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Effects of Ergonomics Training and Corrective Exercises on Musculoskeletal Disorders among Office Computer Users at Qazvin Province Gas Company

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Abstract

Background: Work-related musculoskeletal disorders are major causes of absenteeism, increased costs, and human injuries among computer users. This study aimed to examine the effects of ergonomics training and corrective exercises on musculoskeletal disorders among a gas company computer users.

Material and Methods: This experimental study was conducted on 19 office computer users who participated in training programs, including correct sitting postures, workplace layouts, and corrective exercises. For this purpose, training programs and corrective exercises were employed in four one-hour sessions in one week and 16 one-hour sessions in eight weeks.

Results: Musculoskeletal disorder prevalence, postures, and workplace layouts were assessed using the Nordic Questionnaire and a researcher-made checklist. Accordingly, the highest prevalence was observed in the lower back (63.2%), neck (52.6%), and knees (42.1%). Differences in the rates of proper postures and workplace layouts were statistically significant before and after the ergonomic training so that 81.25% of postures and 47.8% of workplace layouts were improved. The results showed that training programs on ergonomics principles and corrective movements reduced musculoskeletal disorders among office computer users within the range of 10.5 to 52.6%.

Conclusions: Increasing employee awareness of appropriate postures, workplace layouts, and corrective movements effectively reduced musculoskeletal disorders in computer users.

Keywords: Training, Ergonomics, Exercise, Posture, Computer, Musculoskeletal.

Introduction

Musculoskeletal disorders (MSDs) are considered the major health issue in most occupations as well as one of the most common and costly work-related problems worldwide [1]. According to the World Health Organization (WHO), work environments along with sociological, psychological, and social risks contribute to developing work-related musculoskeletal disorders (WMSDs) [2]. The lower back, neck, shoulders, and upper back are the most affected body parts by MSDs [3]. If diseases of the musculoskeletal system are not treated, they can result in a greater number of workdays lost for incapacity [4].

Computer users are at the risk of musculoskeletal disorders, for they spend long working hours using

computers. Long-term use of computers and sitting for a long time at the desk are the main causes of musculoskeletal disorders among office computer users [5]. Individuals in gas and oil refineries are exposed to a wide range of risk factors causing musculoskeletal disorders [6]. Studies have verified the high prevalence of MSDs among office computer users in the neck (60.16%), lower back (57.1%), shoulders (54.03%), and hands/wrists (48.46%) [7]. In a study, common symptoms were reported in the neck (57.2%), shoulders (38.5%), upper back (28.5%), and lower back (46.2%) [1].

Musculoskeletal disorders can be managed by reducing related risk factors through increasing rest breaks during working hours, breaking up working periods into some shorter sessions, adopting proper postures in the workplace, and taking exercise in the workplace during rest breaks [2]. Workplace health promotion has positive effects on health-related productivity in workers. The scope of health promotion interventions in the workplace is broad, which includes both workers as well as physical and psychosocial aspects of the workplace. Management of workplace ergonomics can optimize a healthy office environment, thereby producing positive productivity outcomes [8].

Physical activity is effective in healthy life, being vital for maintaining the musculoskeletal system in a proper functioning order. On the other side, lack of exercise stiffens and weakens joints and muscles. People with a sedentary lifestyle lose muscle strength and flexibility that are effective in maintaining physical fitness and a natural posture [9]. Since there is a high prevalence of musculoskeletal disorders and occupational risk factors among computer users, correct use of computers is essential for maintaining health among staff. According to research, installing exercise software on workplace computers and taking exercise could reduce WMSDs. A study reported beneficial effects of training in ergonomics principles on reducing awkward postures [10].

Gas company office workers often use computers, so the prevalence of musculoskeletal disorders (by 45 and 55% in the regions of the neck and low back pain) is relatively high among them [11]. Sufficient research has not been conducted on the effects of ergonomics training and corrective exercises in preventing and reducing musculoskeletal disorders. Thus, based on the request made by the Qazvin Province Gas Company, this study was conducted to investigate the effects of ergonomics training and corrective exercises on musculoskeletal disorders among its office computer users.

