

Diana Puzio¹, Iwona Makowska¹, Krystyna Rymarczyk²

Screen device use and common health problems in children and adolescents

Używanie urządzeń cyfrowych a powszechne problemy zdrowotne u dzieci i młodzieży

¹ Child and Adolescent Psychiatric Department, Medical University of Lodz, Łódź, Poland

² Department of Biological and Behavioral Psychology, SWPS University of Social Sciences and Humanities, Warsaw, Poland

Correspondence: Diana Puzio, Child and Adolescent Psychiatric Department, Czechosłowacka 8/10, 92-216 Łódź, Poland, tel.: +48 42 675 87 16, e-mail: diana.puzio@umed.lodz.pl

ORCID iDs

1. Diana Puzio <https://orcid.org/0000-0002-0870-1632>

2. Iwona Makowska <https://orcid.org/0000-0003-4830-6343>

3. Krystyna Rymarczyk <https://orcid.org/0000-0002-4085-9480>

Abstract

Children are exposed to screen devices from early developmental stages and use them increasingly often as they grow. Screen time has reached unprecedented levels in paediatric population, raising concerns about whether it holds potential for harm. Additionally, a growing number of scholars suggest that different patterns of screen device use may be even more important for well-being than the duration of use itself. In this paper, we summarise the current state of the ongoing debate regarding common paediatric problems and their possible relationships with screen media use. Sleep disorders, obesity, musculoskeletal symptoms, vision problems, cognitive dysfunctions, as well as mood and behavioural disorders are discussed. Most evidence supporting the relationship between health problems and new technologies comes from cross-sectional studies that do not warrant inferences as to the direction of causality. Hence, our aim was to present various aspects of the discussed problems rather than to reach final conclusions. Currently, experts throughout the world agree that parents should guide, supervise and limit children's screen time before the age of 5 years. As children grow, more adequate approach would be to provide guidance and help if needed. Regardless of age, following general principles for raising children in the digital era might prevent health complications.

Keywords: screen time, health, mental health, children, adolescents

Streszczenie

Kontakt z urządzeniami cyfrowymi rozpoczyna się we wczesnych etapach rozwoju dziecka i wraz z upływem czasu jest coraz częstszy. Czas, który dzieci poświęcają „ekranom” (z ang. *screen time* – czas poświęcany smartfonom, tabletom, komputerom, laptopom, telewizji), osiągnął ostatnio niespotykany dotąd poziom, budząc obawy między innymi wśród rodziców i lekarzy. Dodatkowo eksperci coraz częściej sugerują, że sposób, w jaki używane jest dane urządzenie, ma większe znaczenie dla zdrowia od samego czasu poświęconemu ekranom. W niniejszym przeglądzie literatury podsumowano aktualny stan wiedzy na temat częstych problemów zdrowotnych w populacji pediatrycznej i ich ewentualnych związków z używaniem ekranów. Artykuł omawia zaburzenia snu, otyłość, objawy zaburzeń układu mięśniowo-szkieletowego, zaburzenia wzroku, funkcjonowanie poznawcze oraz zaburzenia nastroju i zachowania. Informacje dotyczące opisywanych związków pochodzą głównie z badań przekrojowych, które nie umożliwiają wyciągania wniosków na temat kierunku przyczynowości. Celem autorów zatem było wyczerpujące przedstawienie różnych argumentów pojawiających się w dyskusji, zamiast przedstawienia definitywnych wniosków. Obecnie rekomendacje są zgodne co do tego, że używanie ekranów przez dzieci do 5. roku życia powinno być nadzorowane i ograniczane przez rodziców. Wydaje się, iż w miarę rozwoju dziecka rodzice powinni stawać się bardziej przewodnikami po świecie ekranów i, w razie potrzeby, służyć pomocą. Niezależnie od wieku przestrzeganie podstawowych zasad wychowania dzieci w cyfrowym świecie może pomóc zapobiec problemom zdrowotnym.

Słowa kluczowe: ekrany, zdrowie, zdrowie psychiczne, dzieci, młodzież

Traditional and new technologies permeate multiple facets of life and have profoundly changed the way children and adolescents socialise, play and learn (Twenge, 2017). Access to screen devices often begins in the first postnatal year with approximately 20% to 40% of neonatal population being exposed to screens and a quarter of infants and toddlers owning their own device (Kılıç et al., 2019). Device ownership and screen time increase with age and reach unprecedented levels in adolescence. Virtually all adolescents have at least one screen device, 45% declare using the Internet almost constantly, with daily screen time ranging from 3 hours according to UNICEF report (Gromada et al., 2020) to 7 hours according to Common Sense Media report (Rideout and Robb, 2019). The growth of technology adoption and use since the beginning of the century seems to have occurred simultaneously with the increased prevalence of certain health issues in the paediatric population (Mojtabai et al., 2016). Therefore, concerns have been raised that the omnipresence of screen devices may have a detrimental influence on the well-being of children and adolescents.

