Assessment of Effective Risk Factors Leading to Musculoskeletal Disorders in Jobs of a Central Repair Workshop in an Oil Refinery using Relative Stress Index

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Background & Aims of the Study: Several risk factors lead to musculoskeletal disorders (WMSDs). This study aimed to assess the effective risk factors that result in WMSDs in jobs of a central repair workshop in an Iranian oil refinery using the relative stress index (RSI) during 2019.

Materials and Methods: This study included 172 individuals from 13 different job groups. After collecting personal information, an interview was conducted with the supervisor of each job, and the information of each job was gathered by a checklist. In the next step, the RSI calculator software coded in Excel 2019 was applied, and the ANOVA was used to compare different domains of RSI.

Results: According to the results, the mean±SD of the total RSI in the studied central workshop was estimated at 7.12±1.23. Among the available jobs in the workshop, the welders obtained the lowest RSI value indicating that these workers were at high risk of exposure to harmful environmental factors. The results of the ANOVA revealed that the dimensions of the environment and undesirable posture were significantly associated with the risk of developing musculoskeletal disorders (MSDs) ($P<0.05$).

Conclusion: The job environment and work posture were identified as the most important risk factors in developing MSDs in different jobs. The improvement of the workshop environment, establishment of an air conditioning system, and education on the proper postures through training, and enhancement of the workers' workstation can have a significant impact on reducing MSDs among the workers.

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Background

Work-related musculoskeletal disorders (WMSDs) are among the most important workplace health problems in developed and developing countries (1). These injuries are caused by tissue destruction in the musculoskeletal system during months and years of exposure to risk factors in the workplace (2). There are several risk factors to create musculoskeletal disorders (MSDs), including mechanical, physical, individual, and psychosocial factors (3). Physical or mechanical risk factors include physical needs, undesirable postures, repetition, frequency, required time, and vibration. Individual risk factors also consist of age, gender, physical dimensions, muscle strength, and physical fitness (4-6). The study of the Global Burden of Disease provided evidence about the significant disability burden associated with musculoskeletal conditions. In this study, musculoskeletal conditions had the highest contribution to global disability (7). Previous studies conducted in Iran show that these disorders are the main cause of disability and related costs (8, 9). Based on the available statistics, approximately, 48% of the work-related diseases in Iran are MSDs (10). Many studies have been performed so far in Iran and other countries on the prevalence of these disorders in various industries and occupations (11, 12). It has been reported that workers are exposed to harmful agents, such as noise, gases and chemical vapors, biological agents, and effective risk factors in developing MSDs in various units of process industries, such as operating units of refineries (13, 14). Therefore, it is required to identify these factors promptly and provide the appropriate control strategies to prevent MSDs. In recent years, several methods have been developed and used to assess ergonomic risk factors in the workplace (15).

These methods can be classified into two groups of macro- and micro-ergonomic risk assessments (16). Micro- and macro-ergonomic risk assessments provide further details on the analyzed items and a general analysis of the estimated risks, respectively. Macro-ergonomics is known as the latest component of ergonomics, which is a socio-technical approach and deals with the organizational design and the work system in addition to the design of human-machine, human-environment, and human-job interactions (17). Studies performed by Keyserling et al., Lifshitz and Armstrong, as well as Ramsey showed that macro-ergonomics can examine different dimensions of the work environment (workplace factors) and play an important role in improving organizational performance, productivity, and life quality (18). Habibi et al. also showed a significant direct relationship between macro-ergonomics and job satisfaction (19). Relative stress index (RSI) is one of the macro-ergonomic risk assessment methods to identify the risk factors associated with MSDs in the workplace (20). The risk level of exposure to the factors associated with MSDs can be displayed as numbers at the RSI method with considering variables, such as workload, repetitive movements, time duration, traveled distance, and calculation of a series of mathematical computations. The scores obtained from this index can be used to categorize the jobs in green, yellow, and red areas by which a set of corrective measures can be taken to improve the situation (20). Oil refineries usually have many employees working in operating and repair units. The manual handling of loads (MHL), vibration, undesirable posture, kneeling, and prolonged standing in the workers of the refinery industries have increased the risk of MSDs. A few studies have been performed on the risk factors of MSDs using the macro-ergonomic perspective. Given the importance of the oil industry in the country's economy, it is necessary to pay attention to the workers' health. Therefore, this study aimed to assess the effective risk factors leading to WMSDs in jobs of a central repair workshop in an oil refinery using RSI.

