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Evaluating the ergonomic deficiencies in computer workstations and investigating their correlation with reported musculoskeletal disorders and visual symptoms among computer users in Bangladeshi university

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ABSTRACT

Background: Nowadays, computer users are facing musculoskeletal disorders (MSDs) and visual symptoms. Prolonged sitting in inappropriate, awkward, and static postures on the computer workstation may cause musculoskeletal disorders (MSDs). Similarly, inappropriate placement of monitors, illumination, and other factors such as prolonged usage of computers are related to visual symptoms. Objective: This study aims to evaluate the ergonomic deficiencies of computer workstations and their correlation with MSDs and visual symptoms. Methods: This study involved 271 university employees from a Bangladeshi engineering university. Ergonomic deficiencies were evaluated through direct observations and Occupational Safety and Health Administration checklists. In addition, the Nordic Musculoskeletal Questionnaire was used to assess the prevalence of MSDs and visual discomforts. Binary Logistic Regression (BLR) analysis was also used to examine the correlation between musculoskeletal symptoms and ergonomic deficiencies. Results: Results showed serious deficiencies in workstation setup, seating arrangement, monitor orientations, keyboard orientations, other input device orientations, and accessory setup. Employees reported that the MSDs in different body regions during the last 12 months including lower back (62 %), upper back (53 %), shoulders (47 %), and neck (25 %). Moreover, itchy eyes (69 %), tired eyes (83 %), and unclear vision (56.83 %) were the most common visual discomforts or visual symptoms among the participants. Results also revealed that monitor ergonomics and its orientation deficits were significantly associated with visual discomforts. Gender, job type, age, BMI, work experience, duration of computer work, and beak taking after 2 h were the independent variables reliably predicting the MSDs and visual symptoms. Conclusion: It is evident that MSDs and visual symptoms were associated with computer workstation deficiencies and other work-related factors.

1. Introduction

Computer is an essential part of the university employees in order to achieve the desired organizational outcomes and day to day activities. It has positive effects on the accuracy and efficiency of the work. However, the prolonged use of computers in awkward

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postures can result in musculoskeletal disorders (MSDs). Monitor ergonomics, illumination, and other factors that can cause visual problems. Both problems occur separately and they are being treated separately [1]. MSDs are injuries or disorders affecting the human musculoskeletal system [2]. Common MSDs are Carpal Tunnel Syndrome, Tendonitis, Muscle/Tendon strain, Ligament Sprain, Tension Neck Syndrome, Thoracic Outlet Compression, Rotator Cuff Tendonitis, Epicondylitis, Radial Tunnel Syndrome, Digital Neuritis, Trigger Finger/Thumb, DeQuervain's Syndrome, Mechanical Back Syndrome, Degenerative Disc Disease, Ruptured/Herniated Disc, and many more [3]. Other common names for MSDs are "repetitive motion injury", "repetitive stress injury", "overuse injury", and many more [4]. On the other hand, vision problems mean that a person's eyesight cannot be corrected to a "normal" level or the eyes of a person do not see objects as clearly as usual [5]. The most common visual symptoms experienced by office workers are itchy eyes, pain in the eyes, teary eyes, dry eyes, tired eyes, sore eyes, unclear vision, pain behind the eyes, and double vision [6]. However, MSDs and visual symptoms do not suddenly develop; instead, they develop gradually and display several symptoms. Musculoskeletal imbalances and visual problems happen when a person is too fatigued and their body can't recover fast enough. Both problems emerge with time when fatigue continues to outpace recovery, and the musculoskeletal imbalance and expected level of vision remain untreated. If the treatment is not initiated correctly, various acute musculoskeletal illnesses and visual symptoms may develop [7].

MSDs are complex and multifactorial [1]. Static posture and repetitive activity in organizations are major sources of MSDs for all professional groups [8]. Moreover, individual and other ergonomic factors are also responsible for developing work-related MSDs [6,9]. One study in Jordan showed that significant ergonomic deficiencies were identified in university computer workstations, mainly in seating, working area, keyboard, and other input devices; and found MSDs among the users [1]. Another study found many ergonomic deficiencies in university workstations [9]. Moreover, most of the employees use unadjusted office chairs and tables, and maintain bending and unsupported back postures [7]. So they are mismatched with the furniture dimensions. This mismatch is a potential source for occurring MSDs among users. The term "mismatch" refers to the incompatibility between anthropometry and furniture dimensions [10,11]. To design the workstation, the anthropometry of the users is used to design compatible furniture. When building a workstation without taking into account the anthropometry of the users, the resulting mismatch between the dimensions of the furniture and anthropometric measures is evident. Inappropriate posture is also responsible for developing MSDs. Research confirmed that not only physical factors but also individual characteristics including gender, age, and Body Mass Index (BMI) [12–16] trigger MSDs among computer users. Previous studies showed that some individual characteristics like age, gender, etc. were significantly correlated with MSDs and found MSDs in various body regions among university employees [1,17]. In addition, MSDs were also the most common work-related health issues among visual display users due to prolonged usage, and personal individual characteristics were the most prominent risk factor of MSDs [18]. Moreover, it has a strong correlation with work behaviors, work breaks, and productivity [19]. An employee who works with extended muscle tension may experience MSDs and mental fatigue [20]. Moreover, duration of work, poor working posture, and un-ergonomic design are three most significant risk factors for MSDs [21].

Visual problems are also complex and multifactorial and it is mainly associated with ergonomic deficiencies in monitor ergonomics and monitor orientations [1,12]. Workplace illuminations, screen reflections, screen contrasts, viewing distances, viewing angles, work pressure, and workplace ergonomics are also responsible for visual discomforts among computer users [1,8,22]. The individual characteristics including gender, age, and Body Mass Index (BMI) also trigger visual discomforts among computer users [1].

Several studies showed that MSDs are widespread among computer users [12,16,17]. One study found that MSDs are very common among computer users in the public sector and MSDs were more prevalent in the shoulders, neck, upper back, lower back, elbow, and hand/wrist regions [12]. In addition, such types of problems have been associated with deficiencies in keyboard and other input devices, work experiences, duration of daily computer usage, and higher work demand [17,18,20]. Another study showed the high prevalence of MSDs among public service computer employees (65.7 %) in the neck area during the last 12 months [20]. However, neck, shoulder, and arm pains were prevalent among the computer user employees of offices in a developing country [17]. Moreover, another study found that the prevalence rate of MSDs was higher in upper body parts compared to the lower body parts due to use of workstation accessories [23,24].

Numerous researches revealed that visual symptoms are also common among computer users. An Institution-Based Cross-Sectional Study was conducted to identify the prevalence of visual symptoms Among Academic Staff in the University of Gondar, Northwest Ethiopia. This study disclosed that visual problems were common among academicians and concluded that the prevalence of visual symptoms was affected by years of computer use, visual display terminals use, workplace illumination level, rest breaks, and eye droplets. Taking rest breaks in between work, reducing exposure to display screens, use of eye drops, and optimizing workplace illumination levels are recommended to reduce the problem [25]. Another study was conducted among university staff members in a Saudi medical college to determine the prevalence of CVS (Computer Vision Syndrome). Results showed that CVS prevalence was 81.2 % and Dryness, and headache were the most prominent symptoms among the staff. These results raised attention to the essential need for visual assessment of university staff members for early and proper diagnosis of CVS to minimize its impact on working performance [26]. One study showed that employees who worked more than 6 h per day reported more visual symptoms [22]. According to American Optometric Correlation, more than 58 % of computer users suffer from visual discomforts due to overuse of computers [26]. Moreover, different visual symptoms experienced by the workers including dry eyes, tired eyes, and other visual discomforts were co-related with prolonged computer usage [27].

