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PROBLEMATIC DIGITAL TECHNOLOGY USE IN CHILDREN AND ADOLESCENTS: IMPACT ON PHYSICAL WELL-BEING

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Abstract

Since the evolution of the internet in 1969 and the inception of the personal computer in the early 1970s, a significant body of research has emerged that highlights the impacts of digital technology on education, health and human development. There is extensive research examining the physical, mental, and social health effects on young people and adolescents as well as the impacts of digital technology on their educational achievements.

The aim of the review reported on here was to examine the impact of digital technology, and more specifically the use of Bring Your Own Device (BYOD) policies in schools. BYOD allows students to bring phones, tablets and personal computers to school. Numerous components with a negative impact on physical health have been identified.

Outcomes of this study will be of interest to school leaders as policy makers. There is a need for trustworthy information on which to base reviews and revisions of school policy to ameliorate the risks of digital technology. This research report is also of relevance for tertiary providers and the government with the implementation of more online learning in class and online distance learning during COVID-19 restrictions.

Introduction

According to Aston (2018), in the OECD Education Working Paper, physical health is positively associated with child academic achievement and active participation in society. Current and projected trends in physical health outcomes in part reflect the rise of technology. While digital technology is ubiquitous and has many benefits for education, it is important to be cognisant of its inherent risks so as to mitigate harm for our children and adolescents (0–19 years), and tertiary students.

One of the social determinants of health is education, "often identified as the most modifiable determinant" (Aston, 2018, p. 7). Wise leaders strategise to prevent crises and arrest them in their early stages, rather than letting threats to health increase; wise leaders follow a precautionary principle-led strategy based on international research. Therefore, as change and development in education have continued, policies and usage need to be reviewed. School and government leaders as policy makers need trustworthy information (Kardaras, 2016) and facts form a firm foundation upon which to base reviews and revisions of school policies to safeguard and protect our children and young persons while adhering to relevant New Zealand legislation.

During the rapid adoption of digital technology, its impact on health and human development was relatively unknown. However, over time, there have been increasing concerns about the detrimental and hazardous impacts on people (Aalto et al., 2006; Ahmed et al., 2019; Palmer et al., 2014; Rajpara & Feldman, 2010; Scherer & Hatlevik, 2017; Stewart et al., 2019; Straker et al., 2006). Extensive health research and literature on how digital technology can have a detrimental impact on users' physical health will be presented. The psychological influences of digital technology on users have been discussed in an earlier article (Meates, 2020).

Detrimental developmental and physical wellbeing effects relating to device usage are emerging. According to Vate-U-Lan (2015), modern environments for daily living have become dominated by

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computer technology, often leading to overuse in digital tasks on handheld mobile technology. Physical health problems are becoming increasingly prevalent as digital devices are more frequently used by ever-younger audiences. The negative physical consequences discussed here, including musculoskeletal pain, headaches and skin irritations, hearing difficulties, myopia, developmental delays and obesity, are increasingly prevalent and cannot be ignored. Despite these consequences, there are tremendous benefits when technology is used intelligently, wisely and in a balanced, holistic way in the educational system.

The rapid expansion of digital technology has relevant societal implications and ramifications for the health and wellness of humans, especially our young. We need effective policies, laws and protections for local communities, schools and tertiary institutions and governments. Without these protections, the medical impact on society and our young will be devastating.

Research Design was a systematic review (Boland et al., 2017) of scholarly articles from both New Zealand and international sources. The articles incorporate mixed-method, qualitative and quantitative secondary data analysis as well as meta-analysis. Participants and observers include school principals, teachers, university students, lecturers, UN workers, medical providers, ophthalmologists, physiotherapists and medical practitioners.

Findings

From the review it is evident that there are growing concerns nationally and internationally regarding the widespread and frequent use of digital technology and its impact on physical wellbeing. Numerous separate effects from the overuse of digital devices have been identified in the literature and are discussed. Each section begins by presenting evidence of the issue and ends with recommendations noted in the literature.

Musculoskeletal strain on the neck, back and shoulders

Long-term mobile phone and digital technology use can cause back, neck and shoulder tension, pain and physical discomfort (Scherer & Hatlevik, 2017) from postural and ergonomic defects (Yen et al., 2009). Results from an Australian study of 33 adolescents aged 12–15 years highlighted that 94 percent of the participant group of adolescents reported experiencing physical discomfort (Palmer et al., 2014). The week-long study at Curtin University reported a correlation between high exposure to digital technologies and high incidence of low-level physical discomfort, associated with pain in the head, neck, shoulders, back and legs. The results showed that a quarter of the students were required to use a laptop computer for classwork and homework daily (Palmer et al., 2014). The adolescents in the research reported using ICT for long periods, frequently without breaks. These are considered risk factors for increased musculoskeletal discomfort. Palmer and colleagues concluded that physical activity may act as a protective mechanism and mitigate the risks of physical pain and discomfort (Palmer et al., 2014).

