Original Article

Journal of Occupational Health and Epidemiology
Journal Homepage: https://johe.rums.ac.ir/
JOHE
Rafsanjan University of Medical Sciences

Can Ergonomic Interventions in Knowledge-Based Companies Improve Musculoskeletal disorders, Alter Job Contents, or Increase Quality of Work-Life and Productivity? A Quasi-Randomized Control Trial

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Citation: Heidarimoghadam R, Mohammadfam I, Babamiri M, Soltanian AR, Khotanlou H, Sohrabi MS. Can Ergonomic Interventions in Knowledge-Based Companies Improve Musculoskeletal disorders, Alter Job Contents, or Increase Quality of Work-Life and Productivity? A Quasi-Randomized Control Trial. J Occup Health Epidemiol. 2023;12(3):175-86.

Article Info

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Article history
Received: Dec 2022
Accepted: Jul 2023

10. 61186/johe.12.3.175

Print ISSN: 2251-8096
Online ISSN: 2252-0902

Peer review under responsibility of Journal of Occupational Health and Epidemiology

Abstract

Background: Today, white-collar workers endure a variety of job stress. These factors can cause musculoskeletal problems, threaten aspects of occupational health, and reduce productivity. This study aimed to examine the effect of ergonomic training interventions on the musculoskeletal disorders (MSDs), job contents, work-life quality, and productivity in knowledge-based companies.
Materials & Methods: This study was conducted using quasi-randomized control trial method in 2019-2020. Four groups were included in the study: Ergonomics training, management training, combined interventions, and control group. The participants included 311 office workers who were randomly divided into four groups. Outcome measures were measured in follow-up periods. Repeated-measure ANOVAs was employed to analyze the results.
Results: Interventions performed on neck (P=0.001), right shoulder (P=0.001), left shoulder (P=0.002), and right upper extremity (P<0.025) were associated with significant improvements in MSDs. The interventions significantly increased the control and social support (P=0.001), though they did not affect the psychological demands. The quality of work-life increased significantly in the first month of follow-up, but the long-term trend showed a decline.
Conclusions: Combined interventions significantly increased absolute presenteeism. Simultaneous implementation of individual and managerial ergonomics revealed a greater impact on reducing MSDs and a broader impact on job content and presenteeism.

Keywords: Ergonomics, Musculoskeletal Diseases, Intervention, Randomized Controlled Trial

Introduction

Ergonomics is considered as a practical knowledge to create coordination between work and human beings, one of the most important practical goals of which is to maintain human health and enhance productivity at work [1]. In recent decades, musculoskeletal disorders (MSDs) have been identified as a major threat to human health in the workplace [2]. MSDs include all chronic and cumulative injuries that threaten the health and function of the musculoskeletal system of the human body [3]. Numerous recent studies have reported the prevalence of MSDs in office workers as over 50% [4, 5]. In Iran, recent studies have indicated a 25 to 52% prevalence of MSDs among office workers [6-8]. This high prevalence of MSDs in addition to health issues causes an increase in job stress [9], as well as reduced quality of work-life [10] and productivity [11] among office workers. Meanwhile, in small and medium-sized enterprises (SMEs), work stress and job complexity elevate the risk of ergonomic factors and expose SMEs employees to more threats [12]. In Iran, with the support of the government and private accelerators, a new branch of these SMEs called knowledge-based companies has begun [8, 13]. The employees of these start-ups are generally white-collar workers who are responsible for various tasks including computer work, design, development, marketing, and business management [13]. Due to the variety of activities and complexities of jobs in knowledge-based companies, many psychological and physical job-related stresses appear in their workplace [8]. These stresses are known to threaten health and productivity. Thus, ergonomic researchers' attention to this new sector of industry can be effective on maintaining human health and economic growth.

In recent years, fortunately, numerous and diverse studies have evaluated the effect of ergonomic interventions on the health and productivity of office workers by implementing various intervention programs, and published a practical way to control MSDs [4, 7, 14-16]. However, to the knowledge of the researchers, no study has explored the field of ergonomic interventions in knowledge-based companies. Accordingly, this study was conducted to examine the effect of ergonomic training interventions on the prevalence of musculoskeletal disorders, job contents, quality of work life, and productivity in the officeworkers of knowledge-based companies in Isfahan, Iran.

Materials and Methods

This study was conducted using the quasi-randomized control trial method in 2019-2020. The study groups consisted of three intervention groups and a control group, which were studied in parallel. The study protocol has been described in detail in a previously published article [8].

The samples included the office workers of knowledge-based companies located in Isfahan, Iran with at least one year of work experience. The minimum sample size for each group was 77 subjects considering the possibility of a decline in volunteers. At the beginning of the study, 328 people (106% of the minimum requirement) were selected and randomly divided into four study groups. At the end of the study, 311 participants (equal to 101% of the minimum requirement) successfully completed the interventions with one-, three-, and six-month evaluation stages.

The research was registered in the Iranian Registry of Clinical Trials under the number IRCT20181204041840N1. Ethical approval was granted by Ethics Committee of Hamedan University of Medical Sciences (IR.UMSHA.REC.1397.688).

At the beginning of the study, primary and secondary outcome measures of all participants were measured in the baseline survey. Participants were then randomly divided into four study groups. Apart from the participants in the control group, other individuals underwent ergonomic interventions. Outcome measures were measured during one, three, and six months following the implemented intervention. In the baseline phase, 84 participants from six independent companies were assigned in the first intervention group, 80 participants from four companies in the second intervention group, 81 people from five companies in the third group, and 83 people from five other companies were recruited in the control group. The studied companies were fully organizationally and physically separate, and the participants in the four groups had no official relationship with each other.

Intervention Group 1 (Ergonomics training): Participants in this group received individual ergonomics training in the form of a 6-hour workshop. These ergonomics tutorials included: Familiarity with ergonomics, identification of office-related MSDs and office syndromes, ergonomic principles in controlling MSDs in the office work environment, corrective tips for setting up office workstations, teaching isometric neck exercises, techniques for reducing workplace stress, and improving personal communication.

