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Combating Fatigue in the Office: Findings of a Participatory Ergonomics Intervention

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ABSTRACT

Introduction: The nature of unstandardized office work exposes call center agents to not only work-related musculoskeletal disorders (WRMSDs), but also other mental and physical adversities. Despite this fact, in the occupational health literature, there is a surprising paucity regarding fatigue management interventions among call center agents. Accordingly, a participatory ergonomics intervention was designed to examine its resulting effects on worker's mental and physical fatigue.

Material and methods: A quasi-experimental participatory interventional study with a single arm pretest-posttest design was conducted among 84 call center agents of a private telecommunication company in the city of Tehran, Iran. Prior to the intervention, data regarding mental and physical fatigue were collected via SOFI questionnaires. Then, participants were assigned to a multifaceted intervention program including comprehensive office ergonomic training, work layout improvement, supervised on-site face to face visits, and provision of quality break time encompassing regular exercise program. Follow-up evaluation was done after a 6-month period. Wilcoxon sign test was applied to compare subject's perceived mental and physical fatigue before and after the intervention.

Results: Based on the results, intervention had a significant effect on reducing overall score of the fatigue scale ($P < 0.01$). However, the results for its subscales were mixed. Lack of energy was reported to decrease meaningfully ($P < 0.01$) while lack of motivation and sleepiness didn't change significantly. As for physical fatigue, physical discomfort was perceived to be alleviated by the intervention ($P < 0.001$) although the condition of physical exertion didn't improve significantly.

Conclusions: Findings showed that the intervention had mixed effects on different aspects of employees' fatigue. Customizing interventions to target different aspects of occupational fatigue would be a practicable strategy. Moreover, the contribution of this study is to the body of the literature suggesting a participatory ergonomic intervention can help bring about improvements to the work systems specifically managing occupational fatigue.

KEYWORDS: *Macroergonomics; Office workers; Occupational fatigue*

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INTRODUCTION

Computer-mediated customer service—most notably call center employment—constitutes approximately 3–4% of the global workforce and represents one of the fastest expanding occupational sectors worldwide (1,2). Call center employees devote the majority of their working hours to sedentary activity within a structured workstation—typically consisting of a computer desk and chair—while engaging continuously with digital interfaces and virtual clientele (3), as a result, The inherently sedentary and static nature of call center work—coupled with the concurrent use of communication devices and computer systems to provide uninterrupted responses to customer inquiries—renders employees highly vulnerable to both mental strain and physical fatigue (4–6).

The common term fatigue is difficult to define in a way that is valid in most situations, that is why different fields have their own relevant definition of the phenomenon (7). In field of ergonomics, Ahsberg et al. (2000) offers a comprehensive categorization of fatigue including general, physical and mental dimensions (8). From a physical point of view, fatigue is an outcome of the physical demand of an activity, which demonstrates itself in the pulmonary, circulatory and metabolic systems, as well as in local strength, joints, and the spinal column (9). From a mental perspective, fatigue is a state caused by sustained periods of demanding cognitive activity, which is characterized by feelings of weariness, sleepiness and low energy (10,11).

Occupational fatigue is a widespread phenomenon that contributes substantially to both physical impairment and psychosocial burden (12). Work-related musculoskeletal disorders (WRMSDs) typically manifest initially as muscle fatigue and discomfort, gradually progressing to more severe impairments that compromise limb mobility, muscular strength, and functional capacity (13). Fatigue is also shown to adversely affect work ability of the workforce (14). Moreover, work-related fatigue may lead to interpersonal consequences including decreased quality of communications with colleagues and customers (15).

The literature offers substantial evidence that the origins of work-related fatigue are multifactorial, arising from a complex interplay of personal determinants (e.g., demographic characteristics and occupational habits), physical conditions (e.g., workstation design and sustained or awkward postures), and psychosocial influences (e.g., availability of social support and adequacy of rest breaks) (14,16,17) Empirical evidence indicates that interventions such as posture correction, the incorporation of regular micro-exercises during work, and the cultivation of ergonomically appropriate behaviors among employees are effective strategies for mitigating occupational fatigue (18,19). Enhancing workplace conditions—particularly through the refinement of employees' posture—has been shown to reduce physical fatigue, and emerging evidence further suggests that such improvements may positively influence cognitive dimensions of work, including mental workload and mental fatigue (20–22) Nevertheless, this association remains contentious within the scientific community, underscoring the need for further rigorous investigation (23).

