Impact of Digital Technologies on Health and Wellbeing of Children and Adolescents: A Narrative Review

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ABSTRACT

As the world digitises, children and adolescents are increasingly using digital technologies. These devices offer benefits such as exposure to social contacts and support, potential learning opportunities, and access to health promotion material. However, along with these benefits, emerging evidence is indicating that frequent, extended use of digital technologies is associated with negative impacts on the health and wellbeing of children and adolescents. There are many ways to use digital technologies both for learning and recreation, so understanding the context of use is important when considering these impacts. As the pace of change unfolds, this narrative review provides an overview of the impacts of using digital technologies on the health and wellbeing of children and adolescents across eight areas: vision, hearing, obesity, pain, sleep, cognition, mental health, and social impacts. Key points summarise the current state of evidence with relating expert opinion on reducing the risk of harm (where indicated), with the aim to aid decision-making and risk intervention. Sources include global large-scale studies, systematic reviews, and meta-analyses. Physiotherapists, with a professional scope focusing on physical health, quality of life, health promotion, and advocacy, are well positioned to support children and families, and to contribute to interventions aimed at reducing risk.

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INTRODUCTION

The use of digital technologies (defined in this review as screen-based digital tools including hand held digital devices and computers) is increasing for children and adolescents worldwide. From 2012 to 2018, the global rate of adolescent digital device use increased from 21 to 35 hours per week (OECD, 2021). In Aotearoa New Zealand, it increased from 22 to 42 hours per week in the same period (OECD, 2021). In the school setting, New Zealand students have among the world's highest use of digital devices and the highest use of internet in class in the world (IEA, 2019; Medina & McGregor, 2019; OECD, 2015, 2021).

Screen time further increased with the Covid-19 pandemic response for children and young people (Madigan et al., 2022), and recent research suggests that rates of use have not returned to pre-pandemic levels (Hedderson et al., 2023). Online schooling was rapidly adopted, and a future direction for hybrid schooling has emerged (Raad & Odhabi, 2021). These rapid changes have occurred in a timeframe not matched by policy or guidance in many countries.

Digital technologies present both benefits, such as potential for educational gain, exposure to social connections and support, and access to health promotion information (AAP Council on Communications and Media, 2016), and risks to young people.

Risks can include compromise of privacy and confidentiality, exposure to harmful and inaccurate content, and reduced educational outcomes (AAP Council on Communications and Media, 2016; OECD, 2015; Sutcliffe & Webber, 2021). Screen-based digital tools can be used in many ways, and content and context of use can influence potential impacts. This can include (among other factors) different screen media activities, different devices, the user's age and developmental stage, independent or collaborative use, gender, and pre-existing health. While these factors are highly relevant, an increasing body of evidence also shows potential harm to the health and wellbeing of children and youth associated with frequent and extended use of digital technologies (AAP Council on Communications and Media, 2016; Stewart et al., 2019; Stiglic & Viner, 2019; Wong et al., 2021), across a wide range of health domains, as summarised in Table 1.

An exact figure after which total screen use (including school and home use over a 24-hour day) can be described as excessive remains elusive and difficult to establish. Additionally, both no or low usage and heavy internet use have been associated with adolescent mental and physical health problems (McNaughton, 2021). Furthermore, screen use duration, content, and quality can have an unequal impact on different health and wellbeing domains. Figures associated with harm within this review commonly range from two to six hours of screen use per day for children over 5 years old, between various studies and reports. While there is considerable variation between these figures, they nonetheless highlight the need for interventions to encourage healthier screen behaviours, when considering current rates of total screen use for young New Zealanders.

Concerns about impacts of excessive screen use have been raised by not only parents, health professionals, and educators, but by young people themselves (Jiang, 2018; Sahlburg & Graham, 2020). Parents look to schools and health providers for information. For physiotherapists and other professionals within health and education sectors, understanding the evidence base along with available guidance, strategies, and resources is key to supporting young people to gain benefits from digital technologies, while minimising harms. Physiotherapists, whose professional scope focuses on physical health, quality of life, health promotion, and advocacy (using knowledge to promote health and wellbeing), are well positioned to support children and families, and to contribute to interventions aimed at reducing risk (Appendix A).

This review sets out to examine the impacts of digital technologies on the health and wellbeing of children and adolescents, with the aim to provide a holistic overview to aid risk intervention (implementing interventions to reduce associated risks) and decision-making. Pragmatic recommendations developed by subject experts are provided for clinicians, educators, and parents, to assist with mitigating risk and encouraging safer screen use behaviour in education and home settings. These are set broadly due to a wide relevance, including to physiotherapists. Further to communicating advice or delivery of interventions, developing awareness about what other professional roles entail can aid referral processes and encourage interdisciplinary and patient-centred approaches. Recommendations appear prudent in the context of a growing body of evidence in this space, the rise in digital screen time compounded by the Covid-19 pandemic (Madigan et al., 2022; Wang et al., 2021), an overall earlier age onset of frequent and extended screen use (Kabali et al., 2015), and the development of best-practice guidelines or recommendations for the safer use of digital technologies globally (Appendix B).

METHODS

This narrative review preferentially focused on systematic reviews, meta-analyses, and large-scale studies with sample sizes of thousands of participants. Given the large heterogeneity across disciplines, smaller studies were considered in areas where a high level of evidence was not available, as highlighted in the results and discussion sections. Areas of child and adolescent health and wellbeing investigated were those associated with using digital technologies in the peer-reviewed literature to date (Table 1). Databases searched included PubMed, MEDLINE, EBSCO, CINAHL, Cochrane, and Google Scholar. In addition, references were gained from reference lists of sourced articles. The inclusion criteria required studies to be published between January 2010 to September 2023, in the English language, be peer-reviewed, include participants aged 0 to 19 years old, and report potential effects of screen use in school and/or the home environment. Publications were excluded if participants were over 19 years old, or if they focused only on television (TV) use.