Intervention group 2 (Management training and work changes): In this group, trainings based on organizational ergonomics and macroergonomics aspects were provided for senior managers at the under-study companies. These trainings were

provided to enable managers to design and implement low-cost interventions for reducing job stress at their companies. The subject of these changes included: Strengthening formal and informal communication, increasing control in workplace, enhancing the possibility of decision-making in work units, as well as encouraging social activities in working groups.

Intervention group 3 (Ergonomics training and management training as well as work changes): In this group, participants received both the first and second group interventions simultaneously.

The Persian version of the Cornell Musculoskeletal Disorders Questionnaire [17] was used as the primary outcome measures. Secondary outcome measures included Persian version of Job Content Questionnaire [18] to measure occupational stress factors based on Demand-Control-Support (DCS) model [19], Walton's questionnaire of quality work-life [20], together with absenteeism and presenteeism by the short form of the World Health Organization's Health and Work Performance Questionnaire[21].

Statistical analyses were conducted by SPSS Version 19.0, with asignificance level set at P<.05. The variables were analyzed at four points throughout the process (baseline, 1, 3, and 6 months post-intervention). The effects of nine possible covariates were examined during data analysis. The covariates tested were age, gender, marital status, child numbers, education level, salary, height, weight, and BMI. A significant relationship was observed between BMI at baseline and primary outcomes which were used as a covariate in the analysis. Analysis of repeated-measure ANOVAs was used to determine the effects of interventions on outcome measures. Bonferroni's post hoc procedure was employed for post hoc comparisons if ANOVAs reported a significant main effect. All data analyses were performed by a statistician in a blinded manner.

Results

The study started with 328 participants in the summer of 2019 and ended with 311 participants in the spring of 2020. The results of baseline characteristics of participants are described in Table 1 of the study protocol article [8]. The results were analyzed on 311 participants who successfully completed all stages of the research. The mean age of these individuals was 32.04±5.34 years. Specifically, 36% of these 311 were women and the remaining 64% were men. In terms of education level, 1.9% had a diploma or lower, 5.8% associate, 58.8% bachelor's, 32.8% master's, and 0.6% PhD degree or higher. The average BMI was 24.53±3.35.

Musculoskeletal disorders: The results of the effect of interventions on MSDs are reported in Table 1. Significant effects of interventions were observed on neck (F=5.39, P=0.001), right shoulder (F=3.128, P=0.001), left shoulder (F=3, P=0.002), right forearm (F=3.495, P=0.001), right wrist (F=2.137, P=0.024), and right lower leg (F=2.356, P=0.012). In other body parts, mean changes in intervention groups were not significant. Also, in the neck of the second group, in the right shoulder of the first and second groups, in the left shoulder of the second group, and in the right forearm of the first and second groups significant differences were found with the control group in the same body area.

Table 1. Mean score changes in MSDs (frequency ×discomfort ×interference) during follow-up times

Study Groups		Baseline	Follow times		
MSD Pain Score (0 to 90)			1 month	3 months	6 months
Neck*	Int_1	11.39 ± 23.69	6.27 ±16.57	3.65 ± 11.67	2.92 ± 5.47
	Int_2**	11.34 ± 20.79	10.17 ± 20.24	9.85 ± 17.51	10.16 ± 15.21
	Int_3	9.38 ± 16.11	5.61 ± 13.62	3.65 ± 7.44	2.47 ± 4.82
	Control	0.84 ± 1.95	1.27 ± 3.02	1.33 ± 3.02	1.35 ± 3.16
Right Shoulder*	Int_1**	10.75 ± 21.62	9.58 ± 21.02	9.18 ± 21.06	8.48 ± 19.41
	Int_2**	10.29 ± 22.47	9.25 ± 19.52	8.79 ± 17.65	9.31 ± 17.36
	Int_3	8.81 ± 17.81	6.31 ± 16.41	5.65 ± 13.89	4.12 ± 10.96
	Control	1.07 ± 3.44	1.05 ± 3.44	1.02 ± 2.87	1.16 ± 3.21
Left Shoulder*	Int_1	6.53 ± 17.95	3.17 ± 9.73	3.09 ± 9.72	3.29 ± 9.70
	Int_2**	5.91 ± 17.30	5.73 ± 17.34	5.82 ± 17.32	4.79 ± 15.72
	Int_3	5.00 ± 12.94	2.49 ± 6.70	2.21 ± 5.52	1.74 ± 4.62
	Control	0.76 ± 3.24	0.76 ± 3.24	0.76 ± 3.24	0.63 ± 2.61
Upper Back	Int_1	0.15 ± 0.74	0.15 ± 0.74	0.15 ± 0.74	0.39 ± 1.23
	Int_2	0.54 ± 4.56	0.54 ± 4.56	1.01 ± 5.14	1.06 ± 5.18
	Int_3	1.78 ± 7.78	2.01 ± 7.24	1.53 ± 5.81	1.35 ± 5.44
	Control	0.18 ± .49	0.08 ± 0.34	0.21 ± 0.68	0.25 ± 0.75
Right Upper Arm	Int_1	4.99 ± 13.80	3.51 ± 10.74	3.66 ± 10.74	3.54 ± 10.39
	Int_2	4.79 ± 12.22	4.10 ± 11.50	4.23 ± 11.55	3.20 ± 8.71

