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Original Article

Prevalence of Musculoskeletal Symptoms among Employees of Iranian Petrochemical Industries: October 2009 to December 2012

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Abstract

Background: Work-related musculoskeletal disorders (WMSDs) are a common health problem throughout the world and a major cause of disability in the workplace.

Objective: To determine the prevalence rate of MSDs, assessment of ergonomics working conditions and identification of major risk factors associated with MSDs symptoms among employees of Iranian petrochemical industries between October 2009 and December 2012.

Methods: In this study, we studied 1184 randomly selected employees of 4 Iranian petrochemical companies with at least one year of work experience in office or operational units. For those with office jobs, data were collected using Nordic Musculoskeletal disorders Questionnaire (NMQ) and ergonomics checklist for the assessment of working conditions. For those with operational jobs, NMQ and Quick Exposure Check (QEC) method were used for data collection.

Results: The most prevalent MSD symptoms were reported in lower back (41.5%) and neck (36.5%). The prevalence of MSDs in all body regions but elbows and thighs of the office staff was significantly higher than that of operational workers. Assessment of working conditions in office staff revealed that the lowest index was attributed to workstation. QEC technique among operational workers showed that in 73.8% of the workers studied, the level of exposure to musculoskeletal risks was "high" or "very high." MSDs were associated with type of job, age, body mass index, work experience, gender, marital status, educational level and type of employment.

Conclusion: The prevalence of MSDs in the office staff was higher than that of operational workers. Level of exposure to MSDs risk was high in operational workers. Corrective measures are thus necessary for improving working conditions for both office and operational units.

Keywords: Musculoskeletal diseases; Questionnaires; Human engineering, Checklist; Chemical industry; Risk factors; Body mass index

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Introduction

Musculoskeletal disorders (MSDs) are a worldwide concern and distributed among both industrialized countries and industrially developing countries.[1-4] In developing countries, the problems of workplace injuries are extremely serious.[4] Poor working conditions and the absence of an effective work injury prevention program in developing countries have resulted in a very high rate of musculoskeletal symptoms.[5] Known risk factors of musculoskeletal symptoms are workplace activities such as heavy load lifting, repetitive tasks, taking 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]

For more information on the prevalence of musculoskeletal disorders among paramedics working in a large hospital in Ahwaz, southwestern Iran see www.theijoem.com/ijoem/index.php/ijoem/article/view/98

In petrochemical industry, where the products are being produced continuously, employees are at diverse MSDs 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 during overhauls are also very common among operational workers. In these situations, a high incidence of musculoskeletal symptoms is expected in both groups of employees.

For more information on the prevalence of musculoskeletal disorders among dentists in Shiraz, southern Iran see www.theijoem.com/ijoem/index.php/ijoem/article/view/26

Few studies have so far been conducted on musculoskeletal symptoms and their work-related contributing factors in petrochemical industry. The present study was, therefore, conducted to determine the prevalence of musculoskeletal symptoms among employees, to assess ergonomics working conditions in office and operational workers, and to identify the major contributing factors associated with MSDs symptoms in the study population.

Materials and Methods

This cross-sectional study was conducted from October 2009 to December 2012 in four Iranian petrochemical companies. The participants included 1184 randomly selected employees (871 office workers and 313 operational workers); the sample represented almost 20% of all companies' employees with at least one year of work experience. Employees with background diseases or accidents affecting 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 participant. The questionnaire consisted of two parts: a) personal details including age, weight, height, work experience, daily working time, gender, marital status, level of education, type of employment and working schedule; and b) the general Nordic questionnaire of musculoskeletal (NMQ) symptoms to examine reported cases of MSDs in different parts of the body among the study population.[14] The NMQ provides a mean to screen MSDs cases and to determine the prevalence of MSDs in epidemiological studies.[14] The validity and reliability of the Persian version of NMQ had been surveyed by Choobineh, *et al*.[11] NMQ reported musculoskeletal symptoms during the past 12 months. Each participant received the questionnaire in person in his/her workplace. The questionnaire was completed by workers during the shift while performing their jobs in the presence of an ergonomist.

