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Original

Effects of Ergonomic Interventions on Health Indicators in a Rubber Industry

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ABSTRACT

Background: This study aimed to determine the impact of engineering, organizational, and individual ergonomic interventions on the percentage of workers complaining Musculoskeletal disorders, inappropriate work environment, exposure to manual handling, and the rate of sick-leave in workers of rubber industry. **Methods:** This was a descriptive-analytical and retrospective study conducted in the production department of a rubber manufacturing industry. Ergonomic interventions, which have been fully implemented and have been stable in the industry, were included in the study. Health indicators were determined by reviewing completed Nordic questionnaires, insurance documents, and the documents about different methods of ergonomic risk assessment before and after each intervention. Before and after comparing the indicators, paired t and Wilcoxon tests were done. **Results:** Ergonomic interventions included 114 engineering, 20 organizational, and 7 individual interventions. Engineering interventions had a significant effect on all the indicators such as reducing total MSDs (66%). Organizational interventions led to the improvement of the index of MSDs (60%), inappropriate posture (55%) and pain intensity (30%). Individual interventions had a significant effect on MSDs (85.71%) and sick-leaves (100%) ($P<0.05$). **Conclusion:** All the types of ergonomic interventions in the production sector of the rubber industry have been effective in reducing MSDs. Engineering interventions have had a significant impact on all the health indicators considered in this study; they are highly effective in the rubber industry, and it is better to implement them together with organizational or individual interventions for better results.

Keywords: Musculoskeletal Diseases; Organizational Innovation; Health Education; Manufacturing Industry

Introduction

One of the main goals of today's societies in developed or developing countries is empowerment, economic strength, and prosperity regarding the optimal use of facilities, resources, and especially human power.[1] Improving the optimal performance of human resources is one of the most important concerns in this regard. A worker who does not physically feel comfortable at work place cannot be productive in his/her job performance. Failure to comply with the standards in the working environment is the main challenge in healthcare systems.[2] Due to the existence of many

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machines and tools in industrial environments;, harmful occupational factors are an integral part of the industrial sector, and the health of human resources is always threatened by the exposure to these harmful factors.[3] Among the consequences of harmful factors in many developing and developed countries, there are musculoskeletal disorders (MSD) which impose large economic costs on societies. Due to the importance of this issue, the World Health Organization (WHO) ranked MSDs as the second most common work-related disease in 2013.[4] In order to prevent accidents and diseases caused at work and ensure the health of the workforce, ergonomics, as an efficient approach, rushes to help people.[5] In fact, ergonomics has been developed with the aim of increasing productivity, taking into account health, safety, and well-being of humans in the working environment;[6] it helps individuals to adjust their living and working environment as well as the tools and equipment used in accordance with the individuals' capabilities.[7] Several studies have shown the effective role of ergonomic interventions in reducing the prevalence of Work-related Musculoskeletal Disorders (WMSD) and productivity. For example, in a study analyzing the effectiveness of organizational interventions and training of ergonomic principles on reducing skeletal disorders, the interventions alone were not an effective method to reduce ergonomic risk factors and discomfort.[4] In another study, the effect of ergonomic interventions based on the integration of micro- and macro- ergonomics on life quality of life and productivity of workers in a rubber industry was investigated; the results showed a reduction in workload and fatigue in order to increase the quality of life and production in each work shift. Rubber industry is one of the industries where the direct intervention of the worker in the production process is inevitable. In this industry, physical activities such as lifting and moving materials, pulling, pushing, etc. are frequently observed, and unfavorable work postures are very common. Under such conditions, it can be expected that MSDs in various parts of the workers' body in this industry have a high prevalence.