Materials & Methods

This study aimed to assess the ergonomic risks using RSI in the jobs of a central workshop in an oil refinery located in southern Iran during 2019. The workshop consists of 14 sections, including the converter shop, valve shop, lathing, pump shop, electricity, welding, metalworking, repair of tools and machinery, carpentry, piping, industrial cleaning, and sandblasting. All available equipment in the operating units is sent to the central workshop to be repaired or manufactured. Initially, a list of occupations available in the central workshop was prepared in collaboration with the repair department. Out of 25 jobs, 13 critical occupations in this workshop were selected for the next stage of the study based on the number of people employed in each job, reviewing past evaluations and medical records, as well as conducting face-to-face interviews with supervisors. According to the inclusion criteria, a total of 183 people employed in these 13 identified critical jobs were selected to participate in this study.

The inclusion criteria were: 1) minimum one-year work experience in the workshop, 2) no addiction, 3) no underlying diseases, 4) no history of surgery, and 5) willingness to participate in the study. Out of the selected cases, 11 subjects were removed from the study due to not fulfilling the inclusion criteria, and 172 subjects remained. A demographic characteristic form was utilized to collect personal information. After collecting personal data, a face-to-face and unstructured interview were conducted with the supervisor of each job, and a checklist was employed to collect the information of each job at 30 min. In the next step, the RSI was calculated as a risk assessment index from a macro-ergonomic viewpoint.

Relative Stress Index

Risk assessment by the RSI is based on the job description, checklist, and RSI. Figure 1 illustrates the steps for calculating the RSI (21).

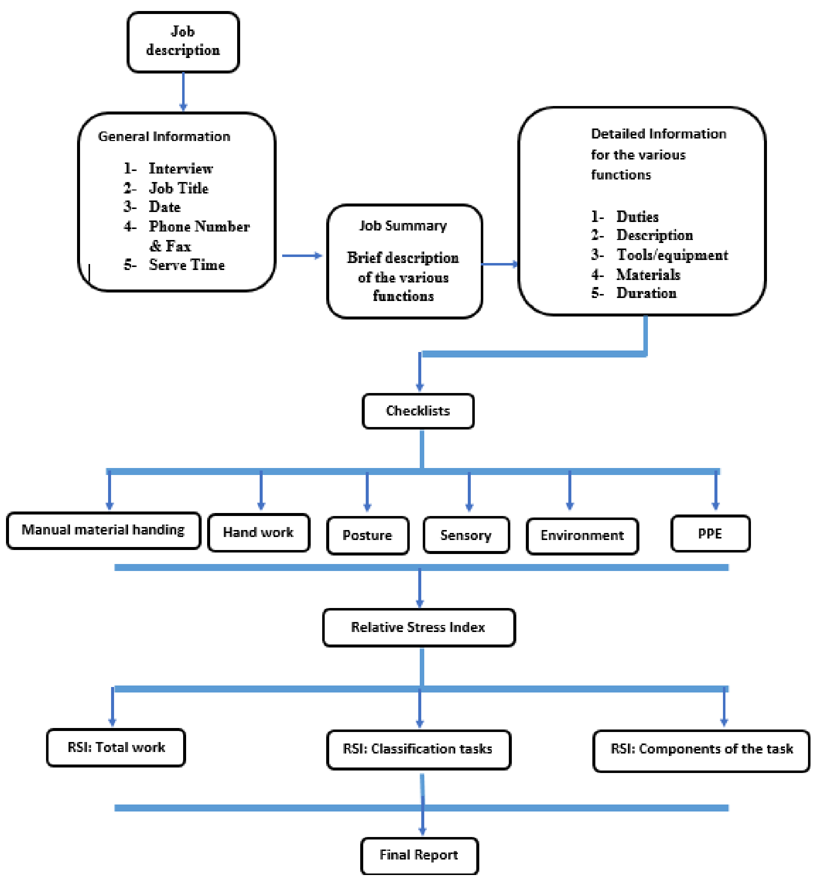

Figure 1) Calculation of Relative Stress Index Steps

Job description includes interview background, job summary, job title, job description, tools and equipment, materials, continuity, and speed. The risk assessment checklist is based on the requirement of each job for one or more classes of some sub-tasks, including physical ability, manual material handling, posture, senses, environmental factors, and the use of personal protective equipment (PPE). These six classified tasks include 64 risk factors (e.g., carrying and lifting). The first and second parts can be completed by referring to the RSI interview reference sheet. The calculation of the RSI is performed in the third section. This index is based on a quantitative assessment of job requirements and is used to calculate several variables, such as loading, repetition, durability, and distance.