	Int_3	3.58 ± 9.70	2.68 ± 8.59	3.50 ± 10.43	3.01 ± 9.54
	Control	0.82 ± 2.55	0.82 ± 2.55	0.82 ± 2.55	0.53 ± 1.28
Left Upper Arm	Int_1	2.19 ± 10.51	2.02 ± 10.50	2.04 ± 10.50	1.27 ± 3.87
	Int_2	2.95 ± 11.83	2.95 ± 11.83	3.01 ± 11.84	2.97 ± 11.84
	Int_3	1.83 ± 4.52	1.49 ± 3.78	1.21 ± 3.03	1.42 ± 5.10
	Control	0.02 ± 0.17	0.02 ± 0.17	0.02 ± 0.14	0.06 ± 0.38
Lower Back	Int_1	4.36 ± 15.71	4.17 ± 15.72	4.27 ± 15.71	4.86 ± 15.24
	Int_2	4.09 ± 12.64	3.47 ± 12.49	3.97 ± 12.59	3.26 ± 7.24
	Int_3	3.39 ± 8.29	2.85 ± 7.91	2.37 ± 6.74	2.50 ± 6.51
	Control	2.36 ± 6.46	2.99 ± 6.70	2.47 ± 5.58	2.56 ± 5.53
Right Forearm*	Int_1**	11.57 ± 23.08	10.54 ± 21.99	9.35 ± 19.58	8.40 ± 14.98
	Int_2**	11.43 ± 22.87	9.38 ± 20.43	9.95 ± 20.75	9.79 ± 20.75
	Int_3	11.44 ± 21.57	6.58 ± 17.25	5.78 ± 15.97	5.08 ± 14.71
	Control	2.57 ± 5.12	2.36 ± 4.95	2.47 ± 5.10	2.01 ± 4.13
Left Forearm	Int_1	3.44 ± 12.42	3.01 ± 12.22	3.07 ± 12.22	3.10 ± 10.41
	Int_2	3.10 ± 9.99	3.10 ± 9.99	2.71 ± 8.16	2.70 ± 7.96
	Int_3	3.56 ± 10.61	2.60 ± 8.41	2.56 ± 8.39	1.69 ± 5.58
	Control	0.08 ± 0.34	0.08 ± .34	0.06 ± 0.29	0.04 ± 0.24
Right Wrist*	Int_1	2.77 ± 8.01	2.34 ± 7.78	2.44 ± 7.77	2.73 ± 7.77
	Int_2	2.64 ± 8.55	2.55 ± 8.55	2.79 ± 8.58	2.89 ± 8.58
	Int_3	3.34 ± 9.32	2.15 ± 6.29	2.08 ± 6.28	1.60 ± 3.85
	Control	2.12 ± 6.13	2.12 ± 6.14	1.70 ± 5.16	1.47 ± 4.47
Left Wrist	Int_1**	11.57 ± 23.08	10.54 ± 21.99	9.35 ± 19.58	8.40 ± 14.98
	Int_2**	11.43 ± 22.87	9.38 ± 20.43	9.95 ± 20.75	9.79 ± 20.75
	Int_3	11.44 ± 21.57	6.58 ± 17.25	5.78 ± 15.97	5.08 ± 14.71
	Control	2.57 ± 5.12	2.36 ± 4.95	2.47 ± 5.10	2.01 ± 4.13
Hip	Int_1**	11.57 ± 23.08	10.54 ± 21.99	9.35 ± 19.58	8.40 ± 14.98
	Int_2**	11.43 ± 22.87	9.38 ± 20.43	9.95 ± 20.75	9.79 ± 20.75
	Int_3	11.44 ± 21.57	6.58 ± 17.25	5.78 ± 15.97	5.08 ± 14.71
	Control	2.57 ± 5.12	2.36 ± 4.95	2.47 ± 5.10	2.01 ± 4.13
Right Thigh	Int_1	3.44 ± 12.42	3.01 ± 12.22	3.07 ± 12.22	3.10 ± 10.41
	Int_2	3.10 ± 9.99	3.10 ± 9.99	2.71 ± 8.16	2.70 ± 7.96
	Int_3	3.56 ± 10.61	2.60 ± 8.41	2.56 ± 8.39	1.69 ± 5.58
	Control	0.08 ± 0.34	0.08 ± .34	0.06 ± 0.29	0.04 ± 0.24
Left Thigh	Int_1	2.77 ± 8.01	2.34 ± 7.78	2.44 ± 7.77	2.73 ± 7.77
	Int_2	2.64 ± 8.55	2.55 ± 8.55	2.79 ± 8.58	2.89 ± 8.58
	Int_3	3.34 ± 9.32	2.15 ± 6.29	2.08 ± 6.28	1.60 ± 3.85
	Control	2.12 ± 6.13	2.12 ± 6.14	1.70 ± 5.16	1.47 ± 4.47
Right Knee	Int_1	2.35 ± 10.76	2.04 ± 10.68	1.94 ± 10.61	2.08 ± 10.68
	Int_2	2.47 ± 11.05	3.19 ± 12.85	2.21 ± 8.47	2.62 ± 9.41
	Int_3	2.24 ± 9.80	1.80 ± 8.41	1.80 ± 8.41	1.21 ± 5.32
	Control	1.33 ± 3.53	1.39 ± 3.61	1.53 ± 3.86	0.79 ± 2.19
Left Knee	Int_1	3.54 ± 15.70	3.46 ± 15.70	2.96 ± 13.05	2.06 ± 8.72
	Int_2	1.72 ± 7.70	3.00 ± 12.06	1.08± 3.85	1.47 ± 4.30
	Int_3	0.23 ± 0.91	0.25 ± 0.89	1.00 ± 6.82	0.90 ± 4.72
	Control	0.08 ± 0.34	0.00 ± 0.00	0.00 ± 0.00	0.02 ± 0.17
Right Lower Leg*	Int_1	5.49 ± 18.57	5.34 ± 18.60	5.34 ± 18.60	4.39 ± 16.02
	Int_2	3.35 ± 12.34	2.73 ± 8.72	3.36 ± 12.36	2.13 ± 7.28
	Int_3	2.34 ± 11.17	1.01 ± 4.82	0.63 ± 2.48	0.67 ± 2.54
	Control	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Left Lower Leg	Int_1	0.75 ± 4.56	0.68 ± 4.52	0.68 ± 4.52	0.62 ± 4.51
	Int_2	0.66 ± 4.61	0.32 ± 1.76	0.66 ± 4.61	0.40 ± 2.39
	Int_3	1.24 ± 6.39	1.12 ± 6.36	0.87 ± 5.04	0.68 ± 4.59
	Control	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00

