Assessment of Risk Factors of Upper Extremity Musculoskeletal Disorders (UEMSD$_S$) by OCRA Method in Repetitive Tasks

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Abstract

The high occurrence of upper extremity musculoskeletal disorders (UEMSD$_S$) in Iranian ironwork industries indicates a need to assess the risk factors of the disorders at such workplaces. In order to prevent such disorders, the Occupational Repetitive Actions (OCRA) carried out to obtain an integrated assessment of the various risk factors, classify different jobs and suggest ergonomic designing solutions. Four data gathering methods including Observational, Interview, Nordic Musculoskeletal Questionnaire (NMQ), and OCRA were utilized. All 385 male workers occupying in five various jabs (72 tasks) in Qaemshahre ironwork industry located in the north of Iran were studied. The percent of work tasks lain in low, moderate, and high-risk level were 6.14%, 69.27%, and 24.59%, respectively. Mean of exposure indices between five jobs including administrative (0.69), lathing (2.87), welding (3.43), melting (3.58) and foundry (5.96) jobs showed significant difference (*F= 4.881, P= 0.003*). In addition, the foundry job had the highest risk of occurrence of UEMSD$_S$. The highest incidence of distal upper extremity was allocated to the hand and fingers region. There was a significant relationship between surveyed work groups and incidences of upper extremities ($\chi^2 = 6.425$, $P = 0.008$). The OCRA Method could be a useful method for evaluating risk factors of UEMSD$_S$ in repetitive tasks of the ironwork industry.

Keywords: *OCRA, UEMSD$_S$, NMQ, Risk factors of disorders, Iran*

Introduction

Musculoskeletal disorders are no recent problem (1). Already in 1706 Bernardo Ramazzini, an Italian physician considered as the father of occupational heath, wrote about office work: “The disease … arises from three causes: first constant sitting, the perpetual motion of the hand in the same manner, and thirdly the attention and the application of the mind. Constant writing also considerably fatigues the hand and the whole arm on account of the continual and almost tense tension of the muscles and tendons”(2).

Today, 30 percent of all workers report that they suffer from back pain and 17 from the upper limbs according to the Second European Survey on Working Conditions in 1996; 45 percent report that they are working in tiring or awkward positions (3). The compensated musculoskeletal disorders vary widely between countries due to different diagnosis criteria and different compensation systems (4). Work-related musculoskeletal disorders arise when exposed to work activities and work conditions the significantly contribute to their development or exacerbation, but not acting as the sole determinant of causation (4). Estimates of the costs are limited and where data exists, i.e. in the Nordic countries and The Netherlands, the costs have been estimated between 0.5% and 2% of the GNP (3). The costs for work-related muculoskeletol disorders in the US have been estimated at $ 20 billion per year and the indirect costs at around $ 60 billion per year. There is, however, a lack of standardized assessment criteria, which makes comparisons between

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countries difficult (4). The return to the workplace of individuals affected by work-related musculoskeletal disorders of the upper limbs represents a critical problem in work settings that feature a multitude of tasks liable to biomechanical strain the upper limbs (3, 4). The European Agency for Safety and Health at Work in Bilbao, Spain, report also pointed out the need of specific and sensitive diagnostic criteria for work-related musculoskeletal disorders (5). All $WMSD_S$, even those without a specific diagnosis or pathology, should be considered in health monitoring and surveillance systems (3-5).

By emphasizing on the mentioned cases, the Qaemshahre ironwork industry was surveyed as an industry with the repetitive tasks. Also, the study was carried out to prevent from inducing $WMSD_S$ and protect workers (5).

Therefore, The Occupational Repetitive Actions (OCRA) method was used for assessing risk factor producing $UEMSD_S$ (shoulder, elbow, wrist, and hand & fingers disorders) (6).

Thereby, the following objectives have been taken into consideration in the study:

Assessment of risk factors featuring upper extremity musculoskeletal disorders ($UEMSD_S$) in shoulder, elbow, wrist, and hand & fingers;

Analyzing repetitive tasks;

Evaluation of risk factors presented in unergonomic jobs;

Introduction of OCRA method;

Classification of jobs on the basis of OCRA action level;

Protection of workers from upper extremity musculoskeletal disorders;

Suggestion of ergonomic solutions and measurements for preventing such disorders.

