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# Ergonomic Perceptions and Practices among Students in E-learning during COVID-19

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**Abstract.** The sudden shift to e-learning during the pandemic has challenged the students in setting up proper work areas with available space and resources. However, it is unclear whether these spaces conform to good ergonomic standards, which apply to information about human behaviour, abilities, limitations and other characteristics to the design of tools, machines, tasks, jobs and environments for productive, safe, comfortable and effective human use. This study was conducted, in order

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to assess the ergonomic perceptions and practices in e-learning during the COVID-19 pandemic among the Princess Nourah bint Abdulrahman University students. An analytical cross-sectional design was used with a convenience sample of 384 students from January to April 2021. A self-administered online questionnaire was used for the data collection. A descriptive data analysis and a Pearson chi-square test were done, using JMP Version 14. The results indicated positive ergonomic perceptions. With regard to practices, most desktop laptop users applied good ergonomic practices (80.7%). In contrast, 50.5% of laptop-without-desk users and 47% of smartphone/tablet users engaged in poor ergonomic practices. Furthermore, the findings showed that there were no significant associations between ergonomic practices and ergonomic perceptions. The study recommends the provision of health-education programmes to encourage the application of correct ergonomic practices. In addition to applying flexible breaks during classes, the study advocates the adoption of practices that avoid.

**Keywords:** ergonomic; perception; practice; e-learning

## 1. Introduction

The global COVID-19 pandemic has affected the education of approximately one billion students worldwide,: since 120 countries have suspended face-to-face learning (Shahzad et al., 2021). As a result, the educational process has shifted dramatically towards e-learning, whereby teaching has been conducted remotely and virtually through digital platforms (Alqabbani et al., 2020). Due to this sudden shift, students can now access online lessons at home by using electronic devices, such as laptops, tablets and smartphones. This has required setting up a work area with the space and the resources that they had at home, such as a dining-room table and chairs, or another makeshift desk with no external monitors or input devices. These home work-spaces may not suit students ergonomically (Davis et al., 2020). According to Dul et al. (2012):

> *Ergonomics is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to the design, in order to optimise human well-being and overall system performance (Dul et al., 2012).*

Ergonomics is influenced by many factors, including body posture and environmental factors (Dul & Weerdmeester, 2003). The purpose of ergonomics is to reduce injuries, such as musculo-skeletal disorders (MSD), which can affect productivity and performance (Dianat et al., 2016).

Environmental ergonomics can be defined as the scientific study of the effects of ambient environmental conditions on human comfort, performance and health (Dianat et al., 2016). People spend 80%–90% of their time indoors at work (Vimalanathan & Babu, 2017). Indoor environmental quality is a critical requirement for improving productivity. An indoor environment is affected by many factors, such as temperature, humidity, air quality, illumination and ventilation (Dianat et al., 2016). During the COVID-19 crisis, the education process shifted to e-learning and away from classrooms that are commonly designed to

meet set ergonomic standards; and this requires a change in the focus of ergonomic practices. As a result of sudden changes in the educational process, students may encounter ineffective ergonomic environmental factors in their home workplace, which may affect their health, comfort and academic performance (Soltaninejad et al., 2021).

Noise is one of the ergonomic problems associated with online learning that has negative effects. Noise has been shown to be detrimental not only to an individual's health, but also to the cognitive ability and the learning performance (Diaco, 2014)). There should be a balanced range of ambient noise in a student's environment during learning, in order to make comfortable learning possible without any distractions.

Nevertheless, as students will attempt to eliminate extraneous noise by closing doors and windows, this in turn, can negatively affect ventilation. A study conducted in Denmark suggests that the learning process of students can be enhanced by an elevated ventilation rate (Haverinen-Shaughnessy & Shaughnessy, 2015). Inadequate ventilation and elevated indoor temperatures were found to be associated with a lack of student comfort, which negatively influenced academic performance. In contrast, a cool room temperature was found to be associated with enhanced academic performance (Soltaninejad et al., 2021). In general, learners should have control (or input) regarding heating or cooling equipment, so that adjustments may be made, according to their needs.

Lastly, proper lighting in a work area, in which learning occurs, is important to improve and increase a student's perception of the information. The quality and direction of light are also important, in order to avoid reflection and glare and to protect the eyes. Natural light is preferred in a learning environment, in order to increase a student's performance. Due to the COVID-19 pandemic, the performance of students may be negatively affected: because classes may be held in spaces where the lighting is not designed for educational purposes; and it is not suitable (Soltaninejad et al., 2021).

Research has shown that poor lighting in a learning environment is a critical problem; and it has an adverse influence on students' performance. Inappropriate lighting may also affect a student's safety and health, and not merely their performance (Samani & Samani, 2012). In brief, a good and suitable environment stimulates workers, in this case students, so that they can perform better. Many people spend most of their time in work and learning environments, so this is consequently an important issue.