In a separate Western Australia study, 88 school children of Grades 5 to 10 (aged 10 to 16) from three private schools who completed questionnaires showed a similar correlation (Coleman et al., 2009). All the schools in the study provided student access to computers, while one school had a laptop computer programme for students in grades 5–12. Coleman et al. (2009) showed that muscular skeletal discomfort was related to screen usage, such as when using computers. Aside from discomfort related to eye soreness, the discomfort that was most commonly related to computer use at school was back—mid and lower back—while neck discomfort affected students from the use of computers at home (Coleman et al., 2009). Research by Shan et al. (2013) of 3,600 high school students in Shanghai reported similar results where 40.8 percent experienced neck/ shoulder pain and 33.1 percent lower back pain.

An earlier Australian cross-sectional survey using questionnaires on computer use and neck posture and shoulder pain of a larger cohort of 884 young people with a mean age of 14 (Straker et al., 2006) had similar findings. The results showed neck and shoulder pain is a significant problem in adolescence.

More recent evidence suggests rates in adolescence have increased in line with increased computer use (Straker et al., 2011).

There are numerous studies that have been undertaken in other countries to substantiate these concerns. An earlier Irish study from the School of Physiotherapy at Trinity College Centre for Health Sciences (Dockrell & Kelly, 2006) examined musculoskeletal discomfort within a participant sample size of 40 secondary school students and computer related posture. The research design used rapid upper limb assessment (RULA) that evaluated ergonomic risk factors. Results showed 80 percent of students reported musculoskeletal discomfort at the closure of the computer class, with spine and shoulder problems the most prevalent cause of discomfort. Similarly, in a study of 1,640 Norwegian students aged between 12 and 13 years (Scherer & Hatlevik, 2017) adolescents reported physical discomfort, with neck and shoulder pain from using ICT extensively. A five-year cohort Swedish study of 7,092 young adults aged 20–24 years examined the associations between text messaging from mobile phones and symptoms of musculoskeletal disorders, including tendonitis (Gustafsson et al., 2017) and bursitis (Cornell, 2019). Results showed ongoing pain symptoms were reported in the neck and upper back from texting on mobile phones. There is also a possible link to fibromyalgia symptoms (El Zohiery et al., 2020).

Many experts have also expressed concern that curvature of the spine is becoming problematic for some students (Neupane et al., 2017) as shown in Figure 1 and Figure 2. Users of mobile phones, as well as other digital technologies, regularly assume a forward head movement while looking at the screens. 'Text neck' is the term used to describe the neck pain and damage sustained from looking down at the mobile phone, tablet, or computer screen too frequently and for too long. Text neck directly affects the spine with frequent forward head flexing at differing angles. The muscles at the back of the neck can be overloaded while flexing. According to Neupane et al. (2017), when the head tilts forward at 15 degrees, the forces on the neck surge to 27 pounds (12.3kg); at 30 degrees, 40 pounds (18.1kg); at 45 degrees, 49 pounds (22.2kgs); and at 60 degrees, 60 pounds (27.2 kg). The weight is the equivalent of transporting an eight-year-old child on your neck. Text neck is especially problematic for children, as their head is larger in proportion to their body than for adults, leading to an increased risk of harm. According to Cuellar and Lanman (2017), text neck has become an epidemic of the modern era of mobile phones and other digital technology devices.

According to Hansraj (2014), stress in the cervical spine caused by posture and position of the head tilted over smartphones and devices can cause early wear and tear, degeneration, and possibly surgeries. Hansraj surmises that if a student spends two to four hours daily in such a position, the cumulative time equates to 1,400 hours a year, with high school students spending a possible 5,000 extra hours in poor posture.

The problem may be compounded in modern learning environment classrooms because of informal seating arrangements that lead to poor posture, particularly when tablets or laptops are used rather than desktop computers. Even when students are seated at desktop computer work stations, poor posture and badly designed classroom furniture can still lead to musculoskeletal pain (Harris et al., 2005; Mustafaoglu et al., 2021). According to Harris's (2010) Australian study of 1,351 children (aged approximately 6, 9, 14 and 16 years), "30% of those children reporting [computer related musculoskeletal] outcomes limited their activity participation, 10% took medication and 7% consulted a treating health professional" (p. iv).

Participant observations of school age and tertiary students are graphic. Prolonged use shows postural changes that exhibit a 'hunch' similar to those shown in Figure 2.

Single-handed use of a mobile phone has a worse impact. A study of muscle activity of young adults using smartphones found that single-handed use of smartphones increased muscle activity in the upper trapezius in the neck, and caused a higher level of increased tenderness in that muscle compared with two-handed use (Lee et al., 2015).

