Chapter 4

Ergonomics Education for Office Computer Workers: An Evidence-Based Strategy

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Additional information is available at the end of the chapter

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Abstract

Work-related musculoskeletal disorders (WMSDs) have become a growing concern in today's society due to their impact on insurance costs, productivity, and employee wellness. Computer workers are at risk of developing WMSDs due to the nature of their work and their work environment. To reduce the prevalence of WMSDs among computer workers, it is critical to promote awareness of various risk factors associated with WMSDs and educate them on healthy work behaviors. This chapter advocates ergonomics education as an evidence-based educational intervention to prevent WMSDs among office computer workers.

Keywords: computer ergonomics, educational intervention, musculoskeletal disorders, prevention, risk factors

1. Introduction

One of the contemporary health issues in today's society is work-related musculoskeletal disorders (WMSDs). Musculoskeletal disorders (MSDs) are injuries and illnesses that affect the muscles, nerves, tendons, ligaments, joints, or spinal discs. According to the United States (US) Bureau of Labor Statistics, MSDs include pinched nerve, herniated disc, meniscus tear, sprains, strains, tears, hernia (traumatic and nontraumatic), pain, swelling, numbness, carpal or tarsal tunnel syndrome, and Raynaud's syndrome; when the event or exposure leading to these injuries or illnesses is overexertion, bodily reaction, repetitive motion involving microtasks, and vibration [1]. Work-related disorders are prevalent among myriad occupational groups such as factory workers [2], truck drivers [3], hair dressers [4], allied health professionals [5], field workers [6], and computer workers [7, 8]. The regions that are prone to developing musculoskeletal injuries are the lower back, upper back, neck, and upper extremities [9].

WMSDs have enormous economic implications. The Institute of Medicine estimates that the total economic burden of WMSDs could be as high as $54 billion annually [10]. Ergonomic injuries related to computer work constitute a significant portion of WMSDs. The US Occupational Safety and Health Administration (OSHA) estimated that employers are "spending $20 billion a year on worker's compensation costs related to ergonomic injuries and illnesses" [11, p. 106].

Occupational injuries and illnesses have many direct and indirect cost implications. When calculating cost implications of WMSDs, one must give due consideration to all factors. Workers' compensation costs and charges involved in medical care and rehabilitation are considered direct costs, while lost productivity, lost time, training new staff, administrative costs, and temporary staffing are considered indirect costs. Web resources may assist employers to calculate cost implications of occupational injuries. For example, the OSHA Safety Pays website calculates the estimated total costs (direct and indirect) of common work-related injuries based on national worker's compensation data of the US [12].

In today's age, computer use has become an integral part of daily life. People use computers for various work-related and non–work-related tasks (social media, banking, shopping, etc.). Office computer workers (OCWs) use computers on an average of 6-12 hours a day [13]. The surge in computer use has also created a surge in computer work-related MSDs. Rehman et al. [8] stated that around 27% of computer users report backaches or discomfort. The chance of sustaining WMSDs is high when computer workers spend long hours on their computers. As the scope of this chapter is limited to the discussion of ergonomics related to the office computer worker population, the following sections review the risk factors related to office computer work, present ergonomics education as an effective intervention for OCWs, and highlight the role of employers and employees in preventing WMSDs among OCWs.

2. Risk factors

Factors that make a worker prone to developing WMSDs are called risk factors. **Table 1** lists various risk factors associated with WMSDs [**Table 1**. Risk factors for WMSDs]. Risk factors related to office computer work are classified into postural risk factors, environmental risk factors, individual risk factors, psychosocial risk factors, and risk factors associated with duration and intensity of office work.

2.1. Postural risk factors

Posture is the carriage of a body as a whole, the attitude of the body, or the position of the limbs [14]. The literature showed an established link between MSDs and improper posture at computer workstations [15, 16]. Sauter et al. [17] found that arm discomfort increased when keyboard height was above the elbow level. Chiu et al. [18] reported a significant association between head posture during computer work and neck pain. Eltayeb et al. [19] highlighted the significant associations between irregular "head and body posture" and "neck, shoulder and forearms/hands complaints."

