

Prevalence of Musculoskeletal Symptoms and Assessment of Working Conditions in an Iranian Petrochemical Industry

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Abstract

Background/Objective: Musculoskeletal disorders (MSDs) are one of the most common causes of occupational injuries. This study was conducted with the objectives of determination of prevalence rate of MSDs and ergonomics assessment of the risk of MSDs among workers of a petrochemical company.

Methods: In this study, 261 randomly selected workers in a petrochemical company with at least one year of job tenure participated. Office and operational personnel were studied separately. In office jobs, data were collected using Nordic musculoskeletal disorders questionnaire (NMQ) and ergonomics checklist for assessment of work conditions. In operational jobs, NMQ and QEC (Quick Exposure Check) methods were applied to gather the required data. Data analysis was performed using SPSS software.

Results: The most prevalent MSDs symptoms were reported in the lower back (36.2%), upper back (31%), neck (31%) and knees (30.3%). The results showed that the prevalence of MSDs indifferent body regions of the office staff was higher than those of operational workers. Also, in 40.9% of the observed cases, total ergonomics index was in action category 1 (inappropriate working conditions) and 59.9% of the subjects taken in action category 2 (appropriate working conditions). The results of assessment by QEC technique among operational workers showed that in 82.8% of the workers studied, the level of exposure to musculoskeletal risks was high or very high.

Conclusions: The prevalence of musculoskeletal disorders in the office staff was higher than that of operational subjects. To improve the working conditions, taking risk factors of the lower back, upper back, neck and knees into consideration seems to be essential.

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Introduction

Musculoskeletal disorders (MSDs) are of worldwide concern and distributed among both the industrialized countries (ICs) and industrially developing countries (IDCs).¹⁻⁴ In IDCs, the problems of workplace injuries are extremely serious.⁴ Poor working conditions and the absence of an effective work injury prevention

program in IDCs have resulted in a very high rate of musculoskeletal symptoms.⁵ Risk factors of musculoskeletal symptoms are known to include workplace activities such as heavy load lifting, repetitive tasks, awkward working postures and seated static postures,⁶ while individual characteristics, psychosocial and organizational factors are also known to be important predictive variables.⁷⁻¹²

In petrochemical industry, where petrochemical products are produced in a continuous process, employees might be exposed to diverse musculoskeletal risk factors.¹³ For instance, long hours of seated activities with high mental workload are observed among control room workers. Highly dynamic repetitive activities in maintenance operation and overhauls are also very common among operational workers. In these situations, high occurrence rate of musculoskeletal symptoms is expected in both groups of employees.

Few ergonomic studies have been conducted on musculoskeletal symptoms and their work-related contributing factors in petrochemical industry. The present study was, therefore, conducted in an Iranian petrochemical industry with the following objectives:

- 1-Determination of the prevalence rate of musculoskeletal symptoms among employees of the petrochemical industry
- 2-Determination of the exposure level to MSDs risk factors in office and operational workers
- 3-Evaluation of ergonomic workplace conditions

It was believed that the results of this study could be an appropriate basis for planning and implementing interventional ergonomics programs in the workplace and improving workers' health in this industry.

Methods

In this cross-sectional study, 261 randomly selected employees including office workers (156) and operational workers (105) who were nearly 20% of all company employees with at least one year of job tenure were included in the study. Workers with background diseases or accidents affecting the musculoskeletal system were excluded from the study.

Data Gathering Tools

-Office Employees

An anonymous self-administered questionnaire was used to collect the required data from each subject. The questionnaire consisted of 2 parts:

- (a) Personal details (including age, job tenure, daily working time and education).
- (b) The general Nordic Questionnaire of musculoskeletal (NMQ) symptoms to examine reported cases of MSDs in different body

regions among the study population.¹⁴ Reported musculoskeletal symptoms were limited to the past 12 months. Each participant received the questionnaire in person in his workplace.