Indeed, several paediatric recommendations have been proposed to limit children’s screen time (Tabs. 1–3), while some researchers question the value of a limitation-based approach and propose different solutions (Przybylski and Weinstein, 2017). Moreover, parental absorption in digital devices may limit their sensitivity and responsiveness and thereby influence children’s development (Braune-Krickau et al., 2021). The discussion continues alongside the growing body of research in this area (Przybylski and Weinstein, 2017). The goal of the present paper is to gather contemporary knowledge about possible relationships between screen media use and selected medical issues that, we believe, are commonly reported to practitioners of different paediatric specialties. Issues such as sleep disorders, obesity, musculoskeletal symptoms, vision problems, cognitive functioning, mood and behavioural disorders are discussed. In an effort to summarise the existing evidence we reviewed the PubMed database and checked reference lists to identify relevant studies. Special attention was paid to most recent meta-analyses and systematic reviews.

| Age groups | Recommendations | | |
|---------------------|---|--|--|
| | American Academy of Pediatrics | World Health Organization | Canadian Paediatric Society |
| 0–24 months | ≤18 months – no screen time except for video chatting 18–24 months – screen time still discouraged however if introduced, avoidance of solo media use is recommended | No screen time | No screen time |
| 24 months – 5 years | ≤1 hour/day limits, avoid solo media use | ≤1 hour/day limits | ≤1 hour/day limits |
| >5 years | Emphasis on the patterns of use | Recommendations on adequate sleep and physical activity, less than 2 hours of recreational screen time | Patterns of media use recommended, less than 2 hours of recreational screen time |

Tab. 1. Recommendations on screen media use (Canadian Paediatric Society, Digital Health Task Force, Ottawa, Ontario, 2019, 2017; Council on Communications and Media 2016a, 2016b; Council on Communications and Media and Strasburger, 2011; World Health Organization, 2019)

| |
|---|
| 1. No screen time below 2 years of age (unless video-chatting with relatives) Limited in preschool children |
| 2. Focus on: daily routines, family activities, physical activity and adequate sleep quality and quantity |
| 3. House ground rules: <ul style="list-style-type: none"> • family media plan and/or media use plan for individual members if needed • screen-free zones e.g. bedrooms, dining rooms • screen-free time during daytime • no screens one hour before bedtime |
| 4. Use a reliable source of information such as Common Sense Media (available at: www.commonsensemedia.org) to search for valuable and innocuous programmes, applications, movies and games |
| 5. Consistent parenting practices and parental involvement in screen time Co-watch, co-view and co-browse with children Reteach and talk about the content |
| 6. Obtain information on parental control means and privacy settings Review privacy settings with your children |
| 7. Encourage active, educational and social ways of media use, e.g. e-reading, content creation, interactions with peers and relatives Discourage passive use |
| 8. Pay attention to oppositional behaviours and negative emotions as they may indicate that the child encounters problems online |
| 9. Pay attention to the ergonomic use of devices: take breaks for physical activity, avoid prolonged sitting position, promote neutral position of spine, avoid neck flexion and provide rest to eyes |
| 10. Replace fat and sugar rich snacks with vegetables and water Avoid meal-time screen use |

56 Tab. 2. Counsel for parents on screen use – own elaboration based on current guidelines and literature

| Lena, 7 years old – screen time individual plan | |
|---|---|
| Screen-free time | <ul style="list-style-type: none"> • On the street • Doing homework • At school (except when needed for studying) • Mealtime • Car travels (except when long) • 1 hour before bedtime • Conversation |
| Screen-free places | <ul style="list-style-type: none"> • Bedroom • Dining room |
| Loading devices | Kitchen, at night |
| How do I use screen devices? | <ul style="list-style-type: none"> • Co-watching • Co-playing • Co-browsing • Video-chat with relatives and friends • Visiting websites that were parent-approved (educational, creative, age adequate) |
| What I do instead of screentime? | <ul style="list-style-type: none"> • Reading • Sleeping • Meeting friends • Hobby • Board games • Sports • Taking a walk |
| Responsibility online | <ul style="list-style-type: none"> • I respect privacy of others and myself • I report to my parents whenever I encounter violent or inadequate content |
| Safety matters | <ul style="list-style-type: none"> • I do not give any personal data (ex. address, photos, telephone number) • I do not engage in new relations on line unless my parents agree to them |
| 1 hour physical activity per day minimum. 9 hours sleep per day minimum. | |

Tab. 3. Example of media use plan for a 7-year-old girl in Poland – own elaboration based on current guidelines and literature

SLEEP

Adequate sleep quantity and quality are essential for healthy development and counteract various harmful outcomes in children and adolescents. Current data on the relationship between sleep and screen media come largely from cross-sectional, observational and self-reported studies, which prevents drawing any conclusions regarding causal dynamics. However, considering the results from multiple studies that were repetitive across time and geographical regions, scholars seem to agree on the existing exposure-response association between media use and sleep outcomes. It seems that the most consistent results have been acquired for the correlation between excessive total screen time and delayed bedtime and shorter total sleep duration (LeBourgeois et al., 2017). Additionally, some studies suggest that using screen media within an hour before bedtime may also be associated with sleep deficits (Hysing et al., 2015). Finally, a 2016 meta-analysis found that bedtime access and use of screen devices had a detrimental effect on sleep quality and duration, as well as the occurrence of daytime sleepiness (Carter et al., 2016).