Awkward and prolonged static postures contribute to musculoskeletal discomforts among OCWs. Twisting the torso to reach file cabinets, cradling the phone between the neck and

Awkward and prolonged static postures
Bending and twisting
Excessive work
Force
Glare
Job strain
Lifting
Monotonous activity
Pace of work
Repetition
Vibration

Table 1. Risk factors for WMSDs.

shoulder, curved sitting (bending the torso toward the monitor), slouched sitting with legs placed on an object under the work surface, and sitting on a high chair with dangling feet are some examples of awkward postures during office computer work. Postures with elevated or abducted shoulders are also considered awkward postures. These postures, when sustained, strain the lower back, shoulders, and neck muscle groups.

As computer workers often engage in tasks that demand high level of concentration, they get absorbed in their work and assume a given posture for long periods of time. During prolonged static sitting, the muscles that sustain body posture undergo a prolonged state of contraction, leading to decreased transportation of sugar and oxygen to dynamically contracting muscles. This causes an accumulation of waste products such as lactic acid and carbon dioxide in those muscles, leading to muscle spasms and fatigue. Prolonged sitting also contributes to myriad health issues such as low back pain [20], coronary artery disease, and kidney disease [21].

2.2. Environmental risk factors

Poor work environments augment the risk of WMSDs. Office work environments that are not conducive to their users can be referred to as "poor work environments." For instance, a workstation where the keyboard and mouse are placed at different levels, causing the user to elevate/abduct shoulders can be considered a poor workstation. A workstation without adjustable components (work surface, office chair, etc.) and necessary accessories (hands-free phone, document holder, etc.) can also be construed as a poor work environment. Further, environments with the heightened noise level, increased glare, and extreme temperatures are considered as poor work environments.

2.3. Individual risk factors

A computer worker may also become prone to developing WMSDs due to personal factors such as health history and poor work behaviors. Individual-related factors contribute to

WMSDs through their effect on body structure, function, and posture. Some of the individual-related risk factors are obesity, pregnancy, arthritis, trauma, and endocrinal disorders. Working without rest breaks, binge working, ignoring the body's warning signs such as pain and discomfort, ignoring flexibility/stretching exercises, failing to alternate work tasks, following poor working techniques, and failing to adjust workstation components as needed are the examples of some maladaptive work behaviors.

Gender has also been hypothesized as a risk factor. The literature reveals that women are at a relatively higher risk than men [22, 23]. This could be due to differences in anthropometrics and physiology in women. Also, women often assume responsibilities of non–work-related activities such as household tasks, which may add to muscle strain and make them more vulnerable to WMSDs.

2.4. Psychosocial risk factors

Psychological variables such as work pressure and job strain may also contribute to WMSDs. Hannan et al. [24] found a correlation between increased job strain and neck musculoskeletal symptoms. Perceived inadequate support from managers, low level of control, and information overload were also identified as psychosocial risk factors in the literature. With information overload, a worker spends an increasing amount of time using electronic gadgets and ignores proper work posture, thereby developing his/her risk for WMSDs. Mental stress can also augment the physical load during computer work because a computer worker with mental stress may exert more force on mouse or keyboard [25].

2.5. Risk factors associated with duration and intensity of work

Working on computers for long hours is a risk factor. The literature reveals a correlation between the duration of computer use and upper extremity (UE) pain, back pain, and eye strain [26]. Repetitive hand, wrist, and finger movements (e.g., typing for extended periods of time), speedy/jerky movements, and force applied while typing may also contribute to UE pain and musculoskeletal discomforts [25]. The demand for productivity and time pressure in today's work culture demand increased keying and extended hours of work from OCWs, thereby making them susceptible to WMSDs. Repetitive motions result in the vasoconstriction of arteries causing ischemic injury and edema due to anoxic damage [27].