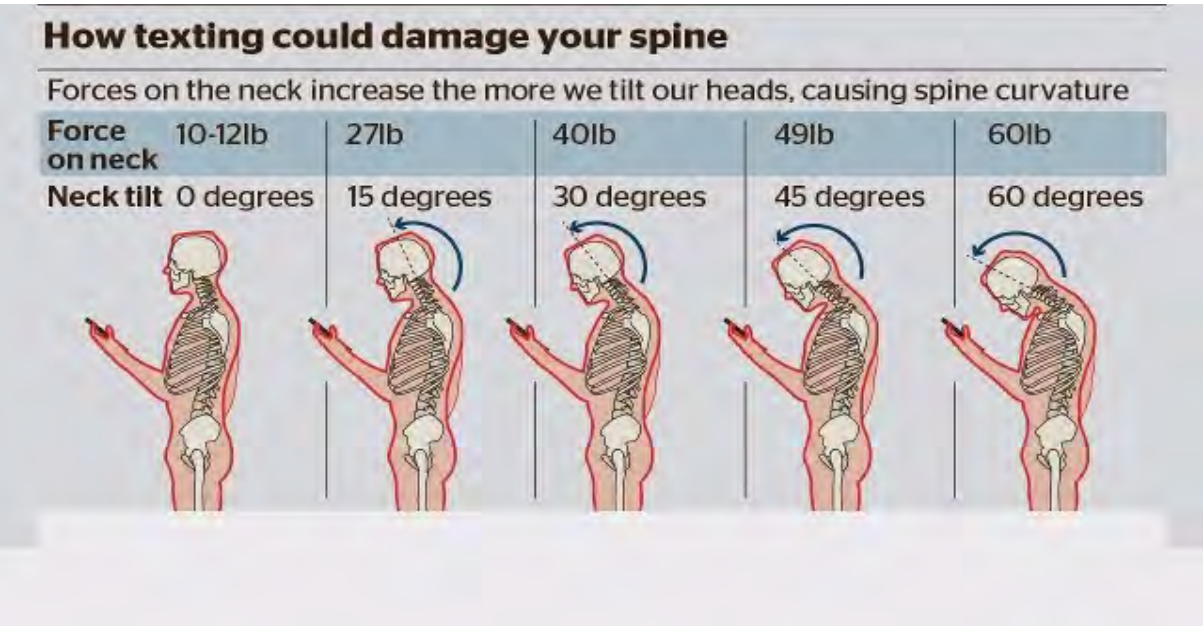

Figure 1: **From *Text neck syndrome-systematic review*** (Neupane, et al., 2017, p. 142–43).

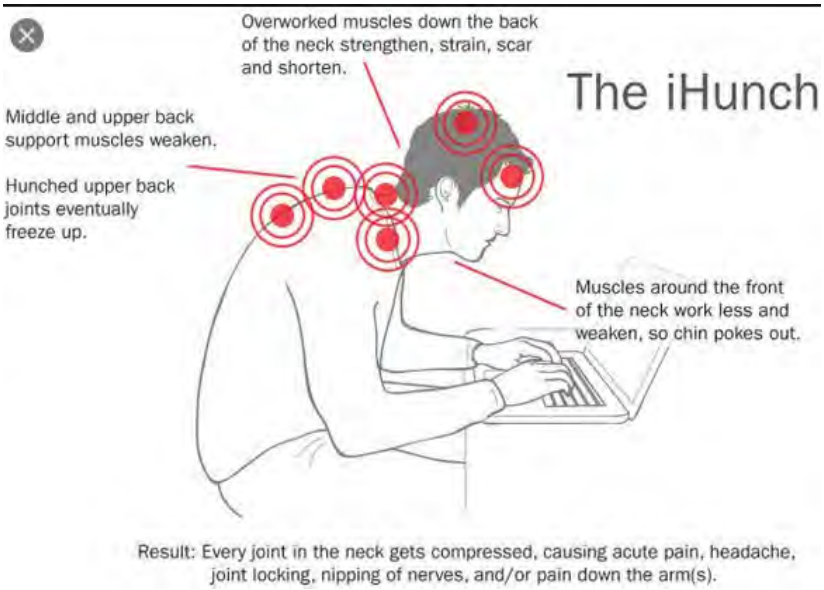

Figure 2: **The iHunch.** Reproduced with permission from https://www.bodystance.co.nz/en/ihunch/.