To assess ergonomic working conditions, a comprehensive ergonomics checklist was developed. The checklist covered 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.[15,16]

The checklist consisted of three sections including environmental working conditions (EWC) (*ie*, noise, illumination and climate), workstation design (WS) (*eg*, workspace room, adjustability, seat, reach envelope, anti-fatigue mat, posture variation, *etc*) and working posture (WP) (*ie*, neck, back, wrists, arms, shoulders and legs). In this checklist, there were 46 items in the three above-mentioned sections.[15,16]

All items of the checklist were observed by the researchers at subjects' workstations. The item was assessed to be either "provided" (yes) or "not provided" (no). The item was, then, scored '1' if it were provided and '0' if it were not provided.[15,16]

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.[15,16]

The indices may thus vary from 0% to 100%. The higher the percentage, the more appropriate the ergonomic condition is.

After calculating the indices, each one was interpreted as either "action category 1" (*ie*, further investigation is needed. Corrective measures are required soon. Attention should be focused on priorities), or "action category 2" (working conditions are acceptable, but attention should be focused on priorities).

Each index was categorized based on a cut off point derived by the receiver operating characteristics curve (ROC) analysis.[17] The cut off points were between 0% and 100% determined based on the prevalence of musculoskeletal symptoms. Table 1 presents action categories as well as cut off points for each assessment index obtained in this study.

TAKE-HOME MESSAGE

- Work-related musculoskeletal disorders are a major cause of disability in the workplace.
- Poor working conditions and the absence of an effective work injury prevention program in developing countries have resulted in a very high rate of musculoskeletal symptoms.
- Workplace activities such as heavy load lifting, repetitive tasks, taking awkward working postures and seated static postures are risk factors for musculoskeletal disorders.
- Long hours of seated activities with high mental workload are observed among control room workers.
- Individual characteristics, psychosocial and organizational factors are also known to be important predictive variables.
- Prevalence of symptoms in the upper/lower back and large joints among the employees studied was significantly higher than those in general Iranian population.
- Age, educational level, gender, BMI, and marital status were significantly associated with development of musculoskeletal disorders in various parts of the body.

Operational workers

An anonymous self-administered questionnaire consisted of personal details and NMQ was also used to collect the re-

Table 1: Action categories for the evaluation indices

Action Category	Evaluation index*			
	EWC (%)	WS (%)	WP (%)	TE (%)
1	0–85	0–66	0–68.18	0–70.65
2	85.01–100	66.01–100	68.19–100	70.66–100

*EWC: Environmental working conditions, WS: Workstation design, WP: Working posture, TE: Total ergonomics index

Table 2: Personal characteristics of the workers participated in the study (n=1184). Value are mean±SD or frequency (%).

Variable	Office workers (n=871)	Operational workers (n=313)	p value
Age (yrs)	36.2±7.9	35.8±8.7	0.536*
Weight (kg)	77.9±13.5	78.9±13.3	0.254*
Height (cm)	173.5±7.9	174.4±6.3	0.064*
BMI (kg/m^2)	25.8±3.8	25.9±4.0	0.711*
Work experience (yrs)	7.7±6.0	8.8±5.9	0.002†
Working hours per day (hrs)	9.2±1.6	9.7±2.3	<0.001*
Male sex	753 (86.5%)	306 (97.8%)	<0.001‡
Marital status			
Single	125 (14.4%)	51 (16.3%)	0.407‡
Married	746 (85.6%)	262 (83.7%)	
Education			
Under diploma/ Diploma	201 (23.1%)	211 (67.4%)	<0.001‡
Academic degree	670 (76.9%)	102 (32.6%)	
Type of employment§			
Formal	495 (56.8%)	75 (24%)	<0.001‡
Contractor	376 (43.2%)	238 (76%)	
Working schedule			
Shift working	201 (23.1%)	140 (44.7%)	<0.001‡
Day working	670 (76.9%)	173 (55.3%)	

*Student's *t* test between the two groups (office and operational workers)
†Mann-Whitney U test
‡χ^2 analysis between the two groups (office and operational workers)
§Formal means permanent employment and contractor indicates transient employment based on a contraction.

