Review Article

Journal of Occupational Health and Epidemiology
Journal homepage: http://johe.rums.ac.ir

Ergonomics-Related Musculoskeletal Disorders among Students during the COVID-19 Pandemic: A Scoping Review

Fateme Heydari Abdolahi[1], Maryam Keramat Kar[2], Payam Heydari[3], Sakineh Varmazyar[4*]

1. M.Sc in Occupational Health Engineering, Faculty of Health, Student Research Committee, Qazvin University of Medical Sciences, Qazvin, Iran.
2. Assistant Prof., of Gerontology, Faculty of Nursing and Midwifery, Social Determinants of Health Research Centre, Research Institute for Prevention of Non-Communicable Diseases Qazvin University of Medical Sciences, Qazvin, Iran.
3. Ph.D Student in Ergonomics, Dept. of Ergonomics, School of Public Health, Hamadan University of Medical Sciences, Hamadan, Iran.
4. Associate Prof., Dept. of Occupational Health Engineering, Social Determinants Health Research Center, Research Institute for Prevention of Non-Communicable Diseases, Faculty of Health, Qazvin University of Medical Sciences, Qazvin, Iran.

Citation: Heydari Abdolahi F, Keramat Kar M, Heydari P, Varmazyar S. Ergonomics-Related Musculoskeletal Disorders among Students during the COVID-19 Pandemic: A Scoping Review. J Occup Health Epidemiol. 2022;11(4):311-20.

Article Info

*** Corresponding author:**
Sakineh Varmazyar,
E-mail:
svarmazyar@qums.ac.ir

Article history
Received: Jul 2022
Accepted: Dec 2022

10.61186/johe.11.4.311

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

Peer review under responsibility of Journal of Occupational Health and Epidemiology

Abstract

Background: During the COVID-19 pandemic and the consequent lockdown, students have been forced to stay at home and use electronic devices in online classrooms. This scoping review aimed to examine the effects of incorrect ergonomics on musculoskeletal pain among students receiving distance education using e-devices during the COVID-19 pandemic.

Materials and Methods: A scoping review was performed on some databases, including Web of Science, Scopus, Google Scholar, Medline, PubMed, Wiley Online Library, BMJ Learning, Springer, and ProQuest, during the COVID-19 pandemic from 2020-2021. Firstly, a total of 75 articles were identified. Next, 15 articles were assessed by inclusion and exclusion criteria. Finally, a total of 9 articles were selected.

Results: Only 5% or less of the students and parents were informed of the principles of working ergonomics while using e-devices. Accordingly, risk factors associated with using e-devices, including prolonged sitting in awkward postures, number and duration of online classes per day (>6 hours/day), and lack of breaks between online classes had significant effects on ergonomics, postures, and musculoskeletal disorders (MSDs) among students during the COVID-19 pandemic. Our review showed the prevalence of a range of MSDs in the neck (24.8-69.9%), shoulders (17.5-25.3%), upper and lower back (18-63.4%), and wrists (30.7%) among the students.

Conclusions: Increasing students' knowledge, using ergonomic tables and chairs, designing correct workplace layouts, using stands for smartphones and tablets, reducing training durations, proving suitable environmental conditions, maintaining ideal distances, installing brake reminding software, and effectively taking exercise reduced musculoskeletal pain among the students.

Keywords: COVID-19, Ergonomics, Student, Musculoskeletal Pain

Introduction

The closure of schools and universities has been affecting many students' educational life during the COVID-19 pandemic [1]. Although distance education can improve teaching and learning, it may result in the increased use of digital devices (DDs), possibly changing and decreasing physical activity [2, 3].

The use of tablets, PCs, laptops, and smartphones makes students adopt awkward postures, thereby leading to many reports on the cases of MSDs due to the duration of use [4]. Regiani et al reported

that university students suffered from musculoskeletal pain most commonly in the neck (43.87%) due to using smartphones [5]. In the study of Karingada et al, 58 and 56% of the students reported MSD symptoms in the right shoulder and right hand fingers, respectively, since the time they started online learning. In addition, over 40% of the students reported some MSD symptoms almost in all the body regions studied due to online learning [6]. Similarly, the results of the study of Leirós-Rodríguez et al showed the highest prevalence of musculoskeletal disorders in the cervical (69.9%) and lumbar (63.4%) regions among students during the COVID-19 pandemic [7]. In addition, in the study of Elsiddig et al, university students who used electronic devices for research purposes reported a higher and more significant prevalence of pain in the regions of the neck and shoulders compared to those who did not use them for these purposes [8].