Materials and Methods

This experimental study was approved by the Ethics Committee of the University in 2021 under code IR.QUMS.REC.1397.087. In addition, this article is taken from research contract no. 951.070.49, with the Qazvin Province Gas Company. In fact, the present experimental study was conducted to assess the practicality of ergonomics training and corrective exercises among office computer users of the Qazvin Province Gas Company. To this end, the participants were randomly selected from computer users in the Gas Company and recruited by administrative units. Thus, a total of 123 participants agreed to participate in the study. A total of 22 participants were not eligible to be included in the study. Out of 101 eligible computer users, 19 participants were willing to receive corrective exercises and attend training sessions on ergonomic principles of working with computers. The inclusion criteria were having a normal BMI, having over one year of work experience, and working with a computer over 4 hours a day. On the other side, the exclusion criteria included having a recent fracture, congenital skeletal abnormalities, specific illnesses, a history of spinal cord surgeries, an accident, neurological and vascular problems, a second job, drug abuse, and a pregnancy.

Demographic and Nordic Questionnaires: Demographic data were collected on the participants' age, height, weight, marital status, work experience, level of education, working hours, and sports activities. In addition, the Nordic Questionnaire was used to assess the prevalence of musculoskeletal disorders during the last week and the last year [12]. Data were collected after providing explanations prior to the intervention. The participants completed the Nordic Questionnaire one week before and one week after the intervention. In addition, posture assessment and workplace layout checklists were completed before and immediately after the intervention.

Assessment of postures and workplace layouts: A checklist was drawn up using evidence on the ergonomic principles of using computers and office activities, observing staff postures, and evaluating workplaces. The checklist consisted of 50 items with the two sections of staff postures (20 items) and workplace layouts (30 items). To this end, clarity, comprehensibility, and overlap of the items were evaluated by five professors and five students (a total of 10 people) specialized in occupational health and ergonomics. The final version of the checklist consisted of 39 items (16

items related to staff postures and 23 items related to workplace layouts). The researcher assessed and completed the checklist with the two choices of observing ergonomics principles (with the response of yes) and not observing ergonomics principles (with the response of no), while the users were performing the work before the intervention.

Training sessions on ergonomic principles: The purpose of these training sessions was to familiarize the staff with traumatic factors and with using a computer, to inform users on the arrangement of desks, to adjust seats, to adopt a proper posture when using a mouse and a keyboard, and to know how the screen must be positioned and adjusted. Instructions on all of the above were taken from books, articles, and faculty commentaries on ergonomics of working with computers [13-15]. The summary of the training sessions included basic definitions of ergonomics, risk factors of musculoskeletal disorders, complications of working with a computer and methods of preventing them, proper body postures when working with a computer, methods of adjusting the screen and the keyboard, and the distance from the former, location of the mouse and its proper size, appropriate height of the seat, features of the seat, and convenient seating places. In addition, a researcher held the four-hour training sessions (four one-hour sessions a week) on proper postures and workplace modifications using face-to-face presentations in the conference room of the Gas Company [16].

Teaching corrective exercises: The training sessions on corrective exercises aimed to prevent pain in the neck, shoulders, arms, lower back, wrists, elbows, knees, thighs, and ankles. Exercises were performed in the gym of the Gas Company by a sports science specialist. Since evidence verifies the effectiveness of 8 weeks of corrective exercises in reducing the prevalence of musculoskeletal disorders [17], corrective exercises were taught for two months (16 one-hour sessions), twice a week. Additionally, corrective exercises were chosen based on the related evidence on corrective exercises [18] focused on reducing the prevalence of the selected muscle disorders.

The training consisted of 5 to 10 minutes of warm-up, 20 minutes of special stretching exercise, 20 minutes of special resistance exercise, and 10 minutes of recovery. In the traditional exercise, the trainees were asked to participate in the main exercise program, which included stretching and strengthening exercises after warming up. The protocol of the exercises for the 8 weeks included first and second weeks (15-second stretching exercises and 10 repeated strength exercises), third and fourth weeks (20-second stretching exercises and 12 repeated strength exercises), fifth and sixth weeks (25-second stretching exercises and 15 repeated strength exercises), seventh and eighth weeks (30-second stretching exercises and 20 repeated strength exercises), with the rest-to-activity ratio having been 2:1.

