

# EVALUATION OF MUSCULOSKELETAL DISORDERS RISK FACTORS AMONG THE CREW OF THE IRANIAN PORTS AND SHIPPING ORGANIZATION'S VESSELS

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**Abstract-** Musculoskeletal disorders (MSDs) are important causes of work incapacity and loss of work days. MSDs are major problems in almost all countries and increasingly can be found in service industries such as maritime sector. This study aimed at evaluation of MSDs symptoms among crew of tugboats, dredgers, pilot boats and barges by using Nordic Musculoskeletal Questionnaire (NMQ) and also determination of work-related MSDs risk factors by application of Ovako Working Analysis Posture System (OWAS). The result showed that 28.4% of body postures rated in action category 3 and 4 of OWAS. It seems that OWAS cannot be used as a determination method of risk factors for all jobs. Also, the best and sometimes the only way to correct awkward postures is correction of worker's back position.

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**Key words:** Ergonomics, musculoskeletal disorders, OWAS method, Nordic musculoskeletal questionnaire, risk factors

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## INTRODUCTION

Several researches have shown that the application of ergonomics principles and programs in almost all workplaces results in increasing productivity, decreasing work-related diseases and fruitful outcomes beyond their costs (1,2). On the other hand, poor workplace or job design will expose workers to poor working postures, awkward postures, repetitive movements, high work load, difficult manual handling tasks and too much bending and stretching effort. The basic consequences will appear as pain and discomfort, feeling particularly at the back, shoulder, neck and upper limbs. Final result of these exposures may appear as musculoskeletal

disorders (MSDs) (3). A survey conducted by the Bureau of Labor Statistics (BLS) showed that in 1994 approximately 705.800 cases were the result of overexertion or repetitive motion (4).

These days, importance of ports is more obvious than before; the ports play a vital role in every country's economy. This role can be seen in several ways such as providing direct and indirect jobs and import and export of goods to and from country. Doing port's activities efficiently and in a productive manner needs both modern equipments and good infrastructures in one hand and healthy and skilled operators, workers and vessel's crew on the other.

Iran with about 2700 km of coastline both in the north and south is a good example of ports' role in country's economy, where more than 90% of goods are imported and exported through its ports. One of the most important items in increasing ports' productivity and decreasing work related diseases and accidents is protection of workers against any hazardous elements such as MSDs risk factors.

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This descriptive-analytical study was carried out from April 2001 to June 2002 to evaluate MSDs risk factors in some of the port's activities. The targeted group was crew of some Iran's Ports and Shipping Organization tugboats, dredgers, pilot boats and barges.

## MATERIALS AND METHODS

In this research all 722 crew of available vessels were chosen and according to their working positions categorized into 12 jobs: captain, boatswain, seaman, electrician officer, dredge officer, chief engineer, motorist, wheelman, deck officer, chief officer and cook. We obtained informed consent from all subjects.

Nordic Musculoskeletal Questionnaire (NMQ) was used to determine the prevalence of MSDs symptoms (5). NMQ comprises general information about age, weight, height, smoking habit, work experience and shift type and also questions about problems on the whole body and body part-specific questions (neck, shoulders and lower back). A body "map" was also used to make it easier for workers to pinpoint their problems in each body area.

The questionnaires were completed through structured interview and then analyzed with SPSS software (ver.6). At the same time to identify and evaluate harmful working postures, the Ovako Working Postures Analyzing System (OWAS) was used (6).

The OWAS method collects simple observational information on worker postures (4 back, 3 arm, 7 leg) and loads (3 loads) according to a breakdown of work tasks. Schematic view of OWAS analyzing system is shown in table 1.

These data were then standardized and the individual activities were rated into four action categories in order of their strain (no harmful effect, some harmful effect, distinctly deleterious effect and extremely deleterious effect).

The OWAS data analyzed with WinOWAS software (7), a computerized system for the analysis of work postures that was prepared by Occupational Safety engineering of Tampere University of Technology in Finland.