In a study, some factors, including being in a static position, duration of repeated movements using mouse and keyboard devices, awkward postures, poor ergonomics [4, 9], large numbers of classes per day, long class sessions or times spent on online learning [6, 10], lack of breaks between classes [10], and environmental factors affected MSDs in students [11]. Research shows that increased neck flexion angles during smartphone use may cause mild neck pain [12, 13]. Based on the study of Agarwal et al, 59.04% of students reported an increase in the use of DDs for more than six hours per day [14]. In the same vein, Choudhary et al reported that online classes that caused an increment in the use of e-devices resulted in MSDs among students because they were not aware of ergonomics [15].

In fact, environmental factors, such as light, sound, temperature, and air conditions are among the constituents and principles of ergonomics, which can affect students' physical health [11]. In addition, excessive gadget use and incorrect postures were reported as the factors causing physical problems among students [10, 11, 16]. Therefore, receiving training in proper ergonomic approaches and principles regarding the use of electronic devices is required to reduce the risk of MSDs.

Objectives of this research

Objective 1: Determining the prevalence of MSDs caused by the use of e-devices among school and college students during the COVID-19 pandemic

Objective 2: Identifying risk factors associated with incorrect ergonomics, including poor postures and environmental factors affecting MSDs among school and college students

Objective 3: Introducing corrective measures for applying ergonomic principles, including correct postures and improvement of environmental conditions to reduce MSDs among school and college students

Materials and Methods

This scoping review followed the guidelines on Preferred Reporting Items for scoping reviews [17]. Scoping reviews are exploratory research projects that systematically map the literature on a topic by identifying key concepts, theories, and sources of evidence, informing practice in a field. Researchers may conduct scoping reviews, instead of systematic reviews, where the aim of a review is to identify knowledge gaps, scope a body of literature, clarify concepts, or investigate research conduct. Being useful because of their special features, scoping reviews may also act as precursors for systematic reviews; besides, they can be used to confirm the relevance of inclusion criteria and potential questions [18].

Inclusion criteria: The inclusion criteria were studies conducted on students with inappropriate postures and MSDs caused by working with e-devices, studies on students at the risk of MSDs because of virtual training, studies on students receiving distance education in online classes, and studies written in English during the COVID-19 pandemic with their full text available.

Exclusion criteria: The studies that did not evaluate MSDs, ergonomics, and postures associated with virtual education among the students were excluded. Besides, articles that were not written in English were removed from the study.

Search strategy: The aforementioned databases were searched using a combination of the keywords of (1) musculoskeletal disease/disorder/pain, (2) school/university students, (3) virtual learning/virtual education/distance education/online classes, (4) electronic devices, (5) COVID-19/Coronavirus, and (6) awkward/poor/incorrect/wrong ergonomics/positions/postures. Accordingly, the search was conducted on the articles published from December 2019 to August 2021 on the databases of Web of Science, Scopus, PubMed, Google Scholar, Medline, Wiley Online Library, BMJ Learning, Springer, and ProQuest.

Data presentation: Fig. 1 and Table 1 show the article identification, screening, and result review steps.

Quality appraisal: The quality of the studies was evaluated using the Joanna Briggs Institute Critical Appraisal Tools for cross-sectional studies. To this

end, two reviewers independently assessed the quality of the studies included. In fact, studies with over three unmet appraisal items were excluded from the review. In addition, any disagreements over the quality of the studies or appraisal items were resolved among the reviewers through discussion

