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ORIGINAL ARTICLE

Effectiveness of Exercise Program Interventions in Reducing Musculoskeletal Disorders Among Operating Room Technicians

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ABSTRACT

Background: Due to demanding work hours and conditions, operating room technicians are at high risk of developing musculoskeletal disorders (MSDs). This study aimed to implement and evaluate the effectiveness of an ergonomic intervention program based on targeted exercise routines tailored to the needs of these professionals.

Methods: This interventional study employed a before-and-after clinical trial design involving 40 operating room technicians (39 female, 1 male) at Rasool Akram Hospital. Data collection tools included the Nordic and Corlett questionnaires. Participants received training as part of a six-week ergonomic exercise program. Post-intervention data were analyzed using SPSS software.

Results: Before the intervention, mean discomfort scores were high in the back (3.18), shoulder and arm (3.53), hand and wrist (0.48), and knee (2.07). Following the intervention, these values decreased to 2.37, 2.90, 0.30, and 1.68, respectively. Repeated measures ANOVA with Greenhouse-Geisser correction indicated statistically significant reductions in the back, neck, shoulder, arm ($p < 0.001$), and knee ($p = 0.002$).

Conclusion: The findings demonstrate that an ergonomic exercise-based intervention can significantly reduce musculoskeletal discomfort among operating room technicians, highlighting the potential of such programs in occupational health strategies.

KEYWORDS: *Ergonomics training, Sports training, Musculoskeletal disorders, Operating room technicians*

INTRODUCTION

Musculoskeletal disorders (MSDs) are among the most common work-related health problems [1] and continue to be a leading cause of work incapacity, reduced productivity, and significant economic and social burdens worldwide [2]. A substantial number of individuals are unable to work due to disabilities caused by MSDs. These disorders account for approximately one-third of all diseases in North America, Northern Europe, and Japan [3]. In fact, the increasing prevalence of chronic conditions such as MSDs has been identified as the third most pressing health issue in the European Union. MSDs affect at

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least 100 million people in the EU, contributing to half of all work absenteeism and 60% of permanent work-related disabilities [4]. The proportion of workers with chronic conditions like MSDs is rising across Europe, with projections indicating that more than 20 million workers in England alone will be affected by 2030 [5]. In the United States, MSDs are responsible for 29% of all workplace injuries [6] and account for 34% of lost workdays [7].

The World Health Organization identifies physical, psychosocial, organizational, and individual factors as key contributors to occupational diseases [8], with musculoskeletal disorders (MSDs) often resulting from a combination of these risks [9]. Among the physical risk factors associated with work-related MSDs are repetitive movements, improper working posture [10], poorly designed work environments [11], exertion of force, prolonged sitting or standing, physically demanding tasks [9], high work pace [12], and exposure to vibration [11]. Evidence suggests that even if job tasks do not directly cause MSDs, certain physical risk factors such as repetitive movement patterns, load lifting, frequent bending and twisting, mechanical pressure, and whole-body or segmental vibration can exacerbate these conditions in the workplace [13].

Musculoskeletal disorders account for a significant proportion of healthcare expenditures, particularly among healthcare personnel. These disorders negatively affect employee health, quality of life, and job satisfaction, and are a leading cause of lost workdays [7, 14]. In surgical departments, the prevalence of MSDs is notably high due to the nature of the work. Numerous community-based surveys have reported a high incidence of MSDs among operating room technicians, with evidence indicating that 58–90% of personnel experience musculoskeletal pain after just one year of clinical work [15]. A 2017 study on surgeons performing minimally invasive procedures revealed that 90% reported MSDs, with higher prevalence observed among the most experienced surgeons. The most frequently affected areas were the back (54%), neck (51%), upper limbs (44%), lower limbs (42%), right shoulder (29%), and right hand (28%) [16].

Other internal studies have reported a 78% prevalence of musculoskeletal disorders (MSDs) among nurses and operating room technicians [16]. However, these studies have primarily focused on prevalence and often conclude with general recommendations. Omer, Ozcan, Karan, and Ketenci [17] conducted a study evaluating the effectiveness of training and exercise programs in managing MSDs. They implemented a stretching exercise regimen and observed a reduction in musculoskeletal symptoms. Stretching exercises targeting the neck and shoulder regions—aimed at reducing pain intensity, disability, and duration—can be easily implemented in workplace settings, as they require no specialized equipment [18]. Regarding exercise types, the most commonly applied interventions are stretching and strength training routines [19, 20], which are considered feasible and effective options for addressing work-related musculoskeletal disorders.
Given the similarity in working conditions and duties among operating room technicians, the generalizability of intervention programs is notably high. Despite the widespread prevalence of musculoskeletal disorders (MSDs) in this occupational group, no ergonomic intervention programs have been specifically designed for operating room technicians in Iran. This gap highlights a pressing need for targeted strategies. Accordingly, the present study aimed to implement and evaluate the effectiveness of an ergonomic intervention program based on exercise routines tailored to the specific conditions and needs of operating room technicians.

