Musculoskeletal Discomfort Evaluation using Quick Exposure Check (QEC) among Tower Crane Operators

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Abstract. Tower crane operators are at risk of developing Musculoskeletal Disorders (MSD) due to work schedules that require prolonged sitting with minimal movements. The aim of this study was to assess the discomfort levels associated with the musculoskeletal disorder and its severity on affected human body areas of tower crane operators while driving and handling of materials. This study was conducted amongst 32 tower crane operators at the construction sites of a high-rise building in Klang Valley. A Quick Exposure Check (QEC) was used to assess the MSDs levels and the affected severity on human body areas. The results from the QEC showed the body parts that were associated with a very high risk of MSDs were the back and neck. Other factors contributed to the high risk of MSDs among tower crane operators were identified as driving and vibration. MSDs among tower crane operators were evident from the QEC analysis. Therefore, it is essential to include ergonomic intervention in the workplace in order to minimize the risk.

1. Introduction

MSDs are conditions that can affect muscles, bones, and joints [1]. MSDs normally affect any musculoskeletal system such as neck, shoulder, wrist, back, hips, legs, knees, and feet. Example of activities that could affect the musculoskeletal system are long sitting in the same position, repetitive movements and lifting of heavy materials.

A tower crane is an indispensable facility in construction sites of high-rise building [2]. It was used for transporting construction supplies and heavy materials to places over 20 to 400-metre-high from the ground. The crane operator was reported one of the sectors that have a higher risk of developing back and lower limb disorders [3]. It was followed by truck drivers, warehouse workers, airplane baggage handlers, construction trades, patient care workers and other large vehicle operators. The tower crane operators are at risk of developing musculoskeletal discomfort because of static or constrained body position, frequency of repetitive movement and concentrated force on small body parts such as hand or wrist and also the work pace [4, 5].

Generally, the tower crane operators were exposed to the neck, hip, upper and lower back of MSDs [6]. A study of tower crane operators in Iran found a high prevalence of musculoskeletal symptoms among the workers [7]. The study reported a majority of the operators disclosed some disorders in one or more parts of the body particularly on the lower back and neck area. Other studies on the crane operators have also recorded similar finding where 42% of operators were observed to suffer from neck pain [8] and 78% of the operators suffered pain at lower back, neck and shoulder [9]. In addition, approximately 70% of crane operators experience discomfort resulting from a bent forward sitting position, which was necessary to keep the payloads in view while executing lifts close to or directly below the operator's cabin [10]. Furthermore, the rubber-tired gantry crane operators were highly liable

to MSDs due to awkward posture, long duration of the working hours, vibration and repeated or continuing of wrist force to handle joysticks [11, 12]. Psychosocial factors such as work shift and project deadline also found contributed to MSDs [13].

To date, there were various ergonomic tools such as QEC, ANOVA, NMQ, body discomfort map, REBA, and RULA that were used to identify the related MSDs factors among workers. in various industries such as sewing machine, rubber production, road building industry, electronic manufacturing, bumper tape-masking and oil palm harvesting. However, many studies suggested QEC was the most reliable tool to assess the workers' exposure to work-related musculoskeletal risk factors [14-17]. QEC developed by [18], is an observational tool developed for Occupational Safety and Health (OSH) practitioners to assess exposure to risks for Work-related Musculoskeletal Disorders (WMSD). It was used to provide a basis for ergonomic interventions. The checklist in QEC assesses the extent of exposure of the four main body areas to identify risk factors contributed to WMSDs. QEC covers many risk factors such as posture, load/force, movement/ frequency, duration, vibration, and others.

Therefore, the aim of this study was to assess the discomfort levels associated with the musculoskeletal disorder and its severity on affected human body areas of tower crane operators while driving and handling of materials using QEC measures.

2. Materials and Methods

The study participants comprised of 32 tower crane operators from eight construction sites in the Klang Valley. The participants were all competent and certified by the Department of Occupational Safety and Health. All participants were informed on the purpose of the study and completed the consent form before participating. All interviews were carried out either before beginning of their work, during lunch time or after working hours.

2.1. Participants

Table 1 summarizes the demographic information of 32 tower crane operators participated in this study.

Table 1. Tower crane operators demographic.

	Mean	Std. deviation
Age (years)	35.9	9.4
Working hour	11.8	4.6
Year of experience (years)	8.1	7.4

2.2. Data Collection

Data were collected through an interview which consisted of two parts. The first part of the questionnaire was on the demographic information and the second part was an assessment of musculoskeletal disorders risk among the tower crane operators by using a standardized tool known as QEC. This questionnaire involves both the practitioner (observer) and the workers (who have direct experience of performing the job) in conducting the assessment and identifying possibilities for change.

