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Working Postures and Musculoskeletal Disorders Among Overhead Crane Operators in a Steel Industry

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Abstract

Background: Overhead crane operators work long hours in a confined space and often face ergonomic and physical risk factors. The main purpose of this study was to find a better understanding of the risk of MSDs in overhead crane operators.
Methods: This study was conducted in a steel industry. The Nordic musculoskeletal questionnaire (NMQ) was used to determine the prevalence of musculoskeletal disorders in overhead traveling crane operators. Moreover, the exposure level to musculoskeletal disorders in 2 crane models (A and B) was investigated using QEC (quick exposure check) method.
Results: Final results obtained from the NMQ revealed a high prevalence of musculoskeletal disorders in overhead crane operators, especially affecting the waist (83%) and the neck (71%). Moreover, final results obtained from posture evaluation indicated a significant difference between postures of the crane operators for the models of A and B. Level of exposure to the risk factors for the back was moderate and average for the A and B model cranes, respectively. However, the exposure level to the risk factors for the neck was high in both models, with the B model (score of 14), causing a higher level of exposure to risk factors compared with the A model (score of 12). Subjective perception of whole body vibration was at an average level, and the range of the operators work stress was found to be high.
Conclusions: Results of the study indicated that the prevalence of back and neck pain among the operators was high. Moreover, the main risk factors that were probable causes of this high level of prevalence were awkward posture and vibrations in the cabins.

Keywords: Musculoskeletal Disorders, Overhead Crane Operators, QEC

1. Background

Work-related musculoskeletal disorders (MSDs) include a wide range of inflammatory and muscle degeneration, nerves, ligatures, junctures and have a high loading on health and social care system. Usually, the lower region of the back and upper limbs, such as neck, shoulder, forearm, and hand, are parts of the body that are more exposed to work-related injuries (1-3). Low back disorders are the most common and most costly damages of work-related musculoskeletal disorders, imposing annual cost of over 100 billion dollars in the United States (4). During 1999 and 2004, a total of 572,508 individuals claimed for compensations related to musculoskeletal disorders and lost working days more than 7 days. Lumbar spine (34.1%), shoulder (30.6%), and neck spine (30.3%) were parts of the body that received the highest percentages in this field. Moreover, the highest cost for compensation claim was $8,750 for lumbar spine, $7,562 for neck spine, and $6668 for shoulder, respectively (5). The cost of cervical and upper limb disorders in the Nordic countries was estimated at around 2% to 5% of gross national product, and in the UK, the costs of upper limb disorders associated with work was estimated at around 1.25 billion pounds annually (6, 7). In 1995, about 4.2 million working days were lost due to musculoskeletal disorders in the upper limbs and neck (8).

In a recent study, Nourollahi et al. repoted the prevalence of musculoskeletal symptoms among overhead crane operators in Iran. Almost all operators reported some disorders in one or more regions of the body. The most frequently reported symptomatic erea was the low back, followed by the neck, with over 75% of the participants reporting that they had experienced pain in each erea within the previous 12 months or were currently experiencing discomfort (9).

Trunk movements including trunk flexion, repetitive rotations, severe bending to the sides, neck extension, and repetitive movement of the arm increase neck, shoulder, and back disorders (10). The physical load on the neck in a

sitting and bent forward position among overhead crane operators is 3 times higher than the sitting and resting position. The results of the Gustafson study showed that 33% of the elevations performed in a 10-week period required a forward-bending position (11).

In another study by Burdorf et al. in 1993, the prevalence of LBP in the last 12 months was 50% among crane operators and 44% among drivers. The results of posture assessment in the observational method showed that factors such as trunk flexion, lumbar spine, and ultimately abnormal posture in static sitting occupations are the main causes of increased physical load and increase the risk of low back pain (12). The results of Bongers et al. study conducted on crane operators (743 persons) and the control group (662 persons) for 10 years showed that the probability of receiving compensation due to paralysis caused by vertebral disc among crane operators was twice the control group and that crane operators with an exposure history of 5 to 15 years with whole body vibration and awkward posture had a higher risk of disability due to vertebral disc (13).

An ergonomic study, which was performed by Courtney et al. in 1999 to assess the workstation and design the work space of the crane's cabin, revealed that drivers used the front and lower window for downward viewing and load control, and this caused awkward postures including a flexion between 30° to 40° for the lumbar area and the flexion of 60° to 70° for the neck area (14). In general, according to past studies and many ergonomic problems among overhead crane operators, the present study was conducted to identify the ergonomic risk factors in 2 types of cranes, A with a fixed lever and B with moving levers, which are most used in steel industries.

2. Methods

Since the statistical society was 45 persons, and this number did not create time and cost constraint for the researcher, the total number of participants in the study was available and accessible to investigate. In this study, the criterion for entering the study was age 25 to 49 years and exclusion criterion was having a history of surgery in the limbs due to massive skeletal disorders.