The final risk level is determined based on the obtained RSI score. The RSI scores within the range from 0 to 2.5 are located in the red area, which means that immediate action is required. Furthermore, the RSI scores within the range from 2.6 to 7.5 are located in the yellow area indicating that some changes are needed although alternation can always be made with changes in the red area. Finally, the RSI scores equal to or higher than 7.6 are located in the green area signifying the requirement of no changes (20). The Cornell questionnaire was applied in order to specify the rate of WMSDs among workers. The validity and reliability of this questionnaire were evaluated in this study by Choobineh et al. (22). In this study, the RSI calculator software coded in Excel 2019 was used to compute the RSI value. After calculating the RSI, the data were analyzed in SPSS software (version 21) through ANOVA to compare different domains.

Results

According to the results, the minimum and maximum ages of the workers were 25 and 58 years, respectively. Moreover, the mean±SD of the participants' age was obtained at 38±7.3 years. Table 1 tabulates other demographic characteristics of the subjects.

Table 1) Demographic characteristics of the subjects (n=172)

Variables		Frequency	Relative frequency
Age	25-30 years	20	10
	31-40 years	163	81.5
	41-50 years	5	2.5
	51-60 years	12	6
Work experience	5-10 years	24	12
	11-20 years	89	44.5
	21-25 years	64	32
	26-30 years	23	11.5
Education status	Under diploma	19	9.5
	Diploma	56	28
	Undergraduate	45	22.5
	Bachelor	67	33.5
	Master	13	6.5
Occupational status	Welders	15	8.7
	Cutters	10	5.8
	Metal workers	10	5.8
	Lift truck drivers	4	1.3
	Electricians	20	8.7
	Mechanics	20	11.62
	Pipe mechanics	15	8.7
	Carpenters	10	5.8
	Site employees	15	8.7
	Fitters	8	4.6
	Molders	15	8.7
	Lathe operators	10	5.8
	General mechanics	20	11.62

The RSI calculator software was used to calculate the RSI of each available job in the central workshop. According to the results, the mean±SD of the total RSI in the studied central workshop was estimated at 7.12±1.23. Table 2 indicates the total score of RSI in different job groups in the central workshop, and the comparison results of RSI categories of the studied jobs are summarized in Table 3.

The results obtained from ANOVA showed that the risk of developing MSDs was significantly different in various environments, undesirable posture, and manual material

Table 2) RSI scores in different job groups in the central workshop

Occupations	RSI	Risk level
Drivers	8.21±1.3	Green
Cutters	8.43±2.5	Green
Metalworkers	2.12±1.7	Red
Welders	1.63±1.1	Red
Electricians	8.23±3.1	Green
Mechanics	5.23±2.3	Yellow
Pipe mechanics	4.82±1.6	Yellow
Carpenters	8.12±2.3	Green
Site employees	8.41±1.2	Green
Fitters	4.23±2.1	Yellow
Molders	3.47±1.4	Yellow
Lathe operators	6.34±1.7	Yellow
General mechanics	7.74±2.7	Yellow

Table 3) RSI categories of the occupations

Categories	Lowest RSI		Highest RSI	
	Job	RSI	Job	RSI
Manual Material Handling	Welders	1.2	Drivers	10
Handwork	Metalworker	4.3	Drivers	8.3
Posture	Metalworkers	2.4	Site employees	7.3
Sensory	Welders	5.3	Mechanics	7.7
Environment	Welders	1.3	Carpenters	8.6
Personal Protective Equipment	Welders	5.5	Drivers	8.9

Table 4) Results of ANOVA regarding six domains of RSI

Category	P-value
Manual Material Handling	0.03
Handwork	0.45
Posture	0.00
Sensory	0.82
Environment	0.02
Personal Protective Equipment	0.76

handling ($P<0.05$). However, this test reported no significant relationship of the occurrence of occupational hazards in different jobs with the handwork, senses, and PPE domains ($P>0.05$, Table 4).