Materials and Methods

In the research, an integrated procedure from four data gathering methods were used that included: Observational method (for job and task analysis featuring repetitive movements), Interview method (for asking about the incidence rate of upper limbs musculoskeletal disorders), Nordic Musculoskeletal Questionnaire (NMQ) method, and Occupational Repetitive Actions (OCRA) index method (5). All 385 male workers of the Qaemshahre ironwork industry placed in Mazandaran Province, the north of Iran, were working in five various jobs completed the Nordic Questionnaire and also every job was analyzed to the corresponding tasks (6). Finally, 72 obtained tasks were analyzed using OCRA software and the gained information was processed applying SPSS (ver.9) software. The Chi-Square (χ^2) statistical test (Fisher's Exact Test) was used to seek the relationship between various surveyed groups and incidences of various regions disorders of distal upper extremities. Also one-sided analysis of variance (ANOVA) test was utilized to compare the means of exposure indices of five jobs presented in case and control groups.

OCRA method The concise exposure index (OCRA) method is the model for the assessment of exposure to occupational repetitive movements of the upper limbs or $UEMSD_S$ presented and introduced by Entrio Occhipinti from Ergonomics of Postures and Movement (EPM) Research Unit in Milan, Italy, in1998 and then was completed and developed by D. Colombini from the same research unit (6-8). The model is conceptually based on the procedure recommended by the NIOSH for calculating the lifting Index in manual load handling activities (6-8). The OCRA is based on the relationship between the daily number of actions actually performed by the upper limbs in repetitive tasks (A_e), and the corresponding number of recommended actions (A_r) (6-8).

In practice:

$$OCRA = EI = \frac{Ae}{Ar}$$

Where:

EI=exposure index (Occupational Repetitive Actions; OCRA)

A_e= total number of technical actions performed within various task(s) during the shift (7).

Then, the following general formula is used to calculate the total number of recommended technical actions to be performed during the shift (A_r) (6, 7):

$$A_r = \sum_{i=1}^{n} CF \times F_f \times F_p \times F_a \times DF \times F_r$$

In which:

$i_{=1,\ldots,n}$ = task(s) featuring repetitive movements of the upper limbs performed during the shift (6,7);

CF= frequency constant of technical actions per minute, used as a reference (30 actions/ minute) (6, 7);

F_f; *Fp*; *Fa* = multiplier factors, with scores ranging between 0 and 1, selected according to the behavior of the' force' (F_f), ' posture')F_p) and ' additional elements' (F_a) risk factors, in each of the (n) tasks (6, 7);

DF= duration of each repetitive task in minutes; and

F_r= multiplier factor, with scores ranging between 0 and 1, selected according to the behavior of the' lack of recovery period' risk factor, during the entire shift (6, 7).

Finally, the following statements may be made for describing the current status (6, 7):

I. Level 1 (green area)

Exposure index scores of <0.75 indicate that the condition examined is fully acceptable;

II. Level2 (amber area)

Exposure index scores in the range of 0.75 to 4.00 are borderline (uncertain), the exposure may be significant and careful monitoring for induced health effects should be introduced (health surveillance); and

III. Level 3(red area)

Exposure index scores in excess of 4.00 are definitely significant and the higher the value the higher the risk. Actions should be undertaken to improve working conditions, as well as close monitoring for induced effects (6-8).

Nordic Musculoskeletal Questionnaire (NMQ)

Since 1987 Nordic Questionnaire was established by Kuornika and his colleagues in Occupational Health Institute of Scandinavian countries aiming for determining the incidence rate of musculoskeletal disorders resulted from the work and the prevalence rate and epidemiological of the diseases (9).