Int_1 = Intervention Group 1 (Individual ergonomics training, n = 79)
Int_2 = Intervention group 2 (Management ergonomics training and work changes, n = 77)
Int_3 = Intervention group 3 (Ergonomics training + Management ergonomics training and work changes, n = 78)
Control = Control group (No intervention, n = 77)
* The mean difference is significant at the .05 level; follow-times × Intervention (Repeated measure ANOVA)
** The mean difference with control group is significant at the .05 level (pairwise comparisons adjustment by Bonferroni)
* Significance at the failures level of 0.05

The mean changes in neck disorders in both the first and third groups were downward, and the descending trend in the third group was similar to the first group. In the right shoulder, the trend of all three intervention groups was diminishing, which was greater in the third group of intervention. In the left shoulder, we witnessed a strong and significant downward trend in the first month of follow-up, but

during the third and sixth months of follow-up, this trend showed no changes. The trend of variations in the mean of MSDs in the right forearm in the first and third groups was remarkable. This alteration for the third intervention group showed the greatest reduction against the first month of follow-up. Also, a decline in changes for the right thigh was evident for the first and third groups. Although, in the second group, in the right thigh area fluctuations were observed between the first, third, and sixth months, these changes were not statistically significant. In most limbs except the lower back and right knee, the average trend of MSDs reported for the first group was diminishing. During the study, there was an alignment between the trend of changes in the mean of MSDs of the first and third groups for most body parts. In other areas, we saw changes according to Figure 1, but according to Figure 1, these changes in other groups were not significant.

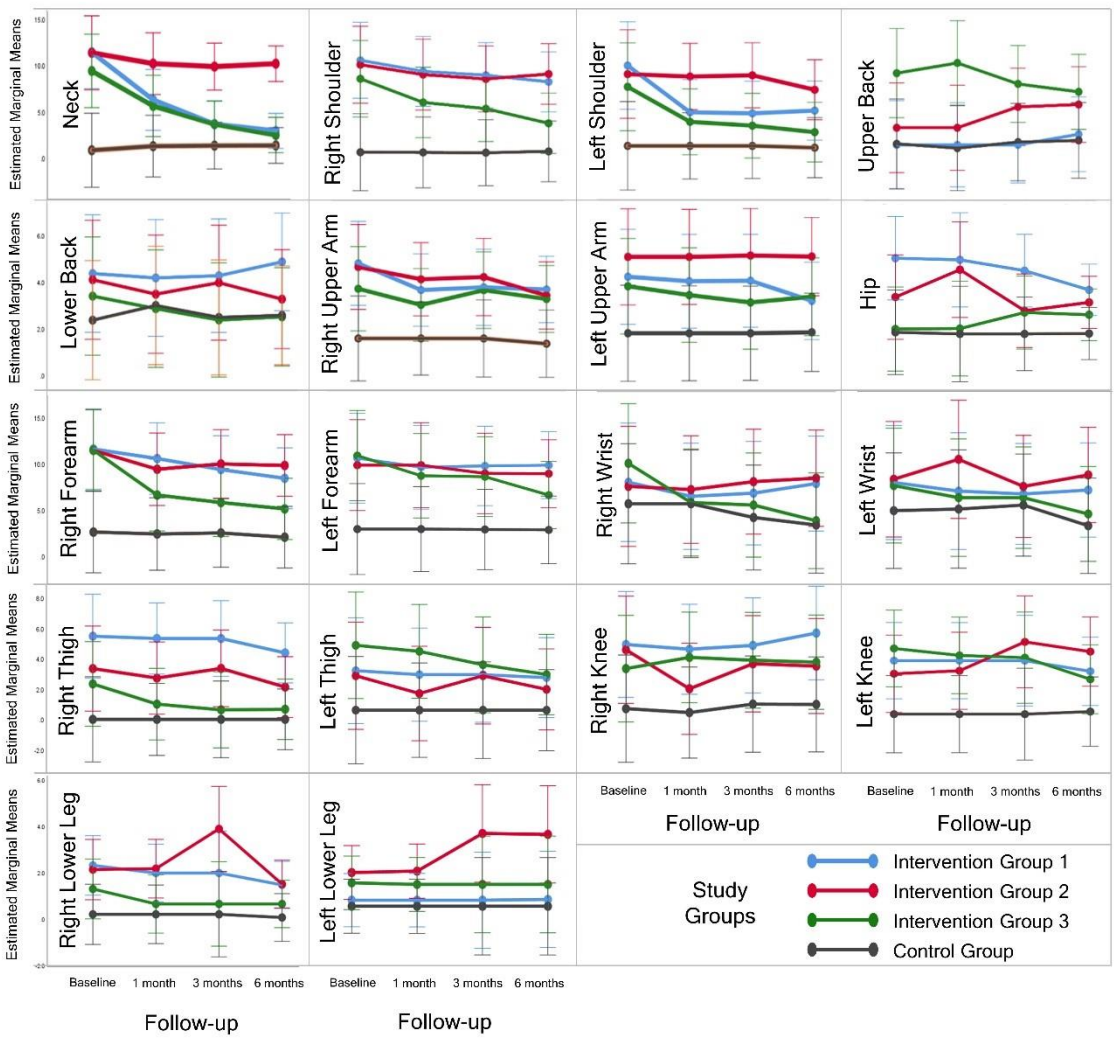

Fig.1. The trend of changes in MSDs during follow-up times

Job contents: In the analysis of skill discretion variable during follow-up, we noticed a significant increase in the mean of changes, especially in the second and third groups (F=2.002, P=0.036), though this trend showed nonsignificant changes in the first group. Decision authority faced a significant increase in the second and third groups, especially in the first month (F=3.109, P=0.001), which indicated the short-term impact of managerial changes in the companies under study. Also, a gradual increase was observed for the control variable (F=3.999, P=0.001). Regarding co-worker support, a strong and significant increase was reported in the first and third groups (F=10.879, P=0.001). The effect of interventions in the second group in supervisor support was obtained with a similar upward slope in the third group (F=5.900, P=0.001). Social support also revealed a significant increase in all three intervention groups (F=9.931, P=0.001). The mean value of changes in physical job demands in the first and third groups showed a reduction (F=2.412, P=0.010). Although, in the sixth month, we saw an increase in the mean psychological job demands in the first and control groups, these changes were not significant. Job insecurity did not record significant change either in the intervention group. Other details of the mean changes of the DCS model variables are presented in Table 2.