Ergonomics can have a wide range of effects on health, both physically and psychologically. A widespread series of physical disorders that result from poor office ergonomics is musculo-skeletal disorders (Choobineh et al., 2012). Musculo-skeletal disorders can be defined as the presence of discomfort, disability or persistent pain in the joints, muscles, tendons and other soft body parts, caused or aggravated by repeated movements and prolonged awkward or forced body postures (Harutunian et al., 2011). Musculo-skeletal disorders include a wide range of conditions, such as tendonitis, carpal-tunnel syndrome, muscle strains, trigger finger, lower back injuries and back pain (Barr et al., 2004).

A study conducted to assess the prevalence of computer-related musculo-skeletal complaints in female college students showed that 80% of the participants experienced nusculo-skeletal discomfort related to their computer usage (Hamilton et al., 2005).

Similarly, a study carried out to investigate the prevalence and risk factors of musculo-skeletal symptoms among office workers showed that there were high prevalence rates of musculo-skeletal symptoms in the shoulders, neck and back. These symptoms were attributed to long hours of prolonged sitting and typing and to a lack of breaks taken (Mahmud et al., 2011). Poor ergonomic factors have also been related to visionary issues associated with using electronic devices during online learning for students.

Research has shown that a few factors can play a role in visionary issues, such as lighting, reflections from the screen and posture (Mashige et al., 2013). These can lead to eye strain, a burning sensation and redness that would negatively affect a student's health and concentration. In addition, ergonomics influences an individual's psychological state. Heat, lights and noise factors in the workplace are associated with stress and depression (Makhbul et al., 2013). Therefore, these issues must be prevented; as they would have an impact on students' abilities and productivity.

Perception can be defined as the way an individual thinks about something and their idea of what it is like (Qiong, 2017). The social-cognitive theory shows how individuals are influenced by their experiences, other people's actions, as well as by the environment. This theory can be applied in different settings, including educational ones (Bandura, 2011). Schools must use effective approaches created, in accordance with ergonomic guidelines, in order to create suitable studying environments that influence students' perceptions and practice. The use of ergonomic approaches would encourage students to learn, to apply these approaches to their environment and to acquire better awareness of ergonomic issues (Koca & Kaya, 2018).

A crucial aspect of practising good ergonomics is maintaining a natural body posture: it is a position of ease for the body to maintain for a prolonged period of time, a position that supports the natural curves of the spine and one that maintains one's body in good alignment, in which the stress on the musculo-skeletal system is reduced (Genaidy & Karwowski, 1993). It includes the maintenance of different parts of the body in correct alignment, such as the wrists, elbows, neck, shoulders, back and lower extremities, including the knees, hips and feet.

A study conducted in Egypt to assess the practice of ergonomics among dental students highlighted that 95% of the students had a poor practice of ergonomics. It was reported that while working, only 8.6% of the participants maintained a neutral posture, in comparison to 37.8% who did not (El-sallamy et al., 2018). A natural body posture can be preserved through a couple of adjustments to office equipment, such as the monitor, chair, workstation, mouse and keyboard.

An appropriate monitor height is one arm or slightly further away, with the top of the screen at eye level. According to one study, it was estimated that 59% of the participants had the screen at face level (Altalhi et al., 2020). As also reported by the United States Department of Labour, the optimal viewing distance is around 20–40 inches (50–100 cm) (OSHA, 2015). Therefore, students can avoid health issues related to their eyes, when practising proper screen ergonomics. However, research has shown that, due to the small screens of some devices, the ergonomic properties of viewing content on laptops and smartphones can be very poor (Zovkić et al., 2011).. This means that students may face challenges in studying uncomfortably online with difficulty, due to the devices they use.

Likewise, a keyboard and mouse are office equipment that students should pay attention to while engaged in online learning. When using a keyboard, the elbows must be at the same height as the keyboard's middle row of keys when typing. Many ergonomists recommend a keyboard with a basic position no higher than 30 mm above the work desk, in order to achieve flatness of the wrist. In addition, the mouse must be placed on the side of the keyboard's front edge, with space for movement. Students should be able to hold the mouse without straining the palm or altering the fingers' position (Zovkić et al., 2011). Thus, the correct ergonomic practices during online learning with these two pieces of equipment, can prevent any unnecessary straining of the hands or back.

The study environment and workspace are important elements for students. Ergonomically sound elements should improve students' health, comfort, concentration and motivation during learning. For instance, students' chairs and desks should provide comfort and enough space to perform school activities. Research has shown that furniture from manufacturers, in general, are designed traditionally and provides one-size-fits-all desks and chairs without consideration of ergonomic standards; thus, they are not suitable for all students, resulting in a lack of concentration, abnormal postures and health issues.

The cause of most health issues related to the student's environment, as shown by many studies, is a mismatch between it and the anthropometric dimensions of the student (Al-Hinai et al., 2018). In addition, sitting on a bed or floor while studying may cause health problems because of the wrong body postures used.

An ergonomically adjusted workstation and equipment alone will not promote good ergonomic practices by individuals. Another aspect that should be considered is employing ergonomic techniques, such as preventing prolonged use of the same position for hours. One study recommends that every two hours of consistent computer work should be followed by a 15-minute break (Shikdar & Al-Kindi, 2007). There are various techniques to prevent the use of a static posture, while working on digital devices.