One author (JC) screened the title and/or abstract of the results and, if meeting criteria, full text articles were acquired. Key words, multiple terms, and Boolean operators are included in Table 2.

For mental health and social impacts, a more systematic search strategy was beyond the scope of this review, and brief narrative reviews were included to provide a comprehensive overview. Case-reports and conference proceedings were excluded from

Table 1

Areas of Children's Health and Wellbeing Impacted by Digital Technology Use Reported To Date

Physical	Neurological/cognitive	Psychosocial
Vision	Attention	Mental health
Hearing	Language	Cyberbullying
Obesity	Cognition	Problematic internet use
Pain syndromes	Behaviour	Family conflict
Sleep	Structural changes	Self-harm/sexual harm

Table 2

Search Equations Used for This Review

Category	Search terms
Vision	(child* OR adolescen* OR teen* OR pre-schooler* OR paediatric OR pediatric OR young OR youth) AND (computer OR digital device OR "screen media" OR "screen use" OR "screen time" OR (electronic OR digital) AND media) AND (dry eye* OR computer vision* OR "occular surface disease" OR "ocular dryness" OR keratoconjunctivitis sicca) AND (myopi* OR refractive error)
Hearing	(child* OR adolescen* OR teen* OR pre-schooler* OR paediatric OR pediatric OR young OR youth) AND (personal music player OR personal listening device OR headphones OR earbuds) AND ("hearing loss" OR ''hearing risk" OR "noise induced hearing loss" OR "noise-induced hearing loss" OR NIHL OR hearing threshold* OR hearing problem*)
Obesity	(child* OR adolescen* OR teen* OR pre-schooler* OR paediatric OR pediatric OR young OR youth) AND (computer OR "digital device" OR "screen media" OR "screen use" OR "screen time" OR (electronic OR digital) AND media) AND (obesi* OR adipos* OR "weight gain" OR "body mass index")
Pain	(child* OR adolescen* OR teen* OR pre-schooler* OR paediatric OR pediatric OR young OR youth) AND (computer OR "digital device" OR "screen media" OR "screen use" OR "screen time" OR (electronic OR digital) AND media)) AND (back pain OR neck pain OR posture OR spinal OR cervical) OR (headache* OR repetitive strain OR musculoskeletal pain)
Sleep	(child* OR adolescen* OR teen* OR pre-schooler* OR paediatric OR pediatric OR young OR youth) AND (computer OR "digital device" OR "screen media" OR "screen use" OR "screen time" OR (electronic OR digital) AND media) AND (sleep OR bedtime routine)
Cognition	(child* OR adolescen* OR teen* OR pre-schooler* OR paediatric OR pediatric OR young OR youth) AND (computer OR "digital device" OR "screen media" OR "screen use" OR "screen time" OR (electronic OR digital) AND media) AND (cogniti* OR *attention OR hyperactivity OR ADHD OR behaviour* OR memory)

the review but were utilised for discussion purposes along with peer-reviewed New Zealand reports, where appropriate.

FINDINGS: IMPACTS OF DIGITAL DEVICE USE ON HEALTH AND WELLBEING

Dry eye disease and screen use

Up to 90% of adult computer users report eye discomfort with extended screen use (Coles-brennan et al., 2019). The visual, cognitive, and ergonomic demands of screen use interfere with the physiological blinking mechanism that drives the production and distribution of tears, to ensure clear, comfortable vision (Talens-Estarelles et al., 2021). This protective tear film destabilises and evaporates more quickly as a result of reduced blinking during digital screen use, causing discomfort (Stapleton et al., 2017). Over time, these symptoms can aggravate and contribute to dry eye disease. Digital screen use, given its pervasiveness, has thus been recognised as a consistent risk factor for dry eye disease. This progressive, multifactorial, chronic condition involves inflammation, damage of the eye surface, discomfort, and visual disturbance (Craig et al., 2017). Dry eye has been shown to impact patients' quality of life, mental health, work productivity, learning, and the economy (Stapleton et al., 2017).

Historically, dry eye disease has been seen to predominantly affect aging populations, with a global prevalence of up to 50% (Stapleton et al., 2017). Lately, however, dry eye is increasingly reported among youth as well, primarily in association with extended screen use, irrespective of content (Muntz et al., 2021). Several recent studies in children reveal that hours of daily screen use can predict symptoms of discomfort (Akib et al., 2021; Alnahdi et al., 2022; Elhusseiny et al., 2021; Moon et al., 2014; Moon et al., 2016; Wu et al., 2020). Emerging evidence suggests a link between the early age onset of extended screen use and structural changes in ocular surface health, some irreversible (Cremers et al., 2021; Kawashima & Tsubota, 2013). As such, a purported earlier onset of dry eye disease may predispose children and youth to a steeper progression of the condition and more severe impacts on quality of life.

Interventions shown to be beneficial in alleviating signs and symptoms of dry eye related to screen use include reducing time of use, the use of breaks, and re-training habitual blinking patterns (Kim et al., 2021; Moon et al., 2014).

Key recommendations:

- Limit daily screen time.
- Regular breaks ("20 min, take a break").

- Education to develop awareness of the relationship between dry eye, screen use, and blinking ("think and blink").
- Implement routine clinical screening and intervention programmes.