The OECD reports, "Interestingly, the most frequent reported causes of discomfort were bad posture and doing too much of a certain activity … Children are aware of the potential negative physical effects of using ICT extensively" (OECD, 2018, pp. 27–28). Professor Straker from the School of Physiotherapy reports:

> Based on the available evidence, it is recommended that children should be encouraged to take a break from computer work every 30 min and not be allowed to work more than 60 min without a break from the computer. These breaks should be physically active and meaningful to the child, rather than a sedentary break (e.g. sitting watching TV, playing video games or using a mobile phone). (Straker et al., 2010, p. 461)

Educators, health leaders and politicians need to be cognisant of the necessity to avoid high or extreme ICT use, for the sake of the developing young body. Habits created in adolescence can cause challenges as adults, with economic and physical costs.

Impact on thumb, fingers and wrists

Repetitive use of the thumb in texting gives rise to 'SMS thumb'. A study of 113 male and female students aged 17–25 years in India by Ahmed et al. (2019) used the Cornell Hand Discomfort Questionnaire (CHDQ) to investigate the incidents of SMS thumb. The Nomophobia Questionnaire (NMP-Q) was administered to all participants. The latter asks questions about four aspects of nomophobia including being unable to communicate, losing connectivity, being unable to access information, and inconvenience. A significant positive correlation (p = .001) was shown between the Nomophobia Questionnaire (NMP-Q) and the Cornell Hand Discomfort Questionnaire (CHDQ). The study showed that symptoms include aching and throbbing pain in the thumb or fingers, parts of the hand, and in the wrist. Ahmed et al. found that,

> in this study, the prevalence rate of SMS thumb among smartphone users was reported as 28.3–29.2 percent. During message typing, the thumb and palm muscles are used extensively. Sustained gripping and repetitive movements of the fingers and thumb are the main key factors that might lead to the associated syndrome. For texting, the thumb is adducted on the key pad of the mobile device and high force is used to type. (Ahmed et al., 2019, p. 6)

An earlier international meta-study (Binboğa & Korhan, 2014) reported musculoskeletal discomfort among children using laptops or tablet computers for educational purposes: including wrist pain (Zovkic et al., 2011). A further study of 100 healthy physiotherapy students in India showed that musculoskeletal problems in neck and hand (predominantly thumb) can be seen in smartphone-addicted students (Shah & Sheth, 2018). Irritation along the nerve pathways can cause pain to the hand and arm (Neupane et al., 2017). Furthermore, in a study of 10 young adults, risk factors of excessive use of the thumb in texting and playing games in relation to carpometacarpal joint arthritis were identified (Ming et al., 2006).

Impact on eyesight and hearing

Use of digital devices can have significant long-term impact on eyesight. Eye soreness and discomfort was reported by Coleman and colleagues in 2009 (Coleman et al., 2009). Scherer and Hatlevik (2017) also found significant evidence of sore eyes from using digital technology extensively. Other studies have identified a potentially harmful effect of increased use of digital devices is the growing incidents of myopia. Myopia is the scientific term for near-sightedness where the curvature of the lens of the eye causes difficulty in viewing objects at long distance, with objects appearing blurred. While several factors are associated with myopia, research recognises that the excessive use of mobile devices increasingly perpetuates myopia.

Children are particularly vulnerable because their eyes are still developing. Eye experts attribute the increasing rise of myopia to the excessive use of handheld devices (Yang, 2013) and to digital eye strain from staring at a screen (Acharya et al., 2013). In Canada, myopia affects 30 percent of the population, and in the United States, 42 percent of the population. In some Asian countries, the incidents of myopia is 80 percent (Cooper, 2018). Myopia is associated with potentially pathological consequences such as glaucoma, retinal damage and myopic macular degeneration (Holden et al., 2017). Furthermore, Dr Liu from the University of California Berkeley's School of Optometry reported that "even babies are being introduced to electronic games and apps, so we see a very fast progression of myopia" (Unger, 2017, p. 12). Myopia among seven-year-olds increased from five percent in 1983 to 21 percent in 2000. By 12 years of age, myopia was 36.7 percent in 1983, increasing to 61 percent in 2000; and for 15-year-olds it increased from 64.2 percent to 81 percent. For 18-year-olds, myopia increased from 10.9 percent in 1983 to 21 percent in 2000 (Lin et al., 2004). A further study of 715 adolescents from Korea showed

increasing exposure to smartphones can have a negative impact on ocular health (Kim et al., 2016). According to Lee et al. (2013), 80 percent of 18-year-old high school leavers in Taiwan had myopia. The participants in Lee and colleagues' study were males 18 to 24 years old in the Taiwanese military and "the average length of time spent using computers in the sample was quite high (3.8 hours/day)" (Lee et al., 2013, p. 1029). There is a strong correlation between overuse of technology and increased rates of myopia. This could be a potential concern for decision makers in the educational sector and in a broader sense.

