

Ergonomic intervention to reduce musculoskeletal disorders among flour factory workers

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Abstract.

BACKGROUND: Work-related musculoskeletal disorders are the most common occupational health hazards. In the flour production industry, the fast pace of work, high frequency of repetitive movements, manual handling of loads, and awkward postures put a lot of pressure on the worker's body.

OBJECTIVE: Given the high exposure of the workers of the flour production industry to ergonomic risk factors, this study aimed to reduce the rate of musculoskeletal disorders among a group of flour factory workers through ergonomic interventions.

MATERIALS AND METHODS: This interventional study was performed using the census method on the eligible workers of a flour factory. An ergonomic intervention program was planned and implemented with the goal of reducing musculoskeletal disorders. The effectiveness of the program was evaluated by measuring the prevalence of musculoskeletal disorders before and six months after the interventions.

RESULTS: Before the intervention, musculoskeletal disorders were most prevalent in the lower back, arms, shoulders, legs, thighs, knees, neck and wrists, respectively. Evaluation of the prevalence of musculoskeletal disorders after the intervention showed the positive effect of the ergonomic intervention program on musculoskeletal disorders in the neck, shoulders, lower back, thighs, knees, and legs ($P < 0.05$).

CONCLUSION: Engineering and management interventions implemented in this study led to a significant reduction in the level of ergonomic risk factors and a reduced rate of musculoskeletal disorders among workers of different units in the flour factory.

Keywords: Flour factory, ergonomic intervention, nordic questionnaire, musculoskeletal disorders

1. Introduction

Musculoskeletal disorders are the most prevalent medical issues in work environments and are

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associated with a significant portion of occupational illnesses [1]. The prevalence of musculoskeletal disorders in occupational settings is directly related to the ergonomic conditions of the work and particularly the frequency of repetitive movements, awkward postures, carrying heavy loads, and exposure to vibrations [2]. Musculoskeletal disorders are highly prevalent in sugar and cement industries, where workers have to carry heavy loads continuously. Awkward postures, repetitive movements, carrying loads above the shoulder, and frequent manual handling of heavy objects and bags increase the incidence of musculoskeletal disorders in these industries [3, 4]. A study on the prevalence of musculoskeletal disorders in sugar factories has shown that given the nature of the work and the need to handle sugar bags manually, there is a dire need for ergonomic interventions to address the high prevalence of musculoskeletal problems in these factories [3]. A study by Goldsheyder et al. showed the high prevalence of musculoskeletal disorders among cement industry workers and the need for an ergonomic intervention program in this industry [5]. In a study by Salem et al., which aimed to reduce musculoskeletal disorders in cement factories, it was found that reducing the weight of cement bags could reduce these disorders [6].

As stated, one of the common problems among workers of many industries is the awkward posture, manual handling of loads, poor bending and turning in the lumbar region. Research has shown that the prevalence of musculoskeletal disorders in many industries can be reduced by well-planned ergonomic interventions implemented through engineering and management approaches aimed at reducing awkward postures, load weight, and load carrying time, which also improve the working environment [7, 8]. The commitment to an integrated approach consisting of engineering, educational and management interventions to improve the ergonomic conditions of the work environment not only reduces the incident of musculoskeletal disorders, but also increases productivity [9, 10].

In the flour production industry, the fast pace of work, high frequency of repetitive movements, manual handling of bags, and high frequency of awkward postures put a lot of pressure on the body and increase the risk of musculoskeletal disorders among workers. Nevertheless, so far, no study has been conducted on the ergonomic interventions that would be appropriate for the flour production industry. To address this gap in the literature, the present study evaluated the

effectiveness of ergonomic interventions in a flour production and bagging factory.

2. Materials and methods

2.1. Participants

This interventional study was carried out with the participation of 85 employees of a flour factory in Isfahan, Iran. Through a census method, all workers of the factory participated in the study. The inclusion criteria were consent to participate, work experience of at least one-year, full-time employment, no back pain, no spinal surgery, no history of accidents leading to musculoskeletal disorders, and no use of pain medication.

2.2. Ethical considerations

The study was approved in advance by the Ethics Committee of the Research and Technology Department of Iran University of Medical Sciences (authorization no. IR.IUMS.FMD.REC 1396.94114 67004). All participants were asked to sign the ethical consent form.

