Original Article

Musculoskeletal disorders and posture analysis at workstations using evaluation techniques

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Abstract

Introduction:
Despite the global awareness of sustainable use of ergonomics in reducing musculoskeletal disorders and increasing productivity at work, ergonomic considerations in developing countries are not taken seriously. This study aimed to analyze musculoskeletal disorders and ergonomic assessment of manufacturing companies in Qazvin, Alborz Industrial City.

Materials and Methods:
This cross-sectional descriptive study examined 35 workstations. Data were collected through interviews with individuals who completed the Body Map questionnaire and were analyzed using SPSS 17 software. Then the results of imaging workstations and direct observation were analyzed using Win owas, Nexgen softwares.

Results:
71 questionnaires were filled in and analyzed. The results showed that the body posture of individuals at work is 40 percent standing and 29 percent repetitive. According to the results of the studies conducted on the organs under consideration, the most pain has been observed in the middle back, right leg and left leg, respectively. The relationship between job variables and musculoskeletal disorders was evaluated and just pain in the right shoulder was significantly associated with the job. The relationship between age and pain in the upper back, between the fingers of the left hand and left leg was significantly ($P<0.05$). No significant relationship was found between demographic variables and other musculoskeletal disorders.

Conclusion:
The survey of the workstations revealed that filters, engine, chassis welding and molding jobs have more risk factors for musculoskeletal disorders than other jobs.

Keywords: Musculoskeletal Disease, Posture, Analysis

Introduction

NIOSH Organization is one of the most valid international organizations in the field of safety and occupational health and has published numerous standards and reports in different fields of safety and occupational health, has classified occupational diseases and complications according to their national significance in terms of incidence, severity and possible prevention. In this classification, musculoskeletal disorders follow

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occupational respiratory diseases. Several studies indicate that musculoskeletal disorders are economically very costly and rank the first in terms of incidence and pain. Among these disorders, back pains rank the first (1).

Musculoskeletal disorders have always been widely mentioned in scientific papers. In the eighteenth century, Ramazini described these disorders among office secretaries. He believed that these damages were generated due to unfavorable posture, repetitive movements and mental pressures (2). Since then, numerous studies have been conducted on the prevalence and incidence of musculoskeletal disorders, effective risk factors and preventive methods in the world particularly in industrial countries (3).

Based on studies conducted in the U.S., 60% of the incidence of all diseases in the workplace are musculoskeletal disorders in that they have reached an immense growth rate from 5% in 1981 to 30% in 1991 (3). This issue is so important that the United States Occupational Safety and Health Administration (OSHA) has announced that the aim of safety and health programs in the workplace is to prevent damages and diseases by eliminating their causes. In ergonomics, this aim is synonymous with eliminating or reducing workers' exposure to ergonomic hazards that cause musculoskeletal disorders (4).

All of the above indicate the importance of musculoskeletal disorders in workplaces. These disorders can occur in any occupation and industry. Musculoskeletal disorders occur in the vertebrae, upper and lower limbs. These disorders may gradually occur in a long-term exposure to their causing agents, or may be created suddenly due to a big trauma to a large part of the musculoskeletal system. The first type is known as cumulative disorders that are generated by the physical and mechanical factors over time.

By definition, musculoskeletal disorders are disorders of muscles, tendons, tendon sheaths, peripheral nerves, joints, bones, ligaments, and blood vessels that can be created as a result of repetitive stress over time, or as the result of an immediate or acute trauma (such as slip and fall). When the work environment and duty help the development of these disorders, these disorders are considered occupational. In general, musculoskeletal disorders are multifactorial disorders. Mechanical and physical risk factors that cause or aggravate musculoskeletal disorders include improper or fixed posture, applying excessive force, repetitive movement, lifting and carrying loads, contact pressure, whole or local body vibration, low temperatures and finally unfavorable lighting which all lead to unfavorable posture (5).

These risk factors are intensified due to some organizational characteristics such as wrong work/rest cycle, fast work pace, long working hours, unfamiliar tasks, the lack of diversity in work, tasks that a machine determines their speed, payment per task system etc. So, it can be said that occupational musculoskeletal injuries are damages that are created over time due to musculoskeletal activities which sometimes may seem simple and ordinary.

Symptoms of these disorders are a collection of discomforts, pain, tingling, burning, being sensitive to the touch, and swelling, limited range of motion, the loss of strength and ability and sensory disorders in a part of the body. Musculoskeletal disorders affect the parts of the body involved in working. Upper body especially the vertebrae and hands are the most susceptible limbs to the risk factors of these disorders (6).