Myopia: Risks and protective interventions

Myopia, or "short-sightedness" is a common vision problem that causes blurring of distance vision (Martínez-Albert et al., 2023). However, myopia has emerged recently as a serious public health concern; there has been a rise in the prevalence of myopia, as well as a progressively younger age of onset and accelerated myopic progression (Chua et al., 2016; Foreman, Salim, Koca et al., 2021; Morgan et al., 2018). Myopia is a significant cause of visual impairment and, when diagnosed, steps are taken to slow the progression and risk of developing high levels of myopia (high myopia), which is associated with blinding pathologies, including myopic maculopathy, cataracts, and glaucoma. Children with high myopia are at a significantly increased risk of developing these potentially blinding conditions in later life and these risks cannot be prevented with optical correction (Foster & Jiang, 2014). Paediatric myopia has reportedly doubled over the last decade, with the global prevalence predicted to rise to 50% by 2050. Of note, an estimated 10% will qualify as high myopia, which exponentially increases the risk of blinding ocular pathology (French et al., 2013; Holden et al., 2016).

Factors contributing to the onset and progression of myopia include genetic risk, reduced exposure to natural sunlight, and near work (including screen time) (Martínez-Albert et al., 2023; Wong et al., 2021). The link between screen use and myopia in children is considered to relate to increased time spent on visual near work, which usually occurs indoors (Watts, 2020). When compared to books, children use screens for longer periods of time, at younger ages, and may have a closer viewing distance with small screen size and font (Foreman, Salim, Koca et al., 2021; Foreman, Salim, Praveen et al., 2021). Screen time is recognised as a modifiable risk in myopia management, and advising reduced screen time is common practise among paediatric ophthalmologists (Zloto et al., 2018).

Previous studies on the association between screen time and myopia report mixed results (Lanca et al., 2021). A lack of association in some of these studies has been ascribed to the inclusion of television viewing, due to the greater viewing distance compared to a tablet, computer, or phone (Lanca et al., 2021), and the relatively recent emergence of extended digital device use in young populations (Foreman, Salim, Koca et al., 2021). The majority of recent studies (from 2014 onwards) showed an association between screen use and myopia (Alvarez-Peregrina et al., 2020; Enthoven et al., 2019; Enthoven et al., 2020; Foreman, Salim, Praveen et al., 2021; Harrington & O'Dwyer, 2023; Masihuzzaman et al., 2023; Mccrann et al., 2021; Mineshita et al., 2021; Saxena et al., 2017; Wang et al., 2021). A review of studies exploring the impact of increased digital device usage due to lockdown measures on myopia found that increased screen use, near work, and reduced time outdoors were significantly associated with a progression in myopia (Kaya & Uzel, 2023; Kurupp et al., 2022; Wang et al., 2021; Wong et al., 2021). This raised concerns that while temporary online learning from home due to lockdowns was useful, long-term adoption of increased device use could raise risks to children's vision (Wong et al., 2021).

Spending time outdoors has been found to have a protective role in the development of myopia, although not in its progression once diagnosed, and encouraging two hours a day outdoors has been described as a practical public health intervention to lower risk (Wong et al., 2021; Xiong et al., 2017). In China, government policies restricting screen use and promoting outdoor time have been implemented to try to combat the development of the myopia epidemic (Wong et al., 2021).

Key recommendations:

- Educate to develop awareness of the relationship between myopia, near work, and reduced outdoor time.
- Aim for a minimum of two hours per day outdoors.
- Encourage frequent breaks from near work ("20 min, take a break") and limiting recreational screen use.
- Encourage outdoor activities at school, and a balance of screen-based learning with screen breaks and non-digital activities.
- Regular vision testing and education on prevention of myopia and interventions.

Noise-induced hearing loss and headphone/earbud use

Portable digital devices are now frequently used as personal listening devices (PLD) for sounds, speech, and music from audio-visual and audio sources, including smartphones, tablets, laptops, and portable music players (Alcântara et al., 2017; Gilliver et al., 2017). The popularisation and access to such devices have increased the exposure of young people to higher levels of noise (Alcântara et al., 2017). Headphone and earbud use with portable digital devices are considered in this section as they channel audio directly into the ear when compared to speaker use, creating a greater noise level risk to hearing (World Health Organization, 2021). Headphones/earbuds are commonly used by children and teenagers for recreational purposes and while studying or doing schoolwork (Gilliver et al., 2017; Le Clercq et al., 2018). Use can also be required by schools and along with learning apps, audio books, and video content, just under half of teenagers report listening to music through headphones during school time (Le Clercq et al., 2018; Widen et al., 2017).

Exposure to loud noise over a brief period, or high levels of noise over extended periods, can damage the structure of the inner ear, resulting in noise-induced hearing loss (NIHL) (Levey et al., 2012). Children have a unique level of risk, as patterns of hearing at the cochleas can have an important role in central auditory development; therefore, loss of peripheral hearing could affect central mechanisms of hearing (Harrison, 2008; Levey et al., 2012). In addition, children and adolescents are considered a noise-sensitive population, more likely at higher risk from harmful noise impacts than exposed adults (Fink & Mayes, 2021). Noise-sensitive factors include risk of permanent damage during development of the peripheral and central auditory systems, which continues into at least late adolescence. Further, hearing loss has greater consequences for

children and adolescents, because early onset can negatively impact cognition, speech communication, mental health, socialisation, education, and future vocational success (Fink & Mayes, 2021; World Health Organization, 2021).