(c) In order to assess the ergonomic working conditions, a comprehensive ergonomics checklist was developed. The checklist was structured to cover ergonomic problems that might exist in the offices. The checklist integrated the available knowledge on this issue and provided a systematic ergonomic assessment tool for offices. It could also be used to provide a list of priorities for improving working conditions.¹⁵

The checklist consisted of three sections including environmental working conditions (EWC) (i.e. noise, illumination and climate), workstation design (WS) (i.e. workspace room, adjustability, seat, reach envelop, anti-fatigue mat, posture variation, etc.) and working posture (WP) (i.e. neck, back, wrists, arms, shoulders and legs). In this checklist, there were totally 47 items in the three sections mentioned above.¹⁵

All items of the checklist were observed by the researchers at the subjects' workstations. An item was assessed to be either *provided* (yes) or *not provided* (no). The item was, then, scored 1 if it was *provided* (yes) and 0 if it was *not provided* (no).¹⁵

The total ergonomics (TE) index was calculated as a percentage of all provided items in the checklist. Additionally, an index was calculated for each section of the checklist to identify the major sources of problems and ergonomic bottlenecks in the workplace.¹⁵

The indices may vary from 0 to 100%. A low and a high percentage reflect poor and appropriate ergonomic conditions in the corresponding index, respectively.

After calculating the indices, each one was interpreted in accordance to the action categories (AC) described below:

Action category 1 = Further investigation is needed. Corrective measures are required soon. Attention should be focused on priorities.

Action category 2 = Working conditions are acceptable, but attention should be focused on priorities.

Each index was categorized based on cut off point calculated using the receiver operating characteristics curve (ROC) methodology.¹⁶ The cut off points were determined between 0 and 100 (%) based on the prevalence rate of musculoskeletal symptoms. Table 1 presents action categories as well as cut off points for each

Table 1: Action categories for the evaluation indices.

Action category	Evaluation index			
	EWC (%)	WS (%)	WP (%)	Total (%)
1	0-95	0-70.83	0-68.18	0-75
2	95.01-100	70.84-100	68.19-100	75.01-100

assessment index.

-Operational Workers

An anonymous self-administered questionnaire consisting of personal details and Nordic Questionnaire was also used to collect the required data from each subject. QEC technique was applied to evaluate the level of exposure to MSDs risk factors.¹⁷⁻¹⁸The technique included the assessment of the back, shoulder/arm, wrist/hand and neck, regarding their postures and repetitive movement. In QEC, task duration, maximum weight handled, hand force exertion, vibration, visual demand of the task and subjective responses to the work were also considered and the required data were obtained from the worker. The magnitude of each assessment item was classified into exposure levels, and the combined exposures between different risk factors for each body part were calculated using a score table. The exposure scores for the back, shoulder/arm, wrist/hand and neck were categorized into four exposure categories including low, moderate, high and very high. Moderate, high and very high scores should be addressed urgently to reduce the level of exposure to risk factors. To obtain overall exposure score, total scores of the body parts were summed and the result was divided by the highest possible score for overall body, i.e. 176 for manual handling tasks and 162 for other tasks. Low overall exposure scores (less than 40%) indicated acceptable musculoskeletal loading (low risk). For overall exposure scores

ranging from 41% to 50%, further investigations are needed and also some changes might be required (moderate risk). Prompt investigation and changes were required soon for overall exposure scores between 51% and 70% (high risk). Finally, immediate investigation and changes were required for overall exposure scores higher than 70% (very high risk).

Data were analyzed using statistical tests including student's t-test, Chi-square and test of proportion by SPSS software (Version 16.0).

Results

Table 2 summarizes personal details of the workers participating in this study. As shown, the means age, job tenure and daily working hours in operational workers are significantly higher than those of office staff ($p < 0.05$). Additionally, the two groups are different as to the sex, education and type of employment.

The results of NMQ showed that the lower back (36.2%), upper back (31%), neck (31%), knees (30.3%) and shoulders (25.5%) symptoms were the most prevalent problem among the employees studied including office and operational workers.