3. Prevention of work-related musculoskeletal disorders

To prevent WMSDs, measures must be taken to avoid exposure to risk factors. These measures could be *technical* such as an elevated work surface for a tall worker, *organizational* such as conducting ergonomic workshops, and/or *personal* such as working with rest breaks [28]. Some of the WMSD prevention strategies in practice include workstation modification, task modification, and provision of necessary ergonomic accessories. However, "for these prevention measures to work, proper knowledge/awareness about how (a) the work-related factors contribute to WMSDs, (b) to carry out the work tasks safely, and (c) to effectively use the equipment, are essential" [13]. Robertson et al. [29] stated that the availability of adjustable office furniture alone cannot reduce or prevent musculoskeletal injuries. For instance, a lot of computer workers sit on adjustable chairs without adjusting them due to lack of knowledge. Similarly, though many computer users know that bad posture is a risk factor, they continue to assume awkward and risky postures. Hence, to prevent WMSDs among OCWs and ensure their well-being, it is critical to educate them on "ergonomics" and "risk factors associated with WMSDs." An evidence-based strategy to impart this education is *Ergonomics Education* [13, 30].

4. Ergonomics education

Ergonomics means the science of fitting the job to the worker. In the context of office computer work, it refers to the computer user-workstation fit. Interventions that aim to enhance this fit are called ergonomic interventions. Ergonomic interventions differ from traditional therapeutic interventions because they target work posture, work habits, behaviors, and the environment [31]. They range from modifying workstations to long-term educational interventions with the aim of preventing and/or treating WMSDs.

Ergonomics is a recognized intervention strategy. Several occupational health and safety agencies across the world advocate for ergonomics. Many mid- and large-size technology companies offer ergonomic training to their employees as ergonomic interventions have been found to enhance productivity, improve worker well-being, and reduce WMSDs.

One of the well-documented ergonomic interventions is ergonomics education [30, 32, 33]. Ergonomics education is a strategy in which an ergonomic expert educates participants (workers) on ergonomic principles [see **Table 2**. Key ergonomic principles] and other necessary ergonomic information either on-site or virtually. The aim is to enhance participants' knowledge on WMSD risk factors, WMSD prevention strategies, and effective work behaviors. There are two primary objectives for any ergonomics education program. One is to help participants become aware of the risk factors and the other is to encourage participants to modify their work behavior.

Adequate clearance	Computer workers must have adequate thigh/knee clearance under their desk.
Adjustability	Computer workers must ensure that their workstation components, including the office chair, are adjustable.
Keep things within reach	Computer workers must keep frequently used items within forearm's distance and occasionally used items within arm's distance.
Minimize direct pressure	Computer workers must avoid resting their forearms/hands/thighs against sharp edges and hard surfaces.
Minimize fatigue	Computer workers must avoid prolonged work and sustained posture.
Work in good posture	Computer workers must be mindful of their posture and assume the ideal work posture at work.
Work at proper heights	Computer workers must adjust the workstation and chair as necessary to work at proper heights.

Table 2. Key ergonomic principles.

4.1. Types

Ergonomics education can be classified into traditional and participatory ergonomics education. In traditional ergonomics education, the information is presented via lectures, seminars, handouts, videos, etc., and participants assume a passive role. In participatory ergonomics education, participants interact with and learn from the expert using adult learning models [34, 35]. The difference between these two types of ergonomics education is the high level of interaction, which is present in the latter. Participatory ergonomics education was reported to achieve better outcomes than the traditional type [36].

