REVIEW PAPER

JMS Journal of Medical Science

The possible negative effects of prolonged technology-based online learning during the COVID-19 pandemic on body functions and wellbeing: a review article

Shimaa Mohammad Yousof
Associate Professor of Medical Physiology, Faculty of Medicine, King Abdulaziz University, Rabigh, Saudi Arabia; Department of Histology, Faculty of Medicine, Suez Canal University, Ismailia, Egypt
https://orcid.org/0000-0002-5996-8919
Corresponding author: smabrahem@kau.edu.sa

Rasha Eid Alsawat
King Abdulaziz University, Rabigh, Saudi Arabia

Jumana Ali Almajed
King Abdulaziz University, Rabigh, Saudi Arabia
–

Ameera Abdulaziz Alkhamesi
King Abdulaziz University, Rabigh, Saudi Arabia
–

Renad Mane Alsuhaimi
King Abdulaziz University, Rabigh, Saudi Arabia
–

Shrooq Abdulrhman Alssed
King Abdulaziz University, Rabigh, Saudi Arabia
–

Iman Mohmad Wahby Salem
Professor of Community Medicine, Saudi Arabia, King Abdulaziz University, Rabigh; Community Medicine Department, Al Azhar University, Egypt
–

DOI: https://doi.org/10.20883/medical.e522

Keywords: COVID-19, pandemics, technology-based learning, smartphones, tablets, body functions, cognitive function, sleep, headache, life style, food habits, earphones, headphones, eye fatigue, low back pain

Published: 2021-09-03

How to Cite: Yousof SM, Eid Alsawat R, Ali Almajed J, Abdulaziz Alkhamesi A, Mane Alsuhaimi R, Abdulrhman Alssed S, Salem IMW. Impacts of prolonged online learning practice during COVID-19 epidemic on body functions and wellbeing: a review article. Journal of Medical Science. 2021 Sep. 3;90(3):e522. doi:10.20883/medical.e522

ABSTRACT

The COVID-19 pandemic has had impact on life on a global scale, however, one of the most affected aspects are the teaching and learning practices. Advances in technology have made distance learning a good alternative option for on-site learning, as students can both interact with one another and with the tutor, use audio, video, text to learn, as well as use the internet for research purposes. However, this mode of education will extend throughout 2020 and early 2021, which could have negative implications on the health and body functions of university students. This review aims to shed light on the negative consequences of the prolonged technology-based, remote online learning on the students' wellbeing. Therefore, in this review we will discuss some of the physiological functions and body systems which could be affected during the COVID-19 pandemic in an attempt to suggest preventive measures in advance for safe technology-based learning.

Introduction

COVID-19 is a highly infectious disease transmitted through close contact, occurring due to infection with acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Since the outbreak of the disease, it has affected the entire world and resulted in millions of deaths [1]. Internet-based learning is an academic method of distance education that has become common in the wake of the COVID-19 pandemic [2,3]. Moreover, advances in technology have greatly facilitated student-teacher communication in the teaching process. This stems from the fact that students can interact with each other and with the teacher, use audio-visual and text messages in addition to using the internet for research, especially during of the COVID-19 pandemic [4].

The pandemic-related lockdown was double-bladed in regard to university students. This may be attributed to the positive attitudes which have developed in students, particularly students of medicine, towards their communities. In fact, a number of medical students in various countries have volunteered to assist in the ventilation therapy, and to help the nurses in the health care practice during the pandemic. Their participation met with encouragement and gratitude from their colleagues and families, which was subsequently enthusiastically welcomed by the students [5,6]. Another positive aspect which emerged in the course of the pandemic is the students' involvement in the support of vulnerable groups, as well as in the COVID-19-related research practice [7]. Additionally, the learning practice has granted college students more time for studying instead of attending classes nearly every day, which in turn, has been positively reflected on their academic performance and grades [2].

In spite of the positive aspects that have been documented in many countries in response to COVID-19 pandemic emergency, there are certain drawbacks and negative consequences of the quarantine which may affect the learner's health. For instance, students have received their education on-line, seated in front of their laptop screens, mobile phones, or computers at their homes [8]. Notwithstanding the benefits of this technology-based remote education, this method presents several disadvantages, in particular as its effects may only appear following a long period of using technology [9]. Even though electronic devices may be equipped with cutting-edge display technology, looking at the screens of smart mobile devices can lead to severe vision strain and pain [10]. Furthermore, it is worth bearing in mind that excessive smartphone use has been linked to mental, cognitive, emotional, physiological, and neurological alterations, which should be taken into account [11]. In South Korean adolescents, excessive smartphone use was associated with impaired family and friendship relationships, impulsiveness, and low self-esteem. In fact, the studies demonstrate that individuals who use smartphones extensively present with poor concentration, diminished numeric processing skills, increased impulsivity, hyperactivity, and negative social involvement [11].