The association between headphone/earbud use and NIHL are well accepted by international health bodies and institutes, and the World Health Organization (WHO) estimates that 50% of (or 1.1 billion) young people aged 12 to 35 years are at risk of hearing loss due to prolonged or excessive sound, including through the use of PLD (Mayes & Fink, 2021; Wang et al., 2019; World Health Organization, 2021). Headphone/earbud users have up to a 4-fold risk of developing NIHL than non-users, and hearing loss has been reported in users as young as 9 years old (Fink & Mayes, 2021; Le Clercq et al., 2018). Repeated use of headphones/earbuds for more than five years has been found to cause high frequency hearing loss (World Health Organization, 2019c).

The WHO and International Telecommunication Union recommend volumes for using headphones/earbuds should be set at less than 60% for the general population (which equates to approximately 80 dB mean SPL) (Fink & Mayes, 2021; World Health Organization, 2019c). Safer daily average sound exposures for the public have been described as 70 dB LA_{EQ24h} or less (Neitzel & Fligor, 2019; World Health Organization, 2019a), with 8-hour equivalent daily average workplace exposures at or over 80 dB posing a risk of hearing loss in adults (Fink, 2017). Because young people are considered noise-sensitive populations, a threshold for children and adolescents to use the lowest functional personal listening volume below 50% (to limit exposure to less than 70 dB LA_{EQ24h}) has been recommended for a better margin of safety, with health advice that the less time on headphones, the lower the risk of hearing loss (Fink & Mayes, 2021). Current evidence suggests young headphone/earbud users are at risk of hearing loss, and safe practice at home and in schools could reduce harms.

Key recommendations:

- Educate that the less time on headphones, the lower the risk of hearing loss.
- Use headphones/earbuds for children at the lowest functional personal listening setting (that is, the lowest volume they can hear clearly with), generally as low as possible below 50% volume (50% volume equates to around 70 dB).
- Regular hearing testing and education on prevention and interventions.

Obesity/reduced physical activity

Insufficient physical activity in children and adolescents has been highlighted as a health concern by the WHO, noting that high screen use displaces more active health-promoting behaviours (World Health Organization, 2019b). Screen time has been linked to a risk of obesity in preschoolers, children, and adolescents (Buchanan et al., 2016; Chang et al., 2023; Engberg et al., 2019, 2020; Fang et al., 2019; Li et al., 2020; Mineshita et al., 2021; Robinson et al., 2017; Stiglic & Viner, 2019; Tripathi & Mishra, 2020), although a recent review and meta-analysis suggests not in central obesity (Ghasemirad et al., 2023). Strength of evidence has been described as weak (Biddle et al., 2017), to moderate for a dose-dependent relationship with television and total screen time (Li et al., 2020; Stiglic & Viner, 2019). Duration of screen use associated with obesity ranged between studies from greater than one hour for children under 24 months, to greater than two to four hours in children older than 24 months.

A number of experimental studies have examined reducing screen use to test the relationship between screen use and weight, showing a reduction in obesity when screen use is lowered (Biddle et al., 2017; Buchanan et al., 2016; Leung et al., 2012). However, some interventions addressed diet and physical activity in addition to reducing screen time, limiting interpretation of results (Biddle et al., 2017). Current evidence indicates the importance of consideration of the entire 24-hour day (both home and school) when considering the impacts of screen time on the activities of children and youth (World Health Organization, 2019b). Physical activity guidelines in New Zealand recommend recreational screen time limits for 5 to 17 year olds (see Appendix B) and advise at least one hour of moderate to vigorous activity per day, along with participating in light physical activities and breaking up sitting time (Ministry of Health, 2017b).

Key recommendations:

- Educate that high sedentary screen use can displace health-promoting behaviours.
- Recommend moderation of screen time along with encouraging active behaviours in the paediatric population.

Back/neck/repetitive strain injury pain syndromes

Physical complaints including back and neck pain, recurrent headaches, and repetitive strain injury (RSI) of the upper limb have been described in relation to high screen use in children and youth (Lui et al., 2011; Torsheim et al., 2010; Yue et al., 2023), with posture thought to play an aetiological role (Straker et al., 2007). While different screen-based activities can contribute to different ergonomic pressures, using computers and touch screen devices usually involves sitting work in static postures with repetitive upper extremity movements, and can increase flexion of the cervical spine (Joergensen et al., 2021).

Emerging evidence suggests that duration of screen time is associated with back pain in children and adolescents, with evidence of a dose-dependent relationship; however, the level of evidence is weak (Joergensen et al., 2021; Torsheim et al., 2010; Yue et al., 2023). Light and visual stimulation has been linked to headache and migraine onset, with screen use identified as a potential trigger (Montagni et al., 2016). Several large-scale studies have examined the association between headache and screen use in young people. Total screen media use and time spent using computers was significantly associated with headaches (Brindova et al., 2015; Taehtinen et al., 2014; Torsheim et al., 2010), with a dose-dependent relationship found in a study investigating 10 to 12 year olds (Taehtinen et al., 2014), providing a weak level of evidence.

Further research is needed to investigate the association between headache and computer/device use, along with RSI of the upper limb, where only small-scale studies and a weak

level of evidence currently exists in children. Studies examining headache and musculoskeletal pain have also noted that young people reported rarely receiving information on workstation layout and ergonomic advice for device use, and education alongside appropriate furniture in schools may reduce risks (Palm et al., 2007; Straker et al., 2007).

Key recommendations:

- Ergonomic guidance for the safer use of digital devices should be given to youth, schools, and caregivers, alongside appropriate furniture.
- Encourage a balance of screen and non-screen activities.