To date, evidence on the effectiveness of ergonomic interventions among office workers has been inconclusive (24,25). To reconcile these discrepancies, the literature suggests prioritizing participatory, multicomponent ergonomic interventions, which appear to offer advantages over single-component approaches (26–28). Multiple studies among office workers have demonstrated that ergonomically optimized workstation modifications, when combined with practical training, can effectively reduce negative work-related outcomes such as fatigue and musculoskeletal discomfort (1,19,29). In their review, Juhanson and Merisalu (2017) argued that such interventions represent one of the most effective strategies for enhancing workplace conditions. Nonetheless, the overall efficacy of ergonomic interventions continues to warrant further empirical scrutiny (25).

Armitage and Sprigg (2011) highlighted a striking scarcity of research on interventions targeting call center workers, and to the best of our knowledge, this gap in the literature persists to the present day (1). Accordingly, the primary aim of this study was to evaluate the effectiveness of a participatory, multicomponent ergonomics intervention program on both mental and physical fatigue among call center employees, addressing personal (ergonomics training), physical (workstation layout optimization), and psychosocial (enhanced quality of break periods) dimensions of the work system. This intervention aimed to empower employees to become active agents of change in their workplace by fostering and motivating their participation.

METHOD

Study design

This quasi-experimental, non-randomized interventional study employed a one-group pretest–posttest design and

was conducted at a telecommunications company in Tehran between March and September 2017. Over a six-month period, participants received office ergonomics training and were provided with structured quality break periods complemented by an exercise program.

A total of 94 call-center workers were initially enrolled in the program. Five were excluded (four were ineligible and one did not respond), leaving 89 participants in the intervention group. Following the baseline assessment, the intervention—which included the aforementioned training and structured break periods—was implemented. After the intervention, five participants were lost to follow-up (one withdrew, one due to turnover, one on maternity leave, and two due to attendance issues), resulting in a final intervention group of 84 participants. Survey data regarding their work-related musculoskeletal disorders (WRMSDs) and mental workload, (both reported elsewhere (31)) and fatigue were gathered before and after the intervention.

The Study was participatory in nature; participatory ergonomics is the practice of engaging employees in developing and implementing workplace changes which will lead to desired working outcomes such as productivity and health (32); it is the "involvement of people in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes to achieve desirable goals" as Wilson (1995) described it (33). In our study, required knowledge about ergonomics and how translate them into their own work layout and activities were passed down to the participants, so they could be the agent of change and do the necessary workstation modifications even in the absence of the supervisors or research team.

The study received ethical approval from the Ethics Committee of the Industrial Engineering Department at Caspian Higher Education Institute.

Subjects and Setting

The study population included all full-time call center employees of a private telecommunication company in Tehran, recruited through a complete census. Informed consent was obtained from each participant prior to enrollment. Inclusion criteria were: performing more than 24 hours per week of computer-based customer service work (approximately 4 hours per day) and having no active workers' compensation claims involving the upper limbs. All employees worked in standard cubicles, each equipped with a personal computer (flat-screen monitor, keyboard, and mouse) and a headset. Their primary tasks involved answering calls and handling customer inquiries, with minimal use of written materials and most procedures conducted via computer. The physical layout of the cubicles was largely uniform across the organization. Office furniture was minimally adjustable, with little evidence of managerial efforts to enhance ergonomic conditions, and baseline awareness of ergonomics among employees appeared low.

Intervention

The comprehensive, participatory intervention program consisted of four carefully tailored components designed to address the specific needs of the workforce and target multiple dimensions of the work environment (Fig. 1).