MATERIALS AND METHODS

This study employed an interventional research design using a before-and-after clinical trial approach. Based on the study by Robertson et al. [18], back pain was selected as the primary outcome variable. A sample size of at least 37 participants was determined using the reported standard deviation of 1.6 and an average change of 1.04, which indicated a statistically significant difference between pre- and post-intervention measurements

7.78 * 2 (sd/change in min) ^2 = 7.78 * 2 (1.6/1.04) ^2 ≈ 37

This study was conducted on volunteer operating room staff at Rasool Akram Hospital, with 40 participants selected based on the calculated sample size. Inclusion criteria were: a minimum of three years of hospital work experience, willingness to participate, absence of pregnancy, no documented history of mental illness or depression (based on medical records), and the presence of musculoskeletal disorder symptoms. Exclusion criteria included: lacking any of the aforementioned inclusion criteria; a history of fracture or major trauma; arthritis; degenerative disc disease; spondylosis; spinal stenosis; neurological defects; systemic illnesses (as identified through self-report or medical records); congenital abnormalities; prior spinal surgery; current use of medications related to musculoskeletal disorders; and unwillingness to cooperate [21].

Prior to the start of the study, a meeting was held to fully explain its purpose to the participants. They were assured of the confidentiality of their information and informed of their right to withdraw from the study at any stage. Written informed consent was then obtained from all participants. To assess the prevalence of musculoskeletal disorders, the Nordic and Corlett questionnaires were administered. A demographic questionnaire was also used to collect data on age, gender, height, weight, education level, work experience, and average working hours per week.

Nordic Questionnaire: The Nordic Musculoskeletal Disorders Questionnaire was employed as a screening tool in this study [22]. This instrument comprises two sections: (1) a general questionnaire designed to assess musculoskeletal symptoms across the entire body, and (2) a specific questionnaire focusing on detailed analysis of symptoms in targeted regions such as the neck, shoulders, and back. The body is divided into nine anatomical areas: neck, shoulders, elbows, wrists/hands, back, spine, thighs, knees, and legs. Participants were asked whether they had experienced discomfort or problems in any of these areas over the past 12 months, and whether such issues had caused them to miss work or become unable to work. Responses are recorded as either "yes" or "no," with affirmative responses indicating the presence of musculoskeletal disorders. The validity and reliability of the Nordic questionnaire were confirmed in a study by Namnik et al. [23]

Corlet Questionnaire: The Corlett Musculoskeletal Discomfort Questionnaire, developed in 1976, is a widely used instrument for assessing musculoskeletal discomfort [24]. It is employed for both pre- and post-evaluation. The body is divided into eight anatomical regions: neck, shoulder and arm; waist; elbow and forearm; hand and wrist; pelvic area; knee and thigh; and leg and foot. For each region, discomfort is scored before and after a work shift, and the difference between these two values represents the level of discomfort in that area. The validity and reliability of the Corlett Questionnaire have been confirmed in Iran [25].

Intervention program of ability maintenance and injury preventive exercises

Maintaining the ability to function independently in daily life is a universal priority, regardless of age. Healthcare consumers patients and clients commonly seek or are referred to physical therapy services due to impairments arising from injury, disease, or disorders that hinder their ability to engage in essential or meaningful activities. Additionally, individuals without existing impairments may pursue physical therapy to enhance overall fitness or reduce the risk of injury and disease.

The ultimate goal of mentioned therapeutic exercise program was achievement of an optimal level of symptom-free movement during basic to complex physical activities. These exercises were identified by the physiotherapist and from Kisner's textbook of physiotherapy, pages 474, 497, 498, 508, 510, 529, and 601 [26] as suitable for the study subjects and were taught, performed, and followed up by the ergonomic student to the subjects. The duration of this training and its implementation was 6 weeks. First, the volunteer personnel completed the demographic questionnaire according to the entry requirements. Then the Nordic Musculoskeletal Disorders Questionnaire and, in the next step, the Corlette Questionnaire were completed by the participants on three occasions (before the intervention, at the end of the middle week (the third week), and after the end of the intervention (the end of the sixth week).