Therefore, in this review, we aim to highlight the negative consequences of technology-based learning on body functions during the pandemic. The underlying aim is not to incriminate new technology, but rather to identify the possible complications, and thus to prevent the side effects early, in order to maximize the benefits of modern technology in teaching and learning. A summary comparison regarding the advantages and disadvantages of online technology-based learning is shown in **Figure 1.**

Methods

In this narrative review, we used PubMed/Medline and google scholar as search engines for the studies related to our topic in the last 10-year period (2010–2021), as well as the related literature which appeared in the last 20 years. Moreover, a search via the related studies on PubMed has been performed. The keywords which have been used were as follows: "headphones or earphones or tablets or smartphones or technology-based learning, or online learning" and "tinnitus, otitis media, hearing loss, noise-induced hearing loss, telecom workers, infection, hyperacusis, asthenopia, eye strain, myopia, headache, migraine, sleep, memory, cognitive impairment, dietary habits and lifestyle". A summary of the possible negative consequences of prolonged technology-based learning is presented in **Table 1.**

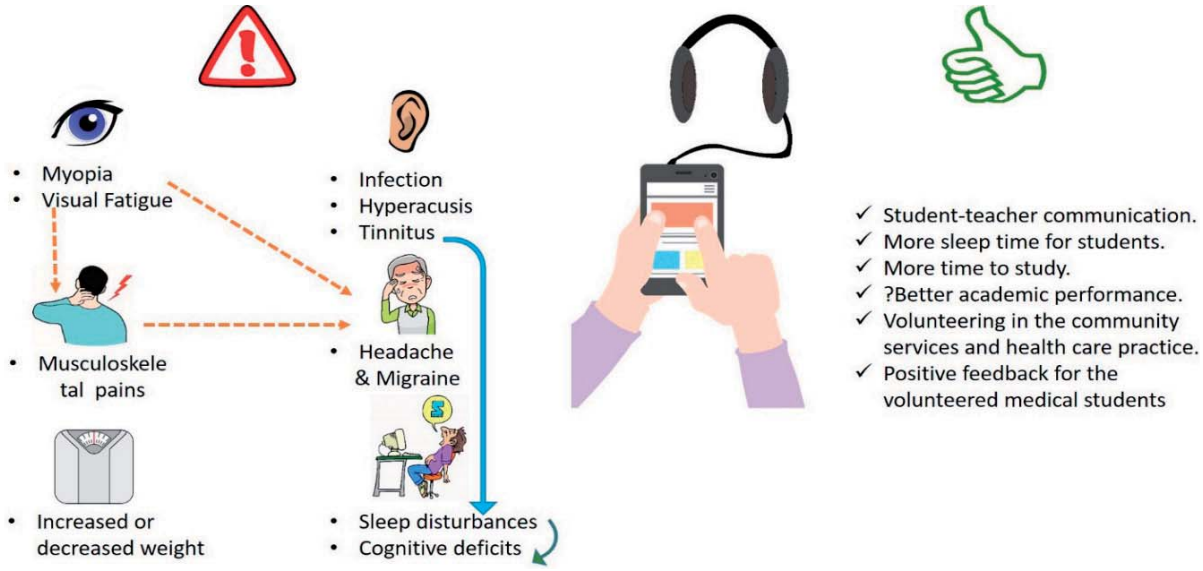

Figure 1. This graphical abstract shows the advantages and disadvantages of technology-based learning. Although there are numerous benefits of online learning, as demonstrated on the right-hand side of the figure, it is vital to note it may also negatively affect body functions as presented on the left-hand side of the figure. Additionally, certain disadvantages may result in other negative aspects, e.g. in tinnitus which, when severe, can lead to disturbed sleep. In fact, sleep disturbances are a known cause of cognitive and memory deficits. Moreover, visual fatigue increases the strain on the neck and shoulder, leading to pain, and may eventually cause headaches

Table 1. The possible negative effects of the technology-based learning on body organs and functions

Body Organ	Effects	References
Eyes	Blue light: toxic to photoreceptors.	[15,17]
	Asthenopia +/- corneal epithelial damage, conjunctival hyperaemia and a decrease in visual acuity.	[12]
	Affected posture control system.	[16,17]
	Computer Vision Syndrome.	[18]
	Tired, sore/aching, irritated, watery, and hot/burning eyes.	[10]
	Reduced blink rate and amplitude.	[21]
	Myopic shift.	[18]
Ears	Hearing loss.	[28]
	Tinnitus.	[31]
	Ear Infections.	[32]
	Hyperacusis.	[33]
Musculoskeletal system	Neck and shoulder pain.	[36]
	Tendonitis and carpal tunnel syndrome.	[37–39]
Sleep	Sleep disorders and anxiety.	[44]
	Memory and cognitive disturbances.	[46,47]
	Increased sleep time.	[48]
	Poor sleep quality.	[49]
Food habits and body weight changes	More frequent cooking instead of fast food consumption.	[53]
	Weight gain or weight loss.	[48,52]
Headache and migraine	Increased incidence of headache and migraine.	[58,59]
	Increased prevalence of aura.	[59]

Effects on the Eye

Smartphones have been widely used nowadays not only for telecommunication, but also as a means of learning, playing games, and social communication on the internet [12]. In fact, millions of students use computers and mobile phones also for learning, in addition to other daily uses, such as entertainment and social communication, particularly during the COVID-19

pandemic and the lockdown [13]. Interestingly, smartphones emit blue light which negatively affects the eyes [14], therefore, their prolonged use could result in vision damage, since blue light is highly toxic, due to the fact that it has a shorter light wavelength than other colors, and hence can damage the receptor cells [12,15].

