Risks of digital screen time and recommendations for mitigating adverse outcomes in children and adolescents

ABSTRACT

BACKGROUND

The COVID-19 pandemic caused an unprecedented move to emergency remote learning around the world, leading to increased digital screen time for children and adolescents. This review highlights the potential risk of increased screen time to the eye and general health and make recommendations to mitigate the risks posed.

METHODS

A narrative review of evidence of increased digital time during the COVID-19 pandemic, the risks linked to increased screen time and offer possible steps to mitigate these in students.

RESULTS

Digital screen time was found to have increased for children and adolescents in all the studies examined during the pandemic and data suggests that this has an impact on eye and general health. We discuss the associated risk factors and adverse outcomes associated with increased digital screen time.

CONCLUSIONS

This review offers evidence of increased digital time, highlights some of the well-known and not so well-known risks linked to increased screen time and offer possible steps to mitigate these in children and adolescents during the pandemic, as well as offering schools and parents strategies to support the eye health of children and adolescents post-pandemic. We discuss a number of interventions to reduce the risk of eye strain, myopia, obesity and related diseases that have been shown to be linked to increased digital screen time.

Keywords: Eye health, digital screen time, children, myopia

The COVID-19 pandemic, originally reported in China, has spread rapidly around the world. In trying to reduce the spread of infection, governments around the world introduced emergency measures including restrictions on unnecessary movement and closure of schools. This has led to teaching courses being delivered online, with resulting increases in screen time and a reduction in time spent outdoors and physical activity.[1] According to the United Nations Educational, Scientific and Cultural Organization (UNESCO), approximately 1.37 billion students (80% of the world's student population) from more than 130 countries globally have been affected by these lockdown measures.[2] School closures caused an unprecedented move to emergency remote learning, defined as 'a temporary shift of instructional delivery to an alternate delivery mode due to crisis circumstances'[3], with many countries adopting digital or e-learning approaches that have replaced face to face and classroom-based learning.

Whilst it is accepted that social isolation may be relieved by increased digital screen time, it is also very important to understand the potential risk to eye and general health of this increased screen time and ensure that a balance is achieved. Increased recreational screen time in schoolchildren (8-17 years old) has previously been linked to various adverse health conditions including eyesight problems, an increase in obesity, insufficient sleep and inadequate physical activity[4], and it is likely that local and national lockdowns due to the pandemic will exacerbate these issues.

LITERATURE REVIEW

Methods

The literature searches for this review were conducted in May 2021, and electronic databases (Scopus and PubMed) were searched using terms including "COVID", "screen time" and "children". Peer-reviewed articles which reported on screen time use during the COVID-19 pandemic were included, while irrelevant articles, those with no data on screen time and unavailable full texts were excluded.

Evidence of increase in digital screen time globally

Evidence suggest that digital screen time has increased globally due to the COVID-19 pandemic. In Italy, digital screen time increased by 4.85 ±2.40 hours/day among children and adolescents (6-18 years old) during the COVID-19 lockdown.[5] Moore *et al.*[6] reported a mean screen time of 5.14 hours/day in younger children (5-11 years old) and 6.53 hours for older children (12-17 years old) with 88.7% of parents reporting that their children were exceeding the Canadian screen time guidelines of 2 hours per day. In Singapore, mean non-academic screen time increased from 1.61 hours to 3.15 hours/day during the national lockdown period in children aged 3-16 years old.[7] In Turkey, 71.7% of families surveyed reported an increase in children's (6-13 years old) screen time (6.42 ±3.07 hours/day during lockdown).[8] In Germany, a study found that recreational screen time among 4- to 17-year-olds increased from an average of 133.3 minutes to 194.5 minutes/day (an average increase of 61.2 minutes/day).[9] In Shanghai, children and adolescents (6-17 years) were found to have increased leisure screen time from an average of 170 to 450 minutes/week with a total screen time increasing from 610 to 2340 minutes per week.[10] In Tunisia, there was an increase of 111.11% in total screen time for children aged 5-12[11], while in Saudi Arabia, mean digital device usage in children aged 10-18 increased from 1.9±1.1 hours to 3.9±1.9 hours/day, and the proportion using digital devices for more than 5 hours/day increased from 1.8% to 36.9%.[12] 44.6% of Chinese students (mean age 13) reported using digital devices for more than 5 hours/day for online study, which was associated with reports of irregular sleep patterns.[13] In the USA, recreational screen time among adolescents (14-18 years old) with autism spectrum disorder increased from 3.69 to 4.24 hours/day during the week, and from 5.84 to 7.39 hours/day at weekends.[14] A study in Chile found that toddlers and preschoolers (1-5 years old) increased their daily screen time from 1.66 to 3.05 hours/day during the pandemic.[15]

