to improve the crane work station.

ACKNOWLEDGMENT

The authors thanks to personnel who were involved in this study especially port crane operators in selected area in Johor. We would also like to thank expertise from Department of Occupational Safety and Health and National Institute of Occupational Safety and Health for their input in completing this study.

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