Materials and Methods

This cross-sectional study was conducted in 2010 in one of the cryogenic equipment manufacturing companies in Alborz industrial city in Qazvin. The census sampling method was used on workers employed at different workstations (35 stations) considering the exclusion criteria:

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suffering from chronic musculoskeletal disorders or having had a surgery on musculoskeletal system. Body map questionnaire was used to determine the incidence of musculoskeletal disorders symptoms in different body parts of workers (7). Seventy-one questionnaires were completed at all workstations. Then the questionnaire data were transferred into SPSS.17 software and various statistical tests were performed on them. Based on the results of questionnaires analysis, Owas and Rula techniques were used for occupational analysis and photography of various stages of work.

Owas technique was offered by Ovako Oy Company in 1992 by the assistance of Finnish Institute of Occupational Safety and Health. In these techniques, different postures are examined and different items are recorded. Using the evaluation table provided in the following, postures can be assessed and their conformity or non-conformity with the acceptable standards can be determined. Rula technique which is the developed form of Owas technique is more appropriate for jobs in which upper limbs are more involved and conformity or non-conformity with the acceptable standards are investigated. For ease of review and a closer analysis of these techniques, WIN OWAS and NEXGEN software programs were used. Both software programs mentioned contain tables and procedures that calculate the final score based on data of each posture.

At first, body map questionnaire was used to identify body regions involved in musculoskeletal disorders and also causes of creating pain and discomfort in mentioned areas at different workstations. This questionnaire begins with questions on the personal profile of people such as gender, age, height and then identifies occupational physical pains, and finally ends with questions on the causes of discomforts.

In this study, tasks at the factory were studied with 680 images provided from different postures. These images nearly indicated all body postures at the factory, and were analyzed by researchers and classified.

In order to assess the risk of musculoskeletal disorders, Owas and Rula techniques were used according to the type of task and the results of body map assessment. Observations were made for one month and a total of 115 postures were selected and at the end of the observation process, data obtained were transferred into the software and analyzed. Similarly, data on postures requiring assessment were transferred into the software by Rula technique and analyzed.

In a study with the aim to evaluate the posture of children who work with computer, Rula technique was found more reliable for reviewing children older than seven years and more appropriate for younger people (9). Also in reviewing musculoskeletal disorders in a manufacturing company through six ergonomic assessment techniques, it was found that hazardous ergonomic situations are confirmed by sophisticated techniques such as Rula (10).

Results

In this study, conducted on 71 workers of production lines in a cryogenic equipment manufacturing company, the mean age of workers was 33.47 years (range: 22-48) years. The mean work experience of workers was 10.2 (range: 2-22) years. The work experience of 63% of workers was under 10 years. The age of 66.2% of the subjects was less than 35 years and the highest frequency related to the age of younger than 30 years which indicates the subjects were young. 91.5% of the subjects were right-handed and the others were left-handed. The mean weight of the studied workers was 75.9 kg and their mean height was 173 cm. As seen in Table 1, most disorders were reported in middle back (8.33%), right leg and left leg (6.98%). Percentages presented in this table are based on the total number of data extracted

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from the body map questionnaire. Also, the options related to pain intensity were added to the questionnaire for better understanding of workers and as it was a subjective criterion, it was not used in the analysis.

The relationship between occupation and musculoskeletal disorders was assessed by Chi-square test and only pain in the right shoulder had a significant relationship with the task. Also, there was a significant relationship between age and pain in upper back, left hand fingers and left leg ($p<0.05$). No significant relationship was observed between demographic variables and other musculoskeletal disorders.

In Table 2, the incidence of musculoskeletal disorder symptoms is provided at least in each limb according to the task type. The most prevalent symptoms of these disorders related to assembling and welding tasks and the lowest prevalence (excluding cases where only one questionnaire was completed) related to a painting unit and forklift driving. The numbers in the table were completed according to percentage based on the total number of questionnaires completed in each workstation. The total number of questionnaires in each workstation is given next to its name on the top of the table. For brevity, only information of a number of workstations with the highest number of disorders is provided. Due to the nature of the task and the amount of musculoskeletal disorders in different limbs, occupational postures were separated and each was analyzed by the more appropriate techniques. The results of the evaluation by Owas technique are shown in Figures 1 and 2 and the results of Rula technique are given in Table 3. It should be noted that all figures have been prepared by specialized Owas and Rula software and each indicates the scoring for the intended postures. In fact, scoring system was changed from numbers to figures so that a better understanding of the posture can be achieved by inserting body posture and limb name. For example in Figure 1, all body postures in filter making workstation are shown as percentage of total postures by using software. These percentages are converted to the final score Owas and indicate the status of this workstation in Figure 2.