4.2. Content

4.2.1. Anatomy and biomechanics

Ergonomics education programs for computer workers typically include content on biomechanics and anatomy of the back, neck, and upper extremities, as they are the body parts that are commonly affected during office computer work [9, 37]. When reviewing the anatomy and biomechanics of the back, ergonomic experts discuss the anatomy of the spinal curves and biomechanical alterations on the spine and intervertebral discs due to postural modifications. Experts also review the anatomy of two major muscles (trapezius and latissimus dorsi) that get used during office computer work and emphasize how these muscles get stretched or strained when a worker cradles the phone between the neck and shoulder, elevates the shoulders to reach high work surfaces, abducts the shoulders to reach the mouse and/or keyboard, hunches over computers, or reaches overhead to retrieve items.

When reviewing the anatomy of the upper extremities, ergonomic experts place a major emphasis on shoulder joints since awkward shoulder positions contribute significantly to WMSDs related to office computer work. They highlight three most common shoulder positions (elevated shoulders, rounded shoulders, and abducted shoulders) that contribute to UE/neck pain and discomfort. Ergonomic experts also review wrist and hand joints and underscore the importance of keeping wrists in a neutral position while working on computers, as incorrect position of these joints may lead to forearm and wrist pain, discomfort, or injury. Further, they review the impact of repetitive wrist and hand movements on forearm muscles and tendons. Information on conditions like muscle strain and carpal tunnel syndrome[1] (a condition that occurs due to increased pressure on the median nerve at wrist) is also presented during these sessions.

4.2.2. Mechanism of injury

Ergonomics education sessions highlight the mechanism of injury behind WMSDs. It has been a generally accepted notion that the theoretical mechanism behind WMSDs is repetitive microtraumas and their cumulative damage on musculoskeletal tissues. Ergonomic experts educate participants on various risk factors and how they affect musculoskeletal tissues and

[1]Though carpal tunnel syndrome (CTS) is a rare condition among office computer workers, certain conditions such as pregnancy, diabetes, and endocrinal disorders increase the likelihood of sustaining CTS.

contribute to WMSDs. They explain how sustained muscle activity leads to muscle spasms, how back rest angle of less than 95° adds pressure on ischial tuberosities, etc. In addition, they highlight the health issues associated with maladaptive work behaviors such as back pain, visual fatigue, visual dryness (due to constant watching of monitors), headaches, and weight gain.[2]

4.2.3. Ideal work posture and workstation

The content related to ideal work posture and workstation forms the core of ergonomics education programs for OCWs. The ideal work posture is the one where the back is straight or slightly reclined (95–110°), the shoulders are abducted less than 20°, the elbows are flexed at 90–100°, and the forearm is pronated with the wrist, hand, forearm in a straight line with the work item. Wrist extension or deviation of more than 15° must be avoided. For lower extremities, the legs need to be perpendicular to the floor, the thighs should be parallel to the floor, and the hip joint should be slightly higher than the knee joint. The feet should rest flat on the floor or a footrest.

According to the US OSHA, an ideal workstation has an adjustable work surface, a keyboard tray, a keyboard and input device (mouse) at the same level and frequently used items placed within easy reach. OSHA recommends a chair with adequate lumbar support, sufficient depth and width to accommodate the user, a seat front with a waterfall edge, and adequate thigh and knee clearance. In an ideal workstation, the top edge of the monitor lies at eye level[3] or slightly below and is placed at a distance from the user so that the user does not have to bend or extend the neck/head to see and read the monitor (approximately at an arm's length from the user). The monitors are placed perpendicular to the window to minimize glare. An ideal workstation also provides adequate space under the work surface so that the user can get close to the work surface and can cross his/her legs without bumping. It is recommended to leave the area under the desk free of storage. OSHA recommends that all workstation accessories and components be well maintained and serviced.

4.2.4. Work behaviors

Ergonomics education sessions also underscore the importance of work behaviors such as taking adequate rest breaks, engaging in exercise, being mindful of posture, and effectively arranging/adjusting the work surface. It is recommended that computer users take adequate rest breaks and vary their work tasks while working on computers [38]. OSHA recommends rest breaks for jobs that require prolonged posture and repetitive tasks. Henning et al. [39] highlighted the fact that frequent short rest breaks from computer-mediated work can benefit worker productivity and well-being. Galinsky [40] found that taking four supplemental 5-min rest breaks and two conventional rest breaks of 15 min

[2]Prolonged sitting at work causes biochemical alterations in lipase (an enzyme that metabolizes fat and glucose) activity. These biochemical changes in lipase activity disrupt fat metabolism, which leads to deposits of fats in adipose tissue rather than being metabolized by muscles and results in weight gain.