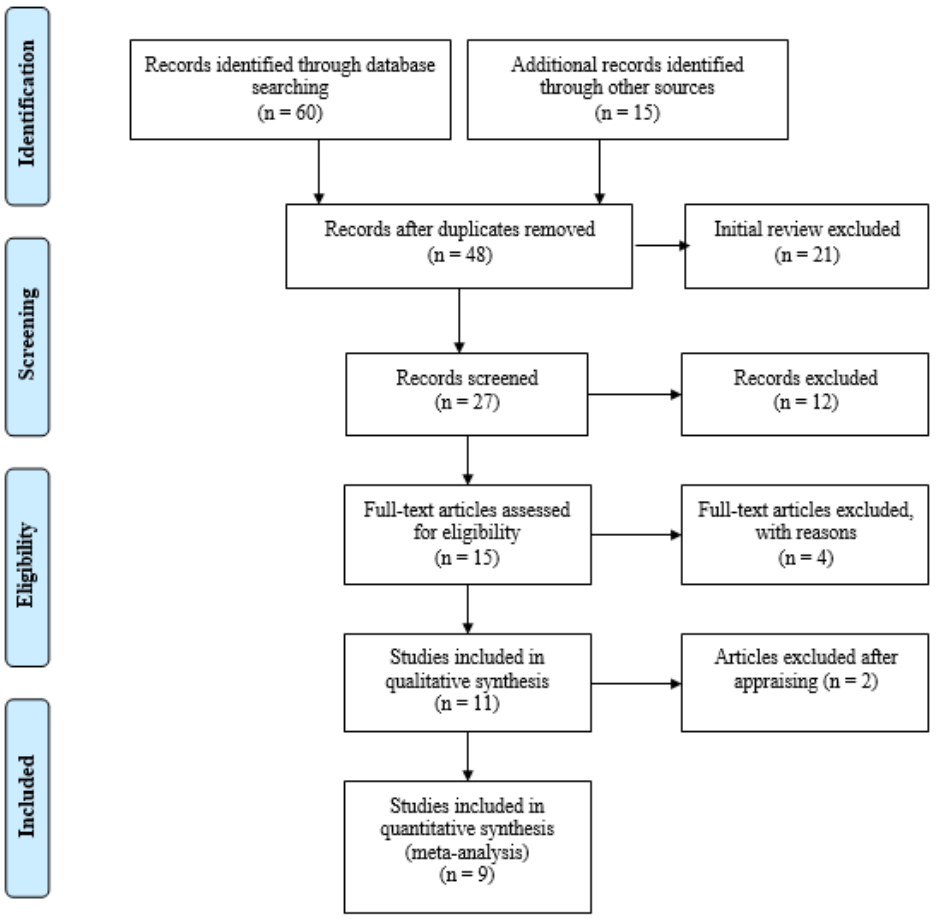

Fig. 1. Search strategy flowchart

Results

Search strategy: Initially, a total of 75 articles were identified. Next, 27 articles were excluded from the review, for they were duplicates, with 48 articles remained. Besides, studies that did not investigate MSDs, ergonomic issues, or environmental factors caused by e-devices in online education during the COVID-19 pandemic among school and college students were excluded. In addition, articles that were not written in English and those not published by reputable journals were excluded. Additionally, the articles that were not suitable, according to the two reviewers' opinion and based on the three-item appraisal checklist of cross-sectional studies, were removed. Fig. 1 shows other steps for eligibility assessment and inclusion of the articles.

Data from all studies were collected using an online questionnaire (Nordic questionnaire or self-administered questionnaire) and the ergonomics assessment method. In fact, according to evidence from 9 studies, the effects of e-devices during the COVID-19 pandemic on students could be categorized into the two fields of musculoskeletal pain and ergonomics (postures and environmental factors) (Table 1).

A summary of the reviewed studies: In general, 55% of the articles meeting the inclusion criteria were on musculoskeletal pain, yet the remaining 45% were on ergonomics (posture and environmental factors). Additionally, among the reviewed articles, 6 articles were written in Asia, 2 in Europe, and 1 in America.

Table 1. Study design categories and outcomes of the reviewed studies among students during the COVID-19 pandemic