Based on the results of the Nordic questionnaire, a set of targeted stretching exercises was approved by a physiotherapist. According to Hess and Hecker [27], several criteria define an effective workplace stretching program. Due to the restrictions imposed by the COVID-19 pandemic, these exercises were delivered through virtual training sessions. Educational materials, including video files and supplementary explanations, were made permanently available offline to ensure continued access. Participants also had direct communication channels with the trainer for additional questions and personalized guidance.

Based on participants' work schedules and the priority of maintaining patient safety during surgical procedures, the exercises were implemented in two phases. The first phase was integrated into surgeries lasting longer than 2.5 hours. In such cases, participants performed stretching exercises at 30–50 minute intervals, each lasting 60–90 seconds. These movements were designed to be performed either seated or standing, without requiring a change in position or location. Participants were instructed to carry out the specified

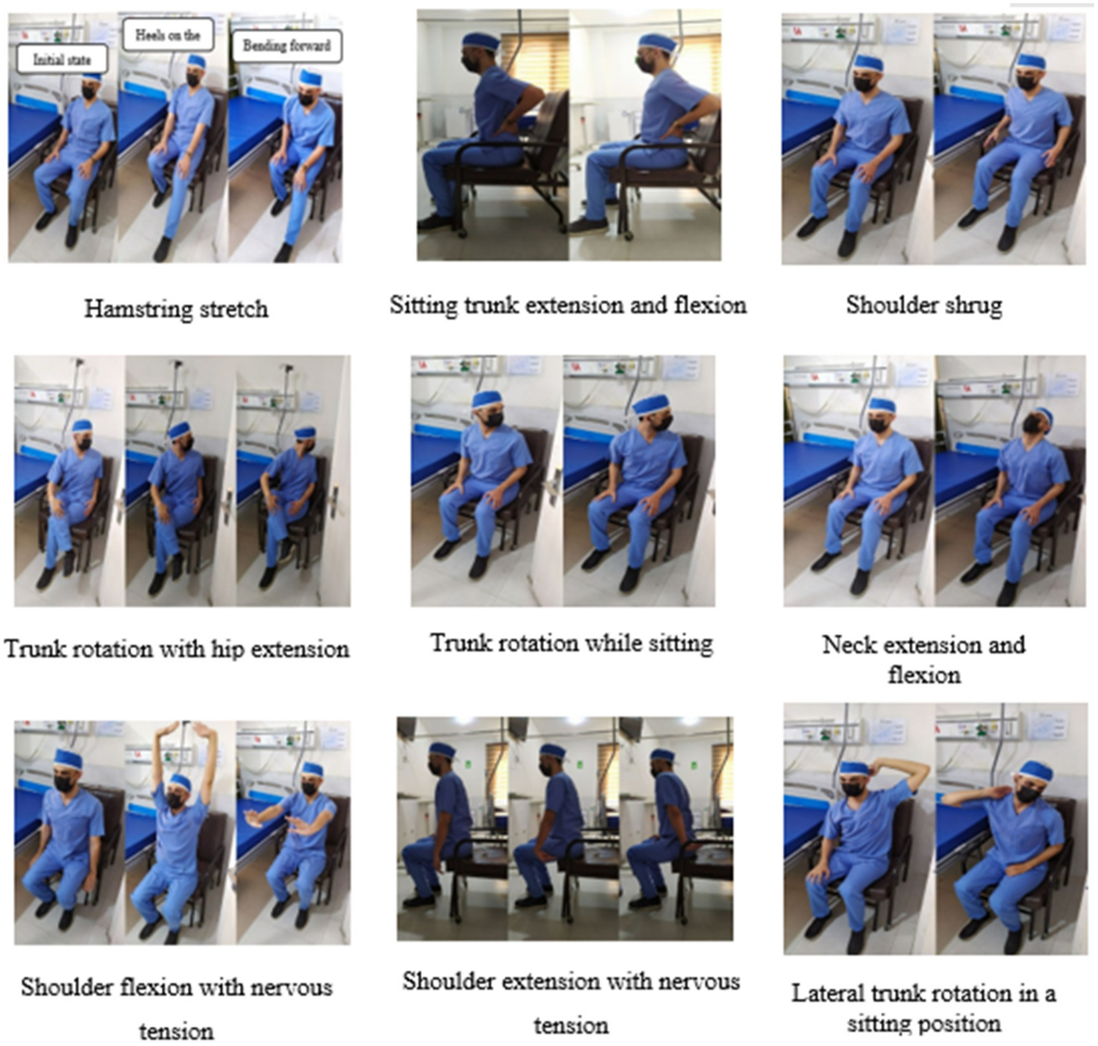

Figure 1. Pictures of the exercise

exercises at regular intervals during the procedure (see Figure 1).