According to the National Academy of Sports Medicine (NASM), the training protocol includes four inhibition, stretching, activation, and coherence exercises. Accordingly, in the first and second weeks, inhibition exercises were performed, and a 30-second increase in length, activation, and coherence exercises with 10 repetitions in one round was practiced; in the third and fourth weeks, inhibition exercises were performed, and a 45-second increase in length, activation, and coherence exercises with 12 repetitions in one round was practiced; in the fifth and sixth weeks, inhibition exercises were performed, and a 60-second increase in length, activation exercises, and coherence with 15 repetitions in two rounds was practiced; in the seventh and eighth weeks, inhibition exercises were performed, and a 40-second increase in length, activation, and coherence exercises with 12 repetitions in one round was practiced [18]. Fig. 1 shows the examples of the exercises.

Due to the high prevalence of pain in some parts of the body, the exercises focused on specific muscles, including levator scapulae muscles, scalene and trapezius muscles in the neck and shoulders, deltoid muscles in the elbows, trapezius and pectoralis major muscles in the front and back of the arms and shoulders, and girdle muscles. Exercise was taken in the lumbar muscles, quadratus lumborum muscles, the ribs, and the tibia inside and outside. Besides, exercise was taken in trapezius muscles 1 to 4, deltoid and corner muscles in the upper back, quadriceps and hamstring muscles in the knees and thighs, as well as biceps and triceps in the elbows. Besides, exercise was taken in the upper arm and the brachialis muscle [18].

Fig. 1. An example of static stretching and flexibility exercises in corrective exercises [2]

Firstly, the Kolmogorov-Smirnov test was performed to check normality of data. Furthermore, the Cramer's V test was performed to assess the relationships between independent (demographic and occupational information) and dependent variables (the prevalence in the body regions during the last year and the last seven days). Additionally, a paired t-test was performed to compare the discomfort prevalence during the last week before and after the intervention. Next, the Wilcoxon test was performed to assess the users' postures and workplace layouts before and after the intervention [19]. All data were analyzed in SPSS V23.0. In all the tests, the significance level was considered less than 0.05.

Results

Results of the evaluation of demographic and Nordic Questionnaires before and after the intervention: Data analysis of 19 employees in the Gas Company showed that the means and standard deviations of their age and height were 39.26 ± 5.56 years and 173.10 ± 8.81 cm, respectively. Table 1 shows other demographic and occupational data of the staff.

Table 1. The subjects' (n = 19) demographic and occupational information

Quantitative variables		Qualitative variables			
Variables	**M ± SD**	**Variables**	**Category**	**Frequency**	**Percentage**
Age (years)	39.26±5.56	Marital status	Single	1	5.3
Height (cm)	173.10±8.81		Married	18	94.7
Weight (kg)	77.57±15.07	Educational status	High school diploma	3	15.8
Total work experience (years)	15.89±5.83		Associate's degree	1	5.3
			Bachelor's degree	7	36.8
Work experience with computers (years)	14.21±6.22		Master's degree and higher	8	42.1
Exercise per week (hours)	2.81±2.34	Exercise activity	Yes	14	73.7
Working hours in shifts (hours)	9.63±1.34		No	5	26.3
Working with computers (hours)	8.21±1.9	Sex	Female	10	52.6
Number of working days (days)	5.26±0.56		Male	9	47.4