Initially and before distributing the questionnaire, the provisions and objectives of the study were explained to each person, and information was collected upon the participants' consent. Participants' demographic characteristics including age, work experience, height, and weight were determined for 45 overhead crane operators in this study. For initial review of musculoskeletal disorders over the past 12 months, the Nordic questionnaire, which was confirmed in previous studies, was used in each of the 9 musculoskeletal systems (15). Therefore, 45 Nordic questionnaires were distributed to operators and they were asked to complete it.

QEC was used because this method considered many risk factors for poor ergonomics conditions in the workstations. The QEC approach includes a number of attractive features, such as the time spent for doing tasks, vibration, degree of tasks, visual demands, and workers response to the ergonomic conditions.

In this descriptive cross-sectional study, QEC method was used separately for both models of cranes (in 2 cranes with different designs) to determine the level of exposure to ergonomic risk factors, taking into account the existing risk factors. Then, the priority level of corrective action was determined for each model type and was compared with each other. Finally, the prevalence of musculoskeletal disorders obtained from the questionnaire was compared with the results of the QEC and the reports of the operators that were obtained through the interview. Due to the rotational performance of crane operators, it was not possible to separate the results of the Nordic questionnaire for the 2 overhead crane models.

All statistical analyses were performed using SPSS 22.0 (SPSS Inc., Chicago, IL, USA). The significance level was set at .05 (or equivalently, 5%). Two independent samples t test were used to assess ergonomic conditions for 2 types of cranes using QEC method.

3. Results

Table 1 demonstrates the demographic characteristics of the participants in this study. The average age of the participants was 30.54 $\pm$ 7.21 years. The average work experience of the participants was 5.98 $\pm$ 6.43 years. The prevalence of musculoskeletal disorders in 9 body regions was determined among the overhead crane operators based on the results of the Nordic questionnaire (Table 2). The highest prevalence rate was in the lower back (trunk) with 83.3%, neck with 71%, and knee (right) with 62.5%; and the lowest prevalence rate was in the ankle with 8.33%, elbow with 16.66%, and hand-wrist with 29.2%.

Table 1. Demographic Characteristics of Overhead Crane Operators (n = 45)

Variable	Mean $\pm$ Standard Deviation
Age	30.54 $\pm$ 7.21
Work experience	5.98 $\pm$ 6.43
Weight	78.12 $\pm$ 9.41
Height	175.6 $\pm$ 7.28

The results of the posture assessment have been determined based on QEC method for the overhead crane model

Table 2. Prevalence (%) of Musculoskeletal Symptoms During the Past 12 Months in Overhead Crane Operators (n = 45)

Region	Past 12 Months (%)
Upper back	33.3
Lower back	83.3
Neck	71
Upper arm	
Dominant	29
Non-dominant	12.5
Bilateral	33.3
Elbows	
Dominant	16.5
Non-dominant	16.7
Bilateral	16.5
Wrists/Hands	
Dominant	25
Non-dominant	8.3
Bilateral	29.2
Hips	37.5
Knee	
Dominant	62.6
Non-dominant	21
Bilateral	62.5

A and for the overhead crane model B (Table 3). Generally, exposure risk level in back and shoulder limbs are higher in model A than in model B, and for the neck, the level of exposure was high for both models. The risk of work speed and vibration factors was determined at a moderate level in both models, and work stress levels were high.

Table 4 demonstrates a significant difference between models of the overhead crane and the risk factors of musculoskeletal disorders in the upper limbs, such as shoulders, arms, back, neck, wrists, and hands (P = 0.011).

4. Discussion

In the present study, the prevalence of musculoskeletal disorders for overhead crane operators was assessed using the Nordic questionnaire. The results of the questionnaire showed an outbreak of 88.5% of musculoskeletal disorders in at least one of the 9 areas of the body; and trunk (83.3%), neck (71%), and knee (62.5%) had the highest prevalence rates, respectively. The highest prevalence of musculoskeletal disorders was related to the trunk (83.3%).

In general, the results of this study revealed a significant difference between postures of the crane operators for the models of A and B. Overhead crane operators need to have their trunk bent to more than 20° about 50% of the working time to have a field view at the ground level [9]. The results of ergonomic studies of Courtney et al. (1999) in evaluating work station and designing the cabin's work space indicated that drivers have back flexion of 30° to 40° in 50% of working time due to using the front and lower window for downward vision and load control. Trunk rotation in crane model A is less than that in model B, however, according to QEC method, the level of exposure was high due to the high flexion in the back area.

While a lower level of back flexion was seen in crane model B and although there was a rotating chair, there was a middle trunk rotation for a better view, and according to QEC method, there was a moderate level of exposure. According to the personal interview with operators, it was found that operators, who complained about back area disorders, felt more pain or discomfort in this area when they worked with crane model A. Moreover, among the overhead crane operators in Courtney's study, discomfort was reported in the back area (88%) and the middle part of the back region (50%) (14).