Exercises can be done sitting or standing, and there is no need to change position or location.
1) Sit straight (stand) and take a deep breath.
2) Gather the shoulders up, then back and down.
3) Move the hands forward along with the shoulder. Bring the shoulder blades together.
4) Look at the ceiling. Take a deep breath. Tuck the chin to the chest. Take a deep breath.
5) Turn your hands away from you.
6) Take the left leg to the back. Turn the head along with the shoulder to the left. Return the left leg to the starting position. Lean to the right.
7) Repeat this situation for the other side.
8) Deep breath, creating an arch in the back area, and exhaling.
9) Deep breathing, contracting the abdominal muscles, and exhaling.
10) Inhale and exhale and finish the movements.

The second part of the exercise regimen was conducted during the breaks between two surgical procedures, when participants had greater flexibility and could perform the exercises with enhanced focus. These exercises were to be performed slowly and without exertion. If any movement caused pain or discomfort, participants were instructed to discontinue the exercise immediately. The targeted exercises included hamstring stretches; trunk stretching and flexion in a seated position; shoulder elevation; trunk rotation while seated; trunk rotation with thigh stretching; lateral trunk rotation in a seated position; and shoulder stretches involving neural tension—specifically shoulder stretching, flexion, and bending under neural tension. Each exercise was thoroughly demonstrated and taught to participants. The overall study design and sequence of interventions are illustrated in Figure 2.

Statistical analysis

The data collected from study participants were analyzed using SPSS software, version 26. To assess changes in musculoskeletal disorders over time, repeated measures ANOVA with Greenhouse-Geisser correction was employed, followed by Bonferroni's post hoc test. A significance level of 0.05 was adopted for all statistical tests. The Kolmogorov–Smirnov test indicated insufficient evidence to confirm the assumption of normality for the questionnaire data.

RESULTS

The demographic characteristics of the operating room technicians included in this study are presented in Tables 1 and 2. A total of 40 technicians (39 female and 1 male) met the inclusion criteria and participated in the study. The average age of participants was 28.18 ± 5.19 years, indicating a relatively young cohort. However, with an average of 5.95 years of professional experience, the participants were also considered experienced. Daily working hours ranged from 6 to 14 hours, with an average of 10.3 hours per day. The most experienced technician had 26 years of work history, while the least experienced had 3 years.

The results related to musculoskeletal disorders data

As can be seen in diagram 1, the prevalence of symptoms in the past year was 72.5%, shoulder and arm 52.5%, hand and wrist 47.5%, and knee 42.5%; disorders were prevalent in a very large percentage of the population (more than 40%). Also, according to chart 2, the prevalence of symptoms in the past 7 days was high in the lower back 62.5%, shoulder and arm 30%, and hand, wrist, and knee 30%, pointing to a higher percentage of the symptoms of skeletal-muscular disorders.

In order to check the effectiveness of the intervention program of exercise, the discomfort obtained during the work shift before and after the intervention was compared (Table 3, Figure 4).

In order to compare the changes in the intensity of discomfort during the intervention, the repeated-

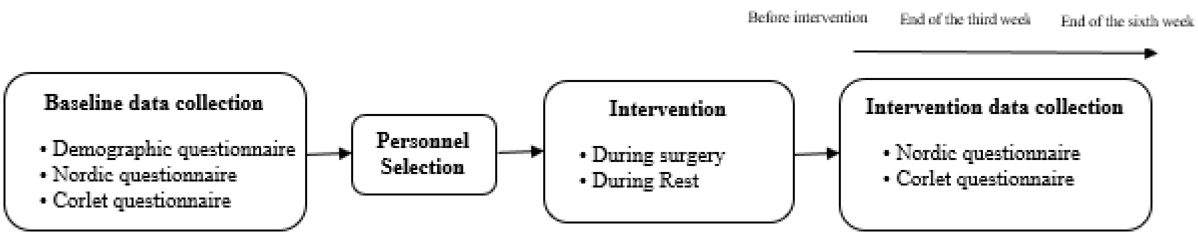

Figure 2. Study design process and intervention sequence.