Asthenopia, Visual Acuity, and Blink Rate

Asthenopia (eye fatigue or strain) constitutes one of the conditions which affects the eyes as a result of a long-term daily use of computers and tablets. It may be accompanied by such symptoms as corneal epithelial cell damage, conjunctival hyperemia, and a decrease in visual acuity [12]. Moreover, prolonged visual fatigue can negatively affect visual feedback processing and the posture control system, which is associated with the integration disorders between the visual feedback, the vestibular organs, and the somatosensory control [16,17]. In fact, studies demonstrate the emergence of "Computer Vision Syndrome; CVS" which affects more than 60 million people worldwide. This syndrome comprises symptoms including asthenopia, sensitivity to light, blurred vision, itchy eyes, and the sensation of a foreign body in the eye [18]. Moreover, the results have shown that visual fatigue is significantly increased if persons look at computer screen, or a tablet for 1 hour, even though these screens are equipped with state-of-the-art technology [10]. Another study has reported that the symptoms of CVS are common among health sciences students at King Saud Bin Abdulaziz University for Health Sciences (KSAUHS) in Jeddah, who use a variety of technological devices. Interestingly, female students, both observing the display glare and those wearing glasses, were considerably more likely to experience CVS symptoms. On the other hand, long-term device use has not been associated with an increase in the severity of CVS symptoms [19]. Nevertheless, another study involving adults (20–26 years old) has demonstrated that using computers has more adverse effects on the ocular surface and the tear film when compared with smartphones [20].

Blink rate data associated with smartphone and tablet use are contradictory, and may possibly be related to the complexity of the measurement, whereas research on blink amplitude is scarce. Blink rate and amplitude are frequently observed to be reduced when using a computer. Furthermore, digital devices, such as PCs, may also have a negative impact on tear stability. Although tear volume is reduced with computer use, there is little evidence to substantiate the impact of mobile devices on tear volume. In fact, the current literature does not present a definitive link between variations in binocular vision, blinking, or the ocular surface with ocular and visual discomfort complaints reported in relation to the use of hand-held digital devices [21]. However, as pointed out in the studies, 1 hour of using smart mobile phones increased the mean total asthenopia score from 19.59 8.58 to 22.68 9.39 ($p = 0.001$). Besides, looking at a smartphone screen substantially increased the ratings for five factors (tired eyes, sore/aching eyes, irritated eyes, watery eyes, and hot/burning eye). Considering the expanding openness to PC shown in everyday life, more rules and investigations are expected in order to maintain visual wellbeing [10].

Myopic Shift

Myopic shift is one of the most prominent effects following prolonged computer and mobile phone use, and is the consequence of a long-term effort to adapt to the constant use of laptops [18]. Myopia is a condition in which the patient can see the near objects clearly, but not the distant ones. In turn, myopia can later lead to further complications, such as retinal detachment and cataracts [22]. It is worth bearing in mind that mobile devices differ from desktop computers in terms of the location and viewing distance, screen size and brightness, as well as with respect to user behaviour. When using mobile devices, eye accommodations change with greater latency and less amplitude, whereas when using smartphones and tablets, fusion convergence is lower and the near convergence point may recede [21]. Decreased physical activity and an increased use of screen devices contributes significantly to the reported 25% prevalence of myopia in the group of healthy young individuals (16–17 years of age). Decreased physical activity for less than 3 hours per week, or using screen devices for more than 6 hours per day are more likely to contribute to myopia. Therefore, taking the abovementioned findings into account, it seems that physical activity may be a protective factor for myopia in teens [23].

Effects on the Ears

Distance education can also affect hearing and ears, particularly in view of a long-term use of headphones. Nevertheless, there are a limited numbers of studies which have described the effects of long-term headphone use on hearing in adolescents and young adults. However, certain studies have reported on the side effects of long-term headphone use by the telecom services employees, as well as on music-induced hearing impairments in young adults [24,25].

Hearing loss

Hearing loss constitutes one of the most common communication issues in the 21st century, and it is a public health concern, since it impairs students' interaction, student achievement, and quality of life. According to the studies, the prevalence ranged from 0.88% to 46.70% [26]. Notably, Mazlan et al. have reported that 21.2% of their study population suffered from hearing impairment. Nevertheless, they have found an insignificant association between hearing loss and exposure to sound during headphone use, which stemmed from the fact that the high frequencies were uninvolved [27]. On the other hand, a Japanese study has reported that employees who use earphones in noisy workplaces may be exposed to noise-induced hearing loss (NIHL) risk factors, such as failure to use appropriate headphones or earphones, and the exposure to sound pressure from the earphones above the occupational exposure limit (Nakao et al. 2014). Similarly, in a study on adolescents, the researchers have found that a large percentage of the study population (79%) used portable music devices, and nearly half used them for prolonged periods of time. This population study indicated the incidence of hearing complaints, such as the need to repeat utterances and to increase TV volume, as well as tinnitus [28]. Another study has been conducted in Poland and found noise-related symptoms in telecom employees [24]. The authors of this study recommended further research related to the use of headphones by the employees due to a limited number of studies addressing this issue [24,27]. Although the aforementioned studies did not focus on the use of headphones or earphones by students, they indicate the possible negative aspects of their long-term use.