One of these techniques is taking short breaks of two minutes, or performing other tasks, and not exceeding thirty minutes of continuous computer work. A study conducted in Jeddah revealed that among the least applied ergonomic practices among students was the taking of breaks while using digital devices: only 66% of the participants reported taking breaks (Altalhi et al., 2020).

Students of various ages face the risk of developing injuries and disabilities that are associated with poor ergonomic practices during virtual learning.

Despite the fact that the burden of the COVID-19 is reducing (Murray, 2022), the integration of e-learning within an educational system is expected to grow (Almuwais et al., 2021). This study was crucial; because the assessment of ergonomic perceptions and practices in e-learning in this setting would help to provide scientific evidence that could be used in future studies, interventions and policy development. This could contribute to the prevention of the associated health risks of poor ergonomic practices among university students who attend virtual classes. To the best of the researchers' knowledge, there have been no other findings on the international and national levels that investigated the prevalence of ergonomic perceptions and practices among students in e-learning during the COVID-19 pandemic.

This paper aimed to assess the ergonomic perceptions and practices in e-learning during the COVID-19 pandemic among Princess Nourah bint Abdulrahman University students. The objectives of the study were: (a) To examine the ergonomic perceptions and practices in e-learning during the COVID-19 pandemic among Princess Nourah bint Abdulrahman University students. (b)To assess the relationship between ergonomic perceptions and practices in e-learning during the COVID-19 pandemic among Princess Nourah bint Abdulrahman University students. The authors hypothesised that there would be a relation between ergonomic perceptions and practices in e-learning, as measured during the COVID-19 pandemic among Princess Nourah bint Abdulrahman University students.

## 2. The Methodology

### 2.1 The study design population and sampling

An analytical cross-sectional study design was used to conduct the study among Princess Nourah bint Abdulrahman University students over a period of three months (January to April 2021). The study population comprised students from Princess Nourah bint Abdulrahman University from health and non-health colleges. In this research, the participants were recruited through a convenience-sampling method. The study population was 38000 students ranging from level one to level twelve. The sample size was calculated to be 384, based on a population size of more than 10,000; the confidence level was set to 1.96, and 0.05 was the degree of accuracy, while 50% was the prevalence of the factor under study.

### 2.2 The data-collection tools

The questionnaire was adopted from previous tools designed by the National Institutes of Health (NIH, 2020) and North Carolina State University (NCSU, 2010). Approval to use those questionnaires was obtained from the copyright holders. The online structured survey consisted of three sections. The first one assessed the characteristics of the participants; and it contained five questions that assessed socio-demographic variables and the personal use of electronic devices, precisely age, the level of study, the type of device used and the length of time using the device generally, and also for educational purposes.

The second section assessed the ergonomic perceptions; and it included six questions using a three-point Likert-scale. The questions specifically assessed the perceptions of the influence of the workstation, prolonged sitting and maintaining a good posture of the musculo-skeletal system, perception of the effect of room lighting on the eyes, the effect of room temperature on concentration, and finally, the effect of ventilation on the students' performance.

The last section assessed ergonomic practices, with three assessment sub-sections that were directed to the users of different devices, in addition to a final sub-section that assessed the space of their environment. The first sub-section of the ergonomic-practices assessment section was directed at the users of office computers/laptops; and it contained three further sub-sections that assessed the user's office chair (four questions), the mouse and keyboard (five questions), and the monitor (six questions).

The second sub-section was directed to the users of laptops without a desk; and it contained five closed-ended questions. The third sub-section was directed to the users of tablets and phones; and it contained nine questions.

The last sub-section of the ergonomic-practices assessment section was the assessment of the space of their environment, which contained six questions. Finally, the last section was one question for assessing their health complaints during e-learning. The survey was distributed through online platforms by using Google Forms. Students from outside Princess Nourah bint Abdulrahman University were excluded from the survey. A pilot study was conducted, with 20 students from the university, in order to check the clarity of the questionnaire and any modifications that were made accordingly.

**2.3 The data analysis**

The data were analysed by using the JMP Version 14. To tackle the first objective, descriptive data of ergonomic perception and practice in e-learning were presented in the form of numbers and percentages. To tackle the second objective, a Pearson chi-square test was used to find the association between ergonomic perception and practice in e-learning.

The perception of ergonomics was categorised into three groups: negative perception, neutral perception and positive perception. Cut-offs were taken at quartile 1 and quartile 3. Ergonomic practice was categorised into two groups: poor and good. A cut-off point was taken at 50%.

**2.4 Ethical considerations**

The study received approval from the Institutional Review Board (IRB) of Princess Nourah bint Abdulrahman University. The purpose of the research was clarified to potential participants in the online questionnaire, and it was clarified that their data would be anonymous. Informed consent was obtained and recorded, as part of the online questionnaire.

## 3. The Results

Table 1 shows that about half of the sample were 21 years or older (51%), and most of these were non-health college students (62%).