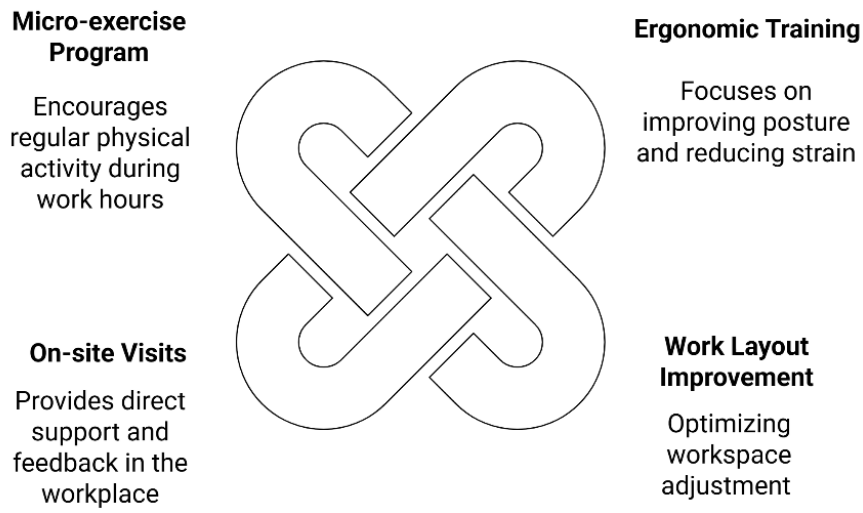

Figure 1. The elements of the intervention

Comprehensive office ergonomic training

Following the baseline evaluation, two 90-minute group training sessions were conducted on-site by the researchers to enhance participants' understanding of fundamental office ergonomics principles. The sessions covered the etiology of work-related musculoskeletal disorders (WRMSDs), including inappropriate workstation layout, awkward postures, and fatigue, and emphasized the importance of workstation modifications and workplace stretching exercises for the prevention of fatigue and WRMSDs. Participants were also trained in self-assessment techniques to enable independent adjustment of their workstations. At the conclusion of the sessions, each attendee received a concise visual pamphlet summarizing all the material presented.

Work layout improvement

With backing from senior management, the office environment underwent substantial ergonomic enhancements. Non-adjustable chairs were replaced with fully adjustable models featuring arm and head support, while existing chairs were upgraded where possible. Additionally, footrests and standardized monitor stands were introduced to optimize posture and workstation ergonomics across the call center.

Supervised on-site face to face visits

Beginning the day after the training sessions, researchers conducted regular visits to participants at their workstations to observe how the training was applied in daily tasks. These visits also provided opportunities to guide behavioral change when necessary, using a motivational interviewing approach. Motivational interviewing is a brief, person-centered technique designed to enhance intrinsic motivation for behavior change by exploring and resolving an individual's ambivalence (34). Participants were individually observed while performing their routine tasks, and photographs were taken when improper postures or movements were identified. These images were later reviewed collaboratively to discuss issues and generate corrective strategies. Following the initial face-to-face training, the research team conducted follow-up visits every two months to ensure that participants maintained healthy work practices and proper postural habits.

Provision of quality break time encompassing regular exercise program

Before initiating the study, an agreement was reached with key company stakeholders to allow employees an additional rest break midway through their shifts. Employees were responsible for timing this break to minimize disruption to customer service and overall workflow. During the training sessions, the duration of the exercise program was discussed and agreed upon with relevant parties to be 10 minutes. The program consisted of a series of stretching and joint-mobilization exercises designed to engage the entire body, with a focus on both upper and lower limbs. Participants were encouraged to perform the exercises once daily whenever they experienced muscle tension or fatigue. While the program was initially based on the protocol of a previous study, it was slightly adapted to better meet the specific needs of this workforce (19). Each participant was also provided with a daily exercise log to record completion of the program. These logs were regularly reviewed and monitored by both supervisors and the research team to track adherence.

Outcome measures

It is noteworthy to mention that prevalence of the WMSDs was the primary focus of the original study, the result of which is reported elsewhere (31). The result for the effect of the intervention on occupational fatigue is reported here. Swedish Occupational fatigue inventory (SOFI-20) was used to assess work-related fatigue among employees (7). This scale has five dimensions. Lack of energy represents a core dimension of fatigue, encompassing both its physical and psychological components; however, when it is considered in service work it can point to mental aspect of fatigue. Physical exertion reflects whole-body sensations often arising from dynamic activity and may indicate early signs of metabolic fatigue. Physical discomfort, by contrast, refers to localized bodily sensations commonly associated with static or isometric workload. Lack of motivation represents a predominantly psychological dimension of fatigue, characterized by feelings of detachment and disengagement from one's work. Finally, sleepiness denotes the subjective experience of drowsiness or a strong inclination to fall asleep. Rating of the scale is on a likert scale ranging from 0 (never had this felling) to 20 (had this feeling to a very high degree). Reliability and validity of this scale were reported satisfactory in Persian population (35).

Data analysis

Data analysis was performed using the SPSS software package. The normality of variables was assessed using the Shapiro–Wilk test. As the variables did not follow a normal distribution, non-parametric statistical methods were employed. Changes in participants perceived fatigue before and after the intervention were evaluated using the Wilcoxon signed-rank test. A significance threshold of $\alpha \leq 0.05$ was adopted for all statistical analyses.