MSDs and visual symptoms could cause people to become permanently disabled or sick, ultimately decreasing an organization's productivity [26,28]. Because of this, the avoidance of MSDs and visual symptoms should be a significant concern for individuals, organizations, society, and the Government. MSDs and visual symptoms have a significant impact on workability, as well as on medical expenses and absenteeism from the job, even though MSDs and visual symptoms have a low fatality rate [26,27]. Therefore, it is urgent to provide a solution for treating MSDs and visual symptoms among workers. However, there is no highly effective treatment for MSDs and visual symptoms; prevention is the best method for avoiding the adverse health, economic, and societal effects of MSDs and visual symptoms [29]. Therefore, it is very urgent to identify the ergonomic deficiencies in the computer workstation and to examine their correlation with MSDs and visual symptoms.

The people of Bangladesh, much like those in other regions of the world, are frequently affected by various MSDs and visual symptoms. According to the recent Population and Housing Census report (2022), there are 165.16 million populations in Bangladesh among them 49.48 % are male and 50.46 % are female. In addition, the percentages of internet users above five years old are 38.02 % of males and 23.52 % of females respectively [30]. Most of them use computers either as employees or to fulfill personal needs. Both men and women perform similar tasks by using the computer in an organization as an employee. Similar to all employment sectors, university employees are excellent computer users. A computer is used in a university for different purposes including internet browsing, information collecting, document filing, question typing, database creating, results preserving, mailing, chatting, and so on. However, prolonged sitting is required on the computer workstation for various purposes for academic as well as administrative personnel. Moreover, they do not maintain ergonomic sitting postures while working due to the absence of ergonomics rules and regulations in the computer workstation. In addition, most of the furniture (like tables, chairs, etc.) in the computer workstation is either made by a local carpenter or imported from suppliers. However, both suppliers and carpenters always follow the approach of "one-size-fits-all" for making the furniture without considering the target user's anthropometry. Besides, the anthropometric database is very scarce in Bangladesh. In addition, the dimensions of the furniture are fixed and un-adjustable. So, there are large percentages of mismatches between furniture dimensions and anthropometric measurements [3,30]. Therefore, users cannot accommodate themself with the dimensions of furniture and do not maintain proper sitting posture while working in the computer workstation. As a result, they have significant risks of getting musculoskeletal disorders and visual symptoms. Furthermore, there are no standard rules and regulations to make the computer workstation furniture. So, furniture dimensions may not be suitable for the anthropometry of the users. Therefore, there are significant risks to developing MSDs and visual symptoms among the users of university computer workstations. For example, one study in Bangladesh showed that university employees complained about MSDs pain in the upper back, lower back, and neck regions. This happened due to inappropriate workstation design [9]. Another study in this country reported that 53 % of the participants suffered from lower back due to the absence of ergonomic intervention in their organization [19]. Besides, they are not aware of ergonomic issues and do not get any ergonomic trainings. So all these incidents and information are alarming for the employees and signify the necessity of investigating the workstations and other related factors. Although a lot of research work was conducted on industrial office workers to investigate the workstation setup and postural, psychological, and environmental factors. To the best of the authors' knowledge, no previous studies were conducted on university employees related to ergonomic issues in Bangladesh. So, it is high time to concentrate on workstation setup and related ergonomic issues of the employees not only improving safety, serviceability, productivity, and satisfaction but also reducing MSDs and visual discomforts. Therefore, this study aims to

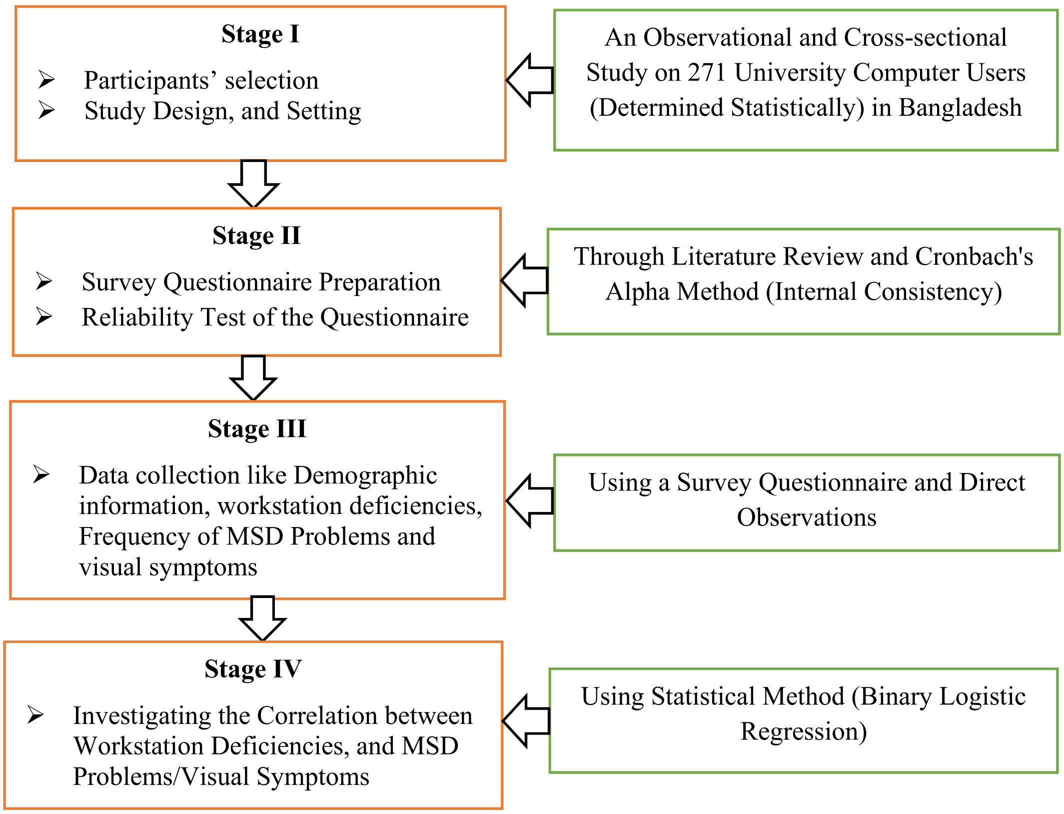

Fig. 1. Research framework.

identify ergonomic deficiencies at the workstation and also examine its correlations with Musculoskeletal Disorders and Visual symptoms.

2. Methods and material

The research framework, as shown in Fig. 1, consisted of four stages that aimed to identify workstation deficiencies and their correlation with MSDs and visual symptoms. Stage I involved selecting participants and designing the study, using an observational and cross-sectional approach. The sample size was determined through statistical calculation. In Stage II, a four-part self-administrative survey questionnaire was developed through a literature review to gather necessary data from the participants chosen in Stage I. The authors ensured the questionnaire's validity and reliability. In Stage III, demographic information, workstation deficiencies, frequency of MSDs, and visual symptoms were collected through survey questionnaires and direct observations. Finally, in Stage IV, Binary Logistic regression analysis was conducted to investigate the correlation between workstation deficiencies and MSDs/visual symptoms.