After the data score for section in the QEC was collected, the risk factor variables were tabulated to represent the level of MSD risk as outlined in Table 2. The exposure scores was categorized into four exposure levels stated as "low" , "moderate", "high" and "very high."

Table 2. Interpretation of QEC score [17]

	Exposure level			
Score	Low	Moderate	High	Very High
Back (static)	8-15	16-22	23-29	29-40
Back (moving)	10-20	21-30	31-40	41-56
Shoulder /Arm	10-20	21-30	31-40	41-56
Wrist / Hand	10-20	21-30	31-40	41-56
Neck	4-6	8-10	12-14	16-18
Driving	1	4	9	-
Vibration	1	4	9	-
Work Pace	1	4	9	-
Stress	1	4	9	16

3. Results and Discussion

Figure 1 shows the result of the QEC for MSD exposure risk among the tower crane operators for four main body areas namely back (static), shoulder, wrist band and neck. Shoulder was the only body parts recorded with a low-level risk of exposure scored of 28%. In the moderate exposure level category, back, shoulder and wrist were identified showing the score of 19%, 47% and 38% respectively. Interestingly, all four body parts were exposed to a high risk of MSD particularly on the wrist/hand with a score of 63% followed by the neck (38%), shoulder/arm (25%) and back (19%). Furthermore, both neck and back were categorized in the very high exposure level of MSD with value of 63%.

The results for other important MSD risk factors such as driving, vibration, work pace and stress is shown in Figure 2. Stress and work pace were found to be in the moderate risk category with a percentage of 66% and 44% respectively. However, majority of the tower crane operators were in a high-risk category due to driving and vibration with the score of 63% and 59% respectively. The overall results of this study demonstrated an increased risk of developing MSD among the tower crane operators due to working conditions and environment.

Our results in this study was comparable with other reported study where neck and lower back of crane operators were reported to have a MSD score of more than 60% [19]. In addition, a similar finding amongst the ready garment workers was also reported in [20]. The study found that 40–60% of operators within 12-month prevalence were having lower back pain (LBP) [20]. Furthermore, a cross-sectional study conducted in Italy shows that approximately 40% of crane operators working in the port of Venice had an overall prevalence of disorders in the lumbar spine [22]. Other studies [14, 23, 24] also recorded a high prevalence of LBF among drivers due to confined space, long working hour, limited movement and exposure of vibration. Therefore, intervention strategies to reduce the MSDs risk which include reducing the duration of exposure to the risk factors, such as vibration and static sitting is required.

The limitation of this study was small sample size due to limited project area which involves high rise building. It is highly suggested that the number of respondents should be greater in order to obtain a more significant and reliable result. Another limitation was time constraint to observe the work posture and interview amongst tower crane operators because the tower crane operators cannot be disrupted during the working hours as it has impact on the project progress. In addition, data and information of the medical leave related to MSDs was not able to be compiled because the tower crane operators belong to the outsourced companies. Adopting QEC has its limitation too since it is only be able to evaluate the upper body parts namely back, shoulder, wrist/ arm, and neck. Therefore, other ergonomics assessment tools that cover the entire body parts are essential to give a better result of MSDs of an individual crane operator.