Risks of increased digital screen time

A. Digital eye strain. Digital eye strain is characterized by eye discomfort during or after using a digital screen. The most common symptoms of digital eye strain are blurred vision, pain in the eyes, dry eyes and headaches. Even prior to COVID-19, studies report 59-95.8% of people experience at least one symptom of digital eye strain[16, 17], with 56.5% of people reporting that their ocular symptoms have increased during the COVID-19 pandemic.[17] Here we highlight some of the reasons for digital eye strain.

Uncorrected refractive error. Whilst working on a computer does not make any refractive errors worse, any uncorrected errors that were previously tolerated may manifest themselves more readily. In some cases, it is a sign of normal ageing (affecting people around the age of 35-45 years) when the lens inside the eye reduces its ability to focus for close distances (or loses its ability to ’accommodate’). It is a normal age-related change in the eye[18-20] and requires a correction for the near working distance.[21-23] In children, however this is not normally the case. However, if a child is strongly hyperopic (long-sighted) in one or both eyes, prolonged screen time may lead to eye strain due to the need for prolonged strain on the eye muscles as the child focusses for closer distance. This may be difficult to diagnose without an eye-test as long-sighted children are likely to have a good distance vision.

Unstable binocular vision. Binocular vision is being able to use both eyes adequately to create a single visual image. Uncorrected binocular vision problems increases the risk of blur and eye strain with screen time[24-26] Binocular vision problems, when the two eyes do not align properly to focus on one point in space, can create strain on the muscles in the eye as the individual is constantly trying to re-align the eyes to eliminate blurriness and double vision.[27, 28]

Dry eyes. Constant use of a computer screen can lead to significant discomfort due to the front part of the eyes drying out, especially if the eye ‘forgets’ to blink during periods of high concentration. Increased concentration during computer use can lead to a decrease in the number of blinks[29, 30] or to incomplete blinking[31-33], both leading to reduced lubrication of the eyes resulting in dry eye symptoms.[34] The humidity of the room is also important as tear evaporation rate, eye comfort, tear stability, and production are adversely affected by dry air.[35]

Screen distance. The positioning of the computer screen is important, as advised by the Health and Safety Executive (HSE).[36] A desktop screen needs to be at a certain height and distance. A bigger desk area may be beneficial in order that the screen can be pushed further away if needed. It is possible that students learning at home during lockdown may not have been advised of the recommended distances especially if they are working in confined spaces.

Hand-held devices. Hand-held devices are near ubiquitous in US households, with 97% of children aged 0-8 having at least one smartphone and 75% having a tablet in their home.[37] Nearly half of 2- to 4-year-olds (46%) and 67% of 5- to 8-year-olds were reported to have their own device (tablet or smartphone) in 2020.[37] Most smartphones and tablets are viewed at shorter distances (between 20-40 cm). The screen and font size is also generally smaller compared to a desktop computer. The reduced working distance, smaller screen and font size will need more accommodative power in the eye with a higher risk of eye strain.