To prevent long-term injury to the eyes, time spent outdoors and access to green space can delay the onset and potentially reduce the progression of myopia (Inchley, 2017). It is important that educational leaders and teachers are aware of this propensity and incorporate a balance between up-close screen work and distance work that allows the eye to rebalance. A further recommendation for schools and tertiary providers is to read and examine the digital technology specifications regarding safe limits for the human body. According to Vate-U-Lan (2015), the application of the 20-20-20 rule is paramount in order to prevent the physical health problem of Computer Vision Syndrome. Vate-U-Lan's advice recommends "every 20 minutes take a 20 second break and focus the eyes on something at least 20 feet away" (Vate-U-Lan, 2015, p. 552).

Also of concern is the finding that damage to hearing from headphone use can lead to damage in auditory perception. The playing of loud music into earphones on portable devices can affect the frequency of the auditory cortex (Okamoto et al., 2011). "Any sounds above 85 decibels can be enough to cause hearing damage" (Schacter et al., 2016, p. 164). Subliminal messaging through the auditory system can also programme the subconscious mind either positively or negatively (Schacter et al., 2016).

Headaches and skin irritations

Several studies show a correlation between mobile phone usage and headaches or skin irritations. A Taiwanese study, for example, by Chiu et al. (2015) of 2,042 children aged 11–15 years showed that mobile phone usage significantly increased adjusted odds ratio (AOR) for headaches, migraine and skin itches: "an elevated risk of 42 percent and 84 percent respectively" (Chiu et al., 2015, p. 603). Children who regularly used mobile phones were also considered to have a health status "worse than it was 1 year ago" (Chiu et al., 2015, p. 598). Rajpara and Feldman (2010) highlighted "facial allergic contact dermatitis" (paragraph 1) to cell phone metals.

In an experimental provocation trial (medical clinical trial) of 71 adults aged 18–45 years, excessive exposure of three hours to 884 MHz GSM wireless communication signals from mobile phone use caused more headaches than for those in the control group (Arnetz et al., 2007). An epidemiological study of 12,000 Swedish and 5,000 Norwegian mobile phone users reported the symptoms, if any, experienced while using or after using a mobile phone. Both digital and analogue mobile phones were used at the time, with both phone systems operating with a carrier wave at 900 MHz (Oftedal et al., 2000). Figures 3 and 4 show that more than 62 percent exhibited a "facial skin symptom and nearly 40 percent of those with headaches experienced the symptom to be ipsilateral relative to the side where the MP was held" (Oftedal et al., 2000, p. 240). For each symptom, the total number of people reporting the symptom (n) is shown.

Experts note that some people are electro hypersensitive (Redmayne & Johansson, 2014). International guidelines for children's exposure to radio frequency electromagnetic fields vary widely but the most common policies suggest minimising exposure, using wired rather than wi-fi links in schools, and children using headsets for calls to maintain distance between the head and the device (Redmayne, 2016).

Children may be more sensitive to potentially adverse effects and will have a longer exposure throughout their lifetime than today's adults. Therefore, a recommended policy decision would be "a cautious use of mobile phones for children because of the impact from mobile phone duration and exposure to radiofrequency electromagnetic fields (RF-EMF)" (Chiu et al., 2015, p. 598).

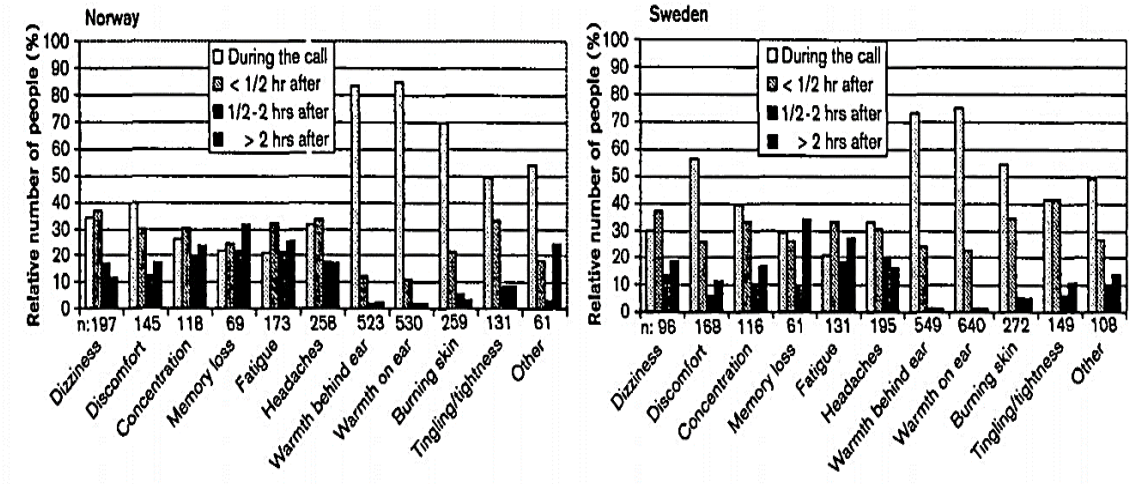

Figure 3: Distribution of people with respect to how quickly they usually experienced the symptom in connection with a call from a mobile phone (MP).