2.1. Participants, study design, and setting

An Observational and cross-sectional study was employed to complete this study. The computer users of Bangladeshi university employees voluntarily participated in this study and they were not paid. The sample size was calculated statistically by using equation (1) [31].

$$n = N/\left(1 + Ne^2\right) \tag{1}$$

where, n is the required sample size; N is the total population size (Number of the total university employees = 670 computer users); e is the margin of error. In previous studies, some researchers used an acceptable margin of error from 4 % to 8 % at the 95 % confidence level [28,29]. Thus, this study used 5 % as the margin of error at 95 % of the confidence level. The acceptable sample size was 251 or more calculated by using equation (1). Therefore, a total of 271 academic and administrative employees (age ranges 23–65 years) from an engineering university named KUET (Khulna University of Engineering & Technology, Khulna-9203, Bangladesh) participated in this study. Participants were selected randomly so that each individual in the target population had an equal and independent opportunity to be selected for participation. Moreover, anonymity was maintained to accurately represent the population of interest. This prevented the collection of personally identifiable information or unique identifiers, ensuring that participant responses or data couldn't be traced back to their identity. A primary survey, which consisted of only a few screening questions, was completed before the data from the sample size was collected. The authors chose the participants after completing a set of screening questions. The screening questions provide mainly some inclusion and exclusion criteria. The authors chose the participants based on two main criteria. The criteria were the average duration of accessing the computer per day (minimum 2 h per day) and frequency of accessing the computer per week (minimum five times per week). Therefore, each participant spends at least 10 h per week at the computer desk seated. In addition, participants, who used contact lenses and had pregnancy, were excluded from this study. Physically disabled people were also excluded from the study to avoid unexpected deviations from the collected data. Different independent variables like age, gender, BMI, type of job, work experience, duration of computer use, OSHA (Occupational Health and Safety Administration) scores, and monitor ergonomics were collected from participants. In addition, participants were requested to respond about musculoskeletal disorders and visual symptoms. All participants provided written consent to conduct the study after being informed of its objectives. In addition, this study was reviewed and approved by Office of the Director for Research & Extension, with the approval number: KUET/DRE/2023/11(02).

2.2. Questionnaires and reliability of the study

In this study, a four-part self-administrative questionnaire was used to collect the required data. The first part of this questionnaire included participants' demographics and other work-related information. Participants' age and work experience were classified into four and three groups respectively. The second part of the questionnaire comprised an OSHA checklist for evaluating the ergonomic status of existing computer workstations [32]. This section included questionnaires related to workstations, input devices, seating, monitor, accessories, and general ergonomic concepts. Each question was in the form of multiple choices. Participants answered the questionnaires on a binary basis (yes or no). The third part of the questionnaire involved the Nordic Musculoskeletal Questionnaire (NMQ) to collect the 12-month prevalence of MSDs involved in different body regions such as shoulders, neck, hand/wrist, elbow, upper and lower back, hips, and knees [33]. Finally, questionnaires related to visual symptoms due to the use of computers were in the fourth part including teary eyes, tired eyes, blurred eyes, itching eyes, double vision, sore eyes, pain in the eyes, pain behind the eyes, and unclear vision. These problems were assessed by a Likert scale from 0 to 3 ranges where 0 = No symptoms, 1 = Mild symptoms, 2 = Moderate symptoms, and 3 = Severe symptoms [19]. These questions are standard and used to evaluate the MSDs and visual symptoms in some relevant studies [1,8,23]. Moreover, the authors measured the validity and reliability of all parts of the questionnaires. The authors calculated the value of Cronbach α to measure the reliability and got Cronbach α = 0.85 which means that the questionnaires were highly reliable [8].

2.3. Data collection procedure

The authors used e-mail and phone call for appointment of the participants. On the appointment day, a professional ergonomist conducted a training session to explain the questionnaires in the presence of the participants and the authors. The ergonomist provided clarification about the questionnaires and also made an explanation of how to answer the questionnaires. After that, each participant and his/her workstation setup were observed by the ergonomist and authors to complete the OSHA checklist questionnaire. Each participant needed approximately 30–35 min to complete all responses in the questionnaire form. The duration of the data collection procedure was around six months.

The authors checked the reliability of collected data by applying the Biasness test. The responses of the participants were organized by the day they responded. All participant responses were divided into two groups: early and late. A Chi-square test was conducted on two groups and compared [34]. The authors found satisfactory results from the chi-square test. Therefore, the study has passed out from the non-response bias issue.

2.4. Statistical analysis

IBM SPSS Statistics (Version 22.0) was used to analyze the collected data. Binary logistics regression analysis was used to predict the outcomes (MSDs and visual symptoms) from the independent variables including demographics and ergonomic factors. Binary logistics regression analysis modeled the correlation between a binary dependent variable (MSDs or Visual symptoms) that was two outcomes (YES or NO) and independent variables (age, gender, BMI, type of job, work experience, duration of computer use, etc.). Logistic regression was separately performed for MSDs and visual symptoms. There was no investigation of the correlation between MSDs and visual symptoms. The basis of logistic regression is the assumption that the correlation between the independent variables (age, gender, BMI, type of job, work experience, duration of computer use, etc.) and the log odds of the dependent variable (MSDs and visual symptoms) is approximately linear. Other crucial presumptions are the independence of the observations and the lack of multicollinearity. A descriptive analysis was conducted to describe the demographic characteristics of participants, including age, gender, BMI, occupation, work experience, and computer use. The OSHA checklist had two possible outcomes (0 for no and 1 for yes) for each item. Total scores of ergonomic components in the OSHA checklist including workstations, seating, keyboards and input devices, monitors, accessories, and general ergonomics were calculated by adding each item's yes response. Dummy coding was used to identify the presence of 12-month MSDs and visual symptoms. In all statistical analyses, $p < 0.05$ was considered as a significance level.

Table 1
Demographic and basic information of the participants.

Variable	Participants	
	n	%
Gender		
Male	172	63.45
Female	99	36.55
Job Type		
Academic	166	61.25
Administrative	105	38.75
Age		
23–29 years	55	20.29
30–39 years	85	31.36
40–49 years	77	28.41
50–65 years	54	19.93
BMI		
<18.5 kg/m^2	38	14.02
18.6–24.9 kg/m^2	135	49.82
>25 kg/m^2	98	36.16
Work Experience		
1–5 years	47	17.34
6–15 years	159	58.67
16–35 years	65	23.99
Duration of Computer Use		
<4 h/day	33	12.18
4–6 h/day	61	22.51
>6 h/day	177	65.31
Taking a Break in Every 2 Hours		
Yes	55	20.30
No	216	79.70

3. Results

3.1. Demographics

The study was conducted among 271 university employees among them academic and administrative 61.25 % and 38.75 % respectively. However, most of the participants were male (63.46 %). Table 1 shows the demographic and basic information of the participants. Participants were classified into 4 groups according to their age, 23–29, 30–39, 40–49, and 50–65 years. 23–49 age range covered more than 80 % of the participants whereas a few participants (19.93 %) were in the 50–65 age range. It is evident that 61 % of participants regularly used the computer for at least 4–6 h or more per day. 79 % of participants did not take a break after every 2 h of working. In addition, around 60 % of the participants had 5–15 years of experience in using computers. The BMI was normal for about half of the participants (49.82 %). However, 14.02 % and 36.16 % of the participants were under and over the normal BMI range respectively.