Author and year of publication	Data collection tool	Sample size, participants, and country	Purpose of the study	Finding	Outcome	
					Musculoskeletal Pain	Ergonomics (Postures and environmental factors)
Majumdar et al. (2020)	Kuorinka Modified Nordic Questionnaire	325 undergraduate and postgraduate university students; India	Investigation of the impact of social distancing caused by COVID-19 on mental and physical health	- There was a significant difference in cellphone/desktop/laptop use before and during the lockdown among students. - Among students, cellphone use increased significantly compared to desktop/laptop/television use. - The time of exposure to the cellphone screen (hours/day) significantly increased in students during the lockdown (5.2 ± 1.73) versus before it (3.0 ± 1.36). - Significant levels of discomfort were reported in the shoulders, upper back, hips/thighs, knees, and ankles/feet by students before and during the lockdown. - The most common discomfort during the lockdown was related to the neck, shoulders, lower/upper back, and wrists/hands.	*	
Leirós-Rodríguez et al. (2020)	Kuorinka Modified Nordic Questionnaire	1,198 students; Spain	Analysis of the relationship between physical activity and the prevalence of musculoskeletal pain in the students' bodies during the COVID-19-associated lockdown	- The prevalence of musculoskeletal pain in cervical (69.9%), dorsal (41.2%), and lumbar (63.4%) regions increased among the entire students, both males and females, during the lockdown caused by the COVID-19 lockdown compared to the year before it. - The prevalence of dorsal pain significantly increased among all students and the subgroup of females. - Except among females who reported pain in both shoulders, the pain in the other body parts of the participants decreased during the quarantine comparted to the year before it. - The change in the type of physical activity and its frequency decreased musculoskeletal pain a bit during the COVID-19 pandemic among university students.	*	

Realyvásquez et al. (2020)	Self-Designed Questionnaire	206 university students; Mexico	Determination of the impact of lighting, noise, and temperature levels on academic performance in university students during the COVID-19 pandemic	- Temperature, lighting, and noise exerted significant direct effects on university students' academic performance. - A total of 28.6, 9.2, 30.6, and 35% of the students always had appropriate lighting, sound levels, temperature, and air quality, respectively, in their ambient study environment as well as in their online classes. - An ergonomically designed study area for online classes, which included a quiet space and temperature-controlled rooms, to mention a few, helped improve sustainability of the students and higher education institutions.		*
Choudhary et al. (2020)	Self-Designed Questionnaire	186 children; India	Determination of the effects of compliance with ergonomic principles on children spending much time on e-devices	- Children in a sitting position spent 5-7 hours/day studying and working with gadgets. - Children spent longer hours on e-devices, such as laptops (58%), android/apple phones (20%), desktops (12%), and tablets (10%). - Contents of the gadgets were by 45, 35, and 20% on the curriculum, games, and others, respectively. - Based on the results, parents were unaware of ergonomic principles and their effects on their children. - Very few parents were aware of the importance of breaks (38%), correct sitting postures (6%), and laptop ergonomics (3%). - About 21% of the children suffered from upper back pain (18%), lower back pain (18%), headaches (11%), irregular sleep (6%), and behavioral changes (6%). -- Poor ergonomics such as awkward posture, long sitting, static loading, and repetitive movement lead to children's MSDs later in life.	*	*
Dey et al. (2020)	Self-Designed Questionnaire	234 college students; India	Investigation of the magnitude of adults' physical and psychological health problems during the lockdown	- The average mobile phone use was reported to be over 6 hours per day in almost half (46.6%) of the students; besides, about 13% of them used PCs or laptops for > 6 hours. - Although 36% of the students did not complain about any musculoskeletal symptoms, pain in different regions of the body was found to be common among others. - Pain levels in the neck, shoulders, and back during the lockdown were reported at 24.8, 17.5, and 30.8%, respectively.	*	
Agarwal et al. (2021)	Online Questionnaire	840 students' parents; India	Investigation of problems among children during the COVID-19 pandemic	- Around 55.23% of the children's ocular symptoms were related to the COVD-19 lockdown. - About 59.04% of the students reported the use of electronic devices for more than six hours per day. - Parents of 34% of the children reported that they had awkward postures while working with DDs.		*