Table 2. Mean score changes in job contents (based on DSC model) during follow-up times

Occupational stress factors		Baseline	Follow times		
			1 month	3 months	6 months
Skill Discretion* (12 to 48)	Int_1**	38.23 ± 4.87	38.41 ± 4.44	38.28 ± 4.39	38.46 ± 4.26
	Int_2**	36.73 ± 4.87	36.99 ± 3.67	37.25 ± 3.49	37.40 ± 3.60
	Int_3**	36.97 ± 4.56	36.92 ± 4.22	37.05 ± 4.21	37.18 ± 4.22
	Control	35.53 ± 2.99	35.25 ± 2.97	35.04 ± 2.89	35.17 ± 2.87
Decision Authority* (12 to 48)	Int_1**	33.82 ± 5.65	33.67 ± 4.82	33.27 ± 4.64	33.47 ± 3.58
	Int_2**	32.21 ± 5.42	33.92 ± 4.14	33.77 ± 3.87	33.35 ± 3.87
	Int_3**	31.23 ± 5.77	32.67 ± 4.25	33.18 ± 4.18	33.28 ± 3.94
	Control	31.17 ± 5.20	30.81 ± 4.99	30.81 ± 4.00	30.96 ± 3.92
Control* (24 to 96)	Int_1**	72.05 ± 8.81	72.08 ± 7.41	71.54 ± 6.79	71.92 ± 6.01
	Int_2**	68.94 ± 8.35	70.91 ± 5.87	71.01 ± 5.48	70.75 ± 5.90
	Int_3**	68.21 ± 8.22	69.59 ± 6.29	70.23 ± 6.04	70.46 ± 5.98
	Control	66.70 ± 6.67	66.05 ± 6.38	65.84 ± 5.19	66.13 ± 5.65
Psychological Job Demands (12 to 48)	Int_1**	34.99 ± 4.60	35.09 ± 4.58	36.04 ± 10.83	36.33 ± 10.65
	Int_2**	33.10 ± 4.19	32.86 ± 3.67	32.48 ± 3.62	32.82 ± 3.37
	Int_3**	33.83 ± 5.05	33.90 ± 4.86	33.97 ± 4.64	34.13 ± 4.35
	Control	29.95 ± 3.24	29.90 ± 3.27	30.09 ± 3.20	31.51 ± 10.21
Co-worker Support* (4 to 16)	Int_1	12.13 ± 1.79	12.15 ± 1.42	12.27 ± 1.15	12.53 ± 0.97
	Int_2**	11.53 ± 1.76	11.65 ± 1.59	11.70 ± 1.21	11.78 ± 1.03
	Int_3	11.01 ± 1.63	11.68 ± 1.49	11.94 ± 1.36	12.14 ± 1.29
	Control	12.21 ± 1.37	12.27 ± 1.15	12.25 ± 0.91	12.01 ± 0.66
Supervisor Support* (4 to 16)	Int_1**	12.14 ± 2.06	11.95 ± 1.76	11.92 ± 1.37	12.03 ± 1.30
	Int_2**	11.14 ± 2.54	11.62 ± 2.05	11.82 ± 1.92	12.39 ± 4.97
	Int_3	10.21 ± 2.90	10.97 ± 2.48	11.28 ± 2.19	11.40 ± 2.05
	Control	10.45 ± 1.98	10.22 ± 1.67	10.16 ± 1.41	10.16 ± 1.40
Social Support* (8 to 32)	Int_1**	24.27 ± 3.11	24.10 ± 2.53	24.19 ± 1.87	24.56 ± 1.69
	Int_2	22.68 ± 3.67	23.27 ± 3.08	23.52 ± 2.63	24.17 ± 5.12
	Int_3	21.22 ± 4.14	22.65 ± 3.52	23.22 ± 3.21	23.54 ± 3.04
	Control	22.66 ± 2.43	22.49 ± 2.07	22.40 ± 1.70	22.17 ± 1.61
Physical Job Demands*	Int_1**	11.18 ± 2.82	11.08 ± 2.43	10.95 ± 2.16	10.78 ± 2.02
	Int_2**	10.53 ± 3.03	10.56 ± 2.61	10.69 ± 2.28	10.58 ± 2.19
	Int_3**	10.47 ± 2.52	10.36 ± 2.24	10.17 ± 2.11	9.99 ± 1.92
	Control	8.56 ± 2.67	8.55 ± 2.26	8.64 ± 2.14	8.66 ± 2.09
Job Insecurity (3 to 17)	Int_1**	9.19 ± 3.96	9.11 ± 3.98	8.97 ± 3.99	9.14 ± 4.16
	Int_2**	9.49 ± 3.71	9.35 ± 3.78	9.22 ± 3.79	9.47 ± 4.01
	Int_3**	8.81 ± 3.91	8.68 ± 3.86	8.67 ± 3.82	8.82 ± 3.97
	Control	6.47 ± 2.29	6.48 ± 2.34	6.36 ± 2.32	6.56 ± 2.39

Int_1 = Intervention Group 1 (Individual ergonomics training, n = 79)
Int_2 = Intervention group 2 (Management ergonomics training and work changes, n = 77)
Int_3 = Intervention group 3 (Ergonomics training + Management ergonomics training and work changes, n = 78)
Control = Control group (No intervention, n = 77)
* The mean difference is significant at the .05 level; follow-times × Intervention (Repeated measure ANOVA)
** The mean difference with control group is significant at the .05 level (pairwise comparisons adjustment by Bonferroni)

Quality of work-life: Table 3 outlines the effect of the interventions on the quality of work-life changes and its subscales. Among these, only interventions on quality of work-life (F=5.942, P=0.001), workplace conditions (F=5.754, P=0.001), use and development of capacities (F=15.969, P=0.001), and chance of growth and security (F=4.619, P=0.036) showed a significant effect. Workplace conditions also increased significantly only for the third group in the first month of follow-up. The average changes in use and development of capacities revealed a significant increase in both second and third groups during the six-month follow-up process. Regarding the chance of growth and security, a significant increase was reported in the first month of follow-up in the third group compared to the control group. There was no significant difference in the mean of changes in other scales of quality of working life.