2.3. Procedure

The study was conducted in five phases, as described below.

2.3.1. Phase I: Formation of a program implementation team

A team was formed consisting of workers' representative, executive manager, technical manager, quality control manager, resident occupational hygiene technician, and an ergonomist. The goal of this team was to engage in identifying risk factors and room for improvement, prioritizing ergonomic interventions, communicating with workers, and monitoring the implementation of changes in the factory.

2.3.2. Phase II: Task analysis

For task analysis, all occupational tasks were monitored to identify their associated sub-tasks and major risk factors. Also, workers and supervisors of each unit were interviewed and the reports of musculoskeletal disorders in periodic examinations of employees were reviewed. The critical occupational tasks to be addressed in the interventions were chosen

according to the results of the study by Gómez-Bull et al. [11].

2.3.3. Phase III: Data collection and pre-intervention ergonomic evaluation

The prevalence of musculoskeletal disorders before and after the ergonomic intervention was measured using the Nordic Questionnaire [12]. The ergonomic risk factors and workers' opinions about potentials for improvement were studied using the Dutch Musculoskeletal Questionnaire [13]. This questionnaire collects information about occupational tasks, physical ergonomic risk factors (load handling, awkward posture and repetitive movements), managerial and organizational factors, process factors, tool/equipment-related factors, environmental factors and workers' opinions, which are of particular importance for ergonomic evaluation of work environments and improvement of ergonomic conditions [13].

2.3.4. Phase IV: Ergonomic intervention

Following the data collection procedure and identification of ergonomic risk factors, the interventions were planned and implemented with the help of the program implementation team. In this study, engineering interventions included installing an automatic bag-sealing machine with an automatic cutter, installing a conveyor belt with adjustable height, installing a rod for putting the bags on the conveyor belt, purchasing ergonomic saddle chairs for the Quality Control Unit, installing an acoustic room, and installing an elevator for the movement of workers between production floors. Managerial and organi-

zational interventions included weekly training on the proper use of equipment, stretching exercises, and ergonomic risk factors of the workplace, preparing work instructions for each workstation, adjusting workflow, increasing rest periods in each work shift, and preparing forms of worker participation in solving ergonomic problems. Several examples of the most important interventions implemented in this study are displayed in Figs. 1 to 4.

2.3.5. Phase V: Evaluation of the effectiveness of the intervention

To evaluate the effectiveness of ergonomic intervention program, musculoskeletal disorders were reassessed six months after the start of the intervention. This evaluation was also performed by the use of the Nordic Questionnaire. Ergonomic risk factors of the work environment after interventions were also re-evaluated using the Dutch Musculoskeletal Questionnaire. Finally, the results of the assessments before and after the program were compared to determine the effectiveness of interventions. A survey was also performed regarding the change in working conditions after ergonomic interventions.

2.4. Data analysis

The prevalence of musculoskeletal disorders and muscle pain before and after ergonomic interventions was compared using the paired *t*-test. The data were analyzed in SPSS version 22. The α -value of less than 0.05 was considered to be statistically significant.

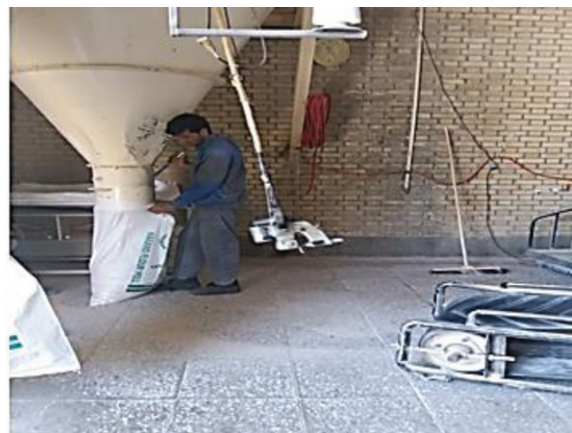


Fig. 1. Installation of an automatic bag-sealing machine for easier bagging. Right: Pre-intervention. Left: Post-intervention.



Fig. 2. Installation of a conveyor belt to reduce manual handling of bags. Right: Pre-intervention. Left: Post-intervention.



Fig. 3. Installation of an adjustable conveyor belt in the loading unit to reduce the pressure due to handling of flour bags during loading. Right: Pre-intervention. Left: Post-intervention.