Multiple devices. It has been reported that children and adolescents often use several devices at once[38, 39], for example to browse social media on their phone while watching content on another device.[40] A UK-based study of 816 adolescent females (mean age 12.8±0.8 years) reported that 59% of participants used more than one screen concurrently after school, with 65% using ≥2 screens concurrently in the evening, 36% before bed and 68% at weekends.[41] Switching between devices increases the strain on the eye by 22%, as this entails switching distances (and hence accommodative power of the eyes) between different devices.[16]

B. Increased risk of myopia. Increased digital screen time would lead to increase in near work and a reduction of outdoor activities, both of which are important risk factors for myopia.

Increased near distance**.** The exact role of increased near work, linked to digital screen time, as a risk factor for myopia onset and progression is still under debate. Some studies report an association between increased computer use and myopia[42-44], whilst others fail to show that link to myopia prevalence.[45] A recent study reported a substantial myopic shift in children (6-13 years old) in China as a result of home confinement.[46] Based on this, it is possible that earlier onset of myopia may occur due to increased digital screen time.[47]

Decrease in outdoor activity. It is undeniable that restrictive measures by governments have led to a decrease in outdoor activity. Increased outdoor activity is an important protective factor for the onset of myopia.[48, 49] Reports suggest that an additional 40 minutes per weekday of outdoor activity leads to a 23% reduction in the incidence of myopia.[50] Wu *et al.* [51] reported a 54% lower risk of myopia progression in children (6-7 years old) who spent more than 11 hours outdoors per week.

C. Neck and shoulder strain. It is recommended that the computer screen is at eye level and correct posture is vital.[36] Incorrect posture has been shown to lead to significant back problems.[52] The use of portable devices requires the need to incline our heads forward by an average of 27°, leading to an increased strain on the neck and shoulders.[53-55] A 27° incline forward of the head has been equated to an increased perceived weight of 18kg whilst a 60° angle looking at a mobile device equates to 27kg strain.[25, 56] In addition, texting using a mobile device has been found to be associated with a non-neutral posture of the cervical spine.[57]

D. Increased sedentary time, overeating and obesity and associated higher risk of systemic diseases. The restricted access to the outdoors and increased screen time during the pandemic, has typically led to increased sedentary time with reports suggesting a reduction of nearly 2.30 h/week of exercise time in children and adolescents.[5] A study from China found that children and adolescents (6-17 years) reduced their physical activity from an average of 540 to 105 minutes per week.[10] Conversely, a study on children in Germany found an increase of an average 36.2 minutes a day in total physical activity among children and young people (4-17 years), which the authors attributed to a substantial increase in habitual physical activities such as playing outside, gardening, housework, and walking and cycling.[9]

Increased screen time and sedentary behavior has been linked to obesity and increased body mass index (BMI) in youths[58, 59], perhaps due to increased exposure to food advertising and passive food consumption.

Screen time has been found to be associated with increased dietary intake, reported to be due to distractions, interruption of physiologic food regulation, screen time as a conditioned cue to eat, disruption of memory formation, and the effects of the stress-induced food-reward system.[60] Using a smartphone during a meal can significantly affect the number of calories ingested, with one study finding an increase in caloric ingestion of 15% compared to eating without distracters.[61]

Poor eating habits have been linked to increased screen time[62], more snack consumption and diet changes.[63, 64] Eating while viewing television has been shown to be positively associated with being overweight in children and adolescents (aged ≤ 18 years).[65] Regular snacking while watching television was associated with being overweight or obesity in pre-school children (4-6 years), as was screen time over 180 minutes per day.[66] In US adolescents (grades 9-12), excessive screen time whilst watching television, use of smartphones, tablets, computers and videogames was associated with a higher likelihood of obesity through increased sugary beverage consumption and reduction in physical activity.[67] In the Netherlands, children (10-14 years) who used screens for over 20 hours per week consumed more snacks than those who used them for 6 hours or less per week.[64]

It is also likely that the pandemic may have reduced the mental wellbeing of children and adults, leading to stress-eating of unhealthy foods leading to linked risk factors of weight gain. Unhealthy food habits increasing among obese children and adolescents (6-18 years old) have been reported in Italy during the pandemic.[5]