Most occupational ergonomics interventions in the workplace are carried out using top-down, middle or bottom-up strategies.[8] According to the standards of the Occupational Safety and Health Administration, control interventions are divided into different types including organizational interventions (structure and environment at the unit level), engineering (duty and job factors) and individual factors (personal protection equipment and training).[18] Ergonomic interventions have been implemented in the country for many years, but the effectiveness of their types has not been much investigated. Due to the importance of knowing the impact of each type of ergonomic intervention and also the difference in the ease of their implementation, it is necessary to measure the effectiveness of different engineering, organizational, and individual interventions separately. For example, in a study, employees were classified into four groups, and except for the control group, a type of ergonomic intervention including engineering, organizational, and training was implemented for each group. The results showed that educational and engineering interventions were effective in reducing the prevalence of WMSDs, and organizational measures alone could not be effective in reducing these disorders. [3] In this study, the effectiveness criteria of ergonomic programs were used in the form of health indicators approved by the Ministry of Health, which included the percentage of employees exposed to ergonomic risk factors based on the type of risk factor. Due to insufficient studies in this field and according to the review of the literature, no study examined the differences in the impact of any type of ergonomic interventions on MSD complaints and other health indicators regarding rubber industry workers. Considering the importance of the health of the workforce, and in response to the question whether ergonomic intervention in the rubber industry is effective or not, research was conducted in this field.

Methods

This was a descriptive-analytical and applied research, and it is retrospective in terms of time. The target population was the workers of the production sector in the rubber industry who have benefited from ergonomic interventions, 588 of whom met the inclusion criteria. The sampling method was the whole census.

Since the interventions were carried out with different goals such as safety, health and ergonomics, the authors included interventions with characteristics related to the study. The criteria for entering the intervention into this study were those which have been fully implemented in this industry, were sustainable, the related population was present before and after the intervention, at least one of the goals of reducing MSDs, improving workstations, and handling the load properly. After determining the interventions, the working populations related to each intervention and each unit were determined. In this study, the indicators by the occupational health center were used. One of the indicators of the ergonomics program in this center is the percentage of employees facing ergonomic risk factors by the type of risk factor; it includes the indicators of the percentage of employees complaining of MSDs, inappropriate workstations, inappropriate load handling, sick leaves, and pain intensity.

By obtaining the Nordic questionnaires, completed before and after each intervention with an interval of one to two months for the relevant people, the frequency of MSDs in neck, back, shoulder, elbow, wrist/hand, knee, hip/Thigh, and foot/ankle were calculated. The result of dividing the frequency of MSDs by the total population of the relevant unit provided the index of employees complaining of MSDs, expressed as a percentage.

Moreover, to determine the index of the percentage of workers in inappropriate workstations, the documentation of the results of posture evaluations was used. To determine this index, the evaluation documents conducted before the implementation of the interventions were used. Assessments included only Rapid Upper Limb Assessment (RULA), and Rapid Entire Body Assessment (REBA) methods, and some included Quick Exposure Check (QEC). First, the frequency of inappropriate workstations (before the intervention) (using the Reba method) whose risk level was medium (necessary action) and higher, was obtained. By dividing this number by the population of the relevant unit, the index was calculated and expressed as percentage. In the same way, the index after the intervention was also obtained.

This index was calculated in a different way for RULA and QEC methods, which included the following items, respectively: 1- the frequency of stations within the range of risk level 2 (ergonomic intervention may be necessary in the future), 2- the frequency of results with a total score of 50% or higher.

By reviewing the documents on the evaluation of interventions related to load handling National Institute for Occupational Safety and Health method, the index before and after the intervention was used. The results of evaluations whose (LI) load lifting index was greater than one before the intervention, the manual handling conditions were considered inappropriate.[9] By dividing the frequency of the number of people working under inappropriate load handling conditions (LI>1) by the total population of the relevant unit, the relevant index was expressed as percentage. In the same way, this index was also calculated after the implementation of the intervention.

The time period between the start and end of each project was considered as the time before the intervention, and from the end of the project to the start of the next project, as the time period after the intervention. By referring to the company's insurance documents, the rate of sick leaves related to MSDs in the relevant time period was recorded. The researchers also determined the number of working days in the time period based on the relevant date. The average number of employees was regarded as the total number of people working in the unit related to each intervention. Through dividing the number of sick people by the average number of employees in working days, the indicator of the percentage of sick people was obtained. This index was calculated before and after the implementation of each intervention. The types of health indicators, their definition, and to the method of calculating them are described in Table 1.