Tinnitus

Tinnitus is the sound perceived in the ear as ringing, buzzing, whistling, occurring constantly or intermittently. Severe tinnitus can lead to anxiety, depression, irritability, sleep disturbances, stress, and sometimes, psychological counselling is necessary [29]. An interesting study has described the effects of different types of music (discos, concerts, and listening to music on headphones) on adolescents (14–18 years old) of both sexes. The researchers reported that 69% of students suffered from tinnitus after listening to different types of music. The females were more affected, and complained of tinnitus more frequently (41% females vs 27% males) [30]. Furthermore, in a Nigerian study on college students of medicine similar results were obtained. The study reported that the prevalence of earphone use and perceptual tinnitus among undergraduates were 95.6% and 20.6%, respectively. Over 90% of earphone users had used them for three to six years [31]. These results indicate the need to develop guidelines for headphones and earphones use by the students with regard to the type of instruments, the amplitude and frequency of the sounds generated, and the headphones are used.

Ear infections

Otitis and ear infections are other side effects which could result from wearing headphones [27]. These conditions are caused by the closure of the ear canal by the headphones, which prevents airflow to the ear,thus increasing the chance of ear infection. Additionally, the long-term use of earphones may lead to the growth of bacteria inside, which in turn leads to infection [32]. In a study assessing the effect of prolonged use of headphones in Customer Service Representative in Malaysia, it has been found that some subjects have suffered from chronic middle ear infections, whereas others suffered from a cerumen build-up [27].

Hyperacusis

Hyperacusis is one of the side effects of long-term headphones use. It is one of the auditory disorders characterized by extreme sensitivity to certain sound frequencies, which include everyday sounds, although the degree and the type of injury vary. Some patients find loud sounds highly uncomfortable in general, others complain when hearing a certain sound, whereas some may suf-

fer when hearing normal sounds. Therefore, this condition may not cause great inconvenience for some patients, although it may negatively affect the lives in another group [33].

Effects on the Musculoskeletal system

Incorrect body posture and position may result in actual medical issues [34]. In the 1990s and early 2000s, a significant increase in the prevalence of neck and shoulder pain (NSP), as well as in the low back pain (LBP) among young people was reported, where the use of the internet and new communication technologies constituted the vital risk factors [35]. Neck and shoulder pain has been considered as a mild musculoskeletal disorder to some extent, and performing excessive homework and incorrect sitting positions have been frequently described as predisposing factors for neck and shoulder pain among students [36]. Due to the fact that many students use their computers for long periods of time to maintain their grades, often without providing a convenient place at home, distance learning may contribute to pain and injury, and could subsequently lead to more severe injuries. Incorrect posture while sitting may cause discomfort, accompanied by pain which could develop within a short period of time. More severe repetitive stress injuries, such as tendonitis and carpal tunnel syndrome may develop in the course of months. It is also worth bearing in mind that remote learning during the COVID-19 pandemic involves students spending more time at computers, frequently at home which may not be as well prepared as a classroom [37–39].

Computer-related activities are an independent risk factor for NSP and LBP. The use of computers for more than 2 to 3 hours daily may be considered as a potential risk for developing NSP, whereas spending more than 5 hours in front of a computer is a risk factor of LBP [35,40]. Considering the physical problems potentially caused by prolonged computer use for online tasks or for remote learning, neck pain has been linked to a low or high screen position and to a maladjusted keyboard. In turn, symptoms associated with shoulder joints have been associated with high screen positioning and shoulder elevation in individuals using a computer mouse. Daily use of a keyboard for four hours or more has been connected with shoulder and wrist pains, although not with neck pain. Moreover, work in front of monitors for more than 15 hours per week is considered a significant risk factor for NSP. Significant reductions in musculoskeletal discomfort in the shoulder, neck and upper back areas have been observed following correct positioning of computer users [35,41,42]. Based on the above findings, it is clear that proper positioning of computers and related equipment is essential to prevent LBP and NSP. Furthermore, time spent using the technology should be minimised, or at least include periods of rest and physical activity while studying.

Sleep Disturbances

Sleep cycle regulation is obtained by means of the circadian rhythm, also referred to as the sleep/wake cycle. The circadian rhythm is the brain's internal clock within the 24-hours which maintains the regularity of awakening, and sleepiness cycles via reacting to environmental light changes. Furthermore, both the body's physiology and behaviour are affected by the rotation of the earth around its axis. The significance of the circadian rhythm is rooted in its role in adapting to environmental changes and anticipating the changes in temperature, radiation and food availability [43].