According to the results of the Nordic questionnaire, the prevalence of neck disorders was 71%, and the results of neck posture assessment indicated that neck posture had a greater flexion and more rotation in the overhead crane model B compared to model A. Moreover, according to the location of the external load that is down the right side of the cabin, the glass floor of the cabin is the operator's scope, so that neck flexion and rotation occurs simultaneously. According to some studies, one-way and static work associated with repetitive work of the arm and hand leads to disturbances in the neck region (15-17). Although the level of exposure in both mobile overhead crane models was high according to QEC method, the exposure score for neck posture (Score 14) was higher in model B compared to the other model (Score 12). According to a personal interview with operators, it was found that operators who worked more with the B model felt more pain and discomfort in the neck.

The incidence of shoulder disorders was reported to be 33% in this study, which was higher in the right shoulder (29%) than the left. In the mobile overhead crane (model A), the arm goes backward and gets a bit away from the trunk because on the one hand, the operator pulls the chair forward for a better view, and on the other hand, the levers are fixed and not part of the chair. Also, the height of the levers is high. Some studies indicate that tasks require high degree of leverage control by the hand / arms, the operator has to avoid unwanted movements by pulling the shoulder muscles (18).

Armrests were not used in the mobile overhead crane

Table 3. Assessment of Body Exposure Levels in 2 Model Crane Operators (n = 45)

Factors	Score		Exposure Level	
	Model A	Model B	Model A	Model B
Back	24	20	Moderate	Low
Shoulder/arm	24	20	Moderate	Low
Hand/wrist	24	24	Moderate	Moderate
Neck	12	14	Hight	Hight
Risk factor Driving*	4	4	Moderate	Moderate
Risk factor Speed work	4	4	Moderate	Moderate
Risk factor Stress work	9	9	Hight	Hight
Whole Body Vibration	9	9	Average	Average

Table 4. The Relationship Between Crane Models Status and the Risk of MSDs in the Upper Limbs

Model	Average Score of Posture	SD	95% Confidence Interval of the Difference		T	P Value
			Upper Limit	Lower Limit		
A	21	3.37	-3.87	-0.51	-2.64	0.011
B	19.5	3.95				

model A, and they were not used much in model B. Shoulder and arm muscle load were examined among drivers of forestry machinery with EMG, and it was found that armrest and small levers reduced the physical load on the trapeze muscle in comparison with fixed armchair and old levers (19, 20).

According to the QEC, the exposure level risk of the shoulders was assessed for models A and B overhead cranes, which was mediocre and low, respectively. Based on the personal interview with operators, it was found that operators, who worked more with crane model A, felt pain and discomfort on both right and left shoulders, while operators working with crane model B felt more pain in the left shoulder.

The prevalence of disorders in both hands / wrists was 29.2%, which was higher in the right wrist and hand (25%) compared to the left wrist and hand. In the mobile overhead crane model A, the bending and rotating of the wrist are slightly higher than that of model B; this might be due to back flexion and the distance of the arms from the trunk during the use of levers, or the inappropriate design of the levers in this model, whose height is higher than model A.

In the observational assessment of the QEC method, lower limbs are not evaluated. However, according to observations and interviewing the operators, the main cause of the prevalence of discomfort in the knee (62.5%), thighs, and buttocks (37.5%), particularly in the overhead crane model A, was described as follows: In some cases, especially when the work speed increased, the operator raised his right foot to control the levers (right-hand levers), and also, the break of the overhead crane model A was hydraulic and much force was needed by the leg. Thus, the prevalence of disorders in the right knee, the right thighs, and buttocks of the operators was also high even though the work was done in a sitting position. Cumulative exposure with whole-body vibration, especially in long-term and static sitting occupations, causes disorders in the lumbar region (18). The result of some studies indicated no significant relationship between neck pain and exposure to high vibration (21). Also, the work speed was moderately evaluated by operators for both models of mobile overhead cranes. Crane operators have a high mental and psychological workload on the operators, which can lead to muscle activity during the work (19). Mental workload during crane working has a significant relationship with increase in the low back disorders (11, 21).

4.1. Conclusions

In general, overhead crane operators are exposed to various ergonomic and physical risk factors, whose combination may lead to discomfort in the trunk and neck region. The results of the present study showed the highest prevalence of musculoskeletal symptoms in the back, neck, and knee of crane operators. Awkward postures of trunk and neck in the static situation and dynamic movements of hands and arms to control the levers and the vibration in the cabin (whole body vibration) are the main causes of this disorder. Therefore, ergonomic interven-

tions can be done by redesigning the cabin and seats and also controlling the exposure of vibration to reduce musculoskeletal disorders among operators. Moreover, ergonomic interventions should focus on reducing trunk and neck flexion angles and exposure time.

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Footnotes

Authors' Contributions: Davood Afshari: developing the study concept, design, and methods. Marzieh Shahryari and Seyed Amin Jazaeri: data collection and analysis. Davood Afshari and Marzieh Shahryari: writing the primary draft of the manuscript. all authors contributed to the revision of the manuscript and read and approved the final version.

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