Discussion

This study aimed to conduct a job risk assessment using a macro-ergonomic viewpoint and RSI in an oil refinery repair workshop. Previously conducted studies have been shown that several factors, such as unsuitable working environment conditions and workstations, high workload, and the values of harmful factors in the working environment can have different effects on workers' health that leads to MSDs (23). On the other hand, regarding gathering data on the macro-ergonomic status of the organization, one can be informed about the general situation and harms of each job and use this information to allocate budget and time for further analysis to decrease the MSDs, thereby increasing the organization productivity (24).

Based on the results, it was found that among six domains related to the RSI, undesirable posture, manual material handling, and environment are the most important dimensions. Dehghan et al. and Tahmasebi et al. reported that undesirable posture was one of the most important risk factors for the development of MSDs, which was consistent with the findings of the present study (25, 26). It is impossible that the workers maintain the proper posture for the entire duration of the work. Moreover, due to the lack of a suitable workstation, all jobs in this field have some weaknesses. A limited number of studies have been performed so far to investigate the association of RSI parameters with MSDs in the industries. Therefore, the results cannot be compared in detail with those of other studies. Akbari et al. carried out a job risk assessment in a textile industry using the RSI. The results of their study showed that among the six domains, handwork and sensory have a significant relationship with occupation hazards. Furthermore, posture and manual material handling obtained the lowest and highest scores in RSI, respectively. The results of a study conducted by Akbari are consistent with the findings of the current study in terms of posture, not other domains. The discrepancies may be due to the differences between the two studies in terms of the work environment. Another reason may be the high effectiveness of environmental risk factors reported by the workers in the RSI calculation in the current study, including noise, humidity, work at high altitude and vibration, and heat in the working environment of the oil refinery repair workshop.

However, in a study carried out by Akbari, these factors have not been reported by the workers (21). Moreover, Barbarian assessed the job risks in the pharmaceutical industry using the RSI and reported that the MHL was the most important domain among the six RSI domains, which was in line with the findings of the present study (20). In a study performed by Kazemi et al. on 15 job groups in the textile industry, it was found that all job groups were in the green or safe zone; moreover, Dolatab and flyer jobs obtained the highest and lowest RSI values, respectively.

In addition to evaluating the environment, the RSI measures the level of individuals' fitness for performing tasks. The present study was also conducted in the textile industry (21). However, it is not possible to compare the score obtained from the RSI because of the different occupations. Based on the results, the rest was in the warning group indicating the dispersion of hazard levels in the workshop. In general, auxiliary devices, such as cranes, are used for transferring and moving the objects; however, in this workshop, the objects and loads were transferred manually since the cranes were defective. Moreover, the manual handling of loads is prevalent during a work shift in the workshop (20). In addition, Mousavi et al. and Moradi et al. concluded that employees working in the oil refinery are exposed to harmful factors, such as gases and chemical vapors, noise, shift work, and undesirable workstations, which can be cited as another reason for obtaining the highest score from the environment domain, compared to other domains (27, 28). The studied workshop is located in a closed environment with different sections and workers working with special expertise. The indoor environment and the lack of a proper ventilation system create a bad condition, which will affect the workers in different sections. For instance, the fume produced during the welding process or the noise generated during cutting can also influence other people, such as electricians working in other sections.

Among the available jobs in the workshop, the welders obtained the lowest RSI value indicating that these workers are at high risk of exposure to harmful environmental factors. The reason for the low RSI score in welders is the undesirable posture and the bending and twisting of the low back due to the lack of a suitable workstation. The results of a study conducted by Choubineh et al. on the assessment of the risk of developing MSDs among welders showed that the risk of developing MSDs among welders was very high, and the poor posture at work was considered the most important factor in increasing the risk of developing MSDs among welders.

Similarly, Malikraj et al. found that welders tolerated an unfavorable physical condition for a long time so that they had to work in a sitting position with the trunk bent forward, which made the susceptibility to MSDs. This result is consistent with the findings of the present study (29, 30). In this study, macro-ergonomics was used to obtain a proper understanding of job requirements in the organization; additionally, 13 job groups and dangerous risk factors were identified in an oil refinery repair workshop. Hassani et al. stated that the negligence of the workplace and equipment standard created and exacerbated the MSDs. The body dimensions of the working people were studied from the viewpoint of the macro-ergonomics, and it was found that the workstation inadequacy caused an unfavorable posture in workers with a high level of risk (31).