Sleep Lack and Cognitive Impairments

Long-term mobile use has been associated with an increase in sleep disruptions and anxiety, which was alleviated when device use ceased [44]. Insufficient sleep affects memory, recall, and judgment, as well as fine motor skills. During sleep, the body rests while the brain is involved in memory processing. Therefore, a lack of sleep increases the liability of medical conditions involving obesity, hypertension, and diabetes [45,46]. Moreover, imaging and behavioural studies refer to the crucial role sleep plays in the process of learning and memorizing, with researchers claiming that a lack of sleep impairs the ability to focus and to learn effectively. Additionally, they have reported that sleep is essential for memory consolidation to occur, so that information can be recalled in the future. A study where

participants who were subject to sleep deprivation demonstrated that they were more prone to think they were correct when they were, in fact, wrong [46,47]. In contrast, a study on medical students in Croatia has found that the period of lockdown positively affected sleeping time, which was reflected by an increased time of sleep (+1.5 hrs.) and, therefore, improved the sense of refreshment following awakening [48].

Sleep Quality

According to a Chinese study, excessive smartphone use has been associated with poor sleep quality in a group of Chinese university students from a health vocational institution. Nevertheless, due to the study's limited sample representativeness and cross-sectional nature, the researchers recommended conducting large-scale prospective representative research to confirm these relationships [49]. Another study demonstrated that looking at a mobile phone screen for 8 hours or longer in a 24-hour period, or using the mobile phone for at least half an hour before sleep after turning off the lights and keeping the mobile near the bed lead to poorer sleep quality. Additionally, researchers have also found that mobile-related sleep risk factors are common among mobile phone users [50]. In fact, limiting cell phone use before sleep has been shown to decrease sleep latency and pre-sleep arousal and thus improve sleep duration and working memory. Therefore, moderate cell phone use is recommended for subjects with sleep disturbances [51].

Food Habits and Body Weight Changes

The lockdown obliged people to stay at home for long periods of time, and consequently resulted in changes in their dietary habits [52]. The availability of fresh food has been limited since the onset of the COVID-19 pandemic, with customers spending more time indoors and limiting their physical activity. On the other hand, spending more time at home may have generated some positive outcomes, such as more frequent cooking instead of eating fast food [53]. Nevertheless, online learning for long periods of time and reduced physical activity in the COVID-19 pandemic may have led to weight gain and its subsequent consequences. Additionally, it is important to note that even when daily caloric intake is maintained, reduced physical activity may lead to an increase in body weight [54].

In their study, Sidor and Rzymski have described the observed changes in dietary habits and food choices during the COVID-19 pandemic lockdown. According to their research, more than 43.0% of persons reported eating more, and about 52% and were snacking more. Moreover, these changes were observed to be higher in overweight and obese individuals. Nearly 30% of the study population have suffered from an increased body weight (mean ± SD 3.0 ± 1.6 kg). However, more than eighteen percent have suffered from weight loss (−2.9 ± 1.5 kg). Interestingly, the researchers have found that weight gain was more often present in overweight, obese, and older participants (36–45 and > 45), whereas weight loss was more frequent in underweight individuals [52]. An interesting study on the medical students in Croatia has assessed the changes in the lifestyle and food habits before and during the COIVD-19 related lockdown. The researchers have observed a change in eating habits which involved an increased consumption of fruits, legumes, sweets, and fish. In contrast, the consumption of dairy products and white cereals was decreased. Additionally, 19% of students have noticed weight gain, whereas about 30% have observed weight loss during lockdown [48].

Headache and Migraine

In migraine sufferers, using a smartphone has been shown to increase the time of headaches. In fact, its excessive use in migraine sufferers has been associated with poor sleep quality and daytime sleepiness [55]. Moreover, the visual problems have been shown to be a risk factor for developing headaches, as well as head and neck pains. An additional factor is the lack of vision correction, which increases the strain on the visual system and head and neck muscles [56,57]. Young adults with extensive exposure to screens are more likely to suffer from migraine, although no association was identified between screen exposure and non-migraine headache [58]. On the other hand, another study that included 400 patients with recent onset headache and/

or patients with primary severe headache who were and were not smartphone users found different results. According to the study, a higher prevalence of aura was found in the smartphone user group compared to non-smartphone users (7.7% vs 17.5%; p = 0.003), although headache characteristics were similar in both groups. In addition, the researchers determined that smartphone use was associated with a greater need for pain medication and a shorter period of relief following medication administration. However, they recommended a longitudinal study to confirm these findings.[59].

Conclusion

The sudden change to remote online learning was necessary during the COVID-19 pandemic in order to fulfil the needs of the learning process and to simultaneously avoid infection. However, prolonged time spent in front of screens, laptops and computers can have an adverse effect on students' health and body functioning in the future. Therefore, urgent and prompt health education programmes for students are required aiming at increasing their awareness on how to maintain a healthy body during the online learning process.

Abbreviations

CVS: Computer Vision Syndrome; KSAUHS: King Saud Bin Abdulaziz University for Health Sciences; LBP: low back pain; NIHL: Noise-induced hearing loss; NSP: Neck–shoulder pain.

Acknowledgements

Conflict of interest statement
The authors declare no conflict of interest.

Funding sources
There are no sources of funding to declare.