Sleep disturbance and associated impacts

Inadequate sleep is associated with numerous poor health outcomes (Janssen et al., 2020). Excessive screen use has been linked to sleep disturbance in young people, from infancy to adolescence (Hale & Guan, 2015; Janssen et al., 2020; Magee et al., 2014; Sahlburg & Graham, 2020). Sleep-onset, quality, and duration are noted impacts of screen use, and several mechanisms are thought to contribute (Hale & Guan, 2015). These include through displacement of physical activity and sunlight that may help to regulate sleep, screen-light exposure delaying the release of melatonin leading to disruption of the circadian rhythm, increased arousal following interactive media content before bedtime, and delayed bedtime due to screen use and nightly alerts. Sleep is particularly important during periods of heightened brain development, such as early childhood and adolescence. A U-shaped relationship has also been described whereby sedentary screen use leads to delayed sleep, which increases fatigue resulting in further sedentary activities the following day (Magee et al., 2014).

While small-scale studies exploring the link between screen use and sleep at various stages of children's development show mixed results, very few studies showed favourable screen-sleep trends (Belmon et al., 2019; Carter et al., 2016; da Silva et al., 2022; Hale & Guan, 2015; Hysing et al., 2015; Janssen et al., 2020; Li et al., 2020; Lund et al., 2021; Mei et al., 2018; Mortazavi et al., 2019). A recent Organization for Economic Cooperation and Development (OECD) report noted that the negative impact of screen time on adolescent sleep duration when objectively measured was small; however, objective measures from a large-scale Spanish birth cohort study were contrary to those referenced (Cabré-Riera et al., 2019; OECD, 2020; Orben & Przybylski, 2020). Further research using objective measures is needed to explore the impact of screen use on sleep.

Key recommendations:

- Promote physical activity and time outdoors.
- Advise removing screens from bedrooms and limit bedtime screen use.

Cognition: Inattention, language, cognitive function, and behaviour

The impact of digital technologies on the developing brain is an emerging area of research. The brain changes in response to experiences, undergoing potentially lasting structural and functional change. Young people have a high level of brain plasticity, particularly in infancy, and again in adolescence, as well as "sensitive" periods for some functions, where experiences may have a greater impact on brain development (Fandakova & Hartley, 2020; Kolb et al., 2017). While measures of digital screen time on cognition have been a common focus in research, different screen media activities may have different impacts (Kirlic et al., 2021).

Large-scale studies and reviews of screen use in excess of guidelines and cognitive outcomes in children under 6 years old (including executive control, emotional maturity, inhibitory control, and attention) have shown a trend of negative association (Corkin et al., 2021; Jourdren et al., 2023; Kerai et al., 2022; Reus & Mosley, 2018; Tamana et al., 2019; Wu et al., 2022). To explore cause and effect, a longitudinal cohort study explored the directional association of screen time and developmental delay in participants at 24, 36, and 60 months, measures of which included communication and socioemotional health. Results supported a directional association between screen time predicting developmental delays, not that children who have developmental delays are given more screen time (Madigan et al., 2019).

Numerous studies and reviews have indicated language delays associated with hours of screen use in infants and toddlers (Karani et al., 2022; Kerai et al., 2022; Raheem et al., 2023; Takahashi et al., 2023). A recent meta-analysis, however, found no significant associations between screen time and vocabulary with non-experimental or "natural" media exposure, and small positive associations with experimental content (content researchers had created) or educational media exposure (Jing et al., 2023). Two systematic reviews investigating the impact of screen use on language skills in children found that greater quantity of screen use was associated with lower language skills (Alamri et al., 2023; Madigan et al., 2020). Educational viewing was positively associated, along with co-viewing and the age of onset of screen use, suggesting that any language benefits from educational content were likely to occur later in childhood than earlier. Authors noted that the quality of educational viewing varied between studies; therefore, caution needed to be taken in interpreting results to mean that all educational viewing is beneficial. Madigan et al (2020) concluded that "too soon, too much" screen use negatively impacts language skills for young children, along with wider negative impacts of excessive screen use on developmental, behavioural, physical, and learning outcomes; therefore, high quality viewing should only occur in moderation, with co-viewing advised.

ADHD symptoms have been found to have a statistically significant association with screen use in children and adolescents, from meta-analyses and longitudinal studies (Liu et al., 2023; Nikkelen et al., 2014; Ra et al., 2018; Yifei et al., 2023). Limitations exist in these studies, however, including symptoms measured through self-report and in the absence of a formal diagnosis of ADHD. Further, causality is not inferred, and a bidirectional effect has been found between ADHD symptoms and screen time, whereby children with symptoms of ADHD seek higher screen exposure, which goes on to heighten symptoms (Yang et al., 2022).

Conversely, a Dutch longitudinal study found no association between screen time in the early years and a diagnosis of ADHD

at 8 and 10 years (Levelink et al., 2021). Notably, children in this study had lower screen time than the previous studies, with an average of 30 minutes per day compared to 1.5 to 3.6 hours at age two in similar studies.

The use of TV, social media, and total screen use have been negatively associated with cognitive performance, including fluid and crystalised intelligence, although educational viewing has been associated with some benefits (Paulus et al., 2019; Walsh et al., 2020). Videogaming has mixed reports, including both enhanced and reduced cognitive performance in specific areas, both increased and decreased grey matter on magnetic resonance imaging (MRI) studies of 14 year olds depending on the strategies used for game playing, and increased reward centres and neural activity in the reward centres. These latter changes have incited concern due to similarities with gambling and addictive behaviours (Kühn et al., 2011). Overall, while the majority of participants studied were adults, video games are thought to have both positive and negative impacts, although gains may depend on age and developmental stage (Gottschalk, 2019; Kühn et al., 2011; Walsh et al., 2020).