Table 1. Some characteristics of the people participating in the study (n=40)

Demographic Characteristic	Mean	Standard Deviation	Minimum	Maximum
age (years)	28/18	5/19	22	49
height (cm)	165/95	5/51	154	178
weight (kg)	63/8	8/65	45	90
Body mass index s	23/2	2/95	16/5	29/7
work history	5/95	4/72	3	26
Average daily working (hour)	10/3	2/44	6	14

Table 2. Some characteristics of the people participating in the study (n=40)

Status		Frequency
Work	standing and sitting	31
	standing	9
Marriage	single	29
	married	11
Degree	Bachelor's degree	37
	Associate degree	3
Sports activity	≥ 3 hours during the week	10
	< 3 hours a week	30

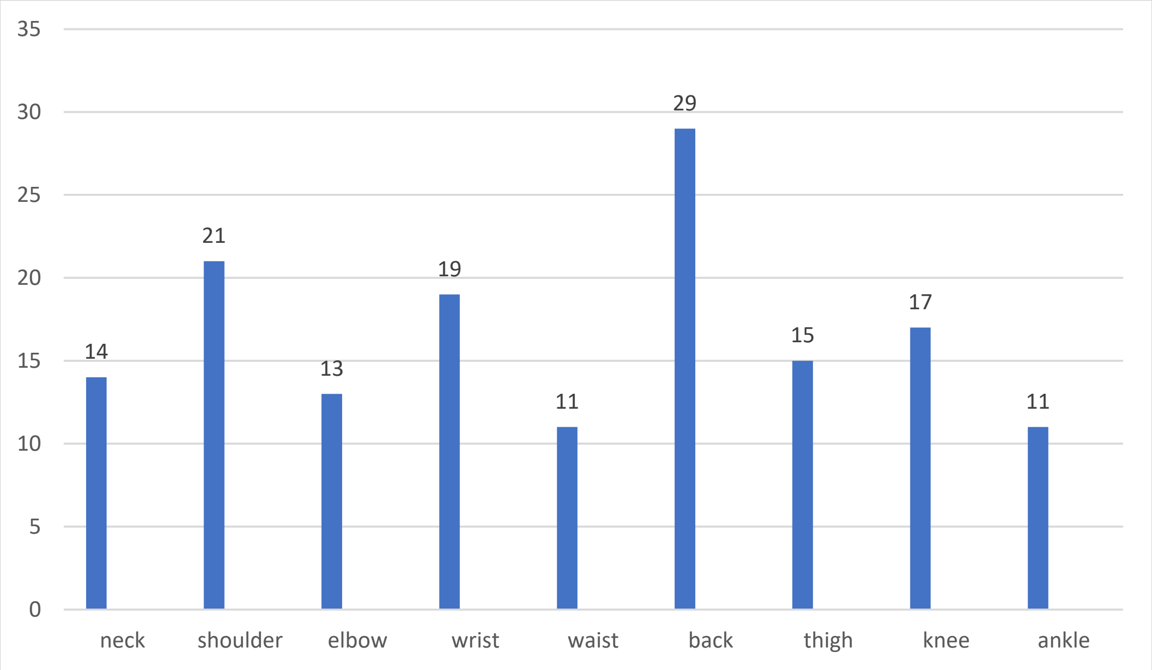

Figure 3. Prevalence of musculoskeletal disorders in different body parts of employees during the past year based on the Nordic questionnaire

Table 3. Comparison of the mean (standard deviation) of discomfort obtained before and after the intervention (n=40)

Body part	Discomfort befor intervention	Discomfort after 3 weeks of intervention	Discomfort after 3 weeks of intervention
neck	4.23 (0.66)	3.73 (0.60)	2.90 (0.49)
shoulder	3.53 (0.68)	2.78 (0.73)	2.25 (0.70)
back	3.18 (0.68)	2.63 (0.77)	2.73 (0.70)
elbow	0.8 (0.41)	0.67 (0.47)	0.28 (0.55)
wrist	0.48 (0.51)	0.33 (0.47)	0.30 (0.46)
buttocks	0.95 (0.67)	0.83 (0.5)	0.75 (0.54)
knee	2.07 (0.73)	1.68 (0.65)	1.68 (0.57)
ankle	1.78 (0.73)	1.60 (0.54)	1.73 (0.71)

measures ANOVA statistical test was used. Benferroni's post hoc test was also used for pairwise comparisons. The results of the repeated-measures ANOVA test with GG modification showed that the difference in the overall discomfort of the neck area between the three time periods—before the intervention, three weeks after the intervention, and six weeks after the intervention was significant ($F(1.98, 77.17) = 57.761$, $p < 0.001$). The results of Benferroni's post hoc test also showed that this difference between before the intervention and the third week of the intervention was significant ($p = 0.001$). In addition, this decrease between before the intervention and the sixth week after the intervention was also significant ($p < 0.001$). The decrease was significant between the third week after the intervention and the sixth week after the intervention ($p < 0.001$).