**Table 1: Characteristics of participants**

| | Number (N) | Percentage (%) |
|---|---|---|
| **Age** | | |
| Less than 21 years old | 186 | 48% |
| Equal/more than 21 years old | 198 | 51% |
| **College** | | |
| Health college | 145 | 38% |
| Non-health college | 239 | 62% |
| **Total** | 384 | 100% |

Among the study participants, 35% reported using devices for 3–5 hours for educational purposes. Approximately, 32% of the students used devices for 7–8 hours; 24% used devices for more than 8 hours; and 9% of them reported using their devices for less than 3 hours for educational purposes. The devices used by the students for the e-learning process were as follows: 43% of the students were using laptops; 30% were using tablets; and 25% were using smartphones.

**Table 2: Ergonomic perceptions**

| | Agree | | Neutral | | Disagree | | Total | |
|---|---|---|---|---|---|---|---|---|
| **Questions** | **(N)** | **(%)** | **(N)** | **(%)** | **(N)** | **(%)** | **N** | **%** |
| I believe prolonged sitting will influence musculoskeletal system issues. | 352 | 92% | 24 | 6% | 8 | 2% | 384 | 100% |
| I think maintaining a good posture while sitting will protect your musculo-skeletal system. | 275 | 72% | 70 | 18% | 39 | 10% | 384 | 100% |
| I think studying at a workstation other than an office, such as a couch, bed or the floor does not influence the musculo-skeletal system. | 67 | 17% | 105 | 27% | 212 | 55% | 384 | 100% |
| I believe a room's lighting can lead to eye strain in reading. | 315 | 82% | 49 | 13% | 20 | 5% | 384 | 100% |
| I think a room's temperature influences one's concentration. | 303 | 79% | 64 | 17% | 17 | 4% | 384 | 100% |
| I think a room's ventilation influences one's performance. | 316 | 82% | 52 | 14% | 16 | 4% | 384 | 100% |

The first objective of the study was to examine the ergonomic perceptions and practices. Table 2 presents the ergonomic perceptions. Approximately 72% of the participants agreed that maintaining a good posture, while sitting, would protect their musculo-skeletal system. As for questions regarding the perception of the work environment, 82% of the participants agreed that room lighting can lead to eye strain; and similar numbers agreed that room temperature (79%) and ventilation (82%) can influence concentration and performance. However, only

55% of the participants correctly indicated that studying on a workstation, other than an office, such as a couch, bed or floor, influences the musculo-skeletal system.

**Table 3: Ergonomic practices of desktop laptop users**

| Questions | Yes | | No | | Total | |
|---|---|---|---|---|---|---|
| | (N) | (%) | (N) | (%) | N | % |
| Are your feet fully supported by the floor when you are seated? | 36 | 43% | 47 | 57% | 83 | 100% |
| Does your chair provide support for your lower back? | 45 | 54% | 38 | 46% | 83 | 100% |
| When your back is supported, are you able to sit without feeling pressure from the chair seat on the back of your knees? | 53 | 64% | 30 | 36% | 83 | 100% |
| Do your armrests allow you to get close to your workstation? | 47 | 57% | 36 | 43% | 83 | 100% |
| Is the keyboard positioned directly in front of and at a distance from the edge of the desk that feels comfortable and supportive for the arms/shoulders? | 55 | 66% | 28 | 34% | 83 | 100% |
| Are your wrists almost flat (10–20-degree extension) whilst keying, not leaning on the desk creating a sharp upward angle at the wrist joint? | 28 | 34% | 55 | 66% | 83 | 100% |
| Are brief pauses (every few minutes) taken from continuous keying work? | 65 | 78% | 18 | 22% | 83 | 100% |
| Is your mouse at the same level, and as close as possible to your keyboard? | 64 | 77% | 19 | 23% | 83 | 100% |
| Is your upper arm vertical, lower arm horizontal, with a 90–95-degree bend in the elbow, while using the mouse? | 33 | 40% | 50 | 60% | 83 | 100% |
| Is your monitor positioned directly in front of you? | 58 | 70% | 25 | 30% | 83 | 100% |
| Is your monitor height slightly below eye level? | 47 | 57% | 36 | 43% | 83 | 100% |
| Is your monitor positioned at least an arm's length away? | 49 | 59% | 34 | 41% | 83 | 100% |
| Are your monitor and work surface free from glare? | 44 | 53% | 39 | 47% | 83 | 100% |
| Do you have appropriate light for the reading or writing of documents? | 71 | 86% | 12 | 14% | 83 | 100% |
| Are frequently used items located within the main work area; and are items that are only used occasionally available adjacent to the work area? | 77 | 93% | 6 | 7% | 83 | 100% |

Table 3 presents the ergonomic practices of desktop users. It was found that 54% of the participants used an ergonomic chair to support their lower back. Approximately 66% of the participants positioned the keyboard properly at a distance from the desk edge to feel comfortable and to support their arms and

shoulders. Also, 77% of the desktop laptop users positioned the mouse at the same level and close to the keyboard. Approximately 30% of the participant's monitors were not positioned directly in front at eye level. The participants who reported taking brief pauses from continuous work represented 78% of the sample. The portion of the participants who had appropriate light for reading and writing amounted to 86%.