Referring to the Nordic questionnaires related to people with MSDs, pain, their pain intensity was graded and recorded according to whether it was very severe, severe or mild before and after the interventions. Very severe pain was assigned a score of 3, severe pain, a score of 2, and mild pain was assigned a score of 1. Then, the average of these scores in the corresponding population before and after each intervention was calculated.

The indicators were entered into SPSS16 software. In order to analyze data, descriptive statistics (frequency, percentage distribution and standard deviation table) were used to describe data. Then, to compare the indices before and after the intervention, the Smirnov-Kolmogorov test was used to check the normal distribution of the indices. Paired t method was used to compare the indicators before and after they had normal distribution, and Wilcoxon method was used to compare non-normal indicators.

Table 1. Types of health indicators and their definition and the method of calculating them

		Definition and formula for calculating indicators
Health indicators	Musculoskeletal diseases (MSDs)	By comparing the percentage of MSDs recorded in the Nordic questionnaire before and after the intervention of each organ and all the organs in general Percentage of workers with MSDs $= \frac{\text{Frequency of people with MSDs}}{\text{The work of the unit employs the entire relevant unit}} \times 100$
	Employees with awkward posture during work	By comparing the percentage of workers with poor body posture before and after the intervention using the evaluation documents of ergonomic interventions (with the aim of improving the workplace) The percentage of workers being exposed to awkward postures $= \frac{\text{Frequency of people exposuring awkward posture}}{\text{The work of the unit employs the entire relevant unit}} \times 100$
	Employees exposed to manual cargo handling	After reviewing the load carrying evaluation results using the NIOSH method, the number of people with improper posture while working before and after the implementation of the intervention (with the aim of eliminating improper load carrying) was divided by the total number of people under the intervention, and the percentage of that index was obtained. The percentage of workers exposuring improper load handling $= \frac{\text{Frequency of workers exposuring improper load handling}}{\text{The work of the unit employs the entire relevant unit}} \times 100$
	The percentage of sick leaves	Through comparing the percentage of sick leaves before and after each intervention by dividing the number of sick leaves in a certain period by working days regarding the average number of employees.[10] Absence rate due to disease $= \frac{\text{Frequency of days of absence due to certified disease in a certain period}}{\text{Average number of employees} \times \text{Total working days in the same period}} \times 100$

Figure 1. Collecting rolls before modification

Figure 2. Rolls made to collect crisps

Results

Out of 230 interventions, 141 were included in this study; they included 114 engineering interventions, 20 managerial interventions, and 7 individual interventions.

According to Table 2, the majority of research samples in the production department of the rubber factory were within the age range of 30-34 (36.73%), and those less than 30 (12.40%) had the lowest frequency. The average and standard deviation of the workers' age was equal to 33.48 ± 5.68. As can be seen in Table 1, the majority (41.83%) had 9-13 work experience. The average and standard deviation of the work experience of the workers was equal to 10.86 ± 4.00. Most of the workers (48.97%) had a normal body mass index (BMI), and the mean and standard deviation of the workers' BMI was equal to 48.44 ± 14.04.

One of the engineering interventions implemented in the belt (coated layers) collection station was that the Belts were collected in 45-meter rolls with an approximate weight of 35 kg by being picked up from a height of about 1.5 meters from the ground by the operator and placed in a special transport cart in the number of 10 pieces. This work was accompanied by bending the legs and back, which definitely caused and musculoskeletal injuries. Besides, transporting the cart with its approximate weight of 600 kg was one of the problems (Figure 1).

After discovering this problem, the design team of the factory thought of modifying and changing the existing system, which resulted in the design of 220 meter wire belt cartridges.

In the new method, by making a special collection cartridge, due to the collection of 220 meters of wire belt in one cartridge, in addition to eliminating the frequency of doing work in removing and moving the filled rolls by hand, as well as eliminating the inappropriate postures of the operator to lift the cartridge that is located on the ground. Suitable conditions have been created that these cartridges are generally transported by tow truck.

Also, by using these cartridges in tire machines, removing, moving and lifting heavy rolls in large numbers has been avoided (Figure 2).