The results of the repeated-measures ANOVA test with GG modification showed that the difference in overall discomfort of the shoulder area between the three time periods—before the intervention, three weeks after the intervention, and six weeks after the intervention—was significant ($F(1.82, 70.77) = 52.33$, $p < 0.001$). The results of Benferroni's post hoc test also showed that this difference between before the intervention and the third week of the intervention was significant ($p < 0.001$). In addition, the decrease between before the intervention and the sixth week after the intervention was also significant ($p < 0.001$), and the decrease between the third week after the intervention and the sixth week after the intervention was also significant ($p < 0.001$).

The results of the repeated-measures ANOVA test with GG correction showed that the difference in overall back discomfort between the three time periods—before the intervention, three weeks after the intervention, and six

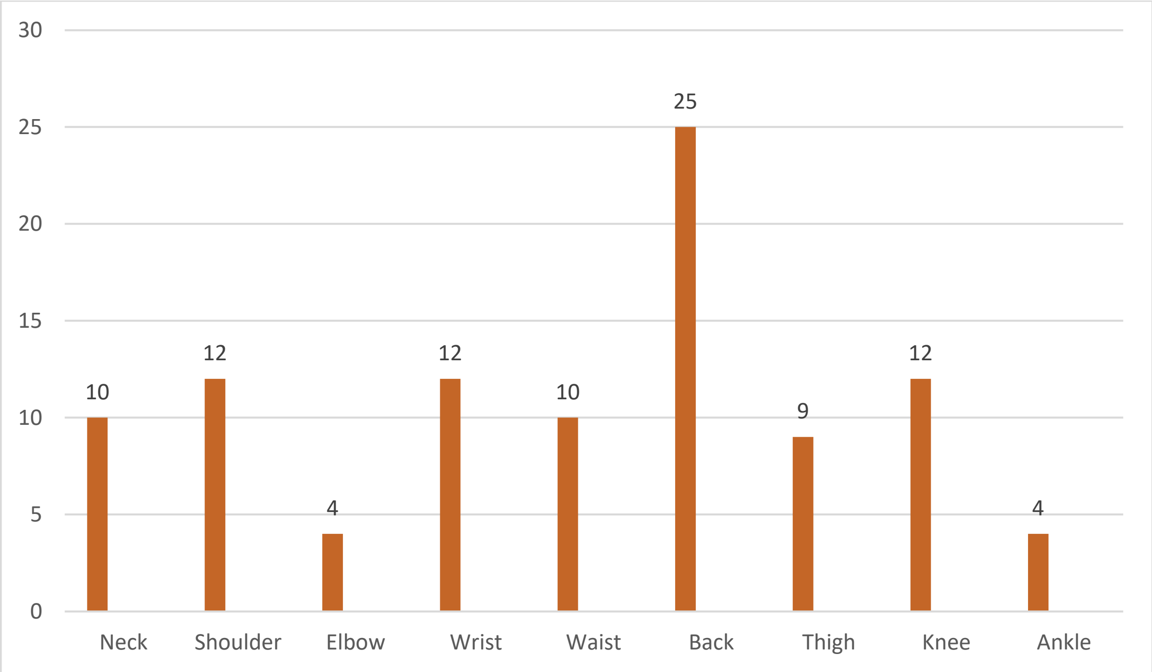

Figure 4. Prevalence of musculoskeletal disorders in different body parts of employees during the last seven days based on the Nordic questionnaire

Table 4. Bonferroni post hoc test for pairwise comparison of discomfort in three time periods (before the intervention, the third week after the intervention and the sixth week after the intervention)

Body areas	Time	Time	Mean difference(I-J)	*sig.*^{b}
Neck	T1	T2	0.50	**0/001**
		T3	1.135	**<0/001**
	T2	T3	0.825	**<0/001**
Sholder and arm	T1	T2	0.75	**<0/001**
		T3	1.275	**<0/001**
	T2	T3	0.525	**<0/001**
Low Back	T1	T2	0.55	**0/001**
		T3	0.8	**<0/001**
	T2	T3	0.25	**0.259**
Hand and wrist	T1	T2	0.15	**0.406**
		T3	0.175	**0.385**
	T2	T3	0.025	**1**
Elbow and forearm	T1	T2	0.125	**0.769**
		T3	0.525	**<0/001**
	T2	T3	0/4	**0.014**
Buttocks	T1	T2	0.125	**1**
		T3	0.2	**0.557**
	T2	T3	0.075	**1**
Thigh and knee	T1	T2	0.4	**0.010**
		T3	0.4	**0.007**
	T2	T3	0	**1**
Foot and leg	T1	T2	0.175	**0.765**
		T3	0.05	**1**
	T2	T3	0.0125	**1**