RESULTS

The demographic characteristics of the call center employees indicated a mean age of 28.1 ± 3.69 years, with females comprising the majority (76%). The average BMI was 24.2 ± 3.69, corresponding to a healthy range. Regarding education, 70% of participants (n = 59) had obtained a university degree, whereas the remaining 30% held a diploma. Additionally, most employees (80%, n = 67) reported a job tenure of under three years.

Table 1 presents the study findings on work-related fatigue and its dimensions. At baseline, the overall fatigue score was 62.33 ± 11.16, significantly exceeding the midpoint. Among the fatigue dimensions, lack of energy was highest at 68.3 ± 18.57, followed by lack of motivation at 64.54 ± 19.99, both indicating relatively elevated levels. Physical exertion scored the lowest at 47.13 ± 10.88. Following the intervention, the overall fatigue score decreased to 60 ± 10.82, representing a significant reduction from baseline ($P < 0.01$). Likewise, lack of energy declined to 66.25 ± 18.0, showing a statistically meaningful improvement compared to the initial measurement ($P < 0.01$). Physical discomfort also decreased significantly after the intervention ($P<0.001$). On the other hand, the changes for physical exertion and sleepiness scores were not scientifically significant after the intervention.

DISCUSSION

This study aimed to evaluate the effectiveness of a multicomponent participatory ergonomics intervention among 84 call center employees at a telecommunications company. In summary, the intervention—which combined formal and on-site ergonomic training, workstation modifications, and structured break periods incorporating regular exercises—produced a significant reduction in overall fatigue scores, although effects on the individual subscales were mixed. As for physical dimensions, physical discomfort was perceived to be alleviated by the intervention although the condition of physical exertion didn't improve significantly. For mental dimensions, lack of energy was reported to decrease meaningfully, while lack of motivation and sleepiness didn't change significantly.

Based on the results, physical discomfort was reported to reduce significantly among call center workers, a finding which is in line with other studies (24,29,36). A study conducted among VDT workers demonstrated that workplace exercises, including range-of-motion activities, stretching, and eye-relaxation techniques, effectively reduce overall body discomfort and improve in-chair postural adjustments, highlighting the link between posture and targeted workplace exercises (37). In another study, Sjorgen et al. (2005) study among office workers showed that performing workplace exercises can reduce headache and neck symptoms while it doesn't affect the prevalence of shoulder symptoms (38). Similarly, Kamalikhah et al. (2018) investigated the impact of various interventions and reported that both ergonomic modifications (e.g., adjustments to work layout) and educational programs (e.g., ergonomic training) independently improved workers' posture, leading to a significant reduction in musculoskeletal disorder complaints (39). These findings indicate that an ergonomically optimized workstation, combined with regular workplace exercises, can effectively mitigate physical strain and related adverse effects.

The comparison of pre- and post-intervention results

Table 1. Scores of work-related fatigue and its dimensions before and after the intervention

Dimensions	Before intervention	After intervention	Z	P-value [a]
	Mean (SD, median, range)	Mean (SD, median, range)		
Fatigue overall score (Mental and physical fatigue)	62.33 (11.16, 63.37, 59.75)	60 (10.82, 61, 56.5)	- 2.818	0.005 **
General fatigue (Lack of energy)	68.3 (18.57, 68.75, 81.25)	65.01 (18.07, 66.25, 80)	- 2.695	0.007 **
Mental fatigue (Lack of motivation)	64.54 (19.99, 64.37, 85)	61.1 (17.38, 61.87, 76.25)	- 1.176	0.240
Mental fatigue (Sleepiness)	59.8 (12.74, 61.25, 61.25)	58.75 (13.27, 61.25, 70)	- 1.230	0.219
Physical fatigue (Physical Exertion)	47.13 (10.88, 49.37, 50)	48.33 (12.95, 50, 56.25)	- 0.625	0.532
Physical fatigue (Physical Discomfort)	71.86 (14.26, 73.75, 66.25)	66.85 (15.72, 65.62, 75)	- 3.593	0.000 **

[a] Wilcoxon signed rank test was conducted.
** $P \leq 0.01$.

revealed a notable improvement in the "lack of energy" dimension, indicating that the intervention helped call center workers sustain higher levels of mental energy during work. This observation aligns with findings from other studies, which suggest that structured break periods incorporating stretching and joint mobilization not only alleviate musculoskeletal complaints but also reduce cognitive load, enhancing memory and concentration (19). Such findings corroborate those of Rhenen et al. (2005), who reported reduced psychological adversities, such as mental fatigue, in approximately 50% of the employees who participated in a physical intervention program (40). It is highly possible that optimal physical condition including layout reconfiguration and exercise program could improve psychological working condition by not wasting time and mental energy on physical adversities such as physical discomfort.