Table 3 presents the prevalence of MSDs symptoms in different body regions of the office employees and operational workers during the last 12 months prior to the study (2011). As shown, the prevalence of MSDs symptoms in all body regions (except elbows and thighs) is higher among office employees as compared to those

Table 2: Some personal details of the workers participating in the study (n=261)

	Variable	Office workers (n=156)	Operational workers (n=105)	P value
Age (yrs):	Mean(SD)	32.40 (7.23)	32.43 (7.23)	0.001*
	Min-Max	23-64	19-64	
Weight (kg):	Mean(SD)	76.53 (10.98)	76.06 (9.57)	0.3*
	Min-Max	50-118	57-103	
Height (cm):	Mean(SD)	174.51 (6.82)	173.73 (6.47)	0.5*
	Min-Max	154-196	154-186	
Job tenure (yrs):	Mean(SD)	5.39 (3.16)	6.20 (3.99)	0.025*
	Min-Max	1-15	1-18	
Working hours per day (Hrs)	Mean(SD)	10.78 (1.95)	12.08 (2.16)	<0.001*
	Min-Max	8-15	8-16	
Sex:	Female	10 (6.4%)	0 (0%)	<0.001†
	Male	146 (93.6%)	105 (100%)	
Marital status:	Single	30 (19.2%)	20 (19%)	0.3†
	Married	126 (80.8%)	85 (81%)	
Education:	Under diploma	47 (30.1%)	97 (92.4%)	<0.001†
	Diploma/Associated D.	21 (13.5%)	4 (3.8%)	
	BSc or higher	88 (56.4%)	4 (3.8%)	
Type of employment:	Official	88 (56.4%)	9 (8.6%)	<0.001†
	Contract	59 (37.8%)	73 (69.5%)	
	Corporation	9 (5.8%)	23 (21.9%)	
Working schedule:	Shift working	47 (30.1%)	42 (40%)	0.1†
	Day working	109 (69.9%)	63 (60%)	

*Mann-Whitney U; †Chi-square

Table 3: Frequency of reported musculoskeletal symptoms in different body regions among office and operational staffs during the last 12 months (n=261).

Body region	Office workers (n=156)		Operational workers (n=105)		P value*
	No.	%	No.	%	
Neck	71	45.5	19	18.1	<0.001
Shoulders	58	37.2	16	15.2	<0.001
Elbows	18	11.5	9	8.6	0.1
Wrists/Hands	47	30.1	13	12.4	<0.001
Upper back	68	43.6	22	21	<0.001
Lower back	84	53.8	21	20	<0.001
Thighs	19	12.2	11	10.5	0.1
Knees	63	40.4	24	22.9	<0.001
Foot and Ankles	30	19.2	18	17.1	0.04

*Chi- square

of operational workers (p<0.05).

Office Employees

The lower back (53.8%), neck (45.5%), upper back (43.6%), knees (40.4%), shoulders (37.2%) and wrist/hand (30.1%) symptoms were the most prevalent reported problems among the office employees studied (Table 3).

Table 4 shows the results of ergonomics assessment of working conditions of the office staff's workstations studied. As seen, WS and WP indices have the lowest means indicating poor conditions in these areas.

The figure 1 shows the frequency of assessment indices in each action category among office staff.

Additionally, based on the results, in 40.9% of the observed cases, total ergonomics index was in action category 1 indicating the overall inappropriate working conditions. In 59.9% of the

cases, it was in action category 2, showing the overall appropriate working conditions.

Table 5 displays the relationship between MSDs in the upper body regions and means of the assessment indices. As seen in this table, the mean score of WS in Yes group is significantly less than the other group (p<0.05). This means that the less the WS index is, the higher the chance of MSDs symptoms occurrence in these regions will be.

The figure 2 shows a common working posture among office staff.

Operational Workers

The results revealed that the knee (22.9%), upper back (21%), lower back (20%) and neck (18.1%) symptoms were the most prevalent problems among the operational workers (Table 3).

As Table 6 displays, the results of assessment of physical exposure to musculoskeletal risks

Table 4: Means (M) and standard deviations (SD) of the assessment indices in office staff's workstations studied (n=156)

Index*	M	SD	Min	Max
EWC	95.06	8.91	60	100
WS	69.51	7.75	48	88
WP†	68.36	8.03	45.45	100
TE	74.77	4.85	60.87	84.78

*EWC=Environmental working conditions; WS=workstation design; WP=working posture; TE=total ergonomics index; †A lower score represents poorer working conditions.