quired data from each subject. Quick exposure check (QEC) technique was used to assess the level of exposure to MSDs risk factors.[18,19] The technique includes the assessment of the back, shoulder/arm, wrist/hand, and neck in regard to their postures and repetitive movement. In QEC, task duration, the maximum weight handled, hand force exertion, vibration, visual demand of the task and subjective responses to the work are also taken into account and the required data is obtained from the worker. The magnitude of each assessment item is classified into exposure levels and the combined exposures between different risk factors for each body part are calculated by using a score table. The exposure scores for the back, shoulder/arm, wrist/hand, and neck are 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 for risk factors. To obtain the overall exposure score, total scores of body parts are summed up; the result is then divided by the highest possible score for the overall body—176 for manual handling tasks, and 162 for other tasks. Low overall ex-

posure scores (<40%) indicate acceptable musculoskeletal loading (low risk). For overall exposure scores between 41% and 50%, further investigation is needed and changes may be required (moderate risk). Prompt investigation and changes are required soon for overall exposure scores between 51% and 70% (high risk). Finally, immediate investigation and changes are required for overall exposure scores >70% (very high risk).

Data analysis

Statistical analyses were done by SPSS (ver 16). *Student's t* test, Mann-Whitney U test and χ^2 were used to examine univariate associations between variables and reported musculoskeletal symptoms. Multiple logistic stepwise regression analysis was performed for each outcome retaining the variables in the models to adjust for potential confounding variables. In the regression analysis, if the p value of χ^2 test for assessing association between the variables and reported symptoms was ≤0.25, the variable was included in the regression model.[20]

Results

Table 2 summarizes personal details of the workers participated in the study. The mean daily working hours in operational workers were significantly (p<0.05) higher than those of office staff. The median (IQR) of work experience in operational workers (8 [11] years) was also significantly (p=0.002) higher than that for office workers (6 [7] years). The distribution of gender, level of education, type of employment and working schedule was also different in the two groups.

NMQ revealed that lower back (41.5%), neck (36.5%), upper back (33.4%), knees (31.8%) and shoulders (29%) were the most common affected sites reported by all studied employees (Table 3). The prevalence of MSD symptoms in all body regions but elbows and thighs, was significantly (p<0.05) higher among office employees as compared to that of operational workers.

Table 3: Frequency of musculoskeletal symptoms in various body regions among office and operational staffs during the last 12 months (n=1184)

Body region	Office workers (n=871), n (%)	Operational workers (n=313), n (%)	p value*
Neck	363 (41.7)	69 (22)	<0.001
Shoulders	280 (32.1)	63 (20.1)	<0.001
Elbows	94 (10.8)	35 (11.2)	0.461
Wrists/hands	202 (23.2)	48 (15.3)	0.002
Upper back	319 (36.6)	22 (21)	<0.001
Lower back	393 (45.1)	98 (31.3)	<0.001
Thighs	123 (14.1)	37 (11.8)	0.178
Knees	294 (33.8)	82 (26.2)	0.008
Feet + Ankles	197 (22.6)	55 (17.6)	0.035

*χ^2 analysis between the two groups (office and operational workers).

Factors associated with musculoskeletal symptoms

Musculoskeletal symptom in various parts of the body was significantly associated with demographic and occupational variables. Table 4 presents significant factors associated with musculoskeletal problems for each body region. The factors for each region were identified by a multiple logistic regression analysis performed to adjust for potential confounding variables. Type of job (*ie*, office *vs* operation work), age, body mass index (BMI), work experience, gender, marital status, educational level, and type of employment (*ie*, formal *vs* contractor) were the main variables retained in the regression models with odds ratios generally >1.35.

Office employees

Lower back (45.1%) and neck (41.7%)

Table 4: Independent risk factors for development of musculoskeletal disorders in various parts of the body in studied employees (n=1184)

Body Region	Variable	OR (95% CI)
Neck	Age	1.49 (1.16–1.93)
	Type of employment	1.62 (1.25–2.08)
	Job tenure	1.62 (1.32–1.99)
	Educational level	1.41 (1.41–1.90)
Shoulders	Type of employment	1.56 (1.17–2.12)
	Gender	1.92 (1.26–2.94)
	Educational level	1.41 (1.03–1.95)
	BMI	1.38 (1.05–1.81)
Elbows	Age	1.68 (1.15–2.44)
Wrists/hands	Type of employment	1.72 (1.25–2.38)
	Gender	2.22 (1.47–3.44)
	Educational level	1.49 (1.05–2.14)
Upper back	Type of job	1.51 (1.11–2.04)
	Type of employment	1.75 (1.37–2.27)
Lower back	Type of job	1.40 (1.20–1.85)
	Gender	1.62 (1.07–2.38)
	Marital status	1.71 (1.20-2.43)
	Educational level	1.78 (1.34–2.37)
Thighs	Type of employment	1.90 (1.35–2.68)
Knees	Type of employment	1.58 (1.23–2.04)
	Gender	1.72 (1.17–2.56)
Legs/feet	Age	1.35 (1.03–1.76)
	Type of employment	1.59 (1.22–2.09)
	Gender	2.35 (1.90–2.91)
	BMI	1.35 (1.02–1.79)