Results

Results obtained from Nordic Musculoskeletal Questionnaire are shown in Table 1. As it has been shown, the incidence rates of the distal upper extremity musculoskeletal disorders (for four parts including shoulder, elbow, wrist, and hands & fingers) in the control or administrative group are negligible and low. Moreover, in the case groups, four jobs including lathing, welding, melting, and foundry jobs were surveyed. According to the corresponding table, it was considered that the most and the least incidence rate of distal upper extremity musculoskeletal disorders was referred to foundry and lathing jobs respectively. As it was perceived from the mentioned table, in each of jobs presented in case group, the most incidence of the distal upper extremity disorders of four parts (including shoulder elbow, wrist, and hands& fingers) was related to the hands & fingers region, and after that, incidences of wrist, elbow, and shoulder disorders were placed. In total, the highest overall incidence percent of the distal upper extremity disorders of four regions (including shoulder, elbow, wrist, and hands & fingers) was allocated to hands & fingers region, and after that, the overall incidence percent of wrist, elbow and shoulder were posed. Besides, the Chi-Square (χ^2) statistical test quantified that there was a significant statistical relationship between various surveyed groups and incidences of various regions disorders of distal upper extremities ($\chi 2$= 6.425, df= 9, P=0.008).

Results obtained from setting up the Occupational Repetitive Actions method are presented in Table 2. Based on data in this table, the highest mean of exposure (OCRA) index belonged to the foundry job, and after that, those of melting; welding, lathing and administrative jobs were placed orderly. Thereby, it was observed that the lowest mean of exposure index was allocated to the administrative job, so that it seemed to be considered as a low risk (safe) job in view of inducing UEMSDs whiles four other jobs including lathing, welding, melting, and foundry jobs were taken into consideration as moderate to high risk level (hazardous) jobs from the viewpoint of causing and appearing UEMSDs. Also one-sided analysis of variance (ANOVA) test showed that there was significant statistical differences between means of exposure indices of five mentioned jobs ($F=4.881$, $df=4$, $P= 0.003$).

Table1: Distribution of the incidences of the upper extremity musculoskeletal disorders

Samples	Job type	Shoulder	Elbow	Wrist	Hand & Fingers
		No. (%)	No. (%)	No. (%)	No. (%)
Control group	Administrative	9(2.33)	13(3.37)	15(3.89)	16(4.15)
Case group	Lathing	54(14.02)	65(16.88)	72(18.70)	77(20.00)
	Welding	24(6. 23)	27 (7.01)	35(9.09)	36 (9.35)
	Melting	37 (9.61)	39(10.13)	48(12.46)	52(13.50)
	Foundry	87(22.59)	109(28.31)	121(31.43)	147(38.18)
	Total	211(54.81)	253(65.71)	291(75.58)	328(85.19)
Healthy group (Lack of the Corresponding region disorders)		174(45.19)	132 (34.29)	94(24.42)	57(14.81)
Total		385 (100.00)	385 (100.00)	385 (100.00)	385 (100.00)

Table 2: Determining risk levels of the various jobs presented in iron work industry

Group Type	Job type	Mean of exposure indices	Risk level	Risk rate	Risk type	Risk area	% of work task, included
Control group	Administrative	0.69	Level 1 $EI\leq 0.75$	Low	Absent	Green	6.14
Case group	Lathing	2.87	Level 2 $0.75< EI\leq 4$	Moderate	Neligible/ Slight (Uncertain)	Amber	35.13
	Welding	3.43	Level 2 $0.75< EI\leq 4$	Moderate	Neligible/ Slight (Uncertain)	Amber	11.09
	Melting	3.58	Level 2 $0.75< EI\leq 4$	Moderate	Neligible/ Slight (Uncertain)	Amber	23.05
	Foundry	5.96	Level 3 $EI> 4$	High	Present	Red	24.59

Discussion

The study showed that there was a distinguished difference between control and case groups in incidence rates of distal upper extremity (DUE) disorders. On the one hand, it was determined that the highest incidence rates of distal upper extremity (DUE) musculoskeletal disorders was allocated to the foundry job, and after that, the lathing, the melting, and welding jobs were placed, on the other, the highest incidence rate of upper extremity musculoskeletal disorders was related to the hand & fingers region, and after that, incidence rates of wrist, elbow, shoulder region disorders were posed. Furthermore, it was observed that the administrative job (control group) was located in level 1 that was not necessary to exert preventive measurements or solutions, but three jobs including lathing, welding, and melting jobs were laid in level 2 that should be taken into account in preventive programs for preventing and controlling $UEMSD_S$ and finally, the foundry job was placed in level 3 that must be taken into consideration in preventive plans soon and it must be exerted ergonomic designing solutions immediately for improving awkward and poor conditions (6- 8)