3.2. Ergonomic deficiencies in computer workstation

The common ergonomic deficiencies were identified in seating arrangement, keyboard and input devices orientation, monitor ergonomics, accessories setup, and working area. Table 2 depicts the ergonomic deficiencies of the workstation according to the responses of the participants. For workstation ergonomic deficiency, most of the participants (80 %) reported that their thighs were not parallel to the floor and their lower legs were not perpendicular to the floor. In addition, 74.53 % of the participants reported that no footrest for supporting their feet at the workstation. As a result, 65.31 % of the employees complained that they felt pressure on the back of the knees through the seat supported by the backside of the body. Moreover, not enough space between the desk and chair for the movement was reported by 56.82 % of participants but a few users (11.44 %) reported that the shoulder was not relaxed and did not maintain ergonomic posture. A notable amount of the participants acknowledged that they did not maintain the proper neck posture and their head and trunk remained in fixed position during working. Almost two-thirds of the participants mentioned no cushion in the chair and seat dimensions like seat depth and size cannot accommodate 57.56 % of the participants. Furthermore, 56.08 % of the participants complained about the chair because they did not support their lower back properly. Moreover, about two-thirds of the participants (68.63 %) stated that the chair was un-adjustable and the backrest was fixed. As a result they could not maintain arms in 90-degree angle with the forearm while typing. Also, 79.33 % of the participants were unsatisfied with the size and shape of the

Table 2
Ergonomic deficiencies of the workstation.

Ergonomic Deficiency	Participants	
	Yes n (%)	No n (%)
Workstation		
Thighs are unparalleled with the floor and lower legs are not perpendicular to the floor	217 (80)	54 (20)
Absent of a footrest for foot support	202 (74.53)	69 (25.47)
Thighs are trapped	182 (67.15)	89 (32.85)
Insufficient spaces for legs and feet	154 (56.83)	117 (43.17)
Legs and feet have insufficient forward clearance	162 (57.77)	109 (42.23)
The head and neck are unbalanced and not in line with the torso	45 (16.61)	226 (83.39)
The trunk is not vertical to the floor	48 (17.71)	223 (82.29)
The shoulders and upper arms are elevated or stretched not relaxed	31 (11.44)	240 (88.56)
The upper arms and elbows are extended outward, not close to the body	37 (13.65)	234 (86.35)
The wrists and the hands are bent, not straight	27 (09.96)	244 (90.04)
The wrists and the hands are not aligned with the forearms	31 (11.44)	240 (88.56)
Seating		
Absence of cushion on the seat surface	192 (70.85)	79 (29.15)
Inappropriate seat width and depth that do not accommodate the users	156 (57.56)	115 (42.44)
Pressure build-up on the knee and lower legs by seat front	177 (65.31)	94 (34.69)
Lumber is not supported by the backrest	152 (56.08)	119 (43.92)
Keyboard and Input Devices		
The input devices are not fitted with users	215 (79.34)	56 (20.66)
Sharp or hard edges are present, and user rest their wrists and hands on it	114 (42.06)	157 (57.94)
Accessories		
The Head is not upright and the shoulders are not relaxed during telephone calls	225 (83.02)	46 (16.98)
The telephone is not close to the users for proper reaching	193 (71.21)	78 (28.79)
General Ergonomics		
Absence of adjustability of the workstation and equipment	186 (68.63)	85 (31.37)
Inadequate maintenance of workstations	60 (22.14)	211 (77.86)
No break is scheduled for workers during computer tasks	42 (15.50)	229 (84.50)
Monitor		
Presence of light reflection from the windows to the user's eyes	200 (73.80)	71 (26.20)
Improper placement of screen that does not place the top of the screen at the user's eye level	156 (57.56)	115 (42.44)
The monitor is not placed directly in front of the user to avoid twisting the head and trunk	89 (32.84)	182 (67.16)
Improper distance between monitor and user	65 (23.98)	206 (76.02)

keyboard and other input devices. Besides, 42.06 % of the participants complained about the sharp and hard edges of the furniture. The majority of computer users (83.02 %) reported that they could not maintain an ergonomic posture for holding the telephone while working on the computer. Moreover, a large percentage of the participants (71.21 %) mentioned that the telephone was not closed or outreached areas. The position of the monitor was directly in front of the participants and the presence of light reflection or glare from the window was stated by 32.84 % and 73.80 % of the participants respectively. Likewise, 57.56 % of the participants reported the position of the monitor was not at eye level.

3.3. Musculoskeletal disorders (MSDs)

The participants reported MSDs for the last 12 months in different body regions like shoulder, lower and upper back, neck, wrist/hand, hips, knee, and leg. They suffered mainly from pain in the lower and upper back regions. Fig. 2 represents the percentages of MSDs according to the body regions and Table 3 shows the prevalence of the Nordic questionnaire by area according to different factors. The findings of this study indicated that 62 % and 53 % of the participants respectively complained about pain in the lower back and upper back regions. Moreover, shoulder pain (47 %), elbow pain (27 %), and neck pain (25 %) were also common among the participants to a remarkable amount. However, very few of them reported hip pain. Table 3 shows that a higher prevalence of MSDs was reported in the age groups 30–39 and 40–49.

3.4. Visual symptoms

Table 4 represents the analysis of visual symptoms according to the responses of the participants. Table 4 revealed that the participants suffered from various visual discomforts including dry eyes, teary eyes, pain behind the eyes, itchy eyes, pain in the eyes, sore eyes, tired eyes, double vision, and unclear vision. The most common visual discomforts were itchy eyes (69 %), teary eyes (83 %), and unclear vision (56.83 %). In addition, according to the severity, itchy eyes (14.39 %), teary eyes (14.39 %), and dry eyes (10.70 %) were the most severe visual symptoms among the participants.

3.5. Correlation between workstation deficiencies and musculoskeletal problems

Table 5 shows the Binary Logistic Regression analysis between workstation deficiencies and MSDs. Table 5 revealed that workstation deficiencies and MSDs have a statistically significant correlation in BLR analysis (at $p < 0.05$). Significant correlations were evident between MSDs in different body regions like the upper back, lower back, neck, shoulders, hands/wrists, etc., and ergonomic deficiencies, particularly in workstations and accessories components. A similar correlation was also found between deficiencies in general ergonomic components and MSDs in different body regions except shoulder and neck regions. However, the probabilities of experiencing MSDs except hand/wrist pain were completely related to seating deficiencies ($p < 0.05$). There was a statistical co-correlation between deficiencies in monitor ergonomics and reported MSDs in shoulders, neck, and upper back ($p < 0.05$). However, a correlation was found between the deficiencies in the keyboard/input device and MSDs, especially in the hand/wrist and shoulder areas ($p < 0.05$). Therefore, the six predictor variables such as workstation, seating, keyboard/input device, accessories, general ergonomics, and monitor ergonomics consistently predicted the MSDs in different body regions.