The relationship between screen use and brain structure is complex (Paulus et al., 2019). MRI studies show neural changes associated with total screen media use in children. General screen media use over and above the time recommended in guidelines for pre-schoolers has been associated with lower integrity of white matter on MRI studies in areas involved with language and emergent literacy skills, as well as poorer performance on behavioural tests (Hutton et al., 2020). In 9 and 10 year olds, over seven hours a day of screen use was associated with a thinner cortex, reduced volume, and difference in sulci depth on MRI, along with reduced fluid and crystalised intelligence and mixed changes in cognitive performance, although cause and effect cannot be determined (Paulus et al., 2019).

The impacts of screen use on cognition are not well understood and appear to differ according to screen media activity and developmental stage. While some content (such as educational content) can have benefits in children over 2 years old, studies have found that greater time spent on screens is associated with negative impacts on cognition and development. Duration of screen use may interfere with experiences needed for healthy development such as social contact, physical activity, and sleep, while displacing non-screen free play and leisure activities that enhance cognitive, social, and emotional skills (Kerai et al., 2022). Guidelines advising no screen use in children under 2 years old, and no more than one hour of high-quality content with co-viewing recommended in children aged 2 to 5 years therefore are positioned to minimise harm in these age groups. Future studies may shed light on this recently explored topic.

Key recommendations:

- Continue current advice for screen time limits for children under 5 years old.
- Educate on the importance of high-quality viewing and recommend co-viewing with children under 5 years old.
- Monitor digital screen content for children.
- Promote a balance of screen and non-screen activities for older children and adolescents.
- Teach healthy screen behaviours to children and adolescents.

Mental health and digital technologies: Moral panic or tangible risk?

Mental health problems in adolescents have increased in recent years, and a connection between the timing of this increase coinciding with increased technology use has been drawn (Tang et al., 2021; Twenge & Campbell, 2018). A number of systematic reviews and meta-analyses have examined this link recently, although from predominantly cross-sectional studies that make causation very difficult to assess. These reviews themselves produce mixed results, from significant associations to significant but small associations, and several have described the strength of evidence as weak (Santos et al., 2023; Stiglic & Viner, 2019; Tang et al., 2021; Zou et al., 2021).

A dose-dependent relationship is demonstrated in numerous studies between excessive screen use and mental health problems. While moderate use was not associated with poorer outcomes, more frequent daily screen use has been found to be associated with lower reported mental wellbeing. However, the amount varies between studies, from more than one or two hours per day of screen use (Twenge & Campbell, 2018; Khan et al., 2021; Kidokoro et al., 2022; Zhang et al., 2020), more than three or four hours of daily screen use (Leung & Torres, 2021; Mougharbel et al., 2023; Yang et al., 2013), and more than six hours per day of screen use (OECD, 2015).

Gender impact, with females showing a greater risk factor for screen use and mental health problems, is a trend that has been reported in numerous studies (Barthorpe et al., 2020; Leung & Torres, 2021; Nigg et al., 2021; Twenge & Farley, 2021). A positive association between high screen use and emotional symptoms and reduced emotional understanding in younger children has also been found in longitudinal studies (Allen & Vella, 2015; Skalická et al., 2019). Whether screen time is directly or indirectly (via an impact on sleep) associated with depression and anxiety in adolescents has also been explored. Leung and Torres (2021) found that more than four hours of screen time was associated with depression and anxiety in adolescents, and that this was not mediated by sleep.

While the use of digital technologies can support wellbeing (Berger et al., 2022), excessive screen use does appear to have a negative association with mental health outcomes in young people, but the strength of evidence is weak. Along with time spent on screens, gender, pre-existing mental health and the type of media matters, and may be more relevant than exposure, with different devices or content impacting results in several studies.

Key recommendations:

- Promote a balance of screen and non-screen activities for older children and adolescents.
- Advise removing screens from bedrooms and limit bedtime screen use.
- Educate older children and adolescents about healthy social media and internet use.

Social impacts: Cyberbullying, self-harm, sexual harm, problematic internet use, and family conflict

Internet use can have positive social impacts for young people, enabling them to connect with like-minded communities, and to seek support and information (among other benefits). Harmful impacts can also occur, and internet use can negatively impact the health and wellbeing of children and adolescents through exposure to inappropriate content and pornography, solicitation and child abuse, cyberbullying, and obsessive or addictive behaviour (see Appendix C) (Sasaki & Hobbs, 2012; Slavtcheva-Petkova et al., 2015). While the severity of harms caused by such online risks can vary from mild to severe, these issues impact on the health and wellbeing of high numbers of children and youth, and therefore are important to target.

Key recommendations:

- Utilise netsafety resources within homes and schools, family media plans, and supervision of screen use for younger children to reduce risks of online harm.
- Continue existing education programmes to reinforce digital citizenship and cyber security within schools.
- Legislative change may be required to reduce harms, such as improving safeguards and enforcing age limits on restricted sites.

DISCUSSION

Digital technologies are here to stay and will be an integral part of the future for children and adolescents, as they already are a part of their lives. Digital technologies can offer benefits and in themselves are not universally harmful. Exploring the impacts and examining the ways in which we use technologies may allow us to maximise their potential and allow young people to gain essential skills.

The impact of quantity versus quality of screen media use on health is not equivocally accepted, nor fully understood. While some suggest that quality is more relevant than quantity, this review found more nuanced relationships. Time spent using digital technologies appears to affect some areas of health (including dry eye disease, myopia, NIHL, and pain syndromes), through mechanisms of use and/or displacement of health-promoting behaviours, more than quality of screen media content. Conversely, quality, and type of screen media may affect mental health, wellbeing, and cognition, with age and developmental stage as further potential confounding factors (Madigan & Reich, 2023). While content and context are fundamental, as many excessive activities can be harmful, emerging research indicates that high use of digital screens comes with numerous risks to health. More studies are needed; however, a broad and growing body of literature outlines a range of harms associated with frequent, extended use of digital technologies.