Gammoh (2021)	Computer Vision Syndrome Questionnaire (CVS-Q)	382 students; Jordan	Investigation of the severity and prevalence of digital vision syndrome among university students in Jordan	- The use of DDs was reported at 55.5% among the sample size, being more than six hours per day. - Pain in the joints of the fingers and wrists was reported among 30.7% of the students due to using mobile phones. - A total of (36.1%, n = 138) spent continuous hours of using DDS. - A total of 53.7% of the students reported using digital devices more often at night. - Shoulder and neck pain was reported by students after using smartphones for prolonged hours (25.3%, n = 96). The students who (93.9%, n = 199) used DDs for over six hours per day reported computer vision syndrome.	*	
Singh et al. (2021)	Self-Designed Questionnaire	1541 and 684 medical and nursing students, respectively; India	Investigation of the students' health in online classes for a long duration during the COVID-19 pandemic	- Duration of each class and previous health issues predicted the occurrence of neck or back pain, eyestrain, headaches, anxiety, and sleep disturbances. - A total of 37-58% of the students reported health problems due to prolonged screen time. - Screen time (all gadgets put together) of over 4 hours per day was shown to increase pain in the neck and shoulders. -The most common problems reported were eye strain (54%), neck pain (40.5%), and back pain (40.4%). - Health issues were more common in students who had to attend classes for over 4 hours per day and those who attended long class sessions (over 40 minutes). - Students reported that they attended 3-6 classes per day, with each class taking less than 40 minutes, they had breaks of 10-20 minutes between classes, and they attended interactive sessions.	*	*
Boatca et al. (2021)	Rapid Office Strain Assessment (ROSA)	53 students; Romania	Assessment of the effects of online classes on students' health	-The highest score of the ROSA method was 8, which was related to a student studying under highly poor ergonomic conditions; accordingly, this student used a coffee table and an armchair; besides, he was in a position bent forward and twisted. Furthermore, the distance between the armchair and the table was long, which caused an awkward position. - A total of 39.6% (n = 21) of the students had score 5 or larger, while 60.4% (n = 32) had scores below 5.		*
				Sum	6	5

Discussion

Objective 1. To determine the prevalence of MSDs and their relationship with the COVID-19 pandemic: Results of the review showed that over two-thirds of the students used smartphones for 7 hours per day during the lockdown [10], and about half of them used DDs for over six hours per day [19, 20]. Besides, discomfort was reported to be significantly associated with the long-term use of e-devices during the lockdown [10]. Furthermore, the duration of smartphone use during the quarantine was found to be associated with MSDs among the students who attended online classes for over 4 hours per day and more than 40 minutes (duration) [10].

Based on the results of the review of different studies, the range of the prevalence of MSDs reported in the neck, shoulders, upper and lower back, and wrists among the students was (24.8-69.9%), (17.5-25.3%), (18-63.4%), and (30.7%), respectively [3, 7, 11, 15, 19]. Some issues resulted in differences in the reported prevalence rates, which included the use of various e-devices, investigation of discomfort using different questionnaires (Nordic, self-designed, and modified Nordic questionnaires), diverse age groups from elementary to university students, and different educational levels. Besides, other reasons included different countries of the studies, multifarious environmental conditions, and the use of workstations, such as sofas and dining chairs instead of desks and chairs suitable for studying.

Objective 2. To determine MSD risk factors among the students: While the majority of the students worked in a sitting position for 5-7 hours per day, only 5% of them were aware of correct postures, and laptop ergonomics [15]. In fact, some factors, including long-term use of gadgets, unawareness of ergonomic principles among parents and students [15], prolonged sitting in awkward postures, use of improper tables and adoption of awkward postures, [21] number and duration of online classes per day (> 6 hours per day) [10, 22], lack of breaks during the study time between online classes, and extraocular symptoms had a serious impact on MSDs in the back, wrists, and hands of the students [10, 15, 22-24].

In facts, poor ergonomics, including the placing of the screen on the left or right side of one's vision, awkward sitting postures, cold environments, and previous back problems had significant effects on neck and back pain [10].

The review also showed that the lack of training in ergonomics at schools or universities and the lack of correct knowledge of ergonomics had a significant effect on developing MSDs among the students [15]. Moreover, similar studies among the general population showed that the low screen of e-devices caused neck flexion, leading to neck pain if practiced for a long time [24]. Research stated that discomfort in students' wrists might be caused by the the extended use of cellphones [3]. In addition, research reported pain in the shoulder and upper back of the academic community who used laptops on the sofa and in bed, having been due to high muscle activity at a low height [25].

Based on the studies included, inappropriate monitor levels and maintaining the head and neck by muscles while focusing on the screen could exert compression on the cervical spine, thereby causing pain [15]. It has been reported that the upright neck position puts less pressure on cervical discs by 10 kg than the neck-forward flexed posture. Accordingly, the flexed neck posture can cause muscle strain in adjacent tissues [12]. Accordingly, prolonged static positions and poor ergonomic conditions exert stress on scalene muscles [26].