Increased BMI in childhood has been demonstrated to increase the likelihood of obesity in adulthood[68], which in turn increases the risk of developing non-communicable diseases. Sedentary behavior has been positively associated with increased risk of disease later in life[69], including Type 2 diabetes[70], diabetic retinopathy[71], cancer[72-74], dementia[75], and cardiovascular disease[70]. Low levels of physical activity, low cardiorespiratory fitness and sedentary behavior are significantly associated with the development of metabolic syndrome.[76]

E. Disturbed sleep patterns. Screen time has been linked to poor sleep in children and adolescents. A systematic review (1999-2014) reported that screen time was associated with poorer sleep outcomes.[77] Another systematic review of studies in children and adolescents aged 6-19 years reported significant associations between the presence of a media device in the sleep environment near bedtime and inadequate sleep quality, poor sleep quality, and excessive daytime sleepiness.[78] A Spanish study found that 44% of children aged between 1 and 14 years had over 120 minutes per day of leisure screen time, which was associated with short sleep duration.[79] A study of American teenagers found that screen device usage of 5 or more hours per day resulted in 80% higher odds of inadequate sleep compared to those who did not use devices (OR = 1.79, 95% CI: 1.54, 2.08).[67] Smartphone use in bed was found to be a strong predictor for sleep problems including prolonged sleep latency and short sleep duration in adolescents.[80] In children under 5, higher levels of daily screen time were associated with shorter sleep duration and more night awakenings.[81]

F. Mental Health. While moderate engagement in digital activities has found not to be harmful[82], and it is clearly important to appreciate that using screens to maintain relationships with friends would mitigate feelings of isolation[83, 84], research also suggest that high screen exposure increases depression among youths.[59, 85] Poorer mental health has also been shown among children and adolescents using screens for more than 2-3 hours per day[86], with severe depressive symptoms being positively associated with higher levels of screen time.[87] Research has also linked problematic smart phone use (i.e. use associated with at least some element of dysfunctional use; examples include anxiety when a phone is not available, or neglect of other activities[88, 89]) to self-reported anxiety, insomnia, increased perceived stress, poor educational attainment[90] and decreased overall quality of life.[91] Excessive screen time has also been found to exacerbate ADHD-related behavior.[92] In children under 5 years of age, touch screen device use has been found to be more damaging than beneficial, and has been linked to emotional problems and attention problems.[93]

Primary caregivers of Portuguese children aged 6 to 82 months reported that screen exposure time increased during COVID-19 confinement, and this was positively correlated with behavioral and emotional problems, with attention problems and parent challenges affected most by increased screen time exposure.[94]

G. Online gaming and other activity. In addition, digital screen exposure has also increased for online gaming and streaming activity during the COVID-19 lockdown in different countries.[95-100]

Long-term behavior change

Although school closures may be short-lived, it is possible that ease of online access to schoolwork may increase the widespread acceptance of online classes and increased use of digital screen time in the longer term, leading to behavioral changes that persist after the pandemic.

IMPLICATIONS FOR SCHOOL HEALTH

Mitigation

Better ergonomics. It is important that the computer is set up correctly in order to reduce eye and back strain. The screen should be at arms length away with the eyes centered in the top third of the screen. The head should be looking straight ahead. The seat adjusted so that feet are flat on the ground, neck and back straight, forearms same height as the desk. It is Important to ensure that the screen is big enough for all the data and that access to the mouse and keyboard is comfortable. The screen should be positioned to avoid glare and reflection and the brightness and contrast of the screen adjusted to ensure they are comfortable. Following correct ergonomic advice and performing eye exercises for 4 weeks was demonstrated to reduce eye fatigue in children (aged 6 to 15 years) attending online classes during the COVID-19 pandemic.[101]