**Table1.** Schematic view of OWAS analyzing system

<b>Back</b>
1. Straight.
2. Forward back ward bending.
3. Side rotation or bending.
4. Both rotation and bending
<b>Legs</b>
1. Sitting posture.
2. Straight standing
3. Standing and bodyweight pressure on one leg.
4. Standing and bending knees.
5. Standing and one bending leg.
6. Sitting on both legs.
7. Movement and walking.
<b>Arms</b>
1. Two arms lower than shoulder.
2. One arm upper than shoulder.
3. Two arms upper/ or on the level of shoulder.
<b>Loads</b>
1. Weight < 10 kg
2. 10 < weight < 20 kg
3. Weight > 20 kg

## RESULTS

The participants were working on different vessels, 15.1% on pilot boats, 55.5% on tugboats, 27.1% on dredgers and 2.4% on barges. For more than 40% of them the NMQ was completed through structured interview. Average job experience was 20 years and its standard deviation equals to 8.5 years. All of participants were male. Other general information can be seen in table 2.

### NMQ results

Data of those participants in whom their MSDs symptoms were related to a previous disease or accident were excluded from later analysis. The NMQ statistical results showed that among all employees, in those who worked as captain, deck officer and wheelman, all on the bridge of ship, there was statistically significant correlation between working on these jobs and prevalence of MSDs symptom at low back region. The *P* value in Chi square test was 0.04 with a confidence interval of 95%. Also there was statistically significant correlation between working as a chief engineer, chief officer, dredger officer and motorist and prevalence of MSDs symptoms at shoulder (*P* = 0.02, CI = 95%).

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**Table 2.** Average and standard deviation of age, weight, height and work experience of participants

	Average	Standard deviation
Age (year)	43	3.7
Weight (kg)	73.8	11.0
Height (cm)	170.4	7.7
Work experience (year)	20.0	8.5

There was no statistically significant correlation to provide support for the relationship between MSDs symptoms and other variables such as work experience, age and shift type.

The highest prevalence of MSDs symptoms among all participants, regardless of the job they were working, were related to low back (32.9%), knee (26.4%), and shoulder (18.8%). Data for other regions can be seen in table 3. The motorists showed the highest rate of different MSDs symptoms in elbow (33.3%), feet (30.8%), ankle (32.7%) and shoulder (27.3%) among all employees. Captains also showed highest rate of symptoms at low back (22.9%), back (29.6%) and leg (28.6%).

### OWAS results

The OWAS results rated postures of captains, deck officers and wheelmen in action category 1; it meant that their postures were harmless for musculoskeletal system. Postures of electrician officers, dredger officers, seamen and cooks were rated in action category 2 of OWAS. Postures of chief engineers, chief officers, motorists and boatswains were rated in action category 3 of OWAS, which meant that preventive measures should be taken as soon as possible.

Considering working hours, in 33.7% of working hours crew had a posture that was rated in action category of 1 (no harmful effect), 37.9% in category 2 (some harmful effect), 19.6% in category 3 (distinctly deleterious effect) and 8.8% in category 4 (extremely deleterious effect).

Doing activities in some jobs exposed workers to postures that was rated in action category 4 of OWAS but those postures were not considered as a frequent or usual part of their every day tasks

Simultaneous consideration of NMQ and OWAS results revealed that while action category 2 of

OWAS included a series of more deleterious postures than category 1, the frequencies of MSDs symptoms were in reverse. All those jobs which were rated in action category 1 showed a higher rate of symptoms in all regions than action category 2. This result was exactly against the OWAS suggestions about harmlessness of postures in category 1. As OWAS predicts and is expectable, MSDs symptoms in category 3 were more frequent than category 2. Details are shown in table 3.

According to the OWAS, those postures which were rated in action category 1 were harmless and workers should not appear to have any symptom of MSDs, but the NMQ results confirmed that low back pain was prevalent in captains, deck officers and wheelmen with action category 1, a finding which was supported by statistical analysis.

For chief engineers, chief officers and motorists rated in action category 3 of OWAS and dredger officers, risk factors that resulted to MSDs symptoms in shoulder region were awkward postures (over head work) and excessive workload during most of working time.

**Table 3.** Prevalence percentage of MSDs symptoms by different regions of body and action categories of OWAS method\*

Region	Symptom prevalence	Category 1 OWAS	Category 2 OWAS	Category 3 OWAS
Back	9.2	29.6	22.2	48.2
Feet	13.4	28.2	20.5	51.3
Knee	26.4	31.2	19.5	49.3
Leg	12.0	37.1	17.1	45.8
Low back	32.9	33.3	22.9	43.8
Neck	15.8	34.8	17.4	47.8
Shoulder	18.8	27.3	16.4	56.3
Hand and wrist	13.0	21.1	26.3	52.6
Elbow	10.3	20.0	33.3	46.7
Ankle	16.8	28.6	14.3	57.1

Abbreviations: MSD, musculoskeletal disorders; OWAS, Ovako working postures analyzing system.