Table 3. Mean score changes in quality of work-life and its subscales as well as productivity loss during follow-up times

		Baseline	Follow times		
			1 month	3 months	6 months
Quality of Work-life* (35 to 175)	Int_1	122.48 ± 16.10	123.15 ± 14.30	122.57 ± 12.56	121.91 ± 10.99
	Int_2**	118.55 ± 17.92	120.30 ± 15.68	119.49 ± 14.86	118.66 ± 14.23
	Int_3	123.49 ± 14.98	126.71 ± 13.06	125.83 ± 12.04	124.99 ± 10.49
	Control	124.95 ± 9.71	123.47 ± 9.15	123.18 ± 8.37	122.01 ± 7.54
Fair and appropriate compensation (4 to 20)	Int_1	11.48 ± 2.53	11.22 ± 2.13	10.94 ± 2.07	10.09 ± 1.83
	Int_2	11.21 ± 2.77	11.14 ± 2.40	10.77 ± 2.24	10.05 ± 2.02
	Int_3**	11.78 ± 2.09	11.76 ± 1.91	11.38 ± 1.85	10.41 ± 1.42
	Control	10.81 ± 2.62	10.75 ± 2.09	10.55 ± 2.08	9.73 ± 2.07
Work place conditions* (6 to 30)	Int_1**	20.52 ± 3.04	20.38 ± 2.83	20.37 ± 2.84	20.48 ± 2.67
	Int_2**	20.48 ± 3.74	20.71 ± 3.18	20.62 ± 3.39	20.61 ± 3.36
	Int_3	21.27 ± 2.95	21.91 ± 2.63	21.78 ± 2.72	21.79 ± 2.49
	Control	22.92 ± 2.44	22.51 ± 2.37	22.45 ± 2.34	22.44 ± 2.33
Use and development of capacities* (5 to 25)	Int_1**	18.63 ± 2.83	18.86 ± 2.55	18.85 ± 2.59	18.68 ± 2.27
	Int_2**	17.95 ± 2.95	18.82 ± 2.56	19.03 ± 2.43	19.10 ± 2.38
	Int_3**	18.59 ± 2.48	19.76 ± 1.97	20.00 ± 1.86	20.15 ± 1.81
	Control	17.19 ± 2.05	17.12 ± 2.06	17.05 ± 2.04	16.97 ± 1.97
Chance of growth and security* (4 to 20)	Int_1**	13.39 ± 2.45	13.85 ± 2.13	13.84 ± 1.92	13.94 ± 1.75
	Int_2	12.53 ± 2.90	13.03 ± 1.95	12.69 ± 1.95	12.56 ± 1.93
	Int_3**	13.65 ± 2.55	14.76 ± 2.07	14.51 ± 2.10	14.38 ± 2.12
	Control	12.75 ± 1.99	12.70 ± 1.86	12.58 ± 1.70	12.52 ± 1.59
Social integration in the organization (4 to 20)	Int_1	14.76 ± 2.91	14.77 ± 2.82	14.71 ± 2.68	14.77 ± 2.58
	Int_2	14.16 ± 2.72	14.30 ± 2.55	14.34 ± 2.46	14.23 ± 2.36
	Int_3	14.90 ± 2.66	15.03 ± 2.58	15.09 ± 2.33	14.96 ± 2.25
	Control	15.21 ± 1.66	15.04 ± 1.70	15.06 ± 1.46	14.99 ± 1.46
Constitutionalism (4 to 20)	Int_1	15.05 ± 2.82	15.20 ± 2.61	15.10 ± 2.25	15.22 ± 2.28
	Int_2	14.04 ± 2.99	14.12 ± 2.88	14.14 ± 2.63	14.19 ± 2.66
	Int_3	14.21 ± 3.38	14.41 ± 3.43	14.31 ± 3.13	14.53 ± 2.98
	Control	15.43 ± 1.37	15.03 ± 1.33	15.09 ± 1.23	15.17 ± 1.14
Work and the total space of life (3 to 15)	Int_1	9.67 ± 2.79	9.65 ± 2.61	9.70 ± 2.33	9.59 ± 2.10
	Int_2	9.69 ± 2.79	9.86 ± 2.30	9.70 ± 2.21	9.61 ± 2.16
	Int_3	10.09 ± 2.47	10.13 ± 2.18	9.95 ± 1.86	9.86 ± 1.76
	Control	9.99 ± 1.82	9.94 ± 1.84	9.96 ± 1.76	9.81 ± 1.65
Social relevance of the work in the life (5 to 25)	Int_1**	18.97 ± 2.93	19.23 ± 2.96	19.08 ± 18.21	19.14 ± 2.45
	Int_2**	18.49 ± 2.98	18.32 ± 2.94	18.21 ± 2.70	18.30 ± 2.52
	Int_3**	19.00 ± 2.60	18.96 ± 2.50	18.81 ± 2.32	18.90 ± 2.18
	Control	20.65 ± 1.89	20.39 ± 1.87	20.43 ± 1.67	20.39 ± 1.56
Absolute Absenteeism*	Int_1**	17.29 ± 21.62	17.29 ± 21.62	14.68 ± 16.95	74.81 ± 22.49
	Int_2**	12.19 ± 27.76	12.19 ± 27.76	11.79 ± 21.96	76.65 ± 22.73
	Int_3**	10.05 ± 19.67	10.05 ± 19.67	8.15 ± 14.81	74.67 ± 19.61
	Control	-6.99 ± 27.23	-6.99 ± 27.23	-2.08 ± 19.89	49.40 ± 27.01
Relative Absenteeism*	Int_1**	0.093 ± 0.107	0.093 ± 0.107	0.080 ± 0.086	0.426 ± 0.120
	Int_2**	0.059 ± 0.134	0.059 ± 0.134	0.057 ± 0.109	0.448 ± 0.125
	Int_3**	0.047 ± 0.168	0.047 ± 0.168	0.043 ± 0.088	0.432 ± 0.109
	Control	-0.044 ± 0.156	-0.044 ± 0.156	-0.014 ± 0.121	0.284 ± 0.151
Absolute Presenteeism*	Int_1**	0.78 ± 0.15	0.78 ± 0.15	0.79 ± 0.10	0.78 ± 0.14
	Int_2	0.74 ± 0.11	0.74 ± 0.11	0.76 ± 0.08	0.76 ± 0.10
	Int_3	0.74 ± 0.14	0.74 ± 0.14	0.79 ± 0.13	0.81 ± 0.11
	Control	0.75 ± 0.10	0.75 ± 0.10	0.74 ± 0.07	0.77 ± 0.10
Relative Presenteeism	Int_1	1.109 ± 0.386	0.101 ± 0.359	1.116 ± 0.218	1.106 ± 0.377
	Int_2	1.274 ± 1.040	1.176 ± 0.240	1.141 ± 0.215	1.154 ± 0.251
	Int_3	1.109 ± 0.236	1.153 ± 0.233	1.156 ± 0.216	1.116 ± 0.204
	Control	1.097 ± 0.135	1.098 ± 0.149	1.111 ± 0.139	1.117 ± 0.143