3.6. Correlation between monitor ergonomic deficiency and visual symptoms

Table 6 represents the correlation between the deficiency of monitor ergonomics and visual symptoms. The monitor ergonomic deficiencies had a statistically significant correlation with reported visual symptoms ($p < 0.05$). It is also evident that the glare or light reflection from windows and inappropriate monitor settings were significantly correlated with reported itching eyes, teary eyes, and unclear vision symptoms ($p < 0.05$). Moreover, there was a significant correlation between the monitor adjustment and itching eyes ($p < 0.05$). However, the participants who did not position the monitor directly in front of them experienced higher chances of teary eyes symptom ($p < 0.05$).

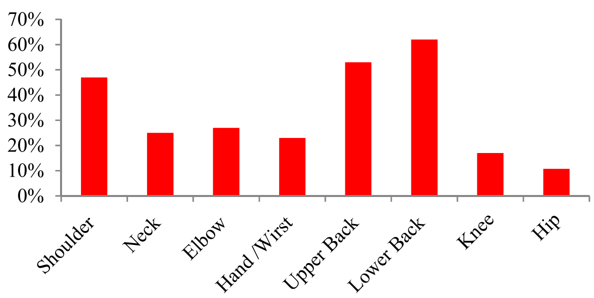

Fig. 2. The percentages of MSD problems according to body regions.

Table 3
Prevalence of Nordic questionnaire symptoms by area.

Factors	Musculoskeletal Anatomical Region				
	Shoulder n (%)	Neck n (%)	Hand/Wrist n (%)	Upper Back n (%)	Lower Back n (%)
Gender					
Male	81 (29.88)	43 (15.87)	41 (15.13)	91 (33.58)	107 (38.75)
Female	47 (17.34)	25 (9.23)	24 (8.86)	53 (19.56)	61 (22.51)
Job Type					
Academic	78 (28.78)	42 (15.50)	40 (14.76)	88 (32.47)	103 (38)
Administrative	50 (18.45)	26 (9.59)	25 (9.23)	56 (20.66)	65 (23.99)
Age					
23–29 years	26 (9.59)	13 (4.80)	13 (4.80)	29 (10.70)	34 (12.55)
30–39 years	40 (14.76)	22 (8.12)	20 (7.38)	45 (16.61)	53 (19.56)
40–49 years	36 (13.28)	20 (7.38)	19 (7.01)	41 (15.15)	47 (17.34)
50–65 years	26 (9.59)	13 (4.80)	13 (4.80)	29 (10.70)	34 (12.55)
BMI					
18.6–24.9 kg/m^2	18 (6.64)	10 (3.69)	9 (3.32)	20 (7.38)	24 (8.86)
<18.5 kg/m^2	64 (23.61)	34 (12.55)	33 (12.18)	72 (26.57)	83 (30.63)
>25 kg/m^2	46 (16.97)	24 (8.86)	23 (8.49)	52 (19.19)	61 (22.51)
Work Experience					
1–5 years	22 (8.11)	12 (4.43)	11 (4.06)	25 (9.23)	29 (10.70)
6–15 years	75 (27.67)	40 (14.76)	38 (14.02)	84 (31)	99 (36.53)
16–35 years	31 (11.44)	16 (5.90)	16 (5.90)	35 (12.92)	40 (14.76)
Duration of Computer Use					
<4 h/day	15 (5.54)	8 (2.95)	8 (2.95)	18 (6.64)	20 (7.38)
4–6 h/day	29 (10.70)	15 (5.91)	14 (5.17)	32 (11.81)	38 (14.02)
>6 h/day	84 (31)	45 (16.61)	43 (15.87)	94 (34.69)	110 (40.59)
Taking a Break after Every 2 Hours					
Yes	26 (9.59)	14 (5.17)	13 (4.80)	29 (10.70)	34 (12.55)
No	102 (37.64)	54 (19.93)	52 (19.19)	115 (42.44)	134 (49.45)

Table 4
Analysis of visual symptoms according to responses of the participants.

Visual symptoms	Participants [n, (%)]			
	No symptoms	Mild symptoms	Moderate symptoms	Severe symptoms
Tired eyes	146 (53.87)	73 (26.94)	37 (13.65)	15 (05.53)
Dry eyes	147 (54.24)	56 (20.66)	39 (14.39)	29 (10.70)
Itchy eyes	84 (30.99)	85 (31.36)	63 (23.25)	39 (14.39)
Pain behind the eyes	151 (55.72)	58 (21.40)	49 (18.08)	13 (04.79)
Pain in the eyes	124 (45.75)	88 (32.47)	53 (19.56)	6 (02.21)
Sore eyes	182 (67.15)	32 (11.81)	33 (12.18)	24 (08.85)
Teary eyes	46 (16.97)	109 (40.22)	77 (28.41)	39 (14.39)
Unclear vision	117 (43.17)	42 (15.50)	90 (33.21)	22 (08.12)
Double vision	187 (69.00)	48 (17.71)	28 (10.33)	8 (02.95)

Table 5
BLR analysis between workstation deficiencies and MSDs.

Predictor Variables Names	Logistic regression for musculoskeletal anatomical regions									
	Shoulder		Neck		Hand/Wrist		Upper Back		Lower Back	
	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Workstation Setup	1.26*	1.05–1.51	0.94*	0.78–1.15	0.87*	0.72–1.06	1.15*	0.97–1.38	1.29*	1.07–1.56
Seating Arrangement	1.62*	1.21–2.17	0.95*	0.69–1.31	.861	0.63–1.17	1.45*	1.09–1.94	0.77*	0.57–1.03
Keyboard/Input Device Orientation	0.53*	0.35–0.79	1.66	1.06–2.60	1.43*	0.93–2.21	1.00	0.68–1.47	2.38	1.58–3.56
General Ergonomics	1.31	0.86–1.98	0.79	0.50–1.22	0.91*	0.58–1.40	1.60*	1.06–2.41	1.12*	0.73–1.71
Accessories Setup	0.95*	0.60–1.51	0.69*	0.41–1.14	1.65*	0.99–2.72	0.46*	0.29–0.75	0.87*	0.54–1.41
Monitor Ergonomics	1.16*	0.85–1.60	1.07*	0.75–1.54	1.01	0.72–1.42	1.12*	0.81–1.54	1.08	0.78–1.51

Foot note: OR=Odds Ratio; CI= Confidence Interval, * Denotes Significant at $p < 0.05$.

3.7. Correlation between individual variables and problems

3.7.1. Musculoskeletal disorders (MSDs)

Table 7 shows the correlation between the independent variables of the participants and MSDs in the different body regions. Gender

Table 6
Correlation between monitor ergonomic deficiencies and visual symptoms.