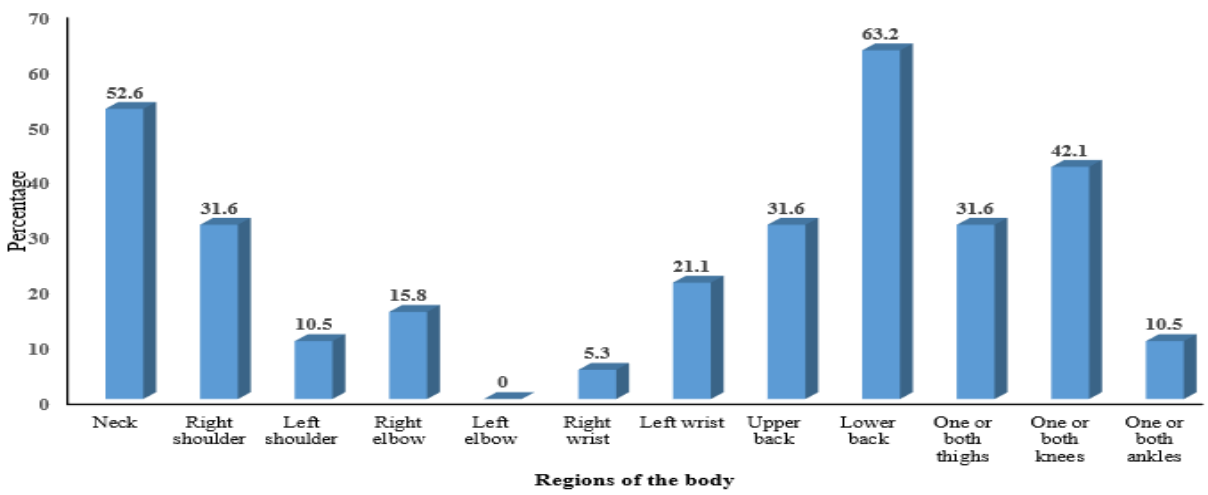

Fig. 2. Prevalence of musculoskeletal disorders in the participants over the last year (n = 19)

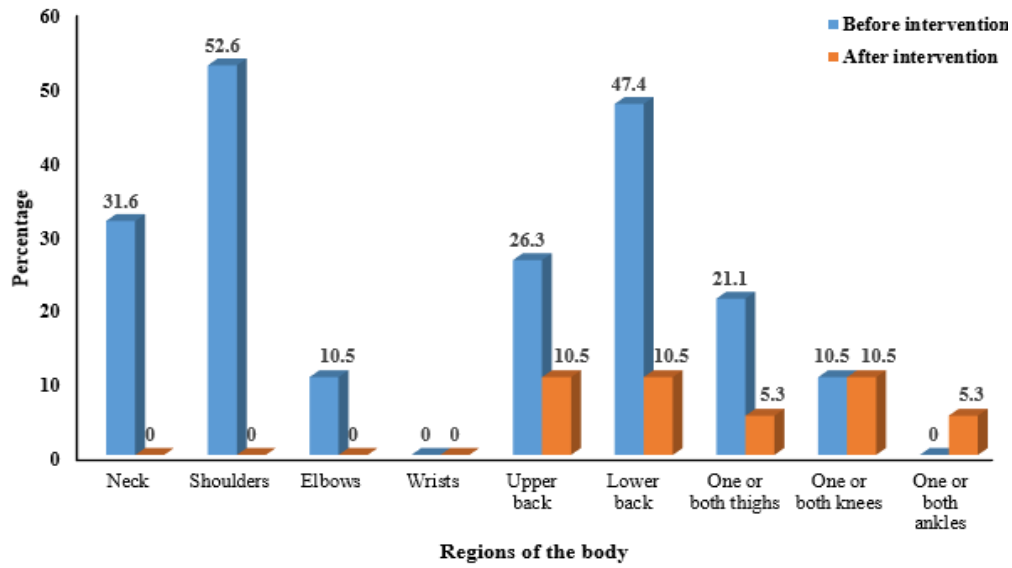

Fig. 3. Prevalence of musculoskeletal disorders in the participants over the last week before and after the intervention (n = 19)

Fig. 2 shows the percentage of musculoskeletal discomfort among the staff participating in the study during the last year before the intervention. Accordingly, disorders were more common in the lower back (63.2%), neck (52.6%), and knees (42.1%).