\* Data are presented as percent.

## DISCUSSION

Investigation of the results of two methods of NMQ and OWAS can be categorized into the following.

### NMQ method results

There was a significant relation between working in command group (captain, wheelman and deck officer) and MSDs in low-back ( $P < 0.04$ ). Also, results in technical group (chief engineer, engine officer, dredger officer and motorist) revealed that there was statistically significant relationship between MSDs at shoulder region and these jobs ( $P < 0.02$ ). No significant difference was observed between working at vessels and MSDs in the other body regions such as neck, back, ankle, elbow, foot, hand and wrist. Comparison of the results showed that the highest prevalence of MSDs in elbow (33.3%), shoulder (27.2%), knee (23.2%) and foot (30.7%) belonged to motorists, while in chief engineers highest prevalence of MSDs were 26.8% (hand and wrist), 33.3% (legs), and 23.9% (neck). In addition, in comparison with other jobs the prevalence of MSDs in captains was found to be high in legs (33.3%), low-back (22.9%), and back (29.6%).

### OWAS method results

Investigation of the presented results through tasks observations among different jobs revealed that captains, deck officers and wheelmen were rated in OWAS action category of 1. Electrician officers, dredger officers, seamen, cooks and gallery boys were rated in OWAS action category of 2, while motorists and boatswains were rated in OWAS action category of 3, and this means that the latter jobs require urgent control and preventive measures.

This was also stated by National Institute for Occupational Safety and Health. Bjelle *et al.* and Ohlsson *et al.* found a significant positive association between the prevalence of neck-shoulder disorders and the frequency of upper arm movements past 60 degrees of flexion or abduction. English *et al.* found a significant association between cases of shoulder disorders and repeated shoulder rotation with an elevated arm posture(4).

### Relationship between OWAS and NMQ

Comparison between results of prevalence of MSDs in OWAS action categories 1 and 2 showed that higher prevalence existed in OWAS action category 1 which belonged to captains, deck officers and wheelmen which might be due to psychosocial factor. Also, prevalence of MSDs in OWAS action category 3 was higher than the two other categories (1 and 2) and this clearly revealed the relationship of MSDs and occupational risk factors.

After determination of risk factors, the OWAS method can be used to identify any possible correction in working posture that leads to a better and less harmful posture. About 81% of those postures which were rated into category 3 of OWAS can be corrected in two ways. First, any decrease in workload (from more than 20 kg to 10 - 20 kg) leads to a new body posture with an action category 2. But this suggestion is not always practical because weight of tools and materials that are used on vessels are fixed and usually can not be changed. Second, correction in worker's back position would have an excellent consequence; in 91% of awkward postures any correction in back position results in a new, less harmful posture with action category 2. This suggestion is more practical and mostly needed a change in worker's habits. Considering OWAS action categories, any change in legs or hands positions would be fruitless. Meanwhile for those postures which were rated in category 4 of OWAS, the only possible way toward a safer posture is correction in back position. This change will improve 95% of postures with extremely deleterious effect (category 4) to new postures with distinctly deleterious effect (category 3).

It can be concluded that increasing ports' productivity and prevention of work-related diseases and accidents need identifying all hazardous factors such as MSDs risk factors. Determination of MSDs risk factors for those who work on the bridge of vessel such as captains, deck officers and wheelmen requires another method instead of OWAS. The best way to decrease harmful postures and prevalence of MSDs symptoms in workers is correction in back position; in 8.5% of postures it is the only possible and practical way. Results of this study suggest a need for more investigations into MSDs risk factors

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as well as evaluation of practical programs to teach workers how to have a correct posture.

It seems that there are other factors which contribute to production of MSDs and OWAS method is unable to determine them. These factors can be physical such as vibration (5) or psychosocial risk factors (8). Meanwhile several researches have shown that psychosocial factors like high responsibility, monotonous work, high-perceived work load, time pressure, less control on the job and lack of social support may result in MSDs (9).

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