In a study, static postures in the shoulder and back while working with e-devices caused muscle contraction in the shoulders and arms; in addition, it exerted high pressure on inter-vertebral discs and the lumbosacral spine, thereby causing pain in those areas among students [15]. A similar study among school students reported that prolonged static positions and poor ergonomic conditions caused stress on trapezius muscles [26].

The repetitive clicking of the mouse, typing on the keyboard, touching the screen, as well as touching the keyboard with palms and wrists caused micro-trauma in fingers, hands, and wrists, which eventually caused pain in those areas as well as Carpal and Guyon's canal syndrome. In addition, having no proper mouse pad when working led to wrist flexion, thereby increasing the risk of discomfort [15].

A systematic review by Bettany et al on programs for the promotion of awareness of back health, ergonomic principles, and postural behavior among school students aged 4 to18 reported that students' awareness of awkward postures as well as health effects of working with e-devices played a crucial role in preventing and decreasing the risk of painful syndromes of MSDs. In addition, they reported that training programs on ergonomics and correct postures through distance education for students could upgrade their ergonomic knowledge, due to boosting their exercise behavior and physical activity [27].

Environmental ergonomic factors at home, such as the lack of environmental light, indirectly affect inappropriate postures and subsequent MSDs. Realyvásquez et al reported that one-third of

students worked under appropriate environmental conditions during the study and online classes [11].

Objective 3. To Adopt corrective measures to reduce MSDs among the students: This review showed that principles of workplace ergonomics and lifestyle management strategies should be included in training curricula of students to prevent the occurrence of inevitable problems in the future [15].

The adoption of correct postures can create an opportunity for reducing MSDs [21]. Workplace adjustments of appropriate postures while working with PCs and laptops, proper provision of workplace lighting, use of suitable chairs with a backrest, as well as use of a keyboard and a mouse separately and commensurate with ergonomic principles can help prevent MSDs. Accordingly, the keyboard must be placed at the elbow height, a suitable distance must be kept between the edge of the desk and the keyboard slot, a proper mouse should be used in terms of size and shape, the mouse should be well reachable without stretching one's body, and the mouse and the keyboard should be on the same level. Besides, the desk should be of proper height to conveniently reach items, the copy holder and the monitor must be placed directly in front of the person, a footrest should be provided, the viewing angle must be 15-20º relative to the center of the screen, screen time should not be very long, and distance from the monitor must be suitable; additionally, proper sitting durations, breaks during work, and physical activity can be very effective in reducing MSDs while working with e-devices among students [15].

According to the reviewed studies, compliance with ergonomic principles of using e-devices can reduce severe pain in the upper and lower back, the neck, and shoulders by about one-fifth [15].

Proper sitting durations, using smartphone and tablet holders, holding one's head straight when looking at the screen without bending forward, taking regular breaks after prolonged sitting, and reducing training time by teachers in online classes can help keep students healthy. Moreover, regular muscle exercise (at least 15 minutes at the end of work) and frequent proper posture changes when working with smartphones and tablets can be effective in preventing health problems caused by e-devices among students [15].

Furthermore, proper number and duration of classes per day (3-6 online classes, maximum class length of 2-4 hours per day), proper length of each class (< 40 min), and breaks between classes (10-20 minutes) are required to promote students' retention capacity and decrease their health problems [10]. Additionally, a proper place should be considered for online classes at home, a suitable table and chair must be used at home, and e-devices must be placed within the optimal viewing distance [10, 21].

On the other hand, suitable physical activity should be taken into consideration for health promotion and improvement of the quality of life among students. The results of the study by Leirós-Rodríguez et al showed that the frequency and type of physical activity could reduce musculoskeletal pain among university students [7]. Thus, taking at least 150 minutes of exercise of moderate intensity and 75 minutes of exercise of high intensity per week is recommended for a healthy life [28]. Besides, it is recommended that software be installed to remind you of frequent short breaks in the sitting posture [15], which plays an important role in changing postures.