According to Table 3, the engineering interventions had a positive effect on health indicators of the production sector and caused a decrease in the average index of MSDs from 11.15, before the intervention to 8.09, after the intervention (P=0.00). In addition, the average indicators of improper posture (17.75 to 1.98), load manual handling (3.63 to 0.71), sick leaves (0.69 to 0.18), and pain intensity (1.55 to 1.11) have been decreased (P=0.00).

Table 2. Distribution of demographic characteristics of the population

Demographic variables		Number	Percent	
Age *	Less than 30	141	23.97	**Mean**
	30-34	216	36.73	33.48
	35-39	138	23.46	**Standard deviation**
	Less than 30	93	15.81	5.68
Work experience*	8 years and less	201	34.18	**Mean**
	9-13	246	41.83	10.86
	14 years and above	141	23.97	**Standard deviation** 4.00
BMI**	Underweight	37	6.29	**Mean**
	Normal	288	48.97	24.88
	Overweight	178	30.27	**Standard deviation**
	Fat	85	14.45	4.69

*Year,
**Kg/m^2

Table 3. Comparing index scores regarding MSDs of limbs, inappropriate postures and load handling, and sick leaves based on the Wilcoxon signed rank test and Paired t-test regarding the workers before and after engineering interventions

Type of intervention	Health indicators		Mean	Standard deviation	Middle	Number of cases (percentage) Increased	Unchanged	Decreased	P-value
Engineering	MSDs in neck	Before	6.31	9.27	0.000	5(4.38)	84(73.6)	25(21.9)	Z=-3.12
		After	4.03	7.06					*0.00
	MSDs in shoulder	Before	5.76	8.00	0.000	3(2.6)	90(78.9)	21(18.4)	Z=-3.70
		After	3.62	6.80					*0.00
	MSDs in elbows	Before	2.10	5.42	0.000	2(1.7)	107(93.8)	5(4.3)	Z=-0.254
		After	2.05	5.46					*0.799
	MSDs in wrists	Before	8.90	12.22	0.000	6(5.2)	78(68.4)	30(26.3)	Z=-3.88
		After	4.99	7.93					*0.00
	MSDs in knees	Before	20.41	16.80	18.09	3(2.6)	74(64.9)	37(32.4)	Z=-5.12
		After	14.97	14.41	12.50				*0.00
	MSDs in the lower back	Before	27.51	20.97	28.28	11(9.6)	63(55.2)	40(35.0)	Z=-4.21
		After	19.99	17.12	17.39				*0.00
	MSDs in hip/thigh	Before	4.21	9.33	0.00	3(2.6)	99(86.8)	12(105)	Z=-2.01
		After	2.68	5.76	0.00				*0.04
	MSDs in legs	Before	14.11	14.06	12.50	9(7.9)	78(68.4)	27(23.7)	Z=-2.41
		After	13.79	13.79	11.10				*0.01
	Total MSDs	Before	11.15	5.89	11.05	6(5.2)	42(36.4)	66(57.9)	t=-7.53 df=113
		After	8.09	5.35	7.20				**0.00
	Inappropriate posture	Before	17.75	20.81	13.45	0	24(21.0)	90(78.9)	Z=-8.24
		After	1.98	4.33	0.00				*0.00
	Inappropriate load handling	Before	3.63	10.76	0.00	1(0.87)	95(83.3)	18(15.8)	Z=-3.54
		After	0.71	4.04	0.00				*0.00
	Sick leaves	Before	0.69	2.80	0.17	5(4.4)	38(33.3)	71(62.3)	Z=-6.36
		After	0.18	0.32	0.00				*0.00
	Pain intensity	Before	1.55	0.56	2.00	1(0.87)	65(57.0)	48(42.1)	Z=-6.55
		After	1.11	0.34	1.00				*0.00

* Wilcoxon signed rank test
** Paired t-test

Organizational interventions were measures which adjusted working spaces and optimized access limits, such as installing waste and consumable stations at appropriate height, placing rest chairs, desks and work equipment, and painting and cleaning to improve lighting conditions, all of which aimed to improve inappropriate postures and prevent unnecessary movements.