Discussion

According to the survey, the highest incidence of pain was observed in middle back, right leg, left leg, right wrist, lower back and left wrist, respectively. Hip, left hand palm, left hand fingers, right elbow and the back of the left thigh had the lowest frequency, respectively. The high level of musculoskeletal disorders in waist and knees in this study represents unfavorable body postures in people in standing and semi-standing workstations that should be modified.

In a study by Maria et al. on the Ford Motor Company in Venezuela to evaluate body postures in manual welding workstation, totally 548 body postures were recorded. The results of this study showed that welding activities have improper body postures while working, and 27.62% of body postures at workstation F350 and 21.01% at workstation F150 were in a very harmful condition (2). Another study by Owas technique by Fatemeh Sadeghi, Hassan Asilian and Leila Barati in 2004, titled "The assessment of workers' body postures" in one of the rolling mills in Ahvaz, it was found that Drill Radian-2 workstation had the most dangerous mode among the studied body postures. Also according to analyses performed by Owas technique, fixed manual welding workstation was classified as the heavy works and to modify this situation it was recommended that electric or pneumatic fixed welding be used instead of manual welding (12). Mohammad Fam et al. in the study of the risk of musculoskeletal disorders in an industrial company by using LUBA and QEC and comparing the results found that 71.3% of working groups were at priority 4 for modifying

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behavior (13). The results of the current study are consistent with the results of the above studies and reiterate the need for structural reform of manual workstations including filter making, welding and molding.

Table 1: Frequency and intensity of musculoskeletal disorder symptoms in different limbs in the studied workstations in a cryogenic company in 2010 (percentages have been calculated based on data collected from musculoskeletal disorders questionnaire)

Members	Low	Medium	High	Very high	Total frequency	Percentage
Middle back	2	12	15	14	43	8.33
Right leg	2	12	11	11	36	6.98
Left leg	5	14	7	10	36	6.98
Right wrist	4	10	9	11	34	6.59
Lower back	4	4	11	12	31	6.01
Left wrist	6	7	7	9	29	5.62
Right shoulder	2	13	6	4	25	4.84
Neck	2	11	5	7	25	4.84
Right arm	3	6	9	5	23	4.46
Right heel	2	8	7	6	23	4.46
Upper back	2	5	5	10	22	4.26
Left elbow	6	5	7	3	21	4.07
Left shoulder	4	8	7	2	21	4.07
Right hand fingers	2	5	6	7	20	3.88
Left arm	3	3	8	5	19	3.68
Back of the left thigh	2	11	2	3	18	3.49
Back of the right thigh	3	9	2	4	18	3.49
Right hand palm	4	6	5	3	18	3.49
Right elbow	2	4	4	6	16	3.10
Left hand fingers	2	4	6	3	15	2.91
Left hand palm	5	3	5	1	14	2.71
Hip	5	1	3	-	9	1.74

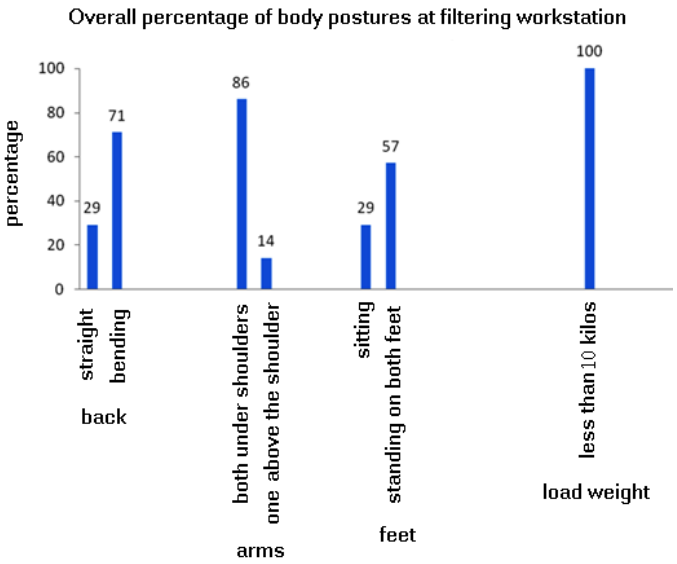

Figure 1: The percentage of body postures separately according to scores obtained from Owas technique in filter making workstation in a cryogenic company in 2010

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Table 2: The prevalence of musculoskeletal disorders (in terms of percentage) separately according to different occupations in a cryogenic company in 2010