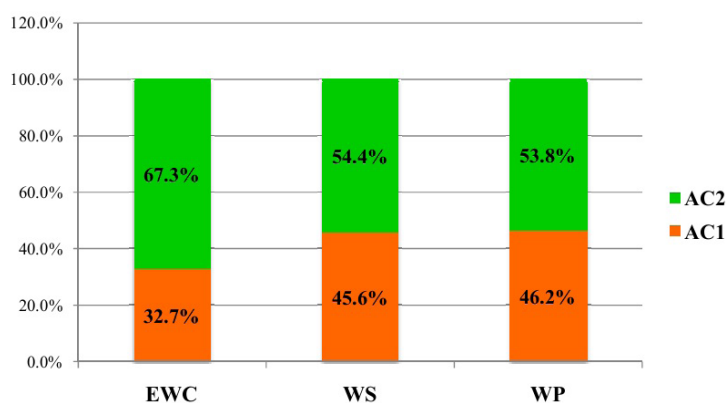


Figure 1: Frequency of assessment indices in each action category among office staff (n=156).

Table 5: Mean of ergonomics indices in with and without musculoskeletal symptoms in the upper body regions (n=156)

Ergonomics index	Upper body symptoms [†]				P value [*]
	Yes (n=71)		No (n=85)		
	M	SD	M	SD	
EWC	95.78	7.1	94.47	10.18	1
WS	68.14	7.65	70.63	7.69	0.05
WP	68.12	9.33	68.56	6.81	0.6
TE	74.01	4.73	75.39	4.89	0.08

*Mann-Whitney U; [†]neck, shoulder, wrist/ hand, back and lower back; EWC=Environmental working conditions; WS=workstation design; WP=working posture; TE=total ergonomics index



Figure 2: A very common working posture among office staff. Shoulders, upper arms and elbows are in awkward postures. Head, neck and back are rotated.

Table 6: QEC level of risk exposure among the operational workers studied (n=105).

Risk level	Frequency	Percent
Low	9	8.6
Moderate	9	8.6
High	33	31.4
Very high	54	51.4

by QEC technique among operational workers showed that:

(a) in 8.6% of the workers studied, the calculated exposure level was less than 40%, indicating that the level of exposure to musculoskeletal risks was acceptable (low risk).

(b) in 8.6% of the workers studied, the calculated exposure level was between 41% and 50% indicating that the level of exposure to musculoskeletal risks needs more attention (moderate risk).

(c) in 34.1% of the workers studied, the calculated exposure level was between 51% and 70% indicating that the level of exposure to musculoskeletal risks was high and ergonomics intervention to the decrease exposure level seemed essential (high risk).

(d) in 51.4% of the workers studied, calculated exposure level was higher than 70% indicating that the level of exposure to musculoskeletal risks was very high and immediate ergonomics

intervention to decrease the exposure level seemed essential (very high risk).

Totally, in 82.8% of the operational workers studied, the level of exposure to musculoskeletal risks was high or very high. This indicated that the jobs and working conditions in the operational units were conducive to developing MSDs. Therefore, ergonomics interventions seem to be necessary to improve working conditions and decrease exposure level.

The figure 3 shows two workers are involved in manual handling of heavy loads.

Discussion

The study population was relatively young with a mean age and job tenure of 33.01 (8.03) and 5.57 (3.48) years, respectively. Most of the subjects were male workers (96.6%) and married (82.1%).

The NMQ questionnaire showed that symptoms from the musculoskeletal system were



Figure 3: Two workers are involved in manual handling of heavy loads. Total QEC score is 82% indicating very high risk level.

common among the studied employees. Back, neck, knees, shoulders and wrists symptoms were found to be the most prevalent problems among the workers studied.

Prevalence rates of MSDs in different body regions of office staff were higher than those of operational workers. This could indicate that eliminating MSDs risk factors among office staff must be a high priority. Although it seemed that working conditions in operational units were heavier, but the nature of tasks in the office environment which was mainly sedentary and static for long periods of time contributed to the occurrence of MSDs among office staff. In operational workers, dynamic nature of work reduced the exposure of individuals to sustained posture which could be considered as a MSDs risk factor. This might partly explain the lower prevalence of symptoms among operational employees.