The impact of educational technology on health specifically has not been explored in depth, partly due to its complexity. The use of digital technologies can certainly support learning; however, devices can be used diversely, and tasks can be high value or low value. As educational and recreational use become more intertwined, with homework tasks completed at home online and recreational screen use taking place during class (Kay et al., 2017; Sahlburg & Graham, 2020), it is useful to factor both cumulative home- and school-based screen use into a child's overall screen use when considering balance and holistic wellbeing. While recreational guidelines for screen use exist in New Zealand with a focus on time limits (Appendix B) (Ministry of Health, 2017a, 2017b), current initiatives to address screen use in education focus largely on cyber security, reducing harmful online content exposure, and cyberbullying (Lee et al., 2023; Ministry of Education, 2024). The United Nations Educational Scientific and Cultural Organization (UNESCO) has recently noted the risk that excessive screen exposure through school use can also contribute to exacerbation of overall risk, and has called for discussion and decision-making to support children's access to safer, fairer, and effective use of technology (UNESCO, 2023; United Nations General Assembly, 2022).

The challenge, however, is that frequent, extended use of digital technologies has become commonplace as screens are used for recreation, school, and work. A return to balance may benefit the long-term health of children and adolescents. Wise solutions are needed to minimise health risks posed by digital technologies, including information about how to engage with screens positively, and a multi-pronged approach will be needed to achieve this (Sahlburg & Graham, 2021; Wilkinson et al., 2021). Some health risks may relate more to content and context of screen use, while others are associated with total screen use (or the displacement of non-screen activities that may be protective or enhance development). Therefore, recommending time limits or a balance of screen and non-screen activities may be a component of such advice, dependent on age and developmental stage of the young person. Further research is needed to better understand and define what qualifies as "excessive" screen use and to guide setting "safer" limits for use duration.

Limitations

This review is not without limitations. Key data may have been missed through the exclusion of non-English publications. The narrow, field-specific focus of many reports hampers the development of a holistic perspective needed for decision-making in a timely manner, especially in the absence of consensus on definitions or methodology (Haby et al., 2016). A broader search strategy and full systematic approach was limited by the breadth and scope of this analysis. This review therefore lacks formal assessment of the quality of evidence of included studies, introducing risk of bias. Further research is needed to explore the impacts of digital technologies on the health of children and adolescents, including longitudinal studies on the impact of recent technologies, and solutions to circumvent the effects of recall-bias with self-reported values. As the majority of studies within this review are international in origin, more research is required within New Zealand to ensure transferability of results, and a cultural understanding of health in the context of this population. Research shaped with Indigenous perspectives of health would not only be more informative with balanced and holistic understandings, but would help improve health access and equity in Indigenous communities in New Zealand and elsewhere.

Digital screen use is not a single construct; different screen media activities can have different influences and future research

needs to take this into consideration to more clearly understand impacts (Kirlic et al., 2021). A reliance on observational research has been noted to limit strength of evidence and proof of causation (Wilkinson et al., 2021). Substantiated evidence through longitudinal, controlled trials is key, if difficult to attain, given the pervasiveness of screens, absence of controls, and slow progression changes. However, in the face of emerging evidence supporting these associations and mechanisms, as well as available interventions to reduce risk, taking steps towards supporting healthy use must be prioritised.

CONCLUSION

As the internet and digital technologies change the way we engage and live in society, the impact of digital technologies on child and adolescent health and safety have increasingly become a global focus. Pragmatic recommendations are needed to support clinicians, parents, and educators by giving information about potential impacts and how to develop healthy habits with screen use, promoting balanced use, and encouraging young people to be critical consumers. Such recommendations could allow children and adolescents to benefit from digital technologies, while lowering existing risks.

KEY POINTS

1. The use of digital technologies is increasing for children and adolescents, and rapid changes in usage have occurred in a timeframe not matched by policy or guidance in many countries.
2. While digital technologies offer benefits, frequent and extended device use is associated with risk of harm to child and adolescent health and wellbeing.
3. This review provides a holistic overview of the impacts of using digital technologies on the health and wellbeing of children and adolescents across eight areas: vision, hearing, obesity, pain, sleep, cognition, mental health, and social impacts, with relating expert opinion on reducing the risk of harm, where indicated.
4. Understanding the effects of screen use on child/adolescent health is important for physiotherapists, who can not only have roles in providing treatment for some health issues associated with excessive screen use, but also in research, health promotion, and guideline development.

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PERMISSIONS

None.

CONTRIBUTIONS OF AUTHORS

Conceptualisation and design, JC, SD, AM, SM, and LS; data curation and analysis – JC; writing – original draft preparation, JC; writing – review and editing, JC, AM, SM, LS, JM, KO'N, and SD. All authors read and approved the final manuscript.

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Appendix A

RELEVANCE OF DIGITAL TECHNOLOGIES TO PAEDIATRIC PHYSIOTHERAPISTS

Understanding the effects of screen use on child/adolescent health is important for physiotherapists. Digital technologies are progressing more rapidly than any other innovation in history. Balancing the opportunities they present to young people against the risk of harms (including harms of excessive use) is a global priority (United Nations General Assembly, 2022). While a broad range of health risks have been found, physiotherapists also operate across a wide field of practice. Not only is the influence of digital technologies on children's musculoskeletal health relevant, but physiotherapists also work in a varied scope with roles that are less prominent, such as eye health, mental health, obesity, and general population health. Alongside other medical disciplines, physiotherapists are positioned to lead in designing health interventions, and their unique skillset brings a valuable perspective to this field. Indeed, guidelines for screen use for children have often focused strongly on the mind, to the exclusion of the body (Straker et al., 2016). Physiotherapists currently have active roles not only in providing treatment for health issues directly associated with excessive screen use, but also in research, health promotion, and guideline development.