Fig. 3 shows the percentage of musculoskeletal discomfort in different parts of the body in the employees participating in the study during the last week before and after the training intervention. Disorders were more common in the shoulder (52.6%) and lower back (47.4%) before the intervention, yet after the intervention, they were more common in the upper back, lower back, and knees (10.5%).

Table 2. Percentage of correct postures (yes responses) according to the posture evaluation checklist among the participants before and after the intervention (n = 19)

Number	Questions	Percentage of observing correct postures (yes responses)	
		Before the intervention	After the intervention
1	Placing forearms horizontally at an angle of 90° relative to the arms	94.7	100
2	Placing arms and elbows close to the body	100	100
3	Horizontally placing the hips at an angle of 90-110° relative to the lower back	89.5	100
4	Feeling comfortable in the shoulders and arms while doing work (the normal position)	94.7	100
5	Holding one's head straight when looking at the screen without bending forward, back, and to the sides	64.8	89.5
6	Supporting the lower back by the seat backrest	57.9	89.5
7	Placing wrists without angles when using a keyboard or a mouse	73.7	89.5
8	Not placing wrists and hands on sharp or hard edges when resting or working	26.3	100
9	Placing foot soles fully on the ground or the footrest	52.6	94.7
10	Not working continuously with the computer during the day (10-15 minutes for a working hour)	64.8	94.7
11	Taking regular muscle exercise (at least 15 minutes at the end of the work)	5.3	5.3
12	Frequently changing proper postures during work shifts	94.7	94.7
13	Looking at a point over 6 m every 20 minutes	42.1	94.7
14	Not rotating the lower back when sitting on a chair	42.1	94.7
15	Not rotating the neck when working with the screen	42.1	94.7
16	Positioning the head comfortably when using the phone	84.2	94.7

Assessment of postures and workplace layouts before and after the intervention: Table 2 provides some information on the staff's postures, who participated in the training course before and after the intervention. According to the posture assessment checklist, 52.6 and 31.6% of improvement were observed in the correct position of the back and neck of the participants, respectively, when sitting on the chair and working with the screen, which reduced the prevalence of disorders in the body.

Table 3 provides information on the workplace layouts before and after the intervention. Based on the results of the workplace layout checklist, observing from the proper position of the keyboard (from the edge of the desk), with an improvement of 57.9%, led to a reduction in the prevalence of disorders in the shoulder region.

Table 3. Percentages of observing the suitable layout (yes responses) according to the computer workplace layout evaluation checklist among the participants before and after the intervention (n = 19)

Number	Questions	Percentages of observing the suitable layout (yes responses)	
		Before the intervention	After the intervention
1	Placing the top edge of the screen slightly below the eye level (the viewing angle of 15-20° relative to the center of the screen)	47.4	47.4
2	Adjustable the screen slope (the slope should not exceed 10-20°)	100	100
3	Observing the 20-40 inch distance (100-50 cm) between the user and the screen	94.7	100
4	Choosing a suitable screen size for better viewing (38-50 cm)	94.7	94.7
5	Placing the mouse and the keyboard at the same level	94.7	100
6	Properly reaching the mouse without stretching	94.7	100
7	Using ergonomic pads	78.9	94.7
8	Using the proper mouse (in terms of shape and size)	100	100
9	Placing the screen directly in front of the person (without the neck or the lower back angled)	84.2	89.5
10	Placing the copy holder directly in front of the person (without the neck or lower back angled)	15.8	15.8
11	Availability of items of frequent use within the reach range of 0-30 cm	64.8	94.7
12	Providing sufficient space underneath the work surface to move legs	57.9	94.7
13	Availability of items of occasional use within the reach range of 30-50 cm	94.7	100
14	Choosing a desk of suitable height (the working desk height being as high as one's elbows)	100	100
15	Not using a glass plate on the table surface	31.6	36.8
16	Using the proper seat able to rotate 360° around one's axis	89.5	89.5
17	Using a seat with the minimum height of 16 inches (40 cm)	100	100
18	Not blocking seat handles for reaching the workstation	100	100
19	Using a chair made of soft material (softcover)	89.5	89.5
20	The keyboard being placed at the elbow height	100	100
21	Observing the 5-10 cm distance between the edge of the desk and the keyboard slot	5.3	63.2
22	Providing suitable workplace lighting for the computer (about 540-215 lux)	68.4	84.2
23	Properly positioning the screen relative to the window (natural light sources located at 90° relative to the screen)	36.8	36.8

Results of statistical tests: The Cramer's V test showed a significant relationship between working hours per shift and working days with the prevalence of discomfort in the left wrist during the last year. However, other independent variables were not significantly associated with the high prevalence of disorders.