weeks after the intervention was significant (F(1.95, 76.27) = 18.27, $p < 0.001$). The results of Benferroni's post hoc test also showed that the difference between before the intervention and the third week of the intervention was significant ($p = 0.001$). In addition, the decrease between before the intervention and the sixth week after the intervention was significant ($p < 0.001$). However, the decrease between the third week after the intervention and the sixth week after the intervention was not significant ($p = 0.259$).

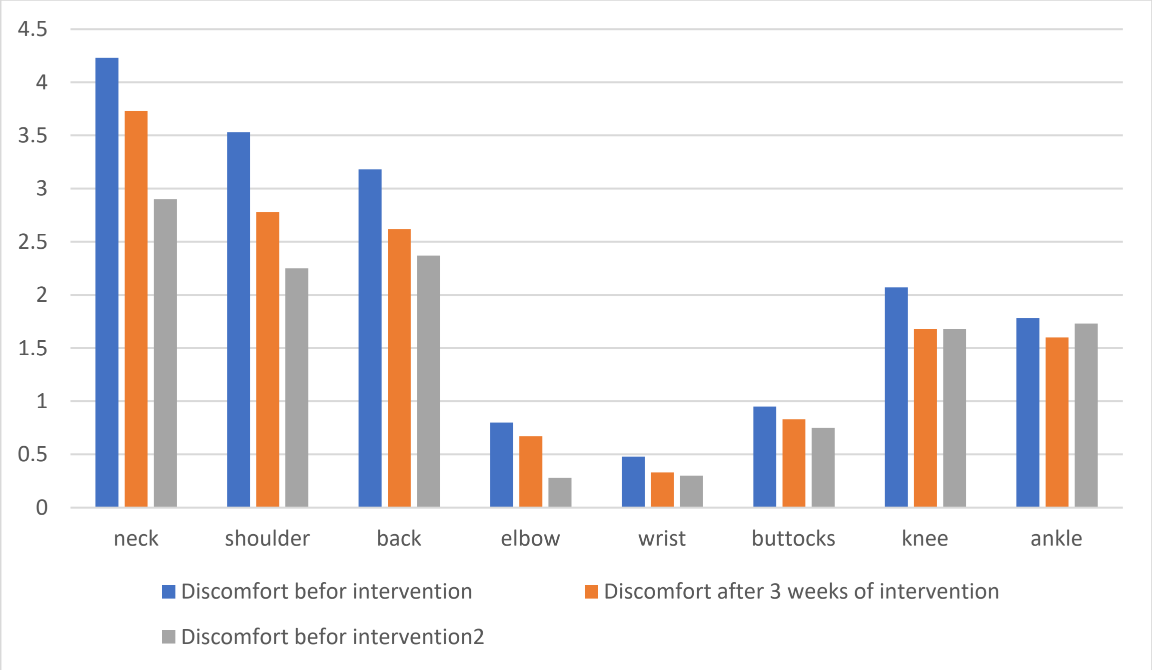

Figure 5. Comparison of discomfort obtained before and after the intervention (n=40)

The results of the repeated-measures ANOVA test with GG correction showed that the difference in overall discomfort of the hand and wrist area between the three time periods—before the intervention, three weeks after the intervention, and six weeks after the intervention was not significant (F(1.93, 75.28) = 1.68, $p = 0.194$). In this case, there is no need to check Benferroni's post hoc test. The results of the repeated-measures ANOVA test with GG modification showed that the difference in overall discomfort of the elbow and forearm between the three time periods—before the intervention, three weeks after the intervention, and six weeks after the intervention—was significant (F(1.93, 69.78) = 11.36, $p < 0.001$). The results of Benferroni's post hoc test also showed that the difference between before the intervention and the third week of the intervention was not significant ($p = 0.769$). However, the reduction between before the intervention and the sixth week after the intervention was significant ($p < 0.001$). This decrease was also significant between the third week after the intervention and the sixth week after the intervention ($p = 0.014$).