**Table 4: Ergonomic practices of laptop-without-desk users**

| Questions | (N) | (%) |
|---|---|---|
| **On what surface do you place your laptop?** | | |
| • Appropriate surface (desk or table) | 24 | 26.4% |
| • Inappropriate surface (bed, sofa or ground) | 67 | 73.6% |
| **What is the brightness level of the device?** | | |
| • Appropriate (moderate) | 52 | 57% |
| • Inappropriate (low/high) | 39 | 43% |
| **What is the viewing distance between your eyes and the screen of the laptop you are holding?** | 4 | 4% |
| • Appropriate (more than 40 cm) | 87 | 96% |
| • Inappropriate (less than 40 cm/between 21–31 cm/between 31–40 cm) | | |
| **Do you use an external mouse when using a laptop?** | | |
| • Yes | 8 | 9% |
| • No | 83 | 91% |
| **Is the screen elevated to slightly below eye level?** | | |
| • Yes | 56 | 62% |
| • No | 35 | 38% |
| **Total** | 91 | 100% |

Table 4 shows the ergonomic practices of laptops-without-desk users. Approximately 73.6% of the students placed the laptop on an inappropriate surface, such as a bed, sofa and the ground. In addition, 96% of them had an inappropriate viewing distance between their eyes and the screen, while 57% had an appropriate brightness level.

**Table 5: Ergonomic practices of smartphones/tablets users**

| Questions | (N) | (%) |
|---|---|---|
| **On what surface do you place the touchscreen device?** | | |
| • Appropriate surface (desk or table) | 83 | 40% |
| • Inappropriate surface (bed, sofa or ground) | 127 | 60% |
| **How do you hold your device?** | | |
| • Appropriate (at neck level) | 44 | 21% |
| • Inappropriate (below/above neck level) | 166 | 79% |

| | | |
|---|---|---|
| **At what brightness level is your device?** | | |
| • Appropriate (moderate) | 123 | 59% |
| • Inappropriate (low/high) | 87 | 41% |
| **What is the viewing distance between your eyes and the touchscreen when you hold it?** | 6 | 3% |
| • Appropriate (more than 40 cm) | 204 | 97% |
| • Inappropriate (less than 20 cm/between 21–31 cm/between 31–40 cm) | | |
| **What is the screen size of your device?** | | |
| • Appropriate (medium) | 135 | 64% |
| • Inappropriate (small/large) | 75 | 36% |
| **Do you support the arm holding the smartphone/tablet,or with your other arm or any object, such as a pillow?** | | |
| • Yes | 141 | 67% |
| • No | 69 | 33% |
| **Do you hold your phone in one hand and type with the thumb of the same hand?** | | |
| • Yes | 133 | 63% |
| • No | 77 | 37% |
| **Do you support your smartphone using your little finger curled under the bottom edge?** | | |
| • Yes | 156 | 74% |
| • No | 54 | 26% |
| **Do you alternate between a sitting and a standing position when using your touchscreen device?** | | |
| • Yes | 126 | 60% |
| • No | 84 | 40% |
| **Total** | 210 | 100% |

Table 5 presents the ergonomic practices of smartphone/tablet users. Approximately 60% of the students placed their smartphones/tablets on an inappropriate surface, such as a bed, or the ground. In addition, 79% of them held their device below/above neck level, and 97% had an inappropriate viewing distance between their eyes and the screen. Approximately 63% held the device in one hand and typed with the same hand, whereas 74% of them supported their device by using the little finger. While using the device, 60% of the students reported alternating between sitting and standing positions.

**Table 6: Learning environment of participants**

| Questions | Yes | | No | | Total | |
|---|---|---|---|---|---|---|
| | (N) | (%) | (N) | (%) | N | % |
| Can your room light be adjusted? | 320 | 83% | 64 | 17% | 384 | 100% |
| Can your screen be seen easily; and is it free from reflections? | 289 | 75% | 95 | 25% | 384 | 100% |
| Is your surrounding environment free from noise? | 202 | 53% | 182 | 47% | 384 | 100% |
| Is the ventilation comfortable and sufficient? | 340 | 89% | 44 | 11% | 384 | 100% |
| Is the temperature comfortable and sufficient? | 343 | 89% | 41 | 11% | 384 | 100% |
| During the e-learning, do you have a private area? | 224 | 58% | 160 | 42% | 384 | 100% |

Table 6 shows that among the study participants, 83% reported that their room light could be adjusted, 89% had sufficiently comfortable ventilation and temperature, and 75% had a reflection-free screen. Approximately 53% of the participants had an environment that was not noisy, and 58% had a private area for e-learning.