[3]The monitor can be positioned a little lower for individuals with bifocals or trifocals.

• Stretch the muscles slowly and avoid jerky movements [53].
• Stretch only to the point of comfortable stretch.
• Feel the stretch.
• Hold the stretch for 5-20 seconds.
• Repeat each stretching exercise 10 times or at least 3–4 times during each episode of exercise [43].
• Breathe slow, deep, and rhythmic while stretching.

Table 3. Stretching exercise guidelines.

throughout the work day can minimize discomfort without impairing productivity. Microbreaks at 20-min intervals were also reported to be effective [8]. During rest breaks, it is wise to step away from the workstation and walk around. Workers may visit a colleague's office, go to the print room, use the restroom or cafeteria, etc. To reduce eye discomfort and dryness, ergonomic experts recommend taking microbreaks to look 20 feet away from the monitor.

Ergonomic experts recommend that computer workers exercise at work [41], as the postural and proximal UE muscles undergo static loading during office computer work. They suggest that computer workers engage in stretching and flexibility exercises. Stretching exercises break cumulative musculoskeletal strain and relieve intervertebral disc pressure. Evidence supports the use of exercise to reduce musculoskeletal discomfort for computer workers [42]. By engaging in exercises, OCWs can reduce perceived discomfort [43], improve posture [44], and minimize fatigue [45]. Neck stretch, neck tilt, chin tuck, side stretch, and torso twist are some recommended exercises for the neck and upper body. Shoulder shrugs and rotations, wrist circles, and stretching the wrist flexors/extensors are some recommended exercises for the upper extremities. Hip marching, leg hug, leg extension, and ankle pumps are some of the exercises for the lower body.[4] Stretching exercises also have psychological benefits. Stretching increases mental alertness while decreasing anxiety and stress [46]. **Table 3** presents the stretching exercise guidelines [**Table 3**. Stretching exercise guidelines].

In office work environments, workers start the work day with good posture, but eventually recline or bend throughout the course of the day assuming risky postures and enhancing their risk for WMSDs [47]. Some workers habitually cradle the phone between the neck and shoulder so that their hands are free to type on the keyboard, thereby adding stress and strain to the lateral supporting muscles. Hence, ergonomic experts advise computer workers to be mindful of their posture when performing computer work. To help computer workers to be mindful of their posture, ergonomic experts suggest them to draw an

[4]It is critical to consult an ergonomics specialist, occupational therapist, physical therapist, physician, or other healthcare provider before engaging in any of the listed exercises or beginning an exercise regime. These exercises should not be considered complete or exhaustive and should not be used for self-treatment.

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imaginary line that connects the ears, shoulders, and hip joints and advise to maintain the line. Ergonomic experts also show participants examples of good (ideal posture) and bad posture (slouching, keeping feet on chair frame, elevating shoulders, etc.) during ergonomics education sessions.

When delivering ergonomics education, experts emphasize that ergonomics is nothing but a fit between worker and work environment. They offer information on arranging the workstation and adjusting its components. They suggest that computer workers keep work items within reach. It is generally recommended to keep frequently used items within forearm reach and less frequently used items within arm's reach. During ergonomics education sessions, experts show participants how to adjust manual and pneumatic office chairs in addition to other workstation components. When teaching chair adjustment, the emphasis is on properly adjusting the backrest because backrests that are tilted too far forward or backward may contribute to back issues.