The results of the repeated-measures ANOVA test with GG modification showed that the difference in overall discomfort of the pelvic area between the three time periods—before the intervention, three weeks after the intervention, and six weeks after the intervention was not significant (F(1.79, 70.14) = 1.17, $p = 0.312$). On the other hand, the results of the repeated-measures ANOVA test with GG correction showed that the difference in overall discomfort of the thigh and knee area between the three time periods—before the intervention, three weeks after the intervention, and six weeks after the intervention—was significant (F(1.98, 23.73) = 7.01, $p = 0.002$). The results of Benferroni's post hoc test also showed that the difference between before the intervention and the third week of the intervention was significant ($p = 0.01$). The reduction between before the intervention and the sixth week after the intervention was also significant ($p = 0.007$). However, the decrease between the third week after the intervention and the sixth week after the intervention was not significant ($p = 0.1$).

DISCUSSION

The present study designed, implemented, and evaluated a 6-month supervised daily exercise program at the workplace for operating room technicians with musculoskeletal pain, targeting nine areas of the human body (cervical spine, shoulder, upper back, elbow, and wrist). The focus was on the hand, back, hip/thigh, knee, and ankle/foot. In this study, the mean musculoskeletal discomfort reported during the work shift prior to the intervention was 3.18 overall, with discomfort levels for specific body regions recorded as follows: shoulder and arm, 3.53; neck, 4.23; elbow and forearm, 0.8; hand and wrist, 0.48; pelvic area, 0.95; knee, 2.07; and leg discomfort, 1.78. After the intervention, discomfort decreased in all areas, and this decrease was significant. These results are consistent with those of the studies by Shariat et al. and Jafari et al. Regarding the neck, arm, and shoulder postures, it can be suggested that investigating the causes and occurrences, and providing a long-term solution for this region, will be an effective measure in reducing musculoskeletal discomfort. Although the middle and final weeks showed a decreasing trend, this decrease was not significant, indicating the need to examine other factors in this body region—such as patient transport methods, appropriate training, and integration with physical exercise.

In the present study, the reduction of discomfort in the hand and wrist area (3.0, p = 0.194) was not significant, whereas in the study by Jafari et al. [28], this reduction was significant. In this regard, it can be suggested that different tools are used by technicians during surgery, and training in this field may lead to better outcomes. It is also possible to reduce pain in this region by designing more appropriate exercises. There was no significant decrease in discomfort in the leg, indicating the need for additional interventions in this area. Future studies should investigate whether one specific exercise method is more effective than another in reducing wrist and ankle pain and disability. Moreover, it should be examined whether certain exercise-based interventions are more effective among workers with different occupational activities. Previous studies conducted to reduce back pain and musculoskeletal disorders in nurses have shown that exercise and stretching movements can lower the prevalence of these conditions [29]. In the present study, stretching movements had a significant impact on reducing musculoskeletal discomfort. Therefore, it can be concluded that performing sports exercises in this study was effective in reducing musculoskeletal disorders in operating room technicians, and may help lower the prevalence of such disorders in the long term. This finding is consistent with the study by Holbeck et al. [30].

This study has limitations that may affect the generalizability of its findings. First, the results are limited to young office workers (39 women and 1 man) with musculoskeletal pain in various parts of the body. Future studies can examine the effectiveness of workplace intervention programs incorporating different types of exercises and physical activities. The sample of operating room technicians was relatively small given the feasibility constraints of the research. Additionally, our selected participants had no history of mental illness, had varying years of work experience, and possessed other unknown characteristics that may have influenced their likelihood of developing musculoskeletal disorders (MSDs). Furthermore, the intervention's impact was evaluated over a six-month period. To produce stronger evidence regarding the efficacy of the educational program, further studies should employ longer intervention durations and account for potential confounding factors influencing MSD risk and prevalence among operating room technicians. An economic evaluation of this program (i.e., cost–benefit analysis) could also be an important focus of future occupational health research. Moreover, the study did not assess the long-term effects of the intervention or whether participants maintained positive changes or continued the program after the six-month period. Another limitation relates to the scheduling of the program during working hours, as well as the frequency and duration of daily training sessions. These factors may interfere with workplace productivity, particularly for workers with high workloads and limited time. Lastly, daily supervision by an exercise specialist is a considerable challenge especially for workplaces that lack the resources to employ such personnel. The study also relied on subjective instruments that required participants to recall past experiences, which could be susceptible to memory bias.

CONCLUSION

In the present study, a sports program using low-cost equipment was implemented, which may be effectively adopted in work environments without requiring a dedicated space. The results indicate that the prevalence of musculoskeletal disorders (MSDs) in at least one body area among operating room technicians is high, and that the implementation of an exercise program is beneficial in reducing the severity of these disorders. These findings support the notion that managers can apply such strategies to mitigate the impact of MSDs on the health and performance of operating room technicians.

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