**Table 7: Health complaints during e-learning among participants**

| Health complaints | Number (N) | Percentage (%) |
|---|---|---|
| Neck pain | 255 | 66.4% |
| Lower-back pain | 215 | 56% |
| Upper-back pain | 142 | 37% |
| Wrist pain | 126 | 32.8% |
| Eye strain | 291 | 75.8% |
| Shoulder pain | 220 | 57.3% |
| Headache | 18 | 4.7% |
| Anxiety | 85 | 22.1% |
| Bone pain | 1 | 0.3% |
| Distraction | 2 | 0.5% |
| Ear pain | 1 | 0.3% |
| Lack of sleep | 1 | 0.3% |
| Laziness | 1 | 0.3% |
| Leg pain | 2 | 0.5% |
| Stress | 88 | 22.9% |
| Tinnitus | 1 | 0.3% |

Table 7 illustrates the health complaints during e-learning. The most reported health effect experienced by participants was eye strain (75.8%). Among the other health effects, musculo-skeletal symptoms had the highest percentages: neck pain was the most experienced symptom (66%), followed by shoulder pain and lower-back pain (56%), followed by upper-back pain (37%) and wrist pain (32%). Among the psychological effects, stress and anxiety were the most prevalent symptoms among the participants (22%).

**Table 8: Associations between ergonomic practices of device users and perceptions**

| | | | Ergonomic perception | | | Total | $X^2$ | *p*-value |
|---|---|---|---|---|---|---|---|---|
| | | | Neg. (–) | Neutral | Pos. (+) | | | |
| Desktop laptop users | Good practice | N | 3 | 24 | 40 | 67 | 1.724 | 0.4224 |
| | | % | 3.61 | 28.92 | 48.19 | 80.72 | | |
| | Poor practice | N | 1 | 3 | 12 | 16 | | |
| | | % | 1.20 | 3.61 | 14.46 | 19.28 | | |
| | Total | N | 4 | 27 | 52 | 83 | | |
| | | % | 4.82 | 32.53 | 62.65 | | | |
| Laptop-without-desk users | Good practice | N | 3 | 16 | 26 | 45 | 1.048 | 0.5920 |
| | | % | 3.30 | 17.58 | 28.57 | 49.45 | | |
| | Poor practice | N | 2 | 21 | 23 | 46 | | |
| | | % | 2.20 | 23.08 | 25.27 | 50.55 | | |
| | Total | N | 5 | 37 | 49 | 91 | | |
| | | % | 5.49 | 40.66 | 53.85 | | | |
| Smartphone/ tablet users | Good practice | N | 4 | 53 | 54 | 111 | 0.510 | 0.7750 |
| | | % | 1.90 | 25.14 | 25.71 | 52.86 | | |
| | Poor practice | N | 3 | 43 | 53 | 99 | | |
| | | % | 1.43 | 20.48 | 25.24 | 47.14 | | |
| | Total | N | 7 | 96 | 107 | 210 | | |
| | | % | 3.33 | 45.71 | 50.95 | | | |

The second objective of the study was to assess the relationship between ergonomic perceptions and practices. The hypothesis was that there would be a relation between ergonomic perceptions and practices in e-learning as measured during the COVID-19 pandemic among Princess Nourah bint Abdulrahman University students. Table 8 presents the distributions of the sample, according to ergonomic practices and perception. For desktop laptop users, almost half had good practices and positive perceptions (48.19%). Regarding the chi-square test, there was no significant association between these two variables, $x^2(2, N = 83) = 1.724$, $p > 0.05$. For the users of laptops without a desk, 28.57% reported having good practices and positive perceptions, whereas 25.27% had poor practices, but positive perceptions. Regarding their chi-square test, there was no significant association between these two variables, $x^2(2, N = 91) = 1.048$, $p > 0.05$. Finally, for smartphone/tablet users, 25.71% of the students reported having good practices and positive perceptions; while 25.24% had poor practices and positive perceptions. In addition, among the sample, 25.14% had good practices with neutral perceptions. According to the chi-square test, there was no significant association between these two variables, $x^2(2, N = 210) = 0.510$, $p > 9.05$).

## 4. Discussion

This study sought to examine the ergonomic perceptions and practices in e-learning during the COVID-19 pandemic. Firstly, in regard to perceptions, the results showed that more than half of the participants indicated that they knew that studying somewhere, other than an office setting, such as a couch, bed or the floor influences the musculo-skeletal system. This might be attributable to the participants' experiences with an inappropriate workstation that resulted in a

musculo-skeletal symptom that made them perceive this behaviour negatively; and they associated it with musculo-skeletal problems. In addition, a majority of the students showed a positive perception of the importance of temperature and lighting. This could be the result of experience and the adoption of previous practices during e-learning, which led them to form a positive perception regarding a proper learning environment; as it resulted in enhanced productivity, comfort and minimal injuries.

Secondly, in regard to practices, desktop laptop users showed a huge difference between those who practised short pauses every few minutes from continuous keying work, and those who did not. The majority of the participants took breaks from continuous keying work. This could be attributed to the long hours of studying during classes. This is contrasted with the research findings from a study conducted in Jeddah, which revealed that, among students, the practice of taking short pauses, while using devices, was amongst the most poorly practised ergonomic practices: just more than half of the participants took breaks (Altalhi et al., 2020).