Monitor Ergonomics	Logistic regression for visual symptoms					
	Itching eyes		Teary eyes		Unclear vision	
	OR	95 % CI	OR	95 % CI	OR	95 % CI
Glare is not reflected on the screen from the window or lights						
Yes	1		1		1	
No	3.26*	2.90–7.34	2.52*	1.90–4.63	2.17*	1.11–4.24
The monitor is positioned directly in front of the user allowing them to maintain their head and neck upright						
Yes	1		1		1	
No	1.53	1.32–3.04	1.47*	0.81–2.49	1.69	0.89–2.84
The monitor has sufficient adjustability to maintain the top of the screen at eye level without bending the head or neck						
Yes	1		1		1	
No	2.16*	1.63–4.14	1.42	0.99–3.94	1.823*	1.01–3.26
The monitor is placed at arm's length allowing users to read without leaning their head, or neck forward and backward						
Yes	1		1		1	
No	1.77*	0.88–3.54	1.50*	0.96–2.96	1.43*	0.76–5.694

Foot note: OR=Odds Ratio; CI= Confidence Interval, * Denotes Significant at $p < 0.05$.

was the strong predictor variable and had an association with neck symptoms ($p< 0.05$). For example, male employees experienced more than 2 times of MSDs in the neck ($OR = 0.55$) as compared to their female counterparts. Results also showed that administrative employees were more experienced in MSDs than academics at shoulder ($OR= 2.11$) and upper back ($OR= 1.56$) regions. Age was also statistically associated with MSDs in the shoulder, hand/wrist, lower back, upper back, and neck ($p = 0.05$) regions. Employees, aged are more than 40–49, likely experienced more MSDs in the shoulder ($OR= 2.42$) and lower back ($OR= 1.13$) regions than the younger counterparts (age 23–29 years). Moreover, the older stuff who had age 50–65 years appeared to be approximately 4 times and 3 times more likely to experience MSDs in the shoulder ($OR = 4.11$) and upper back ($OR= 3.45$) respectively than their younger colleagues.

Results also revealed that there was a strong correlation between employees' BMI index greater than 25 kg/m^2 and MSDs in the upper back and lower back regions ($p < 0.05$). In addition, lower than 25 kg/m^2 BMI index had a significant correlation with MSDs in the upper back region only ($p < 0.05$). Employees who had a BMI index greater and lower than the normal range experienced 1.5 and 2 times more MSDs in the upper back respectively. Moreover, the participants who had a BMI greater than 25 kg/m^2 also experienced 3 times MSDs in the lower back region than normal-ranged participants. Employees who had working experience of 6–15 years had a statistically significant correlation with MSDs in the neck, hand/wrist, and lower back regions ($p< 0.05$). So, 6–15 years experienced employees experienced more MSDs in hand/wrist and lower back regions compared to 1–5 years experienced employees. Moreover, a statistically significant correlation was found between the working experience of ≥16 years and MSDs of employees in the lower back region ($p< 0.05$). They also experienced approximately 5.5 times more MSDs in the lower back region than those who had a shorter duration of work experience. There was a statistically significant correlation between computer usage and MSDs in the shoulder and upper back regions (4–6 h and >6 h daily). Employees who used a computer for 4 h or more on a daily basis experienced more odds of MSDs. Results showed the medium-user employees (4–6 h daily) experienced approximately 5 times and 4.5 times more MSDs in their shoulders and upper back regions respectively than the short-term user employees (<4 h daily). However, employees whose computer usage is more than 6 h daily experienced approximately 7 times and 6.5 times more likely MSDs in their shoulders and upper back regions respectively than the short-term user employees (<4 h daily). There was also a statistically significant correlation between employees who did not take a break after every 2 h on computer work and MSDs in the lower back region ($p< 0.05$). They experienced approximately 4.5 times more MSDs in the lower back region than those who took 2 h breaks from the computer. Therefore, different independent variables like gender, job type, age, BMI, work experience, duration of computer use, and taking a break every 2 h reliably predicted the MSDs among the participants.

3.7.2. Visual symptoms

Table 7 also showed that gender is statistically associated with the visual symptoms of itching eyes ($p < 0.05$). For example, female employees experienced 2 times less likely itching eye symptoms ($OR = 0.54$) than male counterparts. Similarly, age was statistically associated with visual symptoms (itching eyes, teary eyes, unclear vision). The likelihood of experiencing itching eyes, teary eyes, and unclear vision symptoms by 50–65 years old employees were approximately 1.5 times, 5 times, and 2.5 times more than younger counterparts. Likewise, 40-49-year-old employees experienced teary eyes approximately 2 times higher than those who had aged 23–29 years. However, there was no significant correlation between BMI and visual symptoms.

There were statistically significant correlations between older employees (16–35 years of work experience) and visual symptoms particularly for itching eyes and teary eyes symptoms ($p< 0.05$). In addition, they seemed to experience approximately 2 times and 4 times more likely itching eyes and teary eyes symptoms respectively as compared to those who had lower experience (1–5 years of work experience). However, there was no significant correlation between the employment duration of 6–15 years and visual symptoms. There was also a statistically significant correlation between the duration of computer use and visual symptoms. The chance of suffering from visual symptoms increased with the increase in computer use (>6 h per day). It is evident that employees who worked on computers for 6 h or more experienced approximately 1.5 times and 7.5 times more visual symptoms of itching eyes, and unclear vision respectively than the short-term computer users (<4 h daily). A statistically significant correlation was found between

Table 7
Correlation between independent variables and problems (MSDs and Visual symptoms)

Predictor Variables	Musculoskeletal Anatomical Region										Visual Symptoms					
	Shoulder		Neck		Hand/Wrist		Upper Back		Lower Back		Itching eyes		Teary eyes		Unclear vision	
	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Gender																
Male	1		1		1		1		1		1		1		1	
Female	0.88	0.47–1.65	0.55*	0.31–0.99	1.00	0.55–1.79	0.75	0.40–1.39	1.10	0.62–1.96	0.54*	0.40–1.25	1.02	0.52–1.90	0.96	0.56–1.63
Job Type																
Academic	1		1		1		1		1		1		1		1	
Administrative	2.05*	0.47–3.56	1.25	0.31–3.70	1.00	0.65–1.89	1.56*	0.40–2.29	1.23	0.94–2.72	1.34	1.20–2.75	0.85	0.63–1.92	2.13	1.48–3.78
Age																
23–29 years	1		1		1		1		1		1		1		1	
30–39 years	1.01	0.96–2.02	1.42	0.44–4.59	1.89	0.27–2.85	1.11*	0.63–2.38	0.34	0.11–1.03	1.08*	0.08–1.73	1.01*	0.06–1.84	1.19	0.42–3.39
40–49 years	2.42*	1.01–4.48	1.85	0.16–4.57	1.46	0.30–6.94	1.20	1.03–3.21	1.13*	0.42–1.76	0.11	0.02–0.61	1.96*	0.30–8.50	0.67	0.15–2.96
50–65 years	4.11*	2.03–7.41	1.83*	0.60–5.56	1.42*	0.12–1.44	3.45*	2.14–5.40	0.80	0.27–2.31	1.52*	0.35–3.07	4.98*	1.21–10.6	2.50*	0.13–3.33
BMI																
18.6–24.9 kg/m^2	1		1		1		1		1		1		1		1	
<18.5 kg/m^2	0.08	0.05–1.19	1.42	0.44–4.59	0.68	0.14–3.18	2.0*	0.99–2.84	0.80	0.15–4.21	1.11	0.23–1.52	1.25	0.76–2.08	4.19	1.02–9.16
>25 kg/m^2	0.10	0.00–1.38	0.85	0.16–4.57	0.77	0.20–2.95	1.5*	1.23–2.75	3.00*	1.32–4.49	0.120	0.02–0.53	3.04	0.56–7.05	1.51	0.41–5.46
Work Experience																
1–5 years	1		1		1		1		1		1		1		1	
6–15 years	0.53	0.22–1.27	0.33*	0.14–0.75	3.06*	1.27–7.35	0.45	0.17–1.15	3.99*	1.73–9.20	2.01	0.92–4.38	2.07	0.86–4.99	1.41	0.65–3.07
16–35 years	2.37	0.75–7.47	0.41	0.16–1.08	1.37	0.48–3.90	0.84	0.27–2.64	5.43*	2.04–8.40	2.11*	0.85–5.19	3.80*	2.88–9.90	0.92	0.38–2.24
Duration of Computer Use																
<4 h/day	1		1		1		1		1		1		1		1	
4–6 h/day	5.21*	1.84–7.52	0.94	0.29–3.01	3.01	0.90–8.04	4.47*	2.70–8.66	0.10*	0.03–0.33	0.79	0.26–2.41	0.41*	0.05–3.07	2.40	0.75–7.65
>6 h/day	7.08*	1.87–9.73	0.89	0.29–2.68	2.27	0.69–7.40	6.50*	3.74–9.67	0.50	0.16–1.57	1.50*	0.30–2.47	2.07	3.01–6.45	7.62*	2.59–10.42
Taking a Break after Every 2 Hours																
Yes	1		1		1		1		1		1		1		1	
No	0.56	0.17–1.79	1.66	0.60–4.55	0.79	0.29–2.18	2.09	0.69–6.31	4.42*	1.40–7.93	1.42*	0.46–3.77	1.02	0.96–2.13	1.45*	0.58–3.64