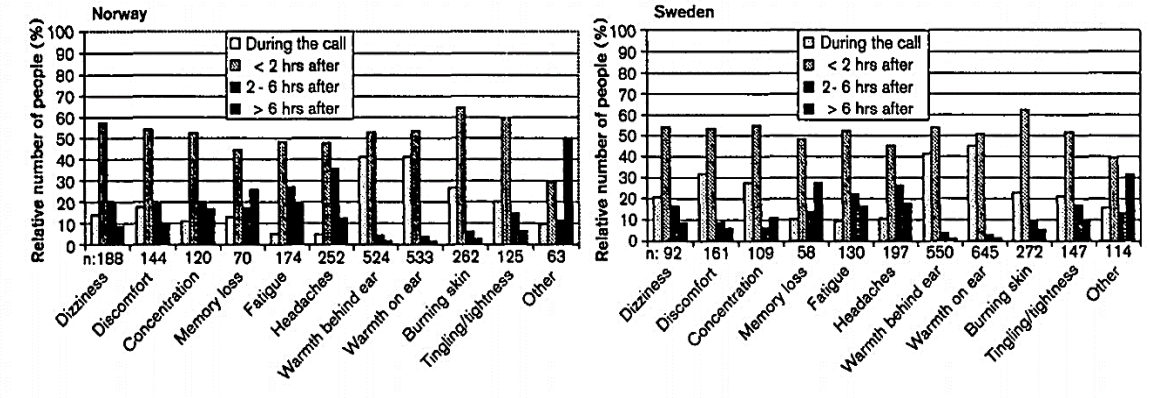

Figure 4: Distribution of people with respect to how long the symptom usually continued in connection with a call from a mobile phone (MP) (Oftedal et al., 2000, p. 40. Copyright 2000 by the Society for Occupational Medicine, Oxford University Press).

Developmental delays

Developmental delays have been observed with technology overuse (Rowan, 2010). Critical milestones for child motor and sensory development are important. International research has shown the detrimental effects of technology use on critical milestones for children (Thakkar et al., 2006; Zimmerman et al., 2007b).

Medical practitioners are now assessing and treating a variety of physical disorders in children that appear to be escalating at an alarming rate. School-based occupational therapists observe increasing referrals of students to family physicians by their teachers for attention impairments or learning difficulties (Mandell et al., 2008; Rowan, 2010; Thakkar et al., 2006; Zimmerman et al., 2007a). There is also concern regarding increasing signs of impairment, with symptoms of attention deficit disorder (ADHD) (Griffiths et al., 2018). In the era shaped by Google and limitless access to digital information, there are potential costs for cognitive and brain development in terms of efficiency and accuracy of performance, especially for younger children whose attention systems and executive functions are immature (Courage et al., 2015; Thomas et al., 2010). Small and Vorgan (2009) refer to the 'iBrain' and query the technological alteration of the modern mind, while Kardaras (2016) refers to the ADHD "epidemic" (p. 24). Dr Victoria Dunckley, an American child psychiatrist, noted an "800 percent

increase in the last 30 years [in ADHD]" (Dunckley, 2012 cited in Kardaras, 2016, p. 24), referring to electronic screen syndrome as an unrecognised disorder.

Research from American paediatricians of 1,077 children aged between six and 24 months focused on language delay (Ma & Birken, 2017). Children who spent more time on a handheld device were more likely to have delays in expressive speech: according to the researchers, a 49 percent increased risk of expressive speech delay for every 30-minute increase in handheld screen time. A later study of 893 children reported similar results (van den Heuvel et al., 2019). These findings support a policy recommendation by the American Academy of Pediatrics to discourage any type of screen media for children younger than 18 months, and aligns with New Zealand Ministry of Health guidelines recommending no screen time for children under two years (Stewart et al., 2019), and similar Australian Ministry of Health recommendations (Australian Government Department of Health, 2020).

The current policy advice for screen time for under-fives from the New Zealand Ministry of Health: "No sedentary screen time for children younger than two years" (Stewart et al., 2019, p. 5). However, research showed 67.2 percent of children aged 2–4 years watched more than the recommended national guidelines of one hour per day. The recommendation from the Ministry of Health was "no more than two hours per day of recreational screen time for children aged 5–17 years" (Ministry of Health, 2017). Few children are meeting this recommendation, with over 8 out of 10 (83.4 percent) of those aged 2–14 years spending two or more hours a day (Ministry of Health, 2018, p. 26). Limited use for older age groups is also recommended since screen time can replace other activities, such as active play, reading, talking and singing, and other positive educational interactions that are critical for healthy child development.