One of the most important organizational interventions implemented on the target industry is daily job rotation at the second stage tire manufacturing workstation. According to the time measurement and based on the produced tires with different sizes, the production statistics were divided into two parts, and each of the operators (the operator assistance and operator have reached a consensus on the word tire manufacturing operator) is obliged to produce fifty percent of the defined statistics. Considering the job rotation plan, the growth trend of MSDs among personnel with the same working conditions, decreased by 10%.

Organizational interventions reduced the average MSDs by 60% (p=0.04). The index of improper posture was decreased by 55% (P=0.01), and the index of pain intensity decreased by 30% (P=0.02) (Table 4).

A special exercise program was designed for 47 weeks, with a 15-minute session every day. It was implemented under the supervision of expert trainers, as one of the individual interventions. The selection of exercises and to the method of performing them ranged from simple to difficult. All the exercises were designed based on the ability of each person according to the desired complication and the scientific principles governing the exercise; they included exercise intensity, gradual increase, duration, the principle of overload, and the movement pattern involved in the exercise. The general framework of training program included warm-up, light special stretching, special resistance exercises, and returning to the initial state. The duration of each session varied according to the training program. In the initial sessions, the movements were simpler and had less intensity, and repetition. In the subsequent sessions, according to the subject's abilities, the intensity of the exercises gradually increased and became more difficult. The special exercise program for the neck region was isometric. The special exercise program for the lower back considered flexion exercises with emphasis on strengthening the muscles of the abdominal and back extensors, and the special exercise program for the shoulder emphasized strengthening muscles and flexibility. Resistance and flexibility exercises were also suggested for hands.

After the implementation of individual interventions, the reduction rate of the total indices of MSDs, pain intensity, and sick leaves decreased by 85.71% (P=0.03), 42.85% (P=0.04), and 100% (P=0.00) (Table 5).

Table 4. Comparison of index scores of MSDs in knees, total MSDs, inappropriate posture, and pain intensity based on the Wilcoxon signed rank test and paired t-test in workers before and after organizational interventions

Type of intervention	Health indicators		Mean	Standard deviation	Middle	Number of cases (percentage) Increased	Unchanged	Decreased	P-value
Organizational	MSDs in knee	Before	28.00	18.61	18.09	0	10(50)	10(50)	t=-3.29 df=19 **0.00
		After	16.90	14.33	12.50				
	Total MSDs	Before	12.36	8.22	10.52	5(25)	3(15)	12(60)	t=2.07 df=19 **0.05
		After	9.64	6.11	9.80				
	Inappropriate posture	Before	16.38	20.45	10.20	1(5)	8(40)	11(55)	Z=-2.51 *0.01
		After	3.48	7.40	0.00				
	Pain intensity	Before	1.65	0.58	2.00	0	14(70)	6(30)	Z=-2.33 *0.02
		After	1.30	0.47	1.00				

* Wilcoxon signed rank test
** Paired t-test

Table 5. Comparison of index scores of total musculoskeletal problems, sick leaves and pain intensity based on the Wilcoxon signed rank test and Paired t-test in workers of the rubber industry before and after individual interventions.

Type of intervention	Health indicators		Mean	Standard deviation	Middle	Caount of cases (percentage) Increased	Unchanged	Decreased	P-Value
Individual	Total MSDs	Before	24.84	9.24	24.10	0	1(14.28)	6(85.71)	t=-3.11 df=6 **0.02
		After	20.94	8.44	20.00				
	Sick leaves	Before	2.65	1.39	3.07	0	0	7(100)	t=-2.678 df=6 **0.03
		After	1.68	0.96	1.40				
	Pain intensity	Before	2.00	0.81	2.00	0	4(57.85)	3(42.85)	Z=-1,732 *0.04
		After	1.57	0.53	1.00				