Adequate visual function, blinking and good eye habits. It is vital to develop good eye habits when using the screen, both during the pandemic and also beyond it. It is important that any uncorrected vision problems are adequately dealt with by an optometrist, ophthalmologist, or eyecare provider. Correct spectacle prescription for the screen distance and binocular vision anomalies should be addressed by exercises, spectacles, and other optical corrections. Adequate correction of binocular vision anomalies has been shown to reduce ocular symptoms of digital eye strain.[102, 103] Blinking exercises for people who suffer from dry eyes and who forget to blink are very useful.[104] A reminder on the computer every hour to forcibly blink ten times every hour can help. For those with more severe dry eyes, artificial tears and omega 3 food additives may be helpful. Trials have shown that interventions aimed at modifying diet and increasing physical activity can improve dry eye disease status[105], with omega 3 supplements resulting in reduced tear osmolarity and increased tear stability in adults with dry eye disease.[106, 107]

The HSE advises short breaks often rather than longer ones less often. Five to ten minutes every hour is better than 20 minutes every 2 hours.[36, 53] A 20-20-20 rule is also useful- a 20 second break every 20 minutes to gaze a distance at least 20 feet away. Frequent short breaks can relax accommodative and binocular vision and encourage normal blinking therefore improving the tear quality. Software which instructs users to blink at regular intervals while using computers has been demonstrated to increase blink rate and improve dry eye symptoms in adults. [108]

Smart use of digital screen time by users and schools. Ensure time spent on digital devices are maximized for learning and less digital time is used for recreational activities. It would be important for government agencies to continue to engage with schools to shape a holistic home-based learning curriculum that encourages creative learning not just from reading and study at home, but also include frequent breaks and indoor physical or household activities such as cooking, baking, and cleaning.

Limiting screen time. A daily schedule setting time for when devices can be used would be beneficial. The World Health Organization's guidelines on physical activity, sedentary behavior, and sleep recommends less than 1 hour of sedentary screen time for children 1-5 years of age.[109] The continuous use of digital devices for non-educational purposes should be limited to <15 minutes per day and a cumulative duration of <1 hour a day. The American Academy of Pediatrics recommends restricting screen time to 1 hour per day of high-quality content for children 18 months to 5 years of age and suggests consistent limits for those 6 years of age and above should have 8-10 hours of day screen-free time.[110]

Increased public awareness. Public education to increase parent awareness about the effects of increased screen time is important over the long term.

Parents and Teachers as role models. Parents can act as role models. It is known that screen time exposure is related to family behaviors. An increase in physically active behavior such as playing indoors (if possible), baking, cooking, craft activities would benefit.[111-114] Xu *et al.* [115] found family roles to play an important role in promoting physical activity. Encouragement and support from parents can increase time spent by their children undergoing physical activity, and reducing parents screen time can lead to a decrease in their children's screen time.[115] Parents need to understand the importance of maintaining good eye habits during the pandemic lockdown and beyond, including frequent breaks from near work and limiting recreational screen time. Parents can reduce the detrimental effects of digital screen time by monitoring recreational usage, setting reminders to disconnect and ensuring that time spent on digital devices are maximized for learning.

Increased time outdoors. Working within government rules during the pandemic, allowable time outdoors should be fully utilized. Increased physical activity and outdoor play has been shown to lead to longer sleep in preschoolers[81, 116], reduced obesity and also a reduced risk of myopia. Outdoor activity time has also been linked to pediatric dry eye disease, with a study of Korean school children (7 to 12 years old) finding that increased outdoor activity time reduced the rate of dry eye disease.[117]

Conclusions

In this review we report increased digital time usage in children and adolescents during the COVID-19 pandemic, the associated risk factors and adverse outcomes and provide a number of interventions to reduce the risk of eye strain, myopia, obesity and related diseases that have been shown to be linked to increased digital screen time. Through increasing awareness of the risks associated with high levels of digital screen use and sharing strategies to reduce the negative effects, teachers and parents will be encouraged to enhance the health and wellbeing of children and adolescents in the pandemic and beyond.

Human Subjects Approval Statement

Preparation of this paper did not involve primary research or data collection involving human subjects, and therefore, no institutional review board examination or approval was required.

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