Based on a study by Vargas et al, an ergonomically designed study environment for online classes in terms of temperature (20-24°C), noise, and light control improved academic performance, reduced distraction levels, and increased comfort among students [11]. Besides, Soltaninejad's study showed that adhering to ergonomic principles in educational spaces could increase comfort, concentration, performance, efficiency, and quality of learning, yet it decreased anxiety and stress among students. Proper lighting can improve vision as well as the ability to perceive visible information among students [1]. In addition, providing suitable wellbeing conditions and adequate light (250-500 lux) reduced awkward postures as well as consequent disorders and pain, thereby improving reading, writing, and learning skills [11].

One of the limitations of this study was inaccessibility of some databases and full-text articles. Thus, some relevant articles might have been missed in our search. In the studies reviewed, the detailed assessment results of school and college students' working postures, while using e-devices via ergonomic methods, were not given. Therefore, it is necessary to take this issue into account in future research. In addition, for future research, it is suggested that the effectiveness of increasing awareness of ergonomic principles and environmental conditions among parents and students be investigated in affecting awkward body postures and reducing MSDs when using e-devices.

Conclusion

The results of this study showed that about half of the students used DDs for over six hours per day during the lockdown. However, only a total of 5%

or less of the students and parents were informed of the ergonomic principles of working with e-devices. Risk factors associated with using e-devices included prolonged sitting in awkward postures, number and duration of online classes per day (> 6 hours per day), and lack of breaks between online classes, having had significant effects on ergonomics, postures, and the resulting musculoskeletal MSDs among the students (neck pain: 24.8-69.9%; shoulder pain: 17.5-25.3%; upper and lower back pain: 18-63.4%; wrist pain: 30.7%, during the COVID-19 pandemic). Accordingly, increasing students' knowledge, using ergonomic tables and chairs, designing correct workplace layout, using stands for smartphones and tablets, reducing training durations, providing suitable environmental conditions, maintaining ideal distance, installing break reminder software, and taking adequate exercise can effectively reduce musculoskeletal pain among students.

Conflict of interest: None declared.

References

1. Soltaninejad M, Babaei-Pouya A, Poursadeqiyan M, Feiz Arefi M. Ergonomics factors influencing school education during the COVID-19 pandemic: A literature review. Work. 2021;68(1):69-75.
2. Sivertsen B, Vedaa Ø, Harvey AG, Glozier N, Pallesen S, Aarø LE, Lønning KJ, Hysing M. Sleep patterns and insomnia in young adults: A national survey of Norwegian university students. J Sleep Res. 2019;28(2):e12790.
3. Majumdar P, Biswas A, Sahu S. COVID-19 pandemic and lockdown: cause of sleep disruption, depression, somatic pain, and increased screen exposure of office workers and students of India. Chronobiol Int. 2020;37(8):1191-200.
4. Binboğa, E., Korhan, O. Posture, Musculoskeletal Activities, and Possible Musculoskeletal Discomfort Among Children Using Laptops or Tablet Computers for Educational Purposes: A Literature Review. J Sci Educ Technol. 2014;23(5):605-16.
5. Regiani Bueno G, Garcia LF, Marques Gomes Bertolini SM, Rodrigues Lucena TF. The Head Down Generation: Musculoskeletal Symptoms and the Use of Smartphones Among Young University Students. Telemed J E Health. 2019;25(11):1049-56.
6. Karingada KT, Sony M. Demonstration of the relationship between MSD and online learning during the COVID-19 pandemic. J Appl Res High Educ. 2021;14(1):200-22.
7. Leirós-Rodríguez R, Rodríguez-Nogueira Ó, Pinto-Carral A, Álvarez-Álvarez MJ, Galán-Martín MÁ, Montero-Cuadrado F, Benítez-Andrades JA. Musculoskeletal Pain and Non-Classroom Teaching in Times of the COVID-19 Pandemic: Analysis of the Impact on Students from Two Spanish Universities. J Clin Med. 2020;9(12):4053.
8. Elsiddig AI, Altalhi IA, Althobaiti ME, Alwethainani MT, Alzahrani AM. Prevalence of neck and shoulder pain among Saudi universities' students who are using smartphones and computers. J Family Med Prim Care. 2022;11(1):194-200.
9. Chetty V, Munsamy A, Cobbing S, van Staden D, Naidoo R. The emerging public health risk of extended electronic device use during the COVID-19 pandemic. S Afr J Sci. 2020;116(7-8):1-2.
10. Singh HK, Joshi A, Malepati RN, Najeeb S, Balakrishna P, Pannerselvam NK, Singh YK, Ganne P. A survey of E-learning methods in nursing and medical education during COVID-19 pandemic in India. Nurse Educ Today. 2021;99:104796.
11. Realyvásquez-Vargas A, Maldonado-Macías AA, Arredondo-Soto KC, Baez-Lopez Y, Carrillo-Gutiérrez T, Hernández-Escobedo G. The impact of environmental factors on academic performance of university students taking online classes during the COVID-19 pandemic in Mexico. Sustainability. 2020;12(21):9194.
12. Kim MS. Influence of neck pain on cervical movement in the sagittal plane during smartphone use. J Phys Ther Sci. 2015;27(1):15-7.
13. Shah PP, Sheth MS. Correlation of smartphone use addiction with text neck syndrome and SMS thumb in physiotherapy students. Int J Community Med Public Health. 2018;5:2512-6.
14. Agarwal S, Bhartiya S, Mithal K, Shukla P, Dabas G. Increase in ocular problems during COVID-19 pandemic in school going children- a survey based study. Indian J Ophthalmol. 2021;69(3):777-8.
15. Choudhary MSB, Choudary AB, Jamal S, Kumar R, Jamal S. The Impact of Ergonomics on Children Studying Online During COVID-19 Lockdown. J Adv Sport Phys Educ. 2020;3(8):117-20.
16. Khan S, Khan S, Midya MZ, Khan IJ, Raghib M. Comparison of Prevalence Data about Digital Eye Strain (DES), Pre-Lockdown versus Post-Lockdown Period in India: A Systematic Review Study. Int J Res Rev. 2021;8(5):59-68.
17. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JP, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. J Clin Epidemiol. 2009;62(10):e1-34.
18. Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic review or scoping review? Guidance for authors when