References

1. Mishra L, Gupta T, Shree A. Online teaching-learning in higher education during lockdown period of COVID-19 pandemic. Int J Educ Res Open. 2020;1:100012.
2. Albeladi FI, Yousof SM, Omar N, Tash R. The outcome of the online virtual classes during COVID-19 pandemic: A study in the female campus of the faculty of medicine in Rabigh-King Abdulaziz University. Medknow Publications; 2021 [cited 2021 Jul 24]; Available from: https://www.jmau.org/preprintarticle.asp?id=321055;type=0 DOI: 10.4103/jmau.jmau_124_20
3. Kim J. Learning and Teaching Online During Covid-19: Experiences of Student Teachers in an Early Childhood Education Practicum. Int J Early Child. 2020;52:145–58. DOI: 10.1007/s13158-020-00272-6
4. Dhawan S. Online Learning: A Panacea in the Time of COVID-19 Crisis. J Educ Technol Syst [Internet]. 2020 [cited 2021 Mar 30]; Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7308790/ https://doi.org/10.1177/0047239520934018
5. Bazan D, Nowicki M, Rzymski P. Medical students as the volunteer workforce during the COVID-19 pandemic: Polish experience. Int J Disaster Risk Reduct. 2021;55:102109. DOI: 10.1016/j.ijdrr.2021.102109
6. Rasmussen S, Sperling P, Poulsen MS, Emmersen J, Andersen S. Medical students for health-care staff shortages during the COVID-19 pandemic. The Lancet. Elsevier; 2020;395:e79–80. DOI: 10.1016/S0140-6736(20)30923-5
7. Guragai M, Achanta A, Gopez AY, Niyotwambaza J, Cardoso LG, Estavillo NL, et al. Medical Students' Response to the COVID-19 Pandemic: Experience and Recommendations from Five Countries. Perspect Biol Med. 2020;63:623–31. DOI: 10.1353/pbm.2020.0051
8. Mahmood S. Instructional Strategies for Online Teaching in COVID-19 Pandemic. Hum Behav Emerg Technol. 2021;3:199–203. https://doi.org/10.1002/hbe2.218
9. Oliveira M, Penedo A, Pereira V. Distance education: advantages and disadvantages of the point of view of education and society. Dialogia. 2018;139–52. DOI:10.5585/dialogia.N29.7661
10. Kim DJ, Lim C-Y, Gu N, Park CY. Visual Fatigue Induced by Viewing a Tablet Computer with a High-resolution Display. Korean J Ophthalmol KJO. 2017;31:388–93. DOI: 10.3341/kjo.2016.0095
11. Wacks Y, Weinstein AM. Excessive Smartphone Use Is Associated With Health Problems in Adolescents and Young Adults. Front Psychiatry. 2021;12:669042. DOI: 10.3389/fpsyt.2021.669042
12. Park Y-H, An C-M, Moon S-J. Effects of visual fatigue caused by smartphones on balance function in healthy adults. J Phys Ther Sci. 2017;29:221–3. DOI: 10.1589/jpts.29.221
13. Hasan N, Bao Y. Impact of "e-Learning crack-up" perception on psychological distress among college students during COVID-19 pandemic: A mediating role of "fear of academic year loss." Child Youth Serv Rev. 2020;118:105355. doi: 10.1016/j.childyouth.2020.105355
14. Kang S, Hong JE, Choi E jung, Lyu J. Blue-light Induces the Selective Cell Death of Photoreceptors in Mouse Retina. J Korean Ophthalmic Opt Soc. The Korean Ophthalmic Optics Society; 2016;21:69–76. http://dx.doi.org/10.14479/jkoos.2016.21.1.69
15. Jakhar D, Kaul S, Kaur I. Increased usage of smartphones during COVID-19: Is that blue light causing skin damage? J Cosmet Dermatol. 2020;19:2466–7. DOI: 10.1111/jocd.13662