The majority of the students reported placing the mouse at the same level, close to the keyboard. This could be attributed to recognising the need to avoid unnecessary stretching and putting strain on the arm. Research has described how the mouse should be placed at the side of the keyboard to prevent straining the palm or fingers (Zovkić et al., 2011). Nearly half of the students who participated in the current study used an ergonomic chair to support their lower back and to avoid health issues related to improper sitting. This result shows a desire to support proper posture. As described previously, most health issues are related to the students' learning environment and the mismatch between chair design and students' anthropometric dimensions, which affects their health and performance (Al-Hinai et al., 2018).

Furthermore, almost two-thirds of the participants answered that their monitor was positioned at least an arm's length away, which is what has been previously described as an appropriate monitor height (Altalhi et al., 2020). Incorrect positioning of the screen may cause students discomfort and pain, and they seem prepared to avoid this.

Moreover, for the ergonomic practices among laptop-without-desk users and smartphone/tablet users, approximately three-quarters of laptop users and three-fifths of smartphone/tablet users stated that they used an inappropriate surface. The reason for this may be a lack of prior preparation for remote study. A majority of students used an inappropriate viewing distance between the eyes and screen, which was less than 40 cm. This is contrary to the reported optimal viewing distance, which is approximately 50–100 cm (OSHA, 2015). This finding could be attributed to the placement of the devices on an inappropriate surface, such as a bed, or the ground.

This might also have been influenced by the small size of their screens and the brightness of the devices. In addition, it was found that more than half of the participants in this study adjusted the brightness to avoid vision issues. Prior research has shown the influence of inappropriate light on proper vision. Other

factors, such as lighting, reflections from the screen, screen glare and brightness, can also impact one's vision. Inappropriate lighting has consequences, such as those leading to eye strain, a burning sensation and redness that negatively affect a student's health and concentration (Mashige et al., 2013).

The majority of the participants stated that their room light could be adjusted. According to recent research, due to the COVID-19 pandemic, students' performance might have been negatively affected, because classes had to be held in spaces where the lighting was not suitable or designed for educational purposes (Soltaninejad et al., 2021). One reason could be economic differences between learning locations. More than half of the participants reported having a private area to study during e-learning; this factor was the least practised environmental factor.

This finding might be attributed to the fact that when family members attend work or school remotely, households might face inconveniences in providing every member of the family with a proper private area. Also, approximately half of the students reported that their environment was free from noise; thus, they were able to concentrate on their classes. This is important, as research has shown that noise affects learners' performance and cognitive abilities (Diaco, 2014).

Musculo-skeletal symptoms were reportedly experienced by a majority of the participants. More than half of them experienced neck, lower back and shoulder pain. These findings were similar to those of a previous study, in which a majority of students experienced musculo-skeletal symptoms in the shoulder, neck and back (Mahmud et al., 2011). This could be attributed to prolonged sitting and inappropriate postures while studying. In addition, three-quarters of the participants in the current study experienced eye strain during e-learning. This was probably caused by prolonged sitting in front of a screen for e-learning activities, or poor practice regarding adjusting the screen brightness.

Some environmental factors might also cause eye strain, such as poor room lighting, glare and reflections on the screen. These factors have been cited in prior research as causing vision problems among students (Mashige et al., 2013). Almost a quarter of the students in the current study reported that they were suffering from psychological effects, such as anxiety and stress. This could be attributed to the lack of availability of a private area for e-learning, in addition to technical problems related to their devices, or their internet connection.

The study also sought to assess the relationship between ergonomic perceptions and practices in e-learning. The hypothesis was that there would be a relation between ergonomic perceptions and practices in e-learning, as measured during the COVID-19 pandemic among Princess Nourah bint Abdulrahman University students. The findings led to rejecting the hypothesis, as there were no significant associations between perceptions and ergonomic practices among the three types of device users: users of a desktop laptop, a laptop without a desk, and smartphone/tablet. This is aligned with social cognitive theory, which states that individual health behaviours can be influenced through an interplay between individual experiences, the actions of others and environmental factors (Bandura, 2011).

Perception can be addressed as an individual experience. The findings of our study rejected an association between perceptions and ergonomic practices; however, the other part of the theory regards the influence of environmental factors and the actions of others, which might better explain the observed behaviour.

## 5. Conclusion

Ergonomic practices were not found to be significantly associated with ergonomic perceptions. The findings revealed that the practice of ergonomics among desktop laptop users was good; whereas the practice among those who used smartphones/tablets and laptops without a desk was poor. In addition to a positive perception of ergonomic practices among students at Princess Nourah bint Abdulrahman University, negative health effects that were experienced during e-learning were found to be prevalent among more than half of the students. It is recommended that health education programmes should be provided for students and their parents.

This would encourage the students to apply the correct ergonomic practices in affordable and convenient ways, in order to reduce or prevent health problems. This would be particularly helpful to students with more limited resources. In addition, enough time should be provided so that the students can take flexible breaks during class, in order to avoid problems related to sitting in a static posture for a long period of time.

## 6. Limitations and Recommendations for Future Research

A limitation of this study was that, due to the COVID-19 pandemic, the participants were recruited through non-probability convenience sampling; consequently, the results cannot be generalised to the population as a whole. Further research on ergonomic perceptions, practices and the relationship between them is needed. In addition, further research with representative samples involving both males and females from different universities should be pursued. Studies are also needed to validate the research tool.