Foot note: OR=Odds Ratio; CI= Confidence Interval; * Denotes Significant at $p < 0.05$.

employees who did not take a break after every 2 h and visual symptoms. Employees who enjoyed 2 h break appeared to be more likely to experience itching eyes and unclear vision symptoms. Therefore, independent variables such as gender, job type, age, computer work experience, duration of computer use, and break taking every 2 h were the input predictor variables and reliably predicted visual symptoms among the employees.

4. Discussion

This study was carried out among university employees to identify the deficiencies in computer workstations and investigate the correlation between different independent variables and MSDs/visual symptoms by using a self-reported questionnaire and OSHA computer workstation evaluation checklist. It is evident that health problems and MSDs were increased with the prolonged use of computers due to inappropriate settings in the workstation. So, the early identification and mitigation of these problems is necessary to reduce the risks of experiencing MSDs and visual symptoms. In addition, all components of the workstation should be redesigned according to ergonomic guidelines that will help not only employees to work effectively and safely but also focus on human well-being [35].

Ergonomic deficiencies were identified for the existing workstations of the employees. The authors included mainly seating, working postures, keyboard and input devices, working area, and monitor ergonomics components to find the ergonomic deficiencies. Results showed that seating and monitor ergonomics were the worst components in the workstation. The deficiencies of seating and monitor ergonomics indicated that the workstation components were not designed according to ergonomic guidelines. Therefore, the users did not maintain correct posture while working in the workstation due to the absence of ergonomic rules and regulations. Similar deficiencies were found in workstation design, layout arrangement, and usage of computers by different similar studies [1,15,16]. The presence of such deficiencies indicated that regular office stations were inadequately designed to meet employees' physical and task needs. The most documented deficiencies in computer workstations for administrative staff were related to the working area, which was not optimized for computer-related tasks [8]. In this study, most of the employees complained about the workstation area; as the workstation was not designed ergonomically for computer-related tasks. In addition, congestion in the workstation did not provide sufficient space for thighs, legs, and feet to freely movement and work properly. Therefore, maintaining correct posture while working on the keyboard was quite difficult and needed huge effort to accomplish the tasks. So, employees suffered from MSDs or visual symptoms frequently due to the use of the workstation. This happened mainly because of management policy. The management authority did not provide enough space to design a computer workstation. Moreover, they did not have any knowledge of ergonomic rules and regulations. In Bangladesh, there were no standard rules and regulations for designing a computer workstation. As a result, management authority believed and considered only output from employees, not their safety. Employee well-being was always neglected when making any decision by higher authority. The authority designed the workstation without considering ergonomic rules, standard regulations, physical, and user needs. So, employees are experiencing MSDs and visual discomforts. Therefore, the only solution for these problems is to design the computer workstation ergonomically [12,36–38].

The findings demonstrated that MSDs were more prevalent in various body regions over 12 months, particularly in the neck, shoulders, upper, and lower back. Similar result was found by one study which reported that MSDs were more common in neck, upper back, and lower back regions among office users [16]. Moreover, many previous studies investigated MSDs and found a high prevalence of MSDs among users due to inappropriate work posture and movement [7,39,40]. These incidents may happen due to the absence of an ergonomic seat design, which increases neck and back bending and muscle load. As a result, users suffered from MSDs. In addition, poor postures and deviation from neutral body position while sitting or other physical factors lead to muscle fatigue and increase the probability of MSDs and visual symptoms [1,41,42].

It is evident from the study that age, job type, work experience, duration of computer use, and taking 2-h breaks from computers reliably predicted MSDs among university employees. Generally, men experienced higher MSDs in upper extremities and neck than women [43]. The current study showed the correlation between the neck symptom and the gender of the participants. In addition, male employees experienced two times more MSDs in the neck region (OR = 0.55) as compared to their female counterparts. Similar results were found in other studies [41,44]. Potential reasons include differences in task allocations to men and women within the job, differences in how men and women perform the same tasks, and even differences between men and women in physiological effects when performing the same tasks in the same way [43,45]. These factors contribute to a complex interaction explaining gender differences in MSDs occurrences. However, females experience more shoulder, and hand/wrist symptoms compared to males [38]. Therefore, due to gender differences, repetitive upper-limb tasking for prolonged periods of time may increase the chance of developing MSDs [9,46]. Similarly, other variables such as job type, age, working experience, and OSHA scores of different workstation components were also significant predictors of the development of MSDs. Results showed that administrative employees experienced 1.5 times more MSDs in the upper back region than academic. Computer-related work patterns and poorly designed furniture were closely associated with a high prevalence of MSDs among administrative employees in upper and lower back regions. This also happened due to the continuous usage of the computer without taking any postural breaks. In addition, ergonomic deficiencies were found in the workstation of administrative staff, particularly in the sitting arrangements like inadequate back support, absence of footrests, insufficient space, insufficient clearance for legs and feet, and so on. Furthermore, age was another predictor variable that reliably predicted the MSDs among university employees, and the employees MSDs increased due to the increase in their age. Similarly, other study reveals that young employees are less likely to experience MSDs than older employees [47]. In this study, the prevalence of MSDs among the older employees was higher than the younger ones. The BLR analysis showed older and oldest participants experienced 2 and 4 times more MSDs in the shoulders region than younger. One study stated that MSDs are more common in the elderly because of decreased physical strength and resistance with age [48]. In addition, MSDs of body regions and pain levels in the elderly are more frequent due to decreased of dynamic balance ability [7,48]. Moreover, the results of this study confirmed the correlation between work experience and the high prevalence of MSDs in the lower back region. Some other studies showed that MSDs in the neck and shoulder regions were the most vulnerable among the participants due to work experience [9,49,50]. A possible explanation could be attributed to the nature of work and other related computer workstation works that allow employees to take more exposure to physical loads at work [49]. In general, long exposure seems to increase the risk of some disorders of the neck and upper limbs, and MSDs [38,42,49].