16. Lateiner J, Sainburg R. Differential contributions of vision and proprioception to movement accuracy. Exp Brain Res Exp Hirnforsch Expérimentation Cérébrale. 2003;151:446–54. DOI: 10.1007/s00221-003-1503-8
17. Park HJ, Yi K. Relationship between Middle school Students' Computer using Time and Dry eye. J Korean Ophthalmol Soc. 2015;43:449–54.
18. Bogdănici CM, Săndulache DE, Nechita CA. Eyesight quality and Computer Vision Syndrome. Romanian J Ophthalmol. 2017;61:112–6. DOI: 10.22336/rjo.2017.21
19. Altalhi A, Khayyat W, Khojah O, Alsalmi M, Almarzouki H. Computer Vision Syndrome Among Health Sciences Students in Saudi Arabia: Prevalence and Risk Factors. Cureus. 2020;12:e7060. DOI: 10.7759/cureus.7060
20. Talens-Estarelles C, Sanchis-Jurado V, Esteve-Taboada JJ, Pons ÁM, García-Lázaro S. How Do Different Digital Displays Affect the Ocular Surface? Optom Vis Sci Off Publ Am Acad Optom. 2020;97:1070–9.
21. Jaiswal S, Asper L, Long J, Lee A, Harrison K, Golebiowski B. Ocular and visual discomfort associated with smartphones, tablets and computers: what we do and do not know. Clin Exp Optom. 2019;102:463–77. DOI: 10.1111/cxo.12851
22. Fredrick DR. Myopia. BMJ. 2002;324:1195–9. doi: https://doi.org/10.1136/bmj.324.7347.1195
23. Hansen MH, Laigaard PP, Olsen EM, Skovgaard AM, Larsen M, Kessel L, et al. Low physical activity and higher use of screen devices are associated with myopia at the age of 16-17 years in the CCC2000 Eye Study. Acta Ophthalmol (Copenh). 2020;98:315–21. DOI: 10.1111/aos.14242
24. Pawlaczyk-Luszczynska M, Dudarewicz A, Zamojska-Daniszewska M, Zaborowski K, Rutkowska-Kaczmarek P. Noise Exposure and Hearing Status Among Call Center Operators. Noise Health. 2018;20:178–89. DOI: 10.4103/nah.NAH_11_18
25. Widen SE, Båsjö S, Möller C, Kähäri K. Headphone listening habits and hearing thresholds in swedish adolescents. Noise Health. 2017;19:125–32. DOI: 10.4103/nah.NAH_65_16
26. Nunes AD da S, Silva CR de L, Balen SA, Souza DLB de, Barbosa IR. Prevalence of hearing impairment and associated factors in school-aged children and adolescents: a systematic review. Braz J Otorhinolaryngol. 2019;85:244–53. DOI: 10.1016/j.bjorl.2018.10.009
27. Mazlan R, Saim L, Thomas A, Said R, Liyab B. Ear Infection and Hearing Loss Amongst Headphone Users. Malays J Med Sci MJMS. 2002;9:17–22. PMCID: PMC3406203
28. Herrera S, Lacerda ABM de, Lürdes D, Rocha F, Alcaràs PA, Ribeiro LH. Amplified music with headphones and its implications on hearing health in teens. Int Tinnitus J. 2016;20:42–7. DOI: 10.5935/0946-5448.20160008
29. Han BI, Lee HW, Kim TY, Lim JS, Shin KS. Tinnitus: Characteristics, Causes, Mechanisms, and Treatments. J Clin Neurol Seoul Korea. 2009;5:11–9. DOI: 10.3988/jcn.2009.5.1.11
30. Zocoli AMF, Morata TC, Marques JM, Corteletti LJ. Brazilian young adults and noise: attitudes, habits, and audiological characteristics. Int J Audiol. 2009;48:692–9. DOI: 10.1080/14992020902971331
31. Sunny OD, Asoegwu CN, Abayomi SO. Subjective tinnitus and its association with use of ear phones among students of the College of Medicine, University of Lagos, Nigeria. Int Tinnitus J. 2012;17:169–72. DOI: 10.5935/0946-5448.20120030
32. Danishyar A, Ashurst JV. Acute Otitis Media. StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 [cited 2021 Apr 2]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK470332/ PMID: 29262176
33. Baguley DM. Hyperacusis. J R Soc Med. 2003;96:582–5. DOI: 10.1258/jrsm.96.12.582
34. Abdollahzade F, Mohammadi F, Dianat I, Asghari E, Asghari-Jafarabadi M, Sokhanvar Z. Working posture and its predictors in hospital operating room nurses. Health Promot Perspect. 2016;6:17–22. DOI: 10.15171/hpp.2016.03
35. Hakala PT, Rimpelä AH, Saarni LA, Salminen JJ. Frequent computer-related activities increase the risk of neck–shoulder and low back pain in adolescents. Eur J Public Health. 2006;16:536–41. DOI: 10.1093/eurpub/ckl025
36. Gheysvandi E, Dianat I, Heidarimoghadam R, Tapak L, Karimi-Shahanjarini A, Rezapur-Shahkolai F. Neck and shoulder pain among elementary school students: prevalence and its risk factors. BMC Public Health. 2019;19:1299. DOI: 10.1186/s12889-019-7706-0
37. Aroori S, Spence RA. Carpal tunnel syndrome. Ulster Med J. 2008;77:6–17. PMCID: PMC2397020
38. Kibret AK, Gebremeskel BF, Gezae KE, Tsegay GS. Work-Related Musculoskeletal Disorders and Associated Factors Among Bankers in Ethiopia, 2018. Pain Res Manag [Internet]. Hindawi Limited; 2020 [cited 2021 Apr 4];2020. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7499342/ DOI: 10.1155/2020/8735169
39. Vc H, Dm U, Hl K, Mr S. Ergonomic design and training for preventing work-related musculoskeletal disorders of the upper limb and neck in adults. Cochrane Database Syst Rev [Internet]. Cochrane Database Syst Rev; 2012 [cited 2021 Apr 3];2012. Available from: https://pubmed.ncbi.nlm.nih.gov/22895977/ UWAGA PEŁNE NAZWISKA : Victor C W Hoe , Donna M Urquhart, Helen L Kelsall, Malcolm R Sim DOI: 10.1002/14651858.CD008570.pub2
40. Korhonen T, Ketola R, Toivonen R, Luukkonen R, Häkkänen M, Viikari-Juntura E. Work related and individual predictors for incident neck pain among office employees working with video display units. Occup Environ Med. 2003;60:475–82. DOI: 10.1136/oem.60.7.475
41. An S. Associations between activities and low back pain in adolescents. Scand J Med Sci Sports [Internet]. Scand J Med Sci Sports; 2004 [cited 2021 Apr 3];14. Available from: https://pubmed.ncbi.nlm.nih.gov/15546330/ UWAGA: Astrid N Sjolie DOI: 10.1111/j.1600-0838.2004.377.x