Exposure to an average of eight hours per day of various forms of technology use has resulted in a physically sedentary yet stressful existence for Canadian children (Rowan, 2010). We can use such research to argue for an intervention and put in place relevant policies and strategies to mitigate risks of developmental delays, since healthy childhood development is important for healthy populations of adults and families.

Sedentary lifestyle effects

According to Wolf et al. (2018), increased levels of early screen exposure have been associated with decreased cognitive abilities and increased levels of obesity. Research on the adverse effects of early screen exposure is mounting, but further epidemiological studies are still needed to inform prevention and regulation policies.

The risk for overweight in adolescents is associated with increased screen time, including television viewing, such that an extra 20 percent risk is incurred with each additional hour of screen time replacing children's physical activity (Aston, 2018). A study carried out among 11–15-year olds in Europe and the United States predicted that increasing daily screen time by two hours decreased physical activity on average by about 30 minutes (OECD, 2018). However, it remains clear that screen time does not *need* to negatively impact on physical development, as many other factors, such as engaging physical educational programmes, outdoor play without technology, sport facilities, safe neighbourhoods, and teacher and parental support, play a role in healthy, balanced child and youth development (UNICEF, 2017; Holden et al., 2017).

While other factors, such as diet, nutrition, morphology and consumption of sugary and highly processed foods, can contribute to obesity, sedentary lifestyle is a key part of many people's lives and can affect health. Obesity figures in New Zealand are increasing and are a major health challenge. Globally, "New Zealand children are also near the top of the league table for childhood overweight and obesity" (Morton et al., 2017, p. 27). According to the Ministry of Health (2018), New Zealand's "obesity rates are among the highest in the developed world … New Zealand had the third-highest rate of obesity" (p. 28). This report (Ministry of Health, 2018) also found that "one in three children aged 2–14 years was either overweight (21.0 percent) or obese (12.3 percent) … rates of obesity ranging

between 14.7 percent of youth aged 15–17 years …" (p. 27–28). An estimated "1.3 million New Zealanders are obese … 99,000 children aged 2–14 years are obese" (p. 28). The obesity rate is close to the population of Auckland alone.

Of significance is that the report *Growing Up in New Zealand*, a longitudinal study of New Zealand children and their families (Morton et al., 2017) stated that the amount of screen time per day was also associated with body weight in four year olds, with children classified as overweight or obese engaging in more screen use than those of normal weight. Stewart et al., (2019) also found that excessive use of screen-based devices can affect the health and development of children, including the likelihood of obesity, and anecdotal evidence from New Zealand kindergarten teachers describe their concern at the implementation of computer technology in preschool and late-night computer gaming by children as young as four years old.

Research highlights that people who watch television and play video and computer games are living a sedentary lifestyle and do not move enough to keep their body healthy. Sedentary lifestyles account for an increase of 60 percent in childhood obesity (Tremblay & Willms, 2003). This health concern is now considered to be an epidemic by physicians in North America (Strauss & Pollack, 2001).

As early as 2003, international evidence showed a link between obesity and physical inactivity. Both organised and unorganised sport as well as physical activity are negatively associated with being overweight. A meta-analysis performed with the data of children and youth between 5 and 17 years examined the relationship between sedentary behaviour and specific health outcomes such as obesity (Tremblay & Willms, 2003). The data showed a 10–24 percent reduced risk of overweight and a 23–43 percent reduced risk of obesity from involvement in organised and unorganised sport and physical activity, whereas watching television and playing video games were positively associated with being overweight (17–44 percent increased risk) or obese (10–61 percent increased risk) (Tremblay & Willms, 2003, p. 1100).

Tremblay and colleagues published the findings of a systematic review of sedentary behaviour and health indicators of 19,014 school-aged children and youth (Tremblay et al., 2011) and showed that screen time of more than two hours per day was "associated with higher blood pressure and increased risk for metabolic syndrome and cardiovascular disease" (see Table 1) (Tremblay et al., 2011, p. 12). Metabolic syndrome includes obesity, particularly excess body fat around the waist. A later systematic review of 235 studies representing 1,657,064 participants (5–17 years) from 71 different countries showed consistent findings (Carson et al., 2016) where higher durations of screen time were associated with unfavourable body composition cardiometabolic risk scores. Television, streaming, video game use and online gaming are risk factors (Carson et al., 2016; Vanderloo et al., 2020).