* Wilcoxon signed rank test
** Paired t-test

Discussion

The results of the present study revealed that the following indicators were significantly reduced: exposure to improper posture, improper load handling, sick leaves and pain intensity, and the average indicators of MSDs in different parts of the body (neck, shoulder, wrist, back, knee, hip/thigh, foot/ankle), as well as the total MSDs before and after the implementation of engineering interventions. The results of the research conducted on a group of flour factory workers in Iran's steel industry to reduce the amount of MSDs [11, 12] were similar to the findings of the present study. Studies such as the one evaluating RULA and REBA assessment techniques in chemical industries[13, 14] on the workers of a shoe production workshop were also in line with the results of this study, and the percentage of awkward posture was reduced. On the other hand, a study by Hagberg, M. and D. Wegman showed that by removing improper load handling, in addition to removing the risk factors of improper load handling, pain in the lower back region was reduced.[15] Any workplace ergonomic intervention program should focus on eliminating poor postures, manual handling of heavy loads, and designing sit-stand workstations in the production line. Awkward posture was known as an important factor regarding MSDs. The main reason for unnatural and fixed posture can be unadjustable workstations. The role of awkward posture in the occurrence of MSDs has been investigated in several studies, as some jobs have been associated with shoulder and neck disorders.[16, 17] Long-term static muscle contraction leads to decreased blood flow in the muscle, tissue damage, and pain; Pain, in turn, leads to muscle spasms, and thus, completes a vicious cycle. Furthermore, the postural angles can be evaluated as an estimator of the risk of musculoskeletal injury, which can be solved by physical modifications. [18, 19]

Considering that the engineering interventions in the present study were designed to eliminate physical ergonomic risk factors in workplace, they led to the reduction of musculoskeletal complaints. The improved physical conditions in the production sector have put the posture of the lower back and lower body in a neutral position, and as a result, the problems in the upper back, back, knees and wrists were reduced.

According to the findings by Dale, the management's commitment and the employees' participation were the most important elements regarding the success of ergonomic programs.[20] In this research, employees were assisted in identifying ergonomic risk factors, assessing the work environment, and implementing improvements; therefore, employees' participation was a fundamental element for the success of the program. This caused higher acceptance of interventions by employees and led to more effective engineering interventions.

As mentioned, engineering interventions were effective in reducing pain intensity and sick leaves. Olive's project, regarding effective interventions in the work environment to reduce the number of sick leaves,[21] reached similar results as the present study. In the study by Reviles, engineering interventions have a positive effect on days of absence caused by MSDs.[22] These results confirmed that physical changes at workplace will eliminate the physical risk factors of the workplace, reduce the pain intensity, and consequently, the number of MSD's sick leaves. The intervention must have a significant effect on the worker's health, and it is important to monitor the process for workers to achieve the desired results. Moreover, compliance with the interventions carried out in the workplace may be effective to some extent in facilitating the return to work and preventing the short-term exacerbation of pain in workers with lower back pain.[23] According to these findings; effectiveness of engineering interventions depends on the partnership created through the officials' responsibility and commitment and their representatives as well as the workers' production department in identifying ergonomic problems, evaluating, designing, and deploying the interventions. Ergonomics has become a part of the culture of an organization; which this has improved the compatibility with the implemented interventions and led to health outcomes.

The study has also demonstrated that management interventions were significantly effective regarding the total index of MSDs, MSDs in knees, exposure to inappropriate posture, and pain intensity. According to a study on job rotation was associated with the reduction of MSD.[24] The study by Samadi, H., et al. further confirms this hypothesis.[25] The effectiveness of the job rotation intervention in this study may be related to the establishment of a system based on the physical characteristics needed by a person to have a job. As the individual's work posture was evaluated based on the Ovako Working Posture Analysis System (OWAS) method, by completing the Nordic questionnaire, a general map of body discomfort was drawn. Based on the general map, the person's working posture in the previous and current job was decided by a trusted doctor and the health and safety unit regarding the transfer; then, that person was sent to the human resources department for implementation proper position. Other interventions which have adjusted working spaces and optimized access limits, such as installing waste and consumable stations at workplace at the appropriate height, placing rest chairs, desks, and work equipment, have prevented unnecessary movements. Interventions such as painting and cleaning to improve lighting conditions have also contributed to appropriate posture and less MSD complaints.