Fig. 4. Use of saddle chairs in the Quality Control Unit to improve comfort and posture. Right: Pre-intervention. Left: Post-intervention.

3. Results

3.1. Demographic characteristics

The participants had a mean age of 37.32 ± 6.54 years and a mean work experience of 10.33 ± 2.64 years. The demographic characteristics of the participants are listed in Table 1.

3.2. Task analysis

Following the data collection procedure in the task identification phase, the identified tasks were classified into six categories: bagging, bag-sealing, loading, cleaning, machine maintenance, and other tasks.

As shown in Table 2, the occupational tasks with the highest prevalence of musculoskeletal complaints were bagging with 67.4%, bag sealing with 63.1%, and loading with 61.3%.

3.3. Ergonomic risk factors before intervention

The results of ergonomic risk assessment showed that, according to the tasks commonly performed by workers, the most prevalent physical ergonomic risk factors in the studied flour factory were prolonged standing on a hard surface (74.9%), lifting and lowering heavy loads (61.3%), lifting and lowering loads above the shoulder (54.9%), turning the neck more

than 30 degrees to the sides (54.8%), and pushing and pulling heavy loads (51.6%). Assessment of organizational and managerial risk factors showed that the most effective factors of this type were task clarity (87.1%), adequate training (83.9%), interaction with colleagues and sense of worthiness (80.6%). The results also showed that among organization-related risk factors, diversity in work and learning new skills (45.2%) was the least effective. Among the work process related risk factors, the most effective were workflow (77.4%), adequate number of rest periods during shifts (67.7%), and the pace of work (65.5%). Access to waste collection containers (96.8%), the presence of mechanical machinery for lifting and lowering loads (83.9%), and timely maintenance and repair (80.6%) had the greatest impact among tool-equipment related risk factors.

3.4. Pre- and post-intervention prevalence of musculoskeletal disorders

The results of pre- and post-intervention prevalence of musculoskeletal disorders in different areas of the body are presented in Table 3. The results show that before the intervention, musculoskeletal disorders were most prevalent in lower back, arms, shoulders, legs, thighs, knees, neck and wrists, respectively. The post-intervention evaluation of musculoskeletal disorders showed that the ergonomic intervention program had a positive effect on reducing musculoskeletal disorders in the neck, shoulders, lower back, thighs, knees, and legs ($P < 0.05$). The results of the survey regarding the change in working conditions showed that 98% of the workers supported the implementation of the intervention program.

3.5. Ergonomic risk factors after intervention

After the ergonomic intervention, evaluations showed a decrease in the level of physical ergonomic

Table 1
Demographic and occupational characteristics of the participants
($N = 85$)

Characteristics	Mean	SD
Age (years)	37.32	6.54
Height (cm)	171.74	8.68
Weight (kg)	69.29	4.3
Work experience (years)	10.33	2.64
Daily working hours (h)	8.41	1.08

Table 2
The result of task analysis

Task	Frequency of repetition of duty in percent			
	Rarely	Sometimes	Usually	Always
Bagging	3	4.5	25.1	67.4
Bag-sealing	3	4.5	29.4	63.1
Loading	7	10.8	20.8	61.3
Cleaning	10.3	0.8	83	5.9
Machine maintenance	32.3	11.7	50.1	5.9
Other tasks	65.5	1.7	10	22.8

Table 3
Pre- and post-intervention prevalence of musculoskeletal disorders ($n = 85$)

Body regions	Neck		Shoulder		Arm		Wrist		Back		Thigh		Knee		Legs	
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%
Before the intervention	36	43.5	58	68.2	65	76.4	37	43.5	75	88.2	46	54.1	41	48.2	52	61.1
Six months after the intervention	24	28.2	42	49.4	57	67	22	25.8	59	69.4	33	38.8	32	37.6	38	44.7
<i>P</i> -value*	0.001		0.01		0.09		0.04		0.01		0.02		0.001		0.03	

*Paired *t*-test between before and after intervention results.

risk factors. The highest reduction in physical risk factors was related to load carrying time and body posture. Among managerial and organizational risk factors, the highest scores were related to adequate training (96.8%) and task clarity (96.8%). Among work process related risk factors, the highest scores were obtained for the adequate number of rest periods (100%) and adequate rest duration (90.3%). Finally, among tool/equipment-related risk factors, the highest score was related to timely maintenance and proper work attire (93.5%).