In addition, by surveying 72 tasks presented in five various jobs, it was characterized that many of the work tasks were laid in moderate risk level, but there were tasks that were located in high risk level (the tasks presented in foundry job), and more considerations must be concentrated on these tasks and their exposure indices must be diminished to low risk level by decreasing or controlling or, as for as possible, eliminating or correcting the rate of risk factors featuring unergonomic situations and upper extremity musculoskeletal disorders (6- 8). The study revealed that the OCRA method could be used as an applicable and useful method for identifying harmful workplace and situations and discriminating hazardous jobs from safe jobs and finally, submitting corrective solutions for reforming hazardous situations to acceptable level (level 1) (6-8). Thereby, a conservative approach is that all workers performing various jobs placed in level 2 and 3 should be taken into consideration in musculoskeletal diseases diagnosis, health surveillance and monitoring programs (6). It was concluded that the OCRA method was a favorable tool for protecting workers from upper extremity musculoskeletal disorders ($UEMSD_S$) and gaining access to the other objectives of the research (6, 8). The OCRA software automatically submits controlling ergonomic solutions for correcting workplace situations (6, 7). The following recommendations and measurements can be suggested:

The jobs such as new foundry, old foundry, displacing & handling fixed packaged pipes, and etc. that they need to serve a lot of forces for doing them, the number of human forces exposed to incidence risk of distal upper extremity musculoskeletal disorders should be diminished by designing suitable handling carts, ergonomic designing of processes, automatizing and mechanizing process, and etc. (6).

By rotating the jobs or workers, the workers who are doing the repetitive works in static positions for a long term have an opportunity for performing actions and movements and thereby preventing cumulation of lactic acid much more in muscles and avoiding acute tiredness and fatigue (6,10).

By taking into consideration rest or recovery intervals between work periods or task times, we can prevent from intervention of blood stream and avoid from fatigue of arm or forearm (Radio-ulnar) muscles (6, 11). This problem is observed at working with pipe welding machine, metal cutting machine, and etc. (6, 10).

The rectification of the work-shift program at the industry and a proper planning according to the human physiology system (in a weekly work-shift, i.e. morning, evening, and night respectively) will effectively be deducted in mental and physiological stress resulted from the works (6, 11).

As the most of the works presented in this factory has been allocated based on the physical ability of the young persons, therefore, it seems to be necessary to apply the anthropometric principles in designing hand tools and work stations and also employ young workforces for doing these jobs to prevent from upper extremity musculoskeletal disorders (6,10).

By designing the chair, the work-table, the proportion of the work type to its height, and the ergonomic intervention in some jobs embarking on transportation by hand, will considerably be reduced the incidence rate of musculoskeletal disorders (6,12).

A periodic educational program as well as daily body practice can play a main role in reducing the musculoskeletal disorders resulted from the work positions and postures or gestures (6, 10).

Therefore, it was concluded that the OCRA method could be used as a useful and applied model for assessing $UEMSD_S$ in repetitive tasks of the ironwork industry. Also the model designed to predict an increased risk of upper limb $WMSD_S$ should include not only a concise index of exposure to biomechanical overload, but also parameters relative to number, age, lack of recovery period, etc. of exposed subjects (6, 8). Finally, it must be considered that the OCRA exposure indices of > 4 need to be as predictive of a significant high occurrence of specific lesions in the relative group of exposed workers, therefore these workers must be placed in the so-called red area (6, 8). OCRA index values ranging from 0.75 to 4 should be considered as inter-mediate (the so-called amber area), in which the relative values of the index neither point necessarily to an excess of "lesions", nor rule them out entirely in the specific group of exposed workers (7,8).

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