In contrary to physical discomfort and lack of energy, the results showed that there was not any significant change regarding other dimensions of work-related fatigue. It was not surprising to see that physical exertion remained unchanged after the improvements. We argue since being a call center worker does not involve heavy and dynamic activities, physical exertion, which is described as "a whole-body sensations that may be the result of dynamic work and, to a certain extent, the sign of metabolic exhaustion (40)," was not significant in the beginning to be affected by the intervention.

In addition to physical exertion, sleepiness did not change significantly after the intervention. In other words, participants did not feel more or less sleepy compared with the pre-intervention condition. The relationship between sleepiness and physical exercise is difficult to be established yet, and its literature is contradictory; In a study by Braeckman et al. (2011), which was done among drivers there was no association between leisure physical activity and sleepiness score, while in Dahlman et al. (2011) study among navy sailors, such association was significant (40,41). The fact is that there are many confounders that can affect such relationship (i.e., sleep quality and quantity, drug and caffeine consumption) that were not collected in our study; therefore, non-existence of such relationship should be interpreted cautiously.

Lack of motivation was another psychological aspect of fatigue which did not change after the intervention. That is, call center workers were not motivated more regarding their job. According to Herzberg's two factor theory, improving physical condition of work can be considered as a hygiene factor which can only reduce dissatisfaction of the employees. Whereas, motivational factors are found within the actual job itself (i.e., achievement, advancement, and growth)(11).

CONCLUSION

To summarize, the intervention including comprehensive ergonomic training (formal and on-site), work layout improvement and quality break time involving regular exercises had a significant effect on reducing overall fatigue of the call center workers although the results for different aspects of fatigue were mixed. Therefore, customizing interventions to target different aspects of occupational fatigue would be a practicable strategy. The contribution of this study is to the body of the literature suggesting a multicomponent ergonomic intervention can help bring significant improvements to the work systems and employees. Consistent with the participatory intervention literature, we recognized that it is equally crucial to ensure employees fully understand the importance of these practices—through appropriate approaches such as motivational interviewing—and actively engage in them, as they serve as the primary agents of change (42)(43). Our findings indicate that while many physical interventions have traditionally targeted the workplace's physical aspects, multicomponent interventions can also effectively enhance cognitive functioning at work.

Limitations and strengths of the study

The present study has several notable limitations. First, the absence of a control group and the non-randomized design represent primary constraints. Given that the intervention was implemented across the entire workforce, it was neither feasible to allocate a subset of employees to a control condition nor to randomize participants, making a full census the most practical approach. Moreover, as all employees shared the same work environment, establishing a control group could have led to information exchange between participants, introducing contamination bias. Consequently, the study's findings should be interpreted with caution. Second, all outcomes were measured via self-report instruments; although these were valid and reliable, reliance on subjective reporting remains a limitation. Third, the study did not formally evaluate participants' comprehension of office ergonomic training at baseline; however, the on-site, face-to-face sessions served both to reinforce training effectiveness and to correct misconceptions or improper practices. Finally, the six-month follow-up period may be insufficient to capture the full impact of the intervention, and longer-term

assessments are necessary to determine its enduring effects.

Despite the aforementioned limitations, the study demonstrated several key strengths. Chief among these was the multifaceted design of the intervention, which integrated personal, physical, and psychosocial strategies to enhance employees' overall work experience. This comprehensive approach was adopted in response to existing literature highlighting the limited effectiveness of single-component interventions (24) (28). Second, full participation represented a significant strength of the study. Despite low baseline awareness of ergonomic principles, strong managerial support and active engagement from all employees enabled rapid dissemination and adoption of the intervention practices. Finally, the study employed a multi-outcome evaluation strategy, assessing both physical and mental dimensions of fatigue. This comprehensive assessment provides a more holistic understanding of the intervention's impact on the work system.

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CONFLICT OF INTEREST

No conflict of interest has been declared by the authors.

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