Table 1: Increased Screen Time Associated with Increased Risk of Metabolic Syndrome and Cardiovascular Disease

Type of Study	Number of Studies	Number of participants	Narrative recommendation and main findings
RCT	0		
Longitudinal	2	1675	>2hr of TV per day is associated with higher serum cholesterol levels. >1.2 hrs of TV per day is associated with increased systolic blood pressure.
Cross sectional	9	17339	>2 of screen time per day is associated with higher blood pressure and increased risk for metabolic syndrome.
Intervention	0		
Total of all studies	11	19014	Increased screen time is associated with increased risk for markers of metabolic syndrome and cardiovascular disease. Risk increases in a dose-response manner. Mean Downs and Black score = 21.7 (± 2.0), Level 3 evidence.

Table 2: Relationship Between Sedentary Behaviour and Academic Achievement

Type of Study	Number of Studies	Number of participants	Narrative recommendation and main findings
RCT	0		
Longitudinal	3	3530	Watching >1hr of TV per day is associated with attention difficulties.
Intervention	0		
Cross sectional	32	157637	>2 hrs of screen time per day resulted in lower academic achievement.
Intervention	0		
Total of all studies	35	161167	>2hrs of screen time per day is negatively associated with academic achievement. Dose-response relation between time spent playing video games, watching TV and using the computer (for non-academic purposes). >3hrs/day associated with poor school performance and lower I.Q. scores. Mean Downs and Black score = 19.1 (± 2.1), Level 3 evidence.

*Tables 1 and 2 reprinted from "Systematic review of sedentary behaviour and health indicators in school-aged children and youth' (Tremblay, et al. 2011), Copyright 2011 by Tremblay et al.; licensee BioMed Central Ltd. Open access article distributed under the terms of the Creative Commons Attribution License. Originally published by Springer Nature. Reprinted with permission.

In a systematic review showing a relationship between sedentary behaviour and academic achievement of 161,167 school-aged children and youth (Tremblay et al., 2011), the results (see Table 2) showed that more than two hours of screen time per day resulted in lower academic performance. The time spent playing video games, watching TV and using a computer for non-academic purposes was associated with poorer school performance when there was more than three hours a day of screen-time. Addiction experts (Throuvala et al., 2019a, 2019b) report that physical inactivity and sedentary behaviour are public health and education issues and can affect academic performance.

Educational and health policies are essential, in this global digital age, to ensure healthy behaviour and habits for our youth. A daily minimum of 60 minutes of physical activity is the recommended optimum requirement by national and international standards (Ministry of Health, 2018; Walsh et al., 2018; WHO, 2020). The World Health Organization (2020) supports such findings, stating that scientific evidence endorses associated health benefits. On their website they recommend "children and adolescents [aged 5–17 years] … should do at least an average of 60 minutes per day of moderate-to-vigorous intensity, mostly aerobic, physical activity, across the week" (WHO, 2020, p. 25). As mentioned above, the NZ Ministry of Health (2018) has similar recommendations. It is important to maintain a healthy balance in New Zealand and international curriculums to prevent postural and physical health risks that could have long term health, wellness and economic ramifications (Stewart et al., 2019, p. 5).

Conclusion

International and national research is compelling**.** While New Zealand and the OECD (2018) can recognise that moderate screen time is not necessarily bad and can also be beneficial, teachers and policy-makers should also recognise that the roll-out of BYOD and access to devices in schools does not restrict students to moderate use and instead can be seen to contribute to excessive use. OECD (2018, p. 10) data shows that New Zealand school students spend more than 160 minutes per typical weekday online outside school, so if a child uses a device for an average of two to three hours a day exclusive of BYOD activity, combined with an additional three hours at school on a device, it is clear that the activities combine to produce a high usage.

The adverse medical effects of digital technology overuse evidenced above are musculoskeletal strain to the upper body and hands, increases in myopia and damage to auditory perception, headaches and skin irritations, developmental delays including in language, and obesity as a result of a sedentary lifestyle.

These potential harms should be considered far more seriously by users, teachers, governments, schools, universities, ministries, and educational and health leaders when promoting digital technology in the New Zealand curriculum. Preventative health interventions are important (Coleman et al., 2009), with a balanced curriculum involving intermittent periods of physical activity and movement, including the use of pen and paper (Mueller & Oppenheimer, 2014). Such a variety of activities can prevent long term physical health effects for our children and ensure that their screen time is within the policy recommendation by the New Zealand Ministry of Health (2017).

There is now an even greater need for social responsibility and a requirement for educational and health leaders to fully understand the growing research on the impact of digital technology—enhanced teaching and learning and its ramifications and deleterious effects on young people. It is important to recognise that key founders of digital technology, such as Steve Jobs, co-founder of technology such as the iPhone and iPad, and Bill Gates, founder of Microsoft, imposed restrictions on their own children regarding technology use (Alter, 2017). The research reviewed here is compelling material. As educational and health leaders, we all have a responsibility to provide safe, positive, balanced and stimulating learning environments while also understanding and dealing with implications of the digital world that exist outside the educational realm.

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