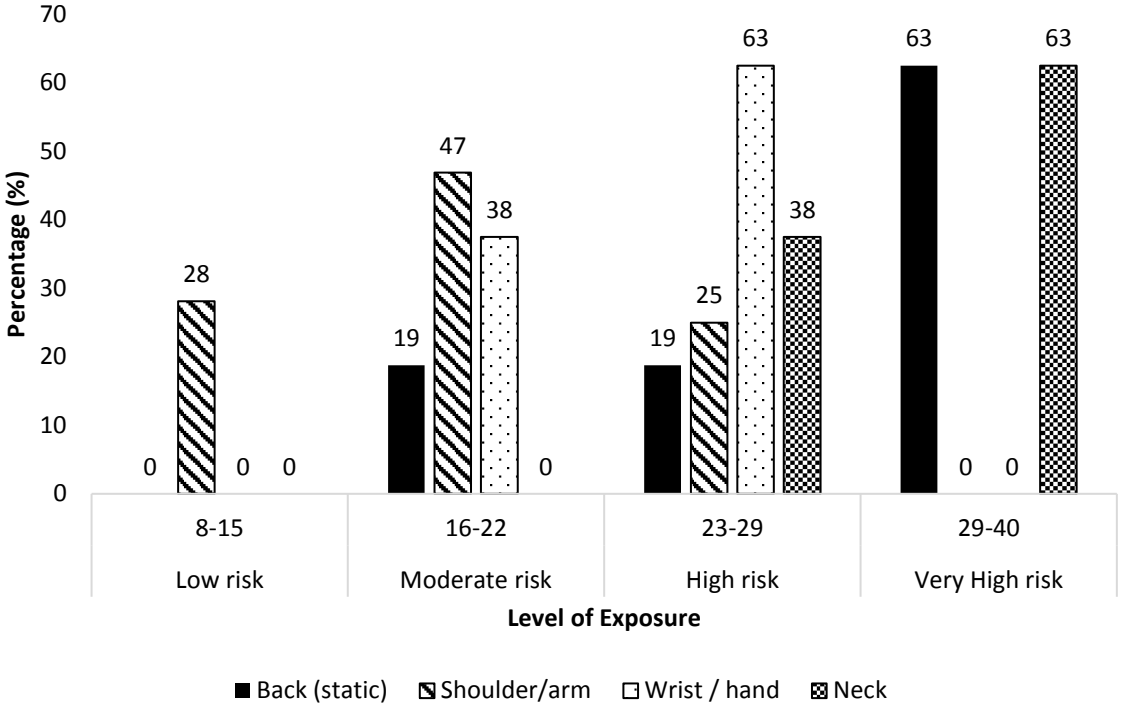

Figure 1. QEC Exposure level and percentage for back, shoulder, wrist, and neck.

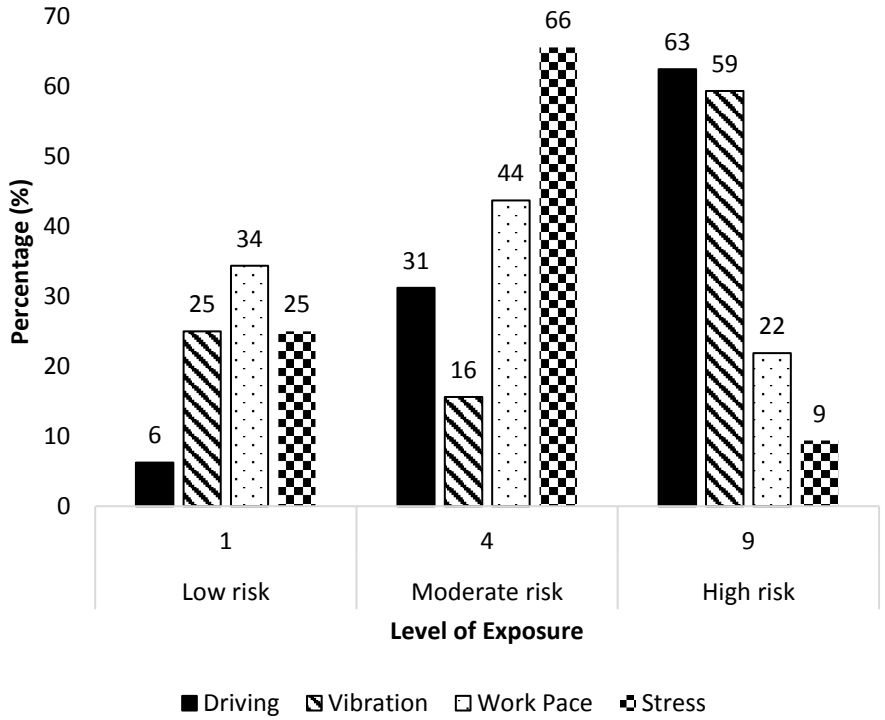

Figure 2. QEC Exposure level and percentage for driving, vibration, work pace and stress.

4. Conclusion

This study was conducted to assess the musculoskeletal discomfort amongst the tower crane operators during the driving and handling of materials of high-rise construction building. The body parts that were

associated with a very high risk category of MSDs were the back and neck whereas the high risks for other factors were driving, vibration and stress. In order to minimize the occupational exposure to work-related musculoskeletal discomfort among the tower crane workers, an ergonomic intervention and control measures are essential.