This study also revealed that there was a statistically significant correlation between the OSHA scores of workstation components and reported MSDs. Participants who had greater OSHA scores seemed to have a "protective" effect and were less likely to experience MSDs. Moreover, the amount of time spent on the computer was strongly correlated with the occurrence of MSDs. In this study, working with computer for 4–6 h or more hours per day increased the chance of experiencing MSDs in the shoulder and back regions. Similarly, another study reported that employees who worked more than 6 h a day with a computer may experience shoulder pain [51]. Another study found a correlation between computer usage hours and reported MSDs in the wrists and hands regions [12]. There was a statistically significant correlation between employees who did not take a break after every 2 h of computer work and lower back pain. They experienced approximately 4.5 times more MSDs in lower back pain than those who took a break every 2 h from the computer. This happens mainly for prolonged usage of wrong-dimensioned furniture. Normally, men and women used the same dimensioned furniture in the computer workstations and performed the same types of work in the organization. However, the furniture dimensions are incompatible with the users' body shape and size of the users due to the absence of anthropometry. Therefore, prolonged usage of this wrong-dimensioned furniture may increase the probability of experiencing MSDs. Moreover, the same posture for a long time or long statics may also be responsible for employees' MSDs. Thus, some body regions like the shoulder, upper back, lower back, wrist, and hand are more prone to MSDs. Furthermore, working experience on the computer for 6–15 years had a statistically significant correlation with MSDs in the neck, hand/wrist, and lower back. They experienced approximately 4 times more MSDs in the lower back region than those who had a shorter duration of work experience. This happens mainly because of prolonged usage of inappropriate computer workstations [15,52]. In addition, due to improper workstations, employees are working with heightened muscle tension and mental fatigue which also lead to MSDs [3,6,17,53].

It is evident from the study that there was a significant correlation between greater BMI index (>25 kg/m^2) and MSDs (upper and lower back regions). So, users, who had higher BMI index, exhibited a higher risk of experiencing MSDs compared to normal BMI indexed persons. According to the study, higher BMI-indexed users experienced 3 times more MSDs in the lower back region than normal BMI-indexed users. Similar results were also found in some studies [16,17,28,35]. A recent study reported that regular exercise can reduce the MSDs of employees who had a BMI index >25 kg/m^2 [15]. A person who has a high BMI experiences more MSDs because the high amount of adipose tissues limits the movements of the person creates pressure on musculoskeletal tissues and pain. In addition, obese people have fewer shoulder movements than people with normal weight [44]. In this study, the most common visual discomforts among university employees were itchy eyes (69 %), teary eyes (83 %), and unclear vision (56.83 %). Another similar research found that itchy eyes and teary eyes were the most prevalent visual complaints among computer users [47]. The presence of bright lighting and glare in the working environment leads to eye strain and difficulty in seeing objects on computer screens [6,23]. A previous study found that visual symptoms were attributed to average daily computer-related work hours, and visual symptoms were higher with increased light glaring in computer workstation areas [27]. There were the lowest percentages of employees who experienced double vision symptoms, which was consistent with another study [1]. It is evident that visual symptoms negatively affect the quality of life and reduce employees' productivity of [23,48].

In this study, gender, age, job type, BMI, computer work experience, daily computer usage, and break-taking every 2 h were the input predictor variables for predicting the visual symptoms among university employees. In particular, monitor ergonomics and its deficiencies was the culprit for experiencing visual symptoms by the employees. Furthermore, age was a significant predictor for predicting itching eyes, teary eyes, and unclear vision symptoms among employees. However, some studies showed that age was not associated with vision syndromes [54,55]. According to a current study, employees who use computers for longer than 6 h are more likely to experience visual issues. In addition, computer usage of >6 h daily were statistically associated with experiencing itching eyes and unclear vision symptoms. Most of the visual symptoms are the effects of the prolonged use of computer monitors or different light reflection objects. Another study found that the occurrence of visual symptoms triggered by the prolonged use of computers [1]. However, job type and BMI did not have any correlation with visual symptoms. This study also found a strong correlation between visual symptoms and improper viewing distance, glare, and inadequate rest breaks during computer usage. Some previous studies also found similar correlations [15,16,22]. The presence of glare in the working environments triggers the chance of having eye strain and unclear vision symptoms [6,26]. Our study showed that inappropriate monitor orientation and glare from windows were associated with visual symptoms. Similar results were evident from the other research that the visual symptoms were attributed to prolonged computer use, light glare from the windows, and this problem was introduced due to the violation of monitor ergonomics [30,51,53].

5. Conclusions

The study found significant ergonomic issues in computer workstations, specifically related to design, layout, and duration of use. In addition, the ergonomic parameters of the workstation related to seating, working areas, and monitor orientations were unsatisfactory. A significant number of university employees suffer from MSDs and visual symptoms. Different independent variables, such as age, gender, years of work experience, workstation ergonomics, and duration of computer use, were found to be statistically significant for MSDs. There were statistically significant correlations between the independent variables, deficits in monitor ergonomics, and visual symptoms. These independent variables reliably predicted the participant's visual symptoms and MSDs.

6. Suggestions, limitations, and future scopes

6.1. Suggestions

The high prevalence of MSDs and visual symptoms indicate that there are some serious problems in the system, which should be overcome in order to improve both quality and productivity. So, ergonomic computer workstations should be designed based on ergonomic guidelines. In addition, ergonomic interventions must be carried out in the organization considering corrective ergonomics, preventive ergonomics, and prospective ergonomics practices to avoid occupational hazards. Moreover, employees need to be provided sufficient ergonomic training and motivation so that they can maintain sitting posture and good working practices. However, employees' awareness of ergonomic issues can also help them to avoid occupational health problems. Furthermore, preventive measures should be taken to ensure an early diagnosis of MSDs and visual symptoms to reduce the severity of the symptoms. Two hours of working breaks from the computer would be the best solution for reducing visual symptoms as well as MSDs. In this case, a computer reminder system can be adopted to prevent long working durations at a time. Besides, eye muscle exercise and frequently using eye drops would be other preventive measures to decrease the severity of unclear vision, itchy eyes, and teary eyes symptoms. Also, unwanted glare or reflection from the window can be eliminated by using an antiglare screen and maintaining a proper lighting system in the workstation. In addition, the monitor should be placed according to OSHA guidelines at 50–100 cm from the eyes while maintaining a viewing angle of 15°-20° to reduce visual symptoms [56].

6.2. Limitations

This study was carried out in a single institution due to time and financial restrictions that could limit the generalizability of the research. In addition, the authors randomly selected the participants, which may have skewed the sample. Moreover, the authors did not measure the impact of MSDs and visual symptoms on the performance of the participants. Finally, the authors used simple statistical tools to analyze the results.

6.3. Future scopes

The study found statistical correlations between independent factors, workstation characteristics, and both musculoskeletal disorders and visual symptoms. In the future, research should focus on affordable interventions to prevent or reduce occupational health issues among employees. The authors suggest a large number of participants from diverse organizations to generalize the findings. This research can be used as a foundation for future research.

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Ethical approval

This study was reviewed and approved by Office of the Director for Research & Extension, with the approval number: KUET/DRE/2023/11(02).

Data availability statement

No data associated with the study has been deposited into a publicly available repository. The authors confirm that the data supporting the findings of this study are available within the article.

Additional information

No additional information is available for this paper.

CRediT authorship contribution statement

Md Golam Kibria: Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Md Shohel Parvez:** Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Palash Saha:** Formal analysis, Data curation. **Subrata Talapatra:** Writing – review & editing, Formal analysis, Data curation.

Declaration of competing interest

The authors declare no conflict of interest.

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