symptoms were the most prevalent reported problems among the office employees (Table 3). WS index had the lowest mean for offices, indicating poor ergonomic conditions (Table 5).

The frequencies of EWC, WS, and WP indices assessed in the offices were 30.1%, 46.4% and 36.9% in action category 1, and 69.9%, 53.6%, and 63.2% in action category 2, respectively. The main ergonomics problems in the offices seemed to be originated from poor workstation design, as the highest frequency in action category 1 was observed in this area.

The total ergonomics index was in action category 1 in 37.5% of the observed cases—indicating overall inappropriate working conditions—and in action category 2 in 62.5% of the cases—reflecting overall appropriate working conditions.

Operational workers

Lower back (31.3%) and knees (26.2%) symptoms were the most prevalent problem among the operational workers (Table 6). Assessment of physical exposure to musculoskeletal risks by QEC technique among operational workers showed that in 14.4% of the workers, the calculated exposure level was <40%, indicating that the level of exposure to musculoskeletal risks was acceptable (low risk). In 11.8% of the workers, the calculated exposure level was between 41% and 50%, indicating that the level of exposure to musculoskeletal risks needed considering (moderate risk). In 36.1% 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 decrease exposure level seemed essential (high risk). In 37.7% of the workers, the calculated exposure level was >70%, reflecting that the level of exposure to musculoskeletal risks was very high and immediate ergonomics intervention to decrease the exposure level seemed necessary (very high risk).

Totally, in 73.8% of the operational workers, 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 for developing MSDs. Therefore, ergonomics interventions seemed necessary to improve working conditions and decrease exposure level.

Discussion

The study population was relatively

young. The mean±SD age of participants was 36.1±8.1 years, respectively. Most of the participants were male (89.4%) and married (85.1%). The distribution of work experience, daily working hours, gender, educational level, type of employment, and working schedule, was different between office and operational workers; they were similar for other demographic variables studied.

The musculoskeletal symptoms were common among the studied employees. Back, neck, knees and shoulders were the most affected sites. Another study reported the most prevalent symptoms in lower back, knees and upper back in a group of petrochemical workers.[13]

Table 6 compares point prevalence of the symptoms among the studied workers, general Iranian population,[21] a group of rubber factory workers,[22] and hospital nurses.[23] The prevalence rates of symptoms in neck among the employees studied and the general Iranian population, rubber workers and hospital nurses were significantly ($p<0.001$) different. The prevalence rate of symptoms in the upper/lower back and large joints among the employees studied was significantly ($p<0.001$) higher than those in general Iranian population.

Prevalence of MSDs in all body regions but elbows of office staff were higher than those of operational workers. This is in keeping with the results of other studies.[13] It means that eliminating risk factors of MSD among office staff is of high priority. Although it seems that working conditions in operational units are heavier that offices, the nature of tasks to de done in the office environment, which is mainly sedentary and static for long period, contributes to development of more MSDs among office staff. In operational workers, the dynamic nature of work would reduce the number of people with sustained posture that could be considered as an MSDs risk factor. This might explain in part the lower prevalence of symptoms among operational employees compared to the office workers.

Table 5: Mean±SD of the assessment indices for office staff's workstations studied (n=871)

Index*	Mean±SD (Min, Max)
EWC	88.43±10.3 (50, 100)
WS	65.56±10.37 (24, 100)
WP	72.33±12.38 (18.18,100)
TE	72.15±6.53 (41.3, 95.65)

EWC: Environmental working conditions, WS: Workstation design, WP: Working posture, TE: Total ergonomics index
*A lower score represents poorer working conditions.