choosing between a systematic or scoping review approach. BMC Med Res Methodol. 2018;18(1):143.
19. Dey S, Dey I. Health concerns during lockdown: an observational study among adults of West Bengal. Int J Community Med Public Health. 2020;7(9):3674-8.
20. Gammoh Y. Digital Eye Strain and Its Risk Factors Among a University Student Population in Jordan: A Cross-Sectional Study. Cureus. 2021;13(2):e13575.
21. Boatca M-E, Robescu D, Corlan R, Mirea N. Education in times of covid-19: are students learning in ergonomic conditions?. MATEC Web Conf. 2021;342.
22. Ganne P, Najeeb S, Chaitanya G, Sharma A, Krishnappa NC. Digital Eye Strain Epidemic amid COVID-19 Pandemic - A Cross-sectional Survey. Ophthalmic Epidemiol. 2021;28(4):285-292.
23. Gupta R, Chauhan L, Varshney A. Impact of E-Schooling on Digital Eye Strain in Coronavirus Disease Era: A Survey of 654 Students. J Curr Ophthalmol. 2021;33(2):158-64.
24. Ahmed S, Akter R, Islam MJ, Muthalib AA, Sadia AA. Impact of lockdown on musculoskeletal health due to COVID-19 outbreak in Bangladesh: A cross sectional survey study. Heliyon. 2021;7(6):e07335.
25. Intolo P, Shalokhon B, Wongwech G, Wisiasut P, Nanthavanij S, Baxter DG. Analysis of neck and shoulder postures, and muscle activities relative to perceived pain during laptop computer use at a low-height table, sofa and bed. Work. 2019;63(3):361-367.
26. Maekawa M, Yoshizawa E, Hayata G, Ohashi S. Physical and psychological effects of postural educational intervention for students experienced school refusal. Curr Psychol. 2021:1-10.
27. Bettany-Saltikov J, McSherry R, van Schaik P, Kandasamy G, Hogg J, Whittaker V, et al. PROTOCOL: School-based education programmes for improving knowledge of back health, ergonomics and postural behaviour of school children aged 4-18: A systematic review. Campbell Syst Rev. 2019;15(1-2):e1014.
28. Rodríguez MÁ, Crespo I, Olmedillas H. Exercising in times of COVID-19: what do experts recommend doing within four walls? Rev Esp Cardiol (Engl Ed). 2020;73(7):527-9.