Int_1 = Intervention Group 1 (Individual ergonomics training, n = 79)
Int_2 = Intervention group 2 (Management ergonomics training and work changes, n = 77)
Int_3 = Intervention group 3 (Ergonomics training + Management ergonomics training and work changes, n = 78)
Control = Control group (No intervention, n = 77)
* The mean difference is significant at the .05 level; follow-times × Intervention (Repeated measure ANOVA)
** The mean difference with control group is significant at the .05 level (pairwise comparisons adjustment by Bonferroni)

Productivity: The mean absolute and relative absenteeism of all three intervention groups were found to be significantly different from the control group (F=3.791, P=0.001) and (F=2.789, P=0.003). The trend of changes in absolute and relative absenteeism did not change significantly in the first to third months, though it showed a significant increase between the third and sixth months. The mean value of absolute presenteeism was significantly different in the first group from the control group (F=5.995, P=0.001). In relative presenteeism (F=1.688, P=0.088), although we noticed a decline in the mean value of the second group in the first and third months, no significant difference was reported. Table 3 presents the details of changes in these scales.

Discussion

There was a significant reduction in the reported disorders in the neck, left shoulder, and right forearm in the first group. These changes occurred for the neck in the first month with a significant downward slope. The results of this part of the study were in line with the findings of similar studies previously performed on white-collar workers examining the short-term effects of interventions on MSDs in the neck and upper limbs [22-26]. Also, several systematic review studies have reported that training exercises interventions in the workplace could be average evidence of a reduction in MSDs in the neck, shoulders, and upper extremities [2, 5]. Meanwhile, the focus of training interventions on stretching or corrective movements strengthening neck muscles showed a greater effect on controlling neck pain and discomfort [5], which was proven in the results of the present study. In most other body parts, no significant effects were found on MSDs in the second group. Driessen et al. reported that the participatory ergonomic interventions did not affect the pain and discomfort in the neck and back regions [27]. However, the second group did not receive any training contents on controlling MSDs. Between the first and third months of follow-up, the mean discomfort in the right lower leg increased only in the second group and then diminished lower than the baseline by the sixth month. Similar changes were also observed in the left lower leg, without a statistically significant effect, except that there was no reduction in the sixth month. These changes might be due to an out-of-control factor, such as environmental factors or factors outside the workplace.

Despite the difference in the type of participants, the blue-collar workers, Viester reported no changes in musculoskeletal symptoms in the intervention group [28]. This similarity was due to the fact that the type of intervention program implemented for the second group in the present study and Viester study did not focus on controlling MSDs and addressed the issues of organizational stress of the participants [28]. MacDonald focused on interventions to enhance physical activity as well as to change sedentary behaviors, and reported no significant difference in the prevalence of MSDs in a six-month measurement [14]. In the third group, we noticed the effect of ergonomic training interventions on the changes of MSDs in most body parts as the significant downward slope of these changes corresponded to the first group. In similar and previous studies, several scientific and statistical reasons have been published for the effect of ergonomic intervention program on reducing MSDs [4, 6, 7, 16, 22-25, 29-31]. The significant effect of reducing MSDs, especially in the neck, shoulders, and upper extremities in the third group was greater than in the first group. Thus, the simultaneous effect of individual ergonomic training interventions and managerial educational interventions were stronger than individual educational interventions. Rempel et al. [16] as well as Robertson and O'Neill [32] also revealed that the combined effect of ergonomic training interventions and workstation design was more effective in reducing MSDs.

Another debatable point was the change in discomfort in the lower back, which is reasonable due to the lack of relevant training such as principles of manual load handling or other control points of MSDs in the lumbar region. Therefore, this increase could be due to the increase in physical load because of manual load handling tasks in the sixth month which coincided with the double workload at the end of the year. According to Choobineh et al. investigating similar participants [6], another reason for this increase in the mean lower back discomfort could be that the effect of workstation modifications and the provision of appropriate office work equipment indicated a significant effect on spinal discomfort. Note that in the present study only low-cost educational interventions were performed. Other studies showed that ergonomics training was able to significantly reduce discomfort in the lower back [26, 29], though the results of this study were contrary to their findings.