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## Appendix 1

**Characteristics of participants**

1. What is your age?
    a. 17–20
    b. 21–25
    c. Above 26
2. At what college do you study?
    a. Health college
    b. Non-health college
3. What type of device do you frequently use for e-learning?
    a. Office computer
    b. Laptop
    c. Tablet
    d. Smartphones
4. On average, how long do you use your devices for educational purposes?
    a. Less than 3 hours
    b. 3–5 hours
    c. 7–8 hours
    d. More than 8 hours
5. On average, how long do you use your devices per day?
    a. Less than 5 hours
    b. 5–7 hours
    c. 8–10 hours
    d. More than 10 hours

**Ergonomic perceptions**

1. I believe prolonged sitting will influence musculoskeletal system issues.
   A. Agree B. Neutral C. Disagree
2. I think maintaining a good posture while sitting will protect your musculoskeletal system.
   A. Agree B. Neutral C. Disagree
3. I think studying at a workstation other than an office, such as a couch, bed or the floor, does not influence the musculoskeletal system.
   A. Agree B. Neutral C. Disagree
4. I believe a room's lighting can lead to eye strain in reading.
   A. Agree B. Neutral C. Disagree
5. I think a room's temperature influences concentration.
   A. Agree B. Neutral C. Disagree
6. I think a room's ventilation influences performance.
   A. Agree B. Neutral C. Disagree

**Ergonomic assessment of office computer\laptop**

**The office-chair**

1. Are your feet fully supported by the floor when you are seated? Yes/No
2. Does your chair provide support for your lower back? Yes/No

3. When your back is supported, are you able to sit without feeling pressure from the chair seat on the back of your knees? Yes/No
4. Do your armrests allow you to get close to your workstation? Yes/No

**Mouse and keyboard**

1. Is the keyboard positioned directly in front, and at a distance from the edge of the desk that feels comfortable and supportive for the arms/shoulders? Yes/No
2. Are your wrists almost flat (10–20-degree extension) whilst keying, not leaning on the desk creating a sharp upwards angle at the wrist joint? Yes/No
3. Are brief pauses (every few minutes) taken from continuous keying work? Yes/No
4. Is your mouse at the same leve,l and as close as possible to your keyboard? Yes/No
5. Is your upper arm vertical, lower arm horizontal with a 90–95-degree bend in the elbow while using the mouse? Yes/No

**Monitor**

1. Is your monitor positioned directly in front of you? Yes/No
2. Is your monitor height slightly below eye level? Yes/No
3. Is your monitor positioned at least an arm's length away? Yes/No
4. Are your monitor and work surface free from glare? Yes/No
5. Do you have appropriate light for reading or writing documents? Yes/No
6. Are frequently used items located within the main work area and items which are only used occasionally available adjacent to the work area? Yes/No

**Assessment of laptop without desk**

1. On what surface do you place your laptop?
    a. Desk
    b. Table
    c. Bed
    d. On the ground
    e. On a sofa
2. What is the brightness level of the device?
    a. Low
    b. Moderate
    c. High
3. What is the viewing distance between your eyes and the screen of the laptop that you are holding?
    a. Less than 20 cm
    b. 21–31 cm
    c. 31–40 cm
    d. More than 40 cm
4. Do you use an external mouse when using a laptop? Yes/No
5. Is the screen elevated to slightly below eye level? Yes/No

**Assessment of tablet and phone**

1. On what surface do you place your touchscreen device?
    a. Desk
    b. Table
    c. Bed
    d. On the ground
    e. On a sofa
2. How do you hold your device?
    a. Below neck level
    b. At neck level
    c. Above neck level
3. At what brightness level is your device?
    a. Low
    b. Moderate
    c. High
4. What is the viewing distance between your eyes and the touchscreen when you hold it?
    a. Less than 20 cm
    b. 21–31 cm
    c. 31–40 cm
    d. More than 40 cm
5. What is the screen size of your device?
    a. Small
    b. Medium
    c. Large
6. Do you support the arm holding the smartphone/tablet with your other arm or another object, such as a pillow? Yes/No
7. Do you hold your phone in one hand and type with the thumb of the same hand? Yes/No
8. Do you support your smartphone using your little finger curled under the bottom edge? Yes/No
9. Do you alternate between a sitting and standing position when using your touchscreen device? Yes/No

**Work environment**

1. Can your room light be adjusted? Yes/No
2. Can your screen be seen easily, and is it free from reflections? Yes/No
3. Is your surrounding environment free from noise? Yes/No
4. Is the ventilation comfortable and sufficient? Yes/No
5. Is the temperature comfortable and sufficient? Yes/No
6. During e-learning, do you have a private area? Yes/No

**Health effects**

Since practising e-learning, have you suffered from the following:

1. Neck pain? Yes/No
2. Lower back pain? Yes/No
3. Upper back pain? Yes/No
4. Wrist pain? Yes/No
5. Shoulder pain? Yes/No
6. Eye strain? Yes/No
7. Other (please specify):_____