On the other side, results of the Kolmogorov-Smirnov test showed that the prevalence of musculoskeletal disorders was normally distributed during the last seven days before and after the intervention. However, posture observation of the staff and proper observation of the workplace layout before and after the intervention did not have a normal distribution ($P \leq 0.05$).

The paired t-test showed a significant difference, with 99% confidence ($p = 0.014$, $t = 3.108$), in the prevalence of musculoskeletal disorders during the last seven days before and after the intervention. In addition, the mean change in the prevalence was lower after the intervention (0.89) than that before the intervention (4.44).

The Willcoxon test showed that changes in postures and workstation layouts were significant in employees before and after the intervention ($z = -2.42$, $p = 0.001$; $z = -2.98$, $p = 0.003$, respectively). Accordingly, proper postures improved after the intervention (mean rank = 14) compared to those before the intervention (mean rank = 7). Additionally, the appropriate workstation layout improved after the intervention (mean rank = 6) compared to that before the intervention (mean rank = 0).

Discussion

The present study aimed to assess the effect of ergonomics training sessions and corrective exercises on improving work-related musculoskeletal disorders among office computer users in the Gas Company.

Accordingly, the highest prevalence rates were related to the lower back, neck, and knees. The relatively high prevalence of disorders can be related to the rotation in the back when sitting on a chair, rotation in the neck when working with the screen, lack of exercise, inadequate space under the desk surface for moving legs, and using improper footrests. Similarly, Singh et al reported the highest prevalence of work-related musculoskeletal disorders in the neck and lower back among office employees. In the study of Motamedzadeh et al, the highest prevalence of discomfort among bank staff was in the neck, shoulder, and lower back areas [20]. Accordingly, such discomforts are highly associated with awkward postures, job demands, and infrequent rest breaks. Thus, it is required to study intervention exercises and workstations more in depth [1]. In the study of Chinedu et al, the lower back, wrists, hands, and shoulders were the most prevalent body parts affected by awkward postures, sustained body positions, improper bending, inappropriate furniture, and inadequate rest breaks [21].

In this study, a significant relationship was found between working hours per shift and working days with the prevalence of discomfort in the left wrist during the last year. Placing wrists on sharp edges while working as well as continuous working with a computer can be known as causative factors as well. In a prospective study on computer users, Chang et al reported a significant relationship between the onset of musculoskeletal disorders and the duration of computer use per day [22]. In this regard, Chinedu et al reported that work-related discomfort in the wrists/hands among office workers was due to the long period of computer exposure, awkward postures, and inadequate rest breaks [21].

In this study, the highest prevalence of musculoskeletal disorders in the employees participating in the training courses before the training in the last 7 days was found to be related to the shoulders and lower back. However, after training, it was related to the upper back, lumbar spine, and knees. In the current study, the highest reduction rate was reported in the region of shoulders (52.6%), while inconsistent with this study, in the study of Khoshakhlagh et al, it occurred in the wrists and hands (52.77%) [23]. This inconsistency could be due to the different nature of the work between office and installation workers of the Gas Company. The results of the present study indicated positive effects of training and corrective movements on reducing the prevalence of musculoskeletal disorders. In the same vein, Shariati et al reported that the group receiving ergonomic training (exercise and training) experienced fewer musculoskeletal disorders in the shoulder, back, and neck areas than the group that did not receive the training [2]. In addition, according to some studies, using participatory ergonomic interventions showed to be potentially effective in reducing the prevalence of work-related MSDs among office workers [24, 25]. Similarly, in the study of Khoshakhlagh et al, using ergonomics-educational interventions, and in the study of Motamedzadeh et al, using educational and physical interventions, the prevalence of musculoskeletal symptoms was reduced significantly among employees of oil and gas installations as well as bank staff, respectively [20, 23].