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References

[1] Perruccio, A.V., Yip, C., Power, J.D., Canizares, M. and Badley, E.M., 2019. Discordance Between Population Impact of Musculoskeletal Disorders and Scientific Representation: A Bibliometric Study. *Arthritis care & research*, **71**(1), pp.56-60.
[2] Abdelmegid, M. A., Shawki, K. M., & Abdel-Khalek, H. 2015. GA optimization model for solving tower crane location problem in construction sites. *Alexandria Engineering Journal*, **54**(3), 519-526.
[3] Gustafson-Söderman, U. (1987). The effect of an adjustable sitting angle on the perceived discomfort from the back and neck-shoulder regions in building crane operators. Applied ergonomics, 18(4), 297-304.
[4] Health and Safety Security (HSE) (2006). Sector Information Minute: 05/2002/58.
[5] Health and Safety Executive (2017). Work-related Musculoskeletal Disorders (WRMSDs) Statistics in Great Britain.
[6] Punnett, L., & Wegman, D. H. (2004). Work-related musculoskeletal disorders: the epidemiologic evidence and the debate. Journal of electromyography and kinesiology, 14(1), 13-23.
[7] Darabad, M. N., Mazloumi, A., Saraji, G. N., Afshari, D., & Foroushani, A. R. (2017). Full shift assessment of back and head postures in overhead crane operators with and without symptoms. *Journal of occupational health*, **17**-0065.
[8] Burdorf, A., & Zondervan, H. (1990). An epidemiological study of low-back pain in crane operators. *Ergonomics*, **33**(8), 981-987.
[9] Krishna, O. B., Maiti, J., Ray, P. K., & Mandal, S. (2015). Assessment of risk of musculoskeletal disorders among crane operators in a steel plant: A data mining–based Analysis. Human Factors and Ergonomics in Manufacturing & Service Industries, 25(5), 559-572.
[10] Lis, A. M., Black, K. M., Korn, H., & Nordin, M. (2007). Association between sitting and occupational LBP. *European Spine Journal*, **16**(2), 283-298.
[11] Carlos, M. C., & Lucero, H. J. (2012). Risk assessment of the job tasks for heavy equipment operators. Risk Analysis VIII, 1(167), 115-26.
[12] Kadir, A., Mohammad R., Othman, N., (2015). Low Back Pain Problem amongst Port Crane Operator. Journal of Advanced Study in Applied Sciences and Engineering Technology. ISSN (online): 2462-1943 | Vol. 1, No. 1. Pages 13-26.
[13] Deeney, C., & O'Sullivan, L. (2009). Work related psychosocial risks and musculoskeletal disorders: potential risk factors, causation and evaluation methods. Work, 34(2), 239-248.
[14] Yasobant, S., Chandran, M., & Reddy, E. M. (2015). Are bus drivers at an increased risk for developing musculoskeletal disorders. An ergonomic risk assessment study. J Ergonom, 2015.
[15] Ericsson, P., Björklund, M., & Wahlström, J. (2012). Exposure assessment in different occupational groups at a hospital using Quick Exposure Check (QEC)–A pilot study. Work, 41(Supplement 1), 5718-5720.
[16] Farhadi, R., Omidi, L., Balabandi, S., Barzegar, S., Abbasi, A. M., Poornajaf, A. H., & Karchani, M. (2014). Investigation of musculoskeletal disorders and its relevant factors using quick exposure check (QEC) method among seymareh hydropower plant workers. Journal of Research & Health, 4(2), 714-20.
[17] Erdinc, O., & Vayvay, O. (2008). Ergonomics interventions improve quality in manufacturing: a case study. International Journal of Industrial and Systems Engineering, 3(6), 727-745.

[18] David, G., Woods, V., Li, G., & Buckle, P. (2008). The development of the Quick Exposure Check (QEC) for assessing exposure to risk factors for work-related musculoskeletal disorders. Applied ergonomics, 39(1), 57-69.
[19] Muthukumar, K et al. (2018). Study on Discomfort in Mobile Crane Operation. International Research Journal of Engineering and Technology (IRJET). Volume: 04 Issue: 12
[20] Hossain, M. D., Aftab, A., Al Imam, M. H., Mahmud, I., Chowdhury, I. A., Kabir, R. I., & Sarker, M. (2018). Prevalence of work-related musculoskeletal disorders (WMSDs) and ergonomic risk assessment among readymade garment workers of Bangladesh: A cross sectional study. PloS one, 13(7), e0200122.
[21] Bovenzi, M., Pinto, I., & Stacchini, N. (2002). Low back pain in port machinery operators. Journal of sound and vibration, 253(1), 3-20.
[22] Piccinni, S., Marchi, T., Lorusso, A., & Magarotto, G. (1992). The prevalence of spondylopathies among the crane operators in the port of Venice. La Medicina del lavoro, 83(2), 146-149.
[23] Hoy, J., Mubarak, N., Nelson, S., De Landas, M. S., Magnusson, M., Okunribido, O., & Pope, M. (2005). Whole body vibration and posture as risk factors for low back pain among forklift truck drivers. Journal of Sound and Vibration, 284(3-5), 933-946.
[24] Chen, J. C., Chang, W. R., Chang, W., & Christiani, D. (2005). Occupational factors associated with low back pain in urban taxi drivers. Occupational medicine, 55(7), 535-540.