Therefore, the results of this study can be used to eliminate or minimize the effects of exposure to these risk factors, which reduce the likelihood of musculoskeletal complications, accidents, as well as direct and indirect costs. This study was only performed on sensitive jobs with a small number of cases in each job due to taking a great deal of time, which can be mentioned as a limitation. However, since there are similarities between the work environment in oil refineries and the job characteristics, the results of this study can be used in other central workshops; nonetheless, necessary precautions should be considered. Therefore, it is suggested that future studies be conducted on a larger sample size in each job to remove the limitations.

Conclusion

Manual material handling, work environment, and undesired posture were identified as the most important risk factors associated with the development of MSDs in different job groups in an oil refinery central repair workshop. Therefore, some measures, such as the improvement of the workshop environment, establishment of an air conditioning system in the workshop, education on how to maintain proper posture while working, elimination or reduction of work activities, and enhancement of the workers' workstation can be recommended to reduce the probability of the risk of developing MSDs among workers.

Footnotes

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Conflict of Interest

The authors declare no conflict of interest regarding the publication of the study.

References

1. Naeini HS, Karuppiah K, Tamrin SB, Dalal K. Ergonomics in agriculture: an approach in prevention of work-related musculoskeletal disorders (WMSDs). J Agr Environ Sci 2014;3(2):33-51. Link
2. Odebiyi D, Akanle O, Akinbo S, Balogun S. Prevalence and impact of work-related musculoskeletal disorders on job performance of call center operators in Nigeria. Int J Occupl Environ Med 2016;7(2):98-06. PMID: 27112718
3. Ziaei M, Choobineh A, Abdoli-Eramaki M, Ghaem H. Individual, physical, and organizational risk factors for musculoskeletal disorders among municipality solid waste collectors in Shiraz, Iran. Ind Health 2018;56(4):308-19. PMID: 29503392
4. Batham C, Yasobant S. A risk assessment study on work-related musculoskeletal disorders among dentists in Bhopal, India. Indian J Dent Res 2016;27(3):236-41. PMID: 27411650
5. Umer W, Li H, Szeto GPY, Wong AYL.