42. Palmer KT, Cooper C, Walker-Bone K, Syddall H, Coggon D. Use of keyboards and symptoms in the neck and arm: evidence from a national survey. Occup Med Oxf Engl. 2001;51:392–5. DOI: 10.1093/occmed/51.6.392
43. Reddy S, Reddy V, Sharma S. Physiology, Circadian Rhythm. StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 [cited 2021 Mar 21]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK519507/ PMID: 30137792
44. Liu S, Wing YK, Hao Y, Li W, Zhang J, Zhang B. The associations of long-time mobile phone use with sleep disturbances and mental distress in technical college students: a prospective cohort study. Sleep. 2019;42. DOI: 10.1093/sleep/zsy213
45. Eugene AR, Masiak J. The Neuroprotective Aspects of Sleep. MEDtube Sci. 2015;3:35–40. PMID: 26594659
46. Rasch B, Born J. About Sleep's Role in Memory. Physiol Rev. 2013;93:681–766. DOI: 10.1152/physrev.00032.2012
47. Potkin KT, Bunney WE. Sleep Improves Memory: The Effect of Sleep on Long Term Memory in Early Adolescence. PLoS ONE [Internet]. 2012 [cited 2021 Apr 4];7. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3413705/ DOI: 10.1371/journal.pone.0042191
48. Dragun R, Veček NN, Marendić M, Pribisalić A, Đivić G, Cena H, et al. Have Lifestyle Habits and Psychological Well-Being Changed among Adolescents and Medical Students Due to COVID-19 Lockdown in Croatia? Nutrients. Multidisciplinary Digital Publishing Institute; 2021;13:97. DOI: 10.3390/nu13010097
49. Huang Q, Li Y, Huang S, Qi J, Shao T, Chen X, et al. Smartphone Use and Sleep Quality in Chinese College Students: A Preliminary Study. Front Psychiatry. 2020;11:352. https://doi.org/10.3389/fpsyt.2020.00352
50. Rafique N, Al-Asoom LI, Alsunni AA, Saudagar FN, Almulhim L, Alkaltham G. Effects of Mobile Use on Subjective Sleep Quality. Nat Sci Sleep. 2020;12:357–64. https://doi.org/10.2147/NSS.S253375
51. He J, Tu Z, Xiao L, Su T, Tang Y. Effect of restricting bedtime mobile phone use on sleep, arousal, mood, and working memory: A randomized pilot trial. PLOS ONE. Public Library of Science; 2020;15:e0228756. doi: 10.1371/journal.pone.0228756
52. Sidor A, Rzymski P. Dietary Choices and Habits during COVID-19 Lockdown: Experience from Poland. Nutrients. Switzerland; 2020;12. DOI: 10.3390/nu12061657
53. Bennett G, Young E, Butler I, Coe S. The Impact of Lockdown During the COVID-19 Outbreak on Dietary Habits in Various Population Groups: A Scoping Review. Front Nutr [Internet]. Frontiers; 2021 [cited 2021 Jul 17];0. Available from: https://www.frontiersin.org/articles/10.3389/fnut.2021.626432/full DOI: 10.3389/fnut.2021.626432
54. Dunton GF, Do B, Wang SD. Early effects of the COVID-19 pandemic on physical activity and sedentary behavior in children living in the U.S. BMC Public Health. 2020;20:1351. DOI: 10.1186/s12889-020-09429-3
55. Demir YP, Sumer MM. Effects of smartphone overuse on headache, sleep and quality of life in migraine patients. Neurosci Riyadh Saudi Arab. 2019;24:115–21. DOI: 10.17712/nsj.2019.2.20180037
56. Chu MK, Song HG, Kim C, Lee BC. Clinical features of headache associated with mobile phone use: a cross-sectional study in university students. BMC Neurol. 2011;11:115. DOI: 10.1186/1471-2377-11-115
57. Thorud H-MS, Aurjord R, Falkenberg HK. Headache and musculoskeletal pain in school children are associated with uncorrected vision problems and need for glasses: a case–control study. Sci Rep. Nature Publishing Group; 2021;11:2093. DOI: 10.1038/s41598-021-81497-w
58. Montagni I, Guichard E, Carpenet C, Tzourio C, Kurth T. Screen time exposure and reporting of headaches in young adults: A cross-sectional study. Cephalalgia Int J Headache. 2016;36:1020–7. DOI: 10.1177/0333102415620286
59. Uttarwar P, Vibha D, Prasad K, Srivastava AK, Pandit AK, Dwivedi SN. Smartphone use and primary headache: A cross-sectional hospital-based study. Neurol Clin Pract. 2020;10:473–9. DOI: 10.1212/CPJ.0000000000000816