4.2.5. Ergonomic workstation issues

The problems associated with poor office chairs (fixed backrests/arm rests, too low or too high, too wide or too narrow, and sharp edges), poor workstations (sharp edges), and poor work environments (bad lighting, glare, hot/cold environments) are reviewed during ergonomics education sessions.

4.2.6. Ergonomic accessories

During ergonomics education sessions, ergonomic experts review various ergonomic accessories and their uses. Keyboard trays, footrests, glare protectors, document holders, large size mouse, hands-free telephones are some of the common accessories that are reviewed. According to ergonomic experts, there is no manufactured ergonomic device because what could be an ergonomically suitable device for a computer worker may not be suitable for another worker due to variations in anthropometric characteristics, nature of work tasks, and workstation arrangements.

4.3. Mode of delivery

Ergonomics education is delivered to computer workers through didactic lectures, PowerPoint presentations, discussions, demonstrations, video, workstation visits, one-to-one consultations, provision of resources, etc.

4.4. Materials

Ergonomic checklists, session handouts, brochures, and pictures of ideal work postures and workstations are some of the commonly provided materials at ergonomics education sessions. Product manuals are also used as ergonomics education tools. These manuals describe the product's features/specifications and how to use/operate the product.

5. Efficacy of ergonomics education

Ergonomics education has been found to be an effective strategy. The literature supports the use of ergonomics education to improve computer workers' awareness of risk factor [13], reduce musculoskeletal injuries [30, 48], improve workers' posture and workstation layout [48], increase perceived control over the physical environment, and improve workers' intrinsic motivation to alter posture and behaviors [29].

Ergonomics education enhances the knowledge about the risk factors associated with WMSDs. In a study conducted in a small nonprofit organization, the authors found that 89% of the participants were able to identify more risk factors and answer more questions correctly in a pre-/postknowledge test after a six-week on-site ergonomics education intervention [13]. Another large-scale field intervention study with more than 200 participants revealed that participants who received education and training to understand office ergonomic principles, perform self-evaluation of work places, and rearrange workstation demonstrated a significant increase in overall ergonomic knowledge [29].

Ergonomics education intervention was reported to be an effective intervention in reducing musculoskeletal pain and discomfort. Bohr [30] stated that those who received ergonomics education reported less pain or discomfort. Ketola et al. [36], through a randomized controlled trial, investigated the efficacy of ergonomics education on workstation changes and musculoskeletal disorders among computer users. Results identified that computer workers who underwent intensive ergonomics and ergonomics education interventions showed less musculoskeletal discomfort at the 2-month follow-up assessment post-intervention.

Several studies found that ergonomics education had a positive influence on the work posture of computer workers. Greene et al. [49] evaluated the effectiveness of an ergonomics training program in computer workers and found that the risk factor exposure of the intervention group participants was significantly reduced. The authors asserted that participative training in workstation ergonomics can improve work postures and work practices. Mahmud et al. [50] used a cluster randomized controlled trial design to investigate the effect of ergonomics education in reducing musculoskeletal disorders among computer users. When the outcomes were evaluated post-intervention, experimental group participants who received the ergonomics education demonstrated improved workstation habits and work posture. Through a cross-over trial that investigated the effectiveness of a 2-week workstation ergonomic intervention (consultation and provision of ergonomic accessories), the authors found that individualized ergonomic interventions may improve work-related posture and reduce low back pain [51]. Esmaeilzadeh et al. [48] examined the effect of ergonomic intervention on work-related UE MSDs among computer workers and found that the ergonomic training significantly improved participants' posture over 6 months.

Ergonomics education was reported to positively influence worker's behavior. Mani et al. [13] stated that after 6 weeks of intervention, study participants demonstrated healthy work behaviors such as adjusting their workstation, taking rest breaks, and engaging in stretching exercises. Robertson et al. [29] found that increased ergonomics knowledge resulted in behavioral translation. In their study, the experimental group participants demonstrated appropriate behavioral changes to their workstations when compared to the control group participants. The experimental group participants also adjusted their workstation and ergonomic accessories post-intervention. Esmaeilzadeh et al. [48] also found a notable improvement in the workstation layouts of the experimental group participants 6 months post-intervention. Some studies reported less psychosocial stress [30] and an increased sense of control [29] as outcomes of ergonomics education.