Psychological job demands in the three intervention groups did not change significantly during the six-month process. This result was similar to findings of [6], [33], and [15]. However, Driessen et al. [34] reported a reduction in psychological job demands after ergonomic

interventions. Differences in the implemented training intervention program could be the main reason for the differences of the present study results. The control was significantly increased in the participants in the second group and the third group. This improvement rose in the first month with the highest slope and later with the lowest slope. Increased control plus reduced physical discomfort in the neck and upper limbs corresponded with the findings of Park and Jang [35] as well as Driessen et al. [34]. Skill discretion grew in the second and third groups, but in the decision authority we found a more intense ascending slope in the second and third groups. It could be interpreted that the main factor in increasing control among the participants was the improvement in decision authority, which was proposed and implemented as one of the strategies of managers in the management ergonomics workshop. Note that the growing trend of these changes was sharper in the first month, which indicated the rapid impact of these interventions. This effect confirmed the influence of control-support also noted by Luchman and González-Morales in their meta-analysis [9].

In the analysis of social support changes in this study, which suggested a significant increase in all three intervention groups, first the mean score of co-worker support in the first group showed a significant and incremental growth in line with the follow-up time, which was also found by [34]and[15]. Secondly, the growth in the second group for supervisor support was sharper than for the first group, and the upward trend continued until the sixth month. Thus, it could be suggested that individual ergonomics training had a significant effect on the support of colleagues, and management ergonomics training was found to have a significant effect on the support of supervisors, which together could be seen in the growth of each social support group. Eklöf and Hagberg [33] reported a growth in social support in the workplace through managerial interventions. A 2008 study by Robertson et al. [31] also showed that ergonomic interventions enhanced interpersonal communication. Thus, increasing formal and informal communication in the office work environment as part of an ergonomic intervention program may improve social support.

Quality of work-life in the second and third groups showed a significant growth in the first month of follow-up and a reduction consistent with the control group up to the sixth month. This finding was concordant with some previous studies, showing improved quality of work life of employees in the short term by implementing a training intervention program or participatory ergonomics [10, 36-38]. The use and development of capacities subscale revealed a continuous and significant upward trend in the second and third groups of the study, which could be implemented due to the increase of control and decision-making power in management strategies. In his study, Abarqhouei also found that one of the main factors affecting the quality of work life was intervention at the managerial and organizational level ergonomics [36]. The chance of growth and security subscale in the second and third groups suggested a significant growth in the first month of follow-up. The reason for this growth could be the early impact of managerial training interventions and the importance that managers place on the company's employees during these interventions. The workplace conditions subscale also indicated a significant and positive change in the first month of follow-up. This might be attributed to managerial changes or stronger formal and informal relationships in the companies under study. Other quality of work life subscales did not show significant changes during the six-month follow-up. Elsewhere, Mejías Herrera and Huaccho Huatuco described the importance of paying attention to subscales of quality of working life and its relationship with employee productivity [39].

We noticed a significant reduction in the absenteeism variable in all three intervention groups until the third month of follow-up, followed by a meaningful jump in the four study groups until the sixth month. However, there was no significant difference between the groups, which was in line with the results of the study by Pereira et al.[4]. This diminishing trend in absenteeism until the third month was greater in the third, first, and second groups, respectively. This corresponded with the results of previous studies showing a significant relationship between MSDs and productivity loss. Also, the improvement of components of job productivity was obtained by controlling MSDs [11, 40]. Thus, it can be stated that ergonomic training interventions and combined interventions were able to reduce absenteeism until the third month. Guimarães [30] reported that absenteeism among in employees diminished after the implementation of comprehensive ergonomic intervention programs. Although the mean trend of absenteeism in the intervention groups dropped until the third month, in the assessment of absenteeism in the sixth month, the mean of all four groups was of a strong growing trend. This was not due to ergonomic interventions or internal organizational factors; rather the increase in absenteeism has been due to the prevalence of Covid-19 in Iran, widespread lockdown and social restrictions affecting staff

working hours. According to a comprehensive study by Holden et al., productivity loss would increase if health conditions were associated with psychological distress [41].

Absolute presenteeism was influenced by the interventions performed in all three intervention groups. This ascending trend was stronger in the third group. This indicated that both types of interventions augmented a person's perception of their productivity. However, in relative presenteeism, a significant decline in the second group in the first month of follow-up was observed. Since this was a relative variable, the probable cause of it could be considered as an increase in formal and informal communication in the company, which led participants to have a better understanding of the performance of other partners. Ergonomic interventions performed by changing staff attitudes and organizational climate may affect the degree of presenteeism expressed by participants [42]. Also, Cancelliere et al.'s systematic review study on measuring the impact of health interventions on presenteeism reported that participatory approaches or indirect continuing education could have a significant effect on employee presenteeism [42]. In the third and sixth months of follow-up, no noticeable changes in presenteeism were observed in any of the study groups. This change in presentation was similar to the results of the studies elsewhere [4, 14, 28]. The interventions were intended to change the job performance of employees, though no significant differences were reported.

The main limitations of this study were time and cost. The duration of follow-up was only 6 months, and free as well as low-cost methods were used to perform the interventions. Increasing the follow-up time to 12 months could determine the long-term impact of the interventions performed. Also, by implementing other ergonomic intervention methods such as the use of office equipment, modifications of office workstations or organizational changes simultaneously with training, the effect of pairing can be examined. Finally, the prevalence of Covid-19 pandemic in Iran as well as the resulting restrictions and economic problems affected some of the results of this study and even changed the conditions of the companies under study, such as working hours and work-life balance, which were not addressed in this study.

Conclusion

The state of musculoskeletal disorders in the neck and upper limb areas was assessed as inappropriate at the beginning of the study, which was significantly reduced after individual ergonomic training interventions. Management training interventions and combined interventions elevated the level of control of the participants, and both types of interventions were found to improve social support. Ergonomic training interventions and combined interventions reduced absenteeism until the third month of follow-up, but out-of-control factors such as societal economic conditions and the prevalence of Coronavirus disease strongly influenced absenteeism. Implementing a multi-component ergonomic intervention program may improve the impact of interventions on employee health and productivity. In this comprehensive program, in addition to ergonomics training in a long-term and sustainable process, a program should also be implemented to improve employee health and productivity with a participatory ergonomics approach, workstation design, and organizational interventions.

Acknowledgement

The authors would like to thank all workers, employees and managers participating in the study.

Conflict of interest: None declared.

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