Member	Press fine 2	Welder 14	Bending 5	Press maker 3	Forklift driver 2	Assembler 16	Turner 2	Cutter	Drilling 3	Painting 3	Air Handling 4	welding spot 4
Left elbow	0	23.8	4.8	0	0	42.9	0	4.8	0	0	4.8	9.5
Left arm	0	26.3	5.3	0	0	36.8	0	5.3	0	0	5.3	5.3
Left shoulder	0	25	10	5	0	35	0	5	0	5	5	5
Right shoulder	2.6	21.1	2.6	0	2.6	26.3	5.3	2.6	7.9	0	10.5	10.5
Right arm	4.2	20.8	8.3	4.2	0	16.7	8.3	4.2	0	4.2	16.7	4.2
Right elbow	3	17.4	4.3	0	0	30.4	8.7	4.3	4.3	4.3	8.7	4.3
Back of the left thigh	0	25	6.3	0	0	31.3	0	0	0	0	12.5	12.5
Back of the right thigh	0	22	16.7	5.6	0	27.8	0	5.6	0	5.6	5.6	11.1
Neck	0	22.2	11.1	5.6	0	6	0	5.6	0	5.6	5.6	5.6
Right heel	0	8	8	8	0	32	4	4	0	4	12	16
Upper back	0	18.1	0	0	4.55	31.8	4.5	4.55	4.55	0	13.6	9.09
Middle back	0	21.7	0	0	4.3	30.4	4.3	4.3	4.3	0	13	7.8
Lower back	4.7	14	7	4.7	2.3	22.6	3.2	3.2	0	3.2	12.9	9.7
Hip	3.2	19.4	6.5	0	2.3	22.6	3.2	3.2	0	3.2	12.9	9.7
Left hand fingers	0	33.3	0	0	0	33.3	0	0	0	0	22.2	11.1
Right hand fingers	0	26.7	0	0	0	33.3	0	6.7	0	0	6.7	13.3
Left Wrist	5.3	31.6	0	5.3	0	21.1	0	5.3	0	0	10.5	10.5
Right Wrist	0	24.1	6.9	0	0	24.1	3.4	3.4	6.9	0	6.9	6.9
Left hand palm	0	20.6	2.9	0	0	29.4	2.9	2.9	5.9	0	11.8	5.9
Right hand palm	20.6	0	7.1	0	0	28.6	0	7.1	0	0	14.3	0
Right shin/calf	5.6	27.8	11.1	0	0	27.6	0	5.6	0	0	11.1	0
Left shin/calf	2.8	16.7	11.1	2.8	0	22.2	0	2.8	0	2.8	11.1	8.3

Table 3: Sample Nexgen software output according to the performance of Rula technique in filter making workstation (Persian) in a cryogenic company in 2010

Right hand

Parts of the body	Range of posture changes	Score based on Rula technique
Wrist	0 to 20	2
Wrist	In the middle range of wrist rotation	1
Arm	21 to 45	1
Forearm	0 to 90	1
Neck	Higher than 20	3
Body	0 to 20	2
Feet	Supported	1

Parts of the body	Posture score	Muscle score	Force score	Total
Arm + wrist	2	1	0	3
Neck + legs + body	2	1	0	3

Final score based on Rula technique: 3

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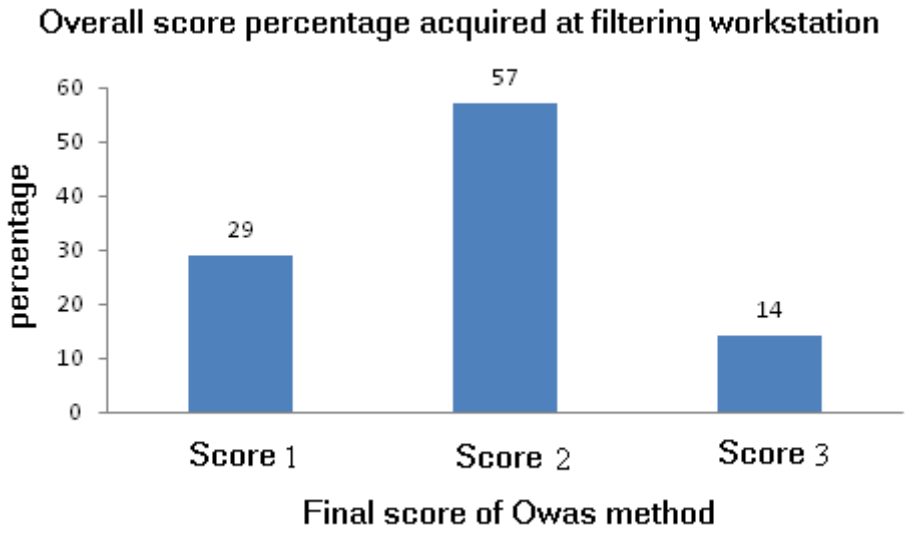