6. Limitations of ergonomics education

One of the biggest limitations of any educational intervention is the retention of knowledge and ergonomics education intervention is not an exception. Studies that investigated the effectiveness of ergonomics education measured the outcome at different intervals that ranged from 1 week to as long as 30-month postintervention [13, 30, 36, 51]. Though the majority of the studies reported short-term improvements, evidence is scarce on long-term gains. One study reported improvements in work posture and reduction in pain during short- and long-term follow-ups [51]. However, another study that reported a short-term gain (2-month follow-up), failed to report a similar outcome at the 10-month follow-up. [36]. Ongoing ergonomics education sessions at specified intervals and provision of ergonomic resources to employees may overcome the problems with latency of knowledge. Showing pictures that highlight good versus bad postures during ergonomics education sessions and encouraging participants to identify what is wrong and why it is wrong may also help solidify their knowledge.

Another limitation of ergonomics education is the lack of application of the learning. Simply presenting the ergonomics information to employees does not solve the problem if they do not have the necessary ergonomic accessories. For instance, as a result of ergonomics education, an employee might become cognizant of the need to adjust his/her office chair to minimize the risk of WMSDs, but either does not have an office chair with adjustable components or has a chair with many adjustable features to the extent that he/she does not know how and what to adjust. Participatory ergonomics education, in which the participants are allowed to evaluate and modify their own workstation with the help of an ergonomic expert, may overcome this limitation to an extent.

Though ergonomics education reported to positively influence work behavior in a short term; in most instances, it fails to elicit the motivation required to induce permanent behavior change. Habits are powerful and difficult to overcome. Often, participants of ergonomics education were seen to resort to their old habits of work posture and behaviors. Ongoing participatory ergonomics education at specified intervals may overcome this limitation.

7. Role of employers

To prevent WMSDs, employers must work collaboratively with their employees and ergonomic experts. Employers must make every effort to offer ergonomic training programs to their employees, as WMSDs related to computer work are preventable and may save a significant amount of money for them. As stated elsewhere, the economic benefits of ergonomics education programs can be realized by reviewing direct and indirect cost implications on OSHA Safety Pays website. There are myriad ways an employer can offer ergonomics education. One way to deliver ergonomics education is to make ergonomic resources easily accessible. For example, a company's intranet site may have a folder where employees can locate useful ergonomic information and resources. Recorded webinars can also be made available on the company's intranet site. Staff may be sent periodic e-blasts with ergonomic tips.

8. Role of employees

The prevalence of WMSDs can only be mitigated if employees act in concert with employers' efforts toward WMSD prevention. Employees should educate themselves on ergonomics, cultivate healthy work behaviors, undergo training programs offered by the employer, and learn to use ergonomic software applications. A variety of public and private web resources offer useful information related to computer ergonomics such as OSHA, Cornell University Ergonomics web, Canadian Center for Occupational Health and Safety, Office-ergo, and Velocity EHS. Software applications such as *Eyeleo, Workrave*, and *PC Work Break* remind computer users to take a rest break, stretch break, and/or eye break during the work day [52]. Some software applications also record the duration of computer usage. Employees may also download and use applications such as *ErgoMinder* and *ergoffice* on their personal digital assistants (smart phones/tablets) to cultivate effective work behaviors.

9. Conclusion

Multiple risk factors make computer workers susceptible to WMSDs. Research evidence favors the use of ergonomic interventions based on educational approaches due to their positive impact on participants' knowledge, behavior, and well-being. Ergonomics education, combined with organizational support and employee motivation to embrace adaptive work behaviors, appears to be a promising intervention to minimize the impact of WMSDs among the ever growing computer work population.

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