The results of the posture assessment of the staff showed that almost one-twentieth of the checklist items was observed before the training, which increased to one-third after the training. In addition, before the training, over half of the subjects experienced rotation in the back region while sitting on a chair. Furthermore, 57.9% of the subjects experienced rotation in the neck when looking at the screen, which could be due to the improper arrangement of equipment, such as the phone and the copyholder on the table, improper position of the monitor, keyboard, and mouse to the user, as well as gross ignorance of ergonomic issues. In this study, the training in some items improved staff postures from 5.3 to 73.7%, showing the positive effect of the training on staff posture changes. In fact, 81.25% of the items improved. Mani's study showed the importance of promoting awareness of various risk factors associated with work-related musculoskeletal disorders among office computer users and training them on healthy work behaviors [15].

The results of the computer workplace layout checklist showed that one-fifth of the checklist items had been observed before training, which increased to almost 50% after the training. In addition, the results showed that over 90% of the people did not observe the appropriate distance from the edge of the table to the keyboard before the training, which led to the inadequate access of the users or the insufficient distance of the arms from the lower back. Mani et al conducted a study on the risk factors of musculoskeletal disorders in offices as well as components of ergonomic training intervention programs. Accordingly, they reported that people's awareness of the correct method of working with computer equipment and proper arrangement of work components in the workstation increased after the training intervention [26]. In total, an improvement was achieved in 47.8% of the items, ranging from 5.3 to 57.9%.

The results of this study verified the effect of ergonomics training interventions on adopting appropriate postures and bringing about computer workplace layout changes. The results were consistent with those of the study by Robertson et al and Motamedzadeh et al who showed ergonomic training in office workplaces significantly improved perceived control, body postures, and workplace layout [20, 27].

In response to the research question of 'how much is the effectiveness of ergonomic interventions and corrective movements in reducing musculoskeletal discomfort among office computer users of the Gas Company?', it was shown that both of them decreased musculoskeletal discomfort by at least 10% and at most 50%. Therefore, employee awareness of the correct ergonomics principles of body postures, workstation layout, and corrective exercises plays an effective role in reducing the prevalence of these disorders. Corrective exercises enhance both muscle strength and flexibility, lower the risk of MSD injuries, and reduce levels of daytime fatigue, thereby causing a high decrease in pain [28]. Another study reported that taking exercise or ergonomics modification led to significant improvements among office workers [2]. Accordingly, with increasing employee awareness of appropriate postures, workplace layouts, and corrective movements, companies can effectively reduce musculoskeletal disorders in computer users. This study had some limitations; accordingly, one of the limitations of this study was the unwillingness of some of the employees to participate in completing questionnaires and attending training sessions. Therefore, it is suggested that employees be informed on the consequences of awkward postures at work to increase their participation and determine effectiveness of interventions more accurately in future studies. It is also recommended that different methods of postural assessment be used before and after the intervention. One of the strengths of this study was the synergic effectiveness of ergonomic training sessions (proper postures and appropriate workstation arrangement) and corrective exercises in reducing musculoskeletal disorders.

Conclusion

The highest prevalence of musculoskeletal disorders was reported in the shoulders, lower back, and neck during the last week. Training the Gas Company office computer users in ergonomics improved posture items (81.25%) and workplace layout (47.8%). Additionally, the combination of ergonomics training and corrective exercises significantly reduced musculoskeletal discomfort (from 10.5 to 52.6% in different body regions). Moreover, effects of both interventions were statistically significant on corrective postures (before =14 to after =7) and workplace layout adjustment (before =6 to after =0). Thus, the promotion of employee awareness of appropriate postures, workplace layouts, and corrective exercises can effectively change their behavior, thereby reducing musculoskeletal disorders among office computer users.

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