Beyond these roles, physiotherapy as a profession involves wider integration of digitalisation in delivery of care. While not the focus of this review, physiotherapists can also utilise digital technologies during sessions for motivation, distraction, physical activity, and planning (including use of exercise-based gaming software), and for remote delivery of services. Understanding a child's daily screen use could therefore influence choice of intervention, and to help shape advice on balance and active play. As an example, physical conditions relating to excessive screen use might indicate interventions including patient and caregiver advice (with reference to recreational screen guidelines and/or family media plans), and non-screen based treatments (Ministry of Health, 2017a, 2017b). Further, treatment ideas could be adapted for co-existing conditions, for example, interventions for patients with high screen use and myopia could include suggestions for outdoor play. Conversely, digital interventions can allow access or engagement with treatment that would otherwise be challenging.

Appendix B

BEST PRACTICE GUIDELINES

Best practice guidelines or recommendations for recreational screen use have been developed in numerous countries worldwide, including New Zealand (Ministry of Health, 2017a, 2017b). Guidelines for recreational screen use in New Zealand focus on time limits, including advice to discourage screen time for under 2 year olds and to limit screen time for children aged 2 to 5 years old to less than one hour per day, noting that "less is best" (Ministry of Health, 2017a). For 5 to 17 year olds, no more than 2 hours per day of recreational screen time is advised (Ministry of Health, 2017b).

The American Academy of Pediatrics has moved away from advising specific time restrictions for children over 5 years old, instead (1) encouraging families to set and enforce their own time limits, (2) providing education on harms of excessive screen use and poor quality screen media content, and (3) providing advice to support higher-quality screen use (American Academy of Pediatrics, 2023).

Best-practice guidelines, recommendations, or legislation for the safer use of digital technologies in education have been developed in numerous countries or states, including among others the United States (Department of Legislative Services, 2018; Maryland State Department of Health and Maryland State Department of Education, 2019; Virginia General Assembly, 2020), China (Cyberspace Administration of China, 2023; The State Council, The People's Republic of China, 2018), India (Nishank, 2020), and Australia (NSW Government, 2020).

Alongside recent commentary from the United Nations and UNESCO on the impacts of digitisation of education, Sweden and Denmark, with comparatively high use of digital technologies in education compared to other wealthy countries, are developing guidelines with a view to encourage a balance of learning on and off screens, and to limit screen use in the classroom for younger school-aged students (UNESCO, 2023; United Nations General Assembly, 2022).

Appendix C

SOCIAL IMPACTS OF DIGITAL TECHNOLOGIES: RELATIONSHIP OF HARMS TO CONTENT AND DESIGN

Sex-related harm due to online experiences for children and adolescents can result from abusive sexting, sexual solicitation, child pornographic exploitation, child abuse, and viewing of pornographic material (whether intentional or unintentional) (Slavtcheva-Petkova et al., 2015). Impacts can include the development of problem sexualised behaviours (PSB), early initiation of sexual behaviours, normalisation and desensitisation of sexual violence, sexual aggression, and the psychological and physical impacts of abuse (Sasaki & Hobbs, 2012).

Websites promoting dietary restrictions, anorexia, self-harm, and suicide can be considered harmful through the normalisation of injurious behaviour and by inciting self-harm (Slavtcheva-Petkova et al., 2015). Nearly 50% of children and adolescents aged 8 to 17 years old have reported seeing inappropriate content online that made them feel worried or upset (Children's Commissioner, 2022).

Cyberbullying is a well-recognised significant public health issue for children and adolescents. New Zealand students have the third highest incidence of cyberbullying globally, with a prevalence of 27% compared to an international range reported at 14 to 21% (Ipsos, 2018). Cyberbullying increases the risk of suicidal thoughts and attempts in young people, and is associated with declining academic results and post-traumatic stress disorder (PTSD). Students who experienced cyberbullying were found to be twice as likely to commit suicide as those who had not (Hinduja & Patchin, 2019).

Much has been made of the addictive nature of technology in media, coined persuasive design. Fifty percent of adolescents have described themselves as feeling "addicted" to their phones, with 90% agreeing that too much time spent online is a problem facing their age group, and 60% saying it's a major problem (Common Sense Media, 2016; Jiang, 2018). The term addiction in relation to technology has been challenged, and the WHO's addition of Gaming Disorder to the International Compendium of Diseases has been criticised.

While also controversial, problematic internet use (PIU), defined as excessive internet use ultimately leading to distress or impairment, has a reported incidence of 1% to 25% (Restrepo et al., 2020). PIU in turn can reduce emotional wellbeing and quality of life. Indeed, while mental health diagnosis can be a precursor to PIU, PIU also has been found to predict poor mental health (Anderson et al., 2017). Certain populations may have a greater risk of PIU, including those with a diagnosis of Autistic Spectrum Disorder, ADHD, and psychiatric disorders. It is also suggested that adolescents are at higher risk due to their developing cognitive control mechanisms (Restrepo et al., 2020). Two thirds of parents report struggling to support children to keep balanced screen habits, and 65% of parents report that negotiating screen use causes conflict with their children (Sahlburg & Graham, 2021; Sasaki & Hobbs, 2012; Slavtcheva-Petkova et al., 2015).