Figure 2: The final score percentage based on Owas technique in filter making workstation in a cryogenic company in 2010

As seen in Table 1, the incidence of musculoskeletal symptoms among workers of the considered industry is more in the middle back and right leg because of the following reasons:

- Unfavorable postures in which joints are in their ultimate range of motion.
- The nature of task and the pieces make individuals to use improper body posture.
- Using excessive and in some cases improper force.
- Applying inappropriate and non-ergonomic tools.

A number of tasks such as welding coils (while sitting and standing), welding header, filter making, welding header panel, chassis motor welding, drilling, air conditioner condenser, coiling were assessed again by Rula technique to increase the accuracy of the evaluation, and investigate all tasks comprehensively. In all cases, the score obtained indicates the need for further examination.

Conclusion

By revealing the high risk tasks and ergonomic weaknesses at workstations, corrective actions were provided to eliminate the shortcomings as follows:

1. Adjusting distance access and work desk height, one of the frequently cases seen in the images was the disproportion of work desk height and distance access to work tools.
2. Choosing electrical devices with vibration-free components, using insulated handles to absorb vibration, increasing the coefficient of friction to reduce the force required.
3. Lifting the worker up by platform and standard use of the tool to reduce the bending of the wrist.
4. Using pad (cushion) on the edges, supports or work desk in order to avoid too much pressure to hands and sudden collusion with sharp edges.
5. Using rotary table with complete control on work, selecting a tool that will reduce the deviation of the wrist, such as a variety of hand tools with proper curve in the handle.
6. Lifting containers up and tilting them for easier access and reducing the bending to lift the load up.
7. Providing proportionate training courses for task groups based on ergonomic principles.
8. Performing proper exercise on a daily basis to protect musculoskeletal system.

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9. Using those people with physical and anthropometric characteristics proportional to their tasks.

Conflict of interests:

Authors had no conflict of interests in this study.

References:

1. Khalil TM, Abdel-Moty E, Steele-Rosomoff R, et al. Programs in post injury management. In: Karwowski W, Marras WS (eds). The occupational ergonomics handbook. Florida: CRC Press; 199.:1015-20.
2. Helander MG. A guide to the ergonomics of manufacturing. London: Taylor & Francis; 1995: 203-20.
3. Vanwonterghem K. Work-related musculoskeletal problems: some ergonomic considerations. J Human Ergol 1996; 25(1): 5-13.
4. Keyserling WM, Stetson, DS, Silverstein BA, et al. A checklist for evaluating ergonomic risk factors associated with upper extremity cumulative trauma disorders. Ergonomics 1993; 36(7): 807-31.
5. Aghilinejad M. Occupational Medicine. 3rd ed. Tehran: Arjmand Publ; 2006: 57-60. (Persian)
6. Moyodi MA. CTD view of Ergonomics. 1st ed. Tehran: Hayyan Publ; 2004: 93-100. (Persian)
7. Dickinson CE ea. Questionnaire development An examination of Nordic Musculoskeletal questionnaire. Appl Ergon 1992; 23(3): 197-201.
8. Choobine A. Posture assessment method in occupational ergonomics. 1st ed. Tehran: Fanavaran Publ; 2004: 41-6. (Persian)
9. Dockrell S, O'Grady E, Bennett K, et al. An investigation of the reliability of Rapid Upper Limb Assessment (RULA) as a method of assessment of children's computing posture. Appl Ergon 2012; 43(3): 632-6.
10. Sala E, Torri D, Tomasi C, et al. Risk assessment for upper extremity work related muscoloskeletal disorders in different manufactures by applying six methods of ergonomic analysis. Giornale italiano di medicina del lavoro ed ergonomia. 2010; 32(2): 162-73.
11. Gandavadi A, Ramsay JR, Burke FJ. Assessment of dental student posture in two seating conditions using RULA methodology - a pilot study. Br Dent J 2007 24; 203(10): 601-5.
12. Fatemeh S. Posture assessment in Ahvaz Navard factory. Behbood. 2007; 11(1): 78-80. (Persian)
13. Mohammadfam I, Kianfar A, Afsartala B. Assessment of musculoskeletal disorders in a manufacturing company using QEC and LUBAmethods and comparison of results. Iran Occup Health J 2010; 7(1): 7-10.

[DOI: 10.29252/jmj.11.3.17]