Individual interventions on the indicators of total MSDs and MSDs in knees, pain intensity, and illnesses have significantly decreased. The results of several studies were consistent with the results of this study. A study investigating the effect of educational interventions on improving body posture and reducing MSDs caused by work, revealed that educational intervention was an effective solution regarding the prevalence, frequency, intensity and impact of workers' pain.[26] According to a research on the rate of back pain in military employees of an air force organization, training was recommended as an effective method.[27] Some studies have acknowledged that effective intervention does not mean only engineering interventions, educational intervention is cheap and fast and can be implemented in any work environment. In this study, educational materials were presented to a large community of workers based on the type of workers' complaints. The materials included informing them of risk factors, especially inappropriate body postures, and introducing strategies to prevent WMSD, and under the headings of the principles of ergonomics in industry, workstation ergonomics, MSDs and their causes, methods of controlling MSDs, and ergonomics of hand tools; they have had a positive effect on reducing MSDs by increasing employees' awareness. The training program created a proper understanding of the ergonomic risk factors because the lack of knowledge or superficial understanding leads to the insufficient application of ergonomic training. Some studies have also found that training workers on the principles of ergonomics and appropriate stretching exercises between work times have a significant effect on the rate of MSDs.[11] These studies confirmed the findings of the present study. Stretching exercises program alone or together with training can prevent lower back pain. Engineering ergonomic interventions alone may not be powerful enough to reduce musculoskeletal symptoms, and stretching exercises strengthen the results of engineering interventions by increasing the individual's capacity to work. The increase in muscle strength as well as the flexibility of the body, created following special exercises, has had a significant effect on reducing the prevalence of MSDs. The program was carried out in an optimal period of time (47 weeks), the minimum time of which was 8 to 12 weeks.[28] The exercises were of isometric type and the duration of treatment, frequency, and intensity of the exercises had a positive effect on MSDs. Individual interventions were effective in reducing the intensity of pain, which were in line with the results of a study on the effect of exercise on the intensity of pain in shoulders.[29] Due to educational intervention, the intensity of neck and shoulder pain was the lowest compared to engineering interventions and a combination of engineering and individual ones.[30]

It was clear that the role of educational intervention in reducing work and workplace risk factors in choosing the intervention strategy was undeniable.[26] One of the limitations of this study was not having a control group. Therefore, in future, it is recommended to design and implement studies which have a control group and are similar to the test group regarding various interventions in terms of demographic characteristics and all the influencing factors to address the effect of the intervention types more accurately.

Conclusion

In general, the present research examined the effectiveness of ergonomic interventions by the type of intervention (engineering, management, and individual) regarding health indicators including total MSD (and organs), inappropriate posture, load handling, diseases, and the severity of pain on the workers of the rubber industry in the east of Iran. Various ergonomic interventions in the production sector of the rubber industry have resulted in the reduction of MSDs. The success factors include management support, employees' participation, teamwork, standard training and sports program, the establishment of a systematic job rotation system, and in general, the implementation of the ergonomics program from top to bottom. Of course, engineering interventions were effective on all health indicators. Due to the fact that engineering interventions concentrate on the elements of working environment, they facilitate intervention and change. By removing physical risk factors, the occurrence and intensity of pain has been improved and sick leaves have been shortened. On the other hand, engineering intervention cannot properly reduce the role of organizational and individual factors. Engineering interventions in rubber industry can be considered a priority, and it is better to implement them together with organizational or individual interventions to boost effectiveness.

Conflict of interest

The authors declared no conflict of interest.

Acknowledgement

This study was reviewed and approved by the Ethics ID IR.SBMU.PHNS.REC.1400.160 at the School of Health and Neuroscience Research Center of Shahid Beheshti University of Medical Sciences .

Authors Contributions

RGh & MS contributed to the study design, managed and planned the project. MB collected the data, writing original draft preparation. RGh, MS & MB were major contributors to data analysis. MB wrote the review and editing interpretation and conclusion. All authors read and approved the final manuscript.

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