4. Discussion

Considering the average age and work experience of the participating workers, the studied population can be considered relatively young. Therefore, their comment on musculoskeletal disorders, work conditions, and ergonomic intervention can be considered valid and reliable. According to the collected demographic data, the average work hour of the participants is more than 8 hours per day. This can increase the exposure of workers to risk factors of musculoskeletal disorders [7]. The results of the task analysis conducted for this flour factory showed that bagging and bag-sealing and manual handling of bags, in general, are the most frequent occupational tasks of the workers. A study by Choobineh et al. on the prevalence of musculoskeletal disorders among workers of the petrochemical industry also reported that manual handling of objects and bags is one of the most common tasks in that industry [14]. In the present study, assessment of ergonomic risk factors in the flour factory environment showed that manual handling of objects can be considered as the most important risk factor in this industry. A risk assessment conducted by Choobineh et al. on the sugar production industry also showed that this task was one of the most important risk factors for the development of musculoskeletal

disorders [3]. In this respect, the results of the present study seem to be consistent with the existing reports. In this study, which aimed to reduce the exposure of the workers of the flour production industry to musculoskeletal disorders through an ergonomic intervention program, pre-intervention assessments revealed a high prevalence of such disorders among the studied workers. Most of the flour factories impose detrimental physical work conditions such as manual load handling, awkward postures, poor task assignment without paying attention to physical requirements of tasks, highly substandard noise exposure, and poor ventilation, which are the major causes of the high prevalence of musculoskeletal disorders among workers in the industry. A study by Tapley et al. on the risk factors of musculoskeletal disorders in the job of carrying cargo bags in the airline industry listed the same risk factors among the most critical parameters [15]. Given the similarities in the nature of the tasks studied in these two studies, there seems to be an agreement between the results. In the present study, the most common musculoskeletal complaints were related to the neck, right and left shoulders, and the upper back and the least common problems were related to the buttocks, left ankle, and the left forearm. Also, disorders were more prevalent in upper limbs (shoulder, upper arm limbs, forearm, and wrist) than in other regions and on the right side of the body than on the left side. This part of the results is consistent with the findings of Yeung et al. [16]. Since ergonomic interventions were focused on reducing the risk factors associated with the involvement of multiple organs, especially the lower back and legs, due to activities such as lifting and lowering loads, use of tools during work, awkward postures and repetitive activities, the interventions were aimed at addressing physical risk factors. Previous studies have reported that the use of conveyors, lifts, and other load-carrying equipment reduces the workers' exposure to musculoskeletal disorders in the production process by reducing the

risk of injury by manual handling of loads [17, 18]. The present work also used this engineering intervention to reduce the risk of musculoskeletal disorders. A study by Dehghan et al. showed that saddle chairs can reduce the rate of musculoskeletal complaints [19]. Similarly, the present study found that the use of saddle chairs reduced the musculoskeletal complaints of the people working in the factory's Quality Control Unit. In this study, training the workers on the principles of ergonomics and stretching exercises that can be performed during work had a significant impact on the rate of musculoskeletal disorders. Therefore, these results can be considered as consistent with the results of Dehghan et al. [9]. The evaluation of musculoskeletal disorders six months after intervention showed that ergonomic interventions reduced musculoskeletal disorders in all organs except the arms. Considering the results of the task analysis, this can be attributed to the extensive involvement of arms in the manual handling of flour bags and other typical tasks of workers in the flour factory. Nevertheless, this finding is consistent with the results of studies conducted in tire manufacturing, sugar production and petrochemical industries which is common in carry and loading bags [3, 5, 6, 14, 20].

5. Limitations

One of the limitations of this study was financial resources, which was solved after numerous meetings to convince factory managers.

6. Conclusion

Given the adverse effects of ergonomic problems on workers' health and productivity, engineering and management interventions are indeed essential for addressing these problems. In the present work, engineering and management interventions led to a significant reduction in the level of ergonomic risk factors and reduced rate of musculoskeletal complaints among workers of different units in the flour factory. These interventions can also be expected to increase the quality of life and job satisfaction of the workers. Continuous monitoring to ensure proper long-term implementation of the interventions can lead to favorable outcomes in terms of productivity, in which the results can be utilized for improvement in similar industries.

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Conflict of interest

None to report

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