Generally, comparison of the results of this study results with those of the National Health Survey of Iran¹⁹ revealed that the prevalence of musculoskeletal problems was higher in this company than in the general Iranian male population. This indicates that the petrochemical company should be considered as a high-risk industry for developing musculoskeletal disorders.

Office Employees

Mean working hours per day in office employees was found to be 10.78 (1.95) hours which was more than the standard 8 hours daily working time. Some studies have shown that prolonged working time is associated with MSDs prevalence rate.^{11,20} This might, therefore, be considered as a contributing factor for the occurrence of MSDs among office workers.

As the results of this study demonstrated, the prevalence of MSDs in different regions of the body is almost high in office staff. This result is in agreement with those of other studies.¹⁵

The results revealed that WP and WS indices had the lowest means. This indicated poor conditions in these areas necessitating adequate

ergonomics solutions. In some studies, the relationship between poor workstation design, awkward working postures and musculoskeletal disorders has been proved.²¹⁻²³

In contrast, EWC had the highest mean indicating relatively appropriate environmental conditions.

Based on the results, the main problems of WP and WS indices originate from:

- bent head and neck
- awkward postures of shoulders and upper arms (abduction, extension and flexion)
- lack of table with adjustable height
- lack of foot rest in the workstation
- inappropriate seat backrest
- lack of seat with adjustable height
- inappropriate position of monitors

Operational Workers

Based on the results of risks assessment by QEC, in 82.8% of the workers studied the level of exposure to musculoskeletal risks was high or very high. Also, as presented in Table 3, the most prevalence of MSDs was observed in the knee, upper back and lower back. This indicated that the jobs and working conditions in the operational units were conducive to develop MSDs. This result is almost in the same line with the results obtained from other studies.^{20,24} Therefore, ergonomics interventions seem to be necessary to improve working conditions and decrease exposure level.

The exact assessment of working conditions using ergonomics checklist in office workers is the strong point of this study.

In this study, a large number of subjects were male workers (93.6%). Thus, the result of this study does not apply to female workers and their working conditions.

Conclusion

The most prevalent MSDs symptoms were

reported in the lower back, upper back, neck and knees. So, to improve the working conditions, risk factors of these regions must be taken into account. The prevalence rates of MSDs in different body regions of office employees were higher than those of operational workers. Based on this finding, it could be concluded that reducing risk factors of MSDs in office workers was very important and should be considered with priority. Operational workers' level of exposure to MSDs risks was high. Taking corrective measures for reducing the risk level into consideration is necessary.

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Conflict of Interest: None declared