Factors associated with musculoskeletal symptoms

The independent demographic variables, age, educational level, gender, BMI, and marital status were significantly associated with development of MSD symptoms in various parts of the body. Age >35 years was a significant factor for development of MSD symptoms in neck, elbows and leg/feet regions (OR ranging from 1.35 to 1.68, Table 4). This is in agreement with the results of previous studies.[24,25]

The risk of MSDs in neck, shoulders, wrists/hands and lower back was higher in those with lower education than more educated workers (OR ranging from 1.41 to 1.78). This is in line with the results of other studies.[24,26] MSDs in shoulders, wrists/hands, lower back, knees and legs/feet were more common among women than men (OR ranging from 1.62 to 2.35), which is in agreement with previous studies.[26] MSD symptoms were more prevalent among subjects with abnormal BMI (*ie*, BMI<18.5 and BMI≥25 kg/m^2) and married workers. We also found that occupational variables including type of job, work experience, and type of employment

For more information on ergonomy of dentistry chairs see www.theijoem.com/ijoem/index.php/ijoem/article/view/138

were significantly associated with MSD symptoms. MSDs are more likely to occur in upper/lower back of office workers compared to operational workers (OR ranging from 1.40 to 1.51, Table 4). Those with a work experience >10 years were more likely to develop neck problems than those wt lower experience (OR=1.62, 95% CI: 1.32–1.99). This is in keeping with the findings of other studies.[21-23] Formal employees were more likely to develop MSD in neck, shoulders, wrists/hands, upper back, thighs, knees, and legs/feet (OR ranging from 1.56 to 1.90) compared to their contract counterparts.

Office employees

The mean±SD working hours per day in office employees was 9.2±1.6 hours, which was more than the standard eight hours per day. Many studies revealed that prolonged working time is associated with a higher prevalence of MSDs.[11,27] This might, therefore, be considered as a contributing factor for the high prevalence of MSDs observed among office workers in our study.

Table 6: Comparison of point prevalence of musculoskeletal symptoms in neck, back and large joints in the employees studied and general Iranian population, rubber workers and hospital nurses.

Body region	Neck	Upper and lower back	Large joints*
Employees studied (age: 19–65 years)	36.5%	47.9%	54.5%
General Iranian population (age: 15–69 years)	10.2%	25.3%	20.0%
Rubber workers (age: 20–60 years)	11.0%	44.1%	53.5%
Hospital nurses (age: 22–66 year)	22.4%	49.3%	60.4%

*Including: shoulders, elbows, wrists, knees and ankles

Poor working conditions (a low WS index) in the studied areas warranted adequate ergonomics considerations. Some studies revealed a correlation between poor workstation design and development of MSD.[28-30] In contrast, EWC had the highest mean indicating relatively appropriate environmental conditions. Based on the results, the main problems of WS index were originated from bending head and neck, taking awkward postures of shoulders and upper arms (*eg*, abduction, extension and flexion), working at tables with appropriate (adjustable) height, lack of foot rest in the workstation, inappropriate seat backrest, lack of seat with adjustable height, and inappropriate position of monitors.

Operational workers

QEC assessment showed that in 73.8% of workers studied, the level of exposure to musculoskeletal risks was “high” or “very high”—the jobs and working conditions in the operational units were conducive for developing MSDs. Therefore, ergonomics interventions seemed necessary to improve the working conditions and decrease the exposure levels.

For the cross-sectional nature of the current study and self-report methodology used for data collection, the results of this study should be interpreted with caution. The self-report method might have problems with recall, denial or deception. Additionally, since the analysis was limited to currently working employees, workers who had left jobs for MSDs symptoms might have been excluded from the study with resultant “healthy worker effect bias.” Therefore, the reported rates may be underestimated.

In conclusion, the most prevalent MSDs symptoms were reported in lower back, neck, upper back, knees and shoulders. So, in working conditions improvement, taking risk factors of these regions

seemed essential. The prevalence of MSDs in all parts of the body but elbows of office employees were higher than those of operational workers. Therefore, reducing risk factors of MSDs in office workers has a higher priority. Operational workers' level of exposure to MSDs risks was high. Taking corrective measures for reducing risk level into consideration is thus necessary. Demographic variables (*ie*, age, educational level, gender, BMI, and marital status) and occupational variables (*ie*, type of job, work experience, and type of employment) were found to be significantly associated with development of MSDs among petrochemical employees.

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