Identification of biomechanical risk factors for the development of lower-back disorders during manual rebar tying. J Construct Eng Manag 2017;143(1): 04016080. Link
6. Anderson SP, Oakman J. Allied health professionals and work-related musculoskeletal disorders: a systematic review. Saf Health Work 2016;7(4):259-67. PMID: 27924228
7. Motamedzade M, Saedpanah K, Salimi K, Eskandari T. Risk assessment of musculoskeletal disorders by Muscle Fatigue Assessment method and implementation of an ergonomic intervention in assembly industry. J Occup Hyg Eng 2016;3(1):33-40. Link
8. Korhan O, Memon AA. Introductory chapter: work-related musculoskeletal disorders. Work-related musculoskeletal disorders. London: IntechOpen; 2019. Link
9. Carrillo-Castrillo JA, Pérez-Mira V, Pardo-Ferreira MC, Rubio-Romero JC. Analysis of required investigations of work-related musculoskeletal disorders in Spain. Int J Environ Res Public Health 2019;16(10):1682. PMID: 31091722
10. Ghamari F, Mohammad Beygi A, Tajik R. Ergonomic assessment of working postures in Arak bakery workers by the OWAS method. J Sch Public Health Institute Public Health Res 2009;7(1):47-55. Link
11. Seidel DH, Ditchen DM, Hoehne-Hückstädt UM, Rieger MA, Steinhilber B. Quantitative measures of physical risk factors associated with work-related musculoskeletal disorders of the elbow: a systematic review. Int J Environ Res Public Health 2019; 16(1):130. PMID: 30621312
12. Heidari M, Borujeni MG, Rezaei P, Abyaneh SK. Work-related musculoskeletal disorders and their associated factors in nurses: a cross-sectional study in Iran. Malays J Med Sci 2019;26(2):122-30. PMID: 31447615
13. Yousefi H, Habibi E, Tanaka H. Prevalence of work related musculoskeletal disorders among the Iranian working population in different sectors of industries. Adv Soc Occup Ergon 2017;24:271-81. Link
14. Akbari J, Mousavikoti M, Kazemi M, Moradirad R. Ergonomics assessment of manual handling tasks using the key item method (Kim) and its relationship with prevalence of musculoskeletal disorders in Abadan oil refinery. Sci J Ilam Univ Med Sci 2018;26(1):122-31. Link
15. Gallagher S, Schall MC Jr. Musculoskeletal disorders as a fatigue failure process: evidence, implications and research needs. Ergonomics 2017;60(2):255-69. PMID: 27376409
16. Habibifar N, Hamid M, Nasiri MM. Concurrent optimization of integrated macro-ergonomics and resilience engineering in a pharmaceutical manufacturer. J Ind Syst Eng 2019;12(3):269-82. Link
17. Ahmadi M, Zakerian SA, Salmanzadeh H. Prioritizing the ILO/IEA Ergonomic Checkpoints' measures; a study in an assembly and packaging industry. Int J Ind Ergon 2017;59:54-63. Link
18. Hales TR, Bernard BP. Epidemiology of work-related musculoskeletal disorders. Orthop Clin North Am 1996;27(4):679-709. PMID: 8823390
19. Habibi E, Amini N, Porabdian S, Rismanchian M. Assessment of relationship between macro ergonomic conditions and employees work satisfaction Touse-eh and Omran factory. Iran Occup Health 2008;5(1):15-20. Link
20. Bararian M, Saraji G, Hosseini M, Adl J. Risk assessment in pharmaceutical industry by using relative stress index (RSI). J Appl Sci 2006;6(13): 2715-23. Link
21. Akbari J, Kazemi M, Safari S, Mououdi MA, Mahaki B. Macro-ergonomics and human ability indices at work: assessment of job groups and workers by using of Relative Stress Index (RSI) and Work Ability Index (WAI). J Basic Res Med Sci 2014;1(2):43-7. Link
22. Afifehzadeh-Kashani H, Choobineh A, Bakand S, Gohari M, Abbastabar H, Moshtaghi P. Validity and reliability of farsi version of Cornell Musculoskeletal Discomfort Questionnaire (CMDQ). Iran Occup Health 2010; 7(4):69-75. Link
23. Sadra Abarghouei N. Comprehensive ergonomic interventions for improving ergonomic conditions in an automobile spare part manufacturing plant: a case study. Iran J Ergon 2015;3(2):1-13. Link
24. Kleiner BM. Macroergonomics: analysis and design of work systems. Appl Ergon 2006;37(1):81-9. PMID: 16226212
25. Dehghan N, Choobineh A, Hasanzadeh J. Interventional ergonomic study to correct and improve working postures and decrease discomfort in assembly workers of an electronic industry. Iran Occup Health 2013;9(4):70-9. Link
26. Tahmasebi R, Anbarian M, Torkashvand S, Motamedzade M, Farhadian M. Ergonomic evaluation of welders' posture and biomechanical analysis of loads on the Spine by CATIA software in Iran Gas Transmission Company. J Occup Hyg Eng Volume 2017;4(3):17-25. Link
27. Mousavi SM, Sharifiniya S, Yazdani Rad S, Esmaeilzadeh A, Hajizadeh R, MoradiRad R. The relationship between shift work and its effects on the health of the operational staff in Abadan Oil Refining Company. J Prev Med 2017;4(2):19-25. Link
28. Mousavi SM, Koohpaei A, Hajizadeh R, Yazdanirad S, Moradirad R, Faghihnia Torshizi Y. Semi-quantitative risk assessment of occupational exposure

area industrial wastewater Treatment unit in an oil refinery and chemical contaminants. Iran Occup Health J 2019;15(6):10-20. Link

29. Choobineh A, Solaymani E, Mohammad Beigi A. Musculoskeletal symptoms among workers of metal structure manufacturing industry in Shiraz, 2005. Iran J Epidemiol 2009;5(3):35-43.
30. Malikraj S, Senthil Kumar T, Ganguly A. Ergonomic intervention on musculoskeletal problems among welders. Int J Adv Eng Technol 2011;2(3):33-5. Link
31. Hasani SA, Mobaraki H, Moghadami Fard Z. The importance of ergonomics in increasing productivity and improving the performance of the staff of the Ministry of Health. Ther Med Educ 2013;4(4):92-101. Link