References

- Bongers PM, Ijmker S, van den Heuvel S, Blatter BM. Epidemiology of work related neck and upper limb problems: psychosocial and personal risk factors (part I) and effective interventions from a bio behavioral perspective (part II). *Journal of Occupational Rehabilitation* 2006;**16**:279–302.
- Genaidy AM, Al-Shedi AA, Shell RL. Ergonomics risk assessment: preliminary guidelines for analysis of repetition force and posture. *Journal of Human Ergology* 1993;**22**:45-55.
- Kemmlert K: Labor inspectorate investigation for the prevention of occupational musculoskeletal injuries [licentiate thesis]. Solna, Sweden, National Institute of Occupational Health, 1994.
- Shahnavaz H. Workplace injuries in the developing countries. *Ergonomics* 1987;**30**: 397-404.
- Jafry T, O'Neill DH. The application of ergonomics in rural development: a review. *ApplErgon* 2000;**31**:263-8. <http://www.ncbi.nlm.nih.gov/pubmed/10855449>
- Bernard BP, editor. Musculoskeletal disorders and workplace factors (NIOSH Publication No. 97-141). Cincinnati, OH, USA: National Institute for Occupational Safety and Health (NIOSH); 1997. Retrieved June 19, 2009, from: <http://www.cdc.gov/niosh/docs/97-141>
- Linton SJ, Kamwendo K. Risk factors in the psychosocial work environment for neck and shoulder pain in secretaries. *J Occup Med* 1989;**31**:609-13.
- Weiser S. Psychosocial aspects of occupational musculoskeletal disorders. In: Nordin M, Andersson GBJ, Pope MH, editors: *Musculoskeletal disorders in the workplace: principles and practice*. St. Louis, MO, USA: Mosby-Year Book; 1997. p. 51–61.
- Howard N, Spielholz P, Bao S, Silverstein B, Fan ZJ. Reliability of an observational tool to assess the organization of work. *Int J IndErgon* 2009;**39**:260–6.
- Larsman P, Hanse JJ. The impact of decision latitude, psychological load and social support at work on the development of neck, shoulder and low back symptoms among female human service organization workers. *Int J IndErgon* 2009;**39**:442–6.
- Choobineh AR, Lahmi MA, Shahnavaz H, KhaniJazani R, Hosseini M. Musculoskeletal symptoms as related to ergonomic factors in Iranian hand-woven carpet industry and general guidelines for workstation design. *Int J Occup Safety and Ergon* 2004;**10**(2):157-68.
- Choobineh AR, Movahed M, Tabatabaie SHR, Kumashiro M. Perceived demands and musculoskeletal disorders in operating room nurses of Shiraz city hospitals. *Ind Health* 2010;**48**:74-84.
- Choobineh AR, Peyvandi Sani GR, Sharif Rohani M, Gangi Pour M, Neghab M. Perceived demands and musculoskeletal symptoms among employees of an Iranian petrochemical industry. *Int J IndErgon* 2009;**39**(5):766-70.
- Kuorinka I, Jonsson B, Kilbom A, Vinterberg H, Biering-Sorensen F, Andersson G, et al. Standardized Nordic Questionnaires for the analysis of musculoskeletal symptoms. *ApplErgon* 1987;**18**:233-7.
- Choobineh AR, Rahimifard H, Jahangiri M, Mahmoodkhani S. Musculoskeletal Injuries and Their Associated Risk Factors in Office Workers. *Iran Occupational Health* 2012; **8**(4): 70-81. [Persian].
- Metz, C.E.: The receiver operating characteristic curve. *Seminar in nuclear medicine* 1978; **8**: 283-98.
- Buckle P and Li G. A practical approach musculoskeletal risk assessment in the real workplace. In: Seppace Lae P, Luopagae Rvi T, Nygaard C and Mattila M, eds. *From experience to innovation. Proceedings of the 13th triennial Congress of the International Ergonomics Association*, Vol. 4, June 29 - July 4, 1997; Tampere, Finland (Helsinki: Finish Institute of Occupational Health), 138-40.
- Li G, Buckle P. The development of practical tool for musculoskeletal risk assessment. In: Robertson SA, editor: *Contemporary Ergonomics*. London; Taylor & Francis;1997. P. 442-7.
- National Research Center of Medical Sciences

- of Iran. National health survey of Iran: overall country. Tehran, Iran: Health Ministry of I.R. Iran, Research Chancellor, 2001.
- 20 Choobineh AR, Soleimani E, Mohammad Beigi A. The frequency of symptoms of skeletal disorders-muscle in steel structures industry workers. *Journal of Epidemiology* 2009; 5(3): 35-43. [Persian].
 - 21 Sauter SL, Schleifer LM, Knutson SJ. Work posture, workstation design, and musculoskeletal discomfort in a VDT data entry task. *Hum Factors* 1991; 33(2):151-67.
 - 22 Lin RT, Chan CC. Effectiveness of workstation design on reducing musculoskeletal risk factors and symptoms among semiconductor fabrication room workers. *International Journal of Industrial Ergonomics* 2007; 37: 35-42.
 - 23 Evans O, Patterson K. Predictors of neck and shoulder pain in non-secretarial computer users. *International Journal of Industrial Ergonomics* 2000; 26: 357-65.
 - 24 Choobineh A, Tabatabaei H, Mokhtarzadeh A, Salehi M. Musculoskeletal problems among workers of an Iranian rubber factory. *J Occup Health* 2007; 26: 418-23.