Several mechanisms underlying the described relationships have been proposed. Sleep displacement theory has been suggested as one of the moderators. Psychophysiological arousal caused by stimulating media content and the impact of blue light exposure are two alternative ways in which screen media may influence sleep (Hysing et al., 2015). Light emitted from electronic devices was shown to

suppress melatonin secretion, shifting the circadian rhythm, increasing alertness and reducing the rapid eye movement sleep duration (LeBourgeois et al., 2017). It was also suggested that the younger the child, the more sensitive he or she is to light due to larger pupil size and increased light transmission through the crystalline lens (Turner and Mainster, 2008).

BODY WEIGHT

Since the 1980s researchers have investigated the relationship between watching television and increased body weight. The association was demonstrated in many longitudinal and epidemiological studies, especially in preschool children (Council on Communications and Media and Strasburger, 2011). One of these studies showed that TV time of 2 hours or more per day during childhood was a predictor for overweight at 26 years of age (Hancox et al., 2004). Further experimental research provided evidence for causality between screen time and weight gain (Robinson, 1999).

Several underlying mechanisms have been proposed to explain the effect of screen media on weight. The strongest evidence comes from randomised controlled trials supporting the detrimental influence of higher total energy intake while viewing and consuming more high-calorie and low-nutrient food. Another plausible mechanism is food advertising which, as has been proven in several experimental studies, alters children's food preferences, food intake

and even taste perception. The likely mediator of the above is the limited ability to recognise persuasive intent, which seems to persist at different levels regardless of child's age (Council on Communications and Media and Strasburger, 2011). It is also possible that sleep deprivation linked to screen use is involved, particularly among children of 3 to 7 years old, with hormonal dysregulation and eating habit changes, which in turn cause weight gain (Magee and Hale, 2012).

MUSCULOSKELETAL PAIN

The burden of musculoskeletal (MSK) diseases in children and adolescents increased significantly in recent years and remains high. Some studies have linked the prevalence of back pain with screen time. One of them showed an independent correlation between lower back pain and 12 hours per week of TV watching or more than 2 hours per day of videogames playing (Ben Ayed et al., 2019).

Some studies explore other factors than the screen time itself that may contribute to MSK pain. For example, neck pain has been attributed to forward head flexion while using handheld devices. It appears that tilting one's head forward at 60 degrees increases the weight put on the spine 6 times. Certain scholars go as far as to recommend educating patients and their parents to reduce the time of neck flexion and to use screen devices maintaining the spine in a neutral position (Fares et al., 2017). Moreover, a recently conducted prospective study on the prevalence of musculoskeletal symptoms and various features of screen device use found that MSK pain at several back sites was not associated with screen time, but only with the pattern of use, such as multitasking and the duration of continuous use (Toh et al., 2020).

To conclude, the 2016 meta-analysis revealed low-quality evidence supporting the link between MSK pain and screen device use, as the majority of studies enrolled were cross-sectional and survey-based (Huguet et al., 2016).

VISION

There is an emerging literature investigating whether and how screen device use influences the sense of sight. Some studies support the argument that it may lead to eye strain, myopia and dry eye disease in children and adolescents (Moon et al., 2014; Yang et al., 2020). One study discriminating the use of different devices and total screen time in children demonstrated that daily duration of smartphone use and total screen time were significantly related to dry eye disease. No such correlations were established for television or computer use (Moon et al., 2014).

Specific patterns of use, such as playing video games, raise further concerns about eye symptoms. A study in over 300 children between 3 and 10 years of age found a significant relationship between playing games for more than 30 minutes per day and asthenopia (defined as headache,

eyelid tic, transient diplopia, and dizziness), absence of fine stereopsis and refractive errors (Rechichi et al., 2017).

The greatest and most rapid eye growth and visual function development are observed during first years of life and slow down with time. This has led Chinese scholars to investigate correlations between screen use and the occurrence of refractive disorders in preschool children. A cohort study in nearly 30,000 children and their parents demonstrated that daily duration of screen exposure and total years of screen exposure in infancy and early childhood were both associated with an increased risk of astigmatism and myopia. The results also implied that the first postnatal year might have been the most sensitive period for these associations to occur (Yang et al., 2020).

It has been known for many years that blue light (wavelength between 400 and 525 nm) is phototoxic to retina. British scientists however declined the need for policy changes regarding exposure to blue light coming from LEDs and screen devices. They concluded that even "under extreme long-term viewing conditions" these devices do not exceed natural exposure to blue light irradiance. However, the younger the child, the greater the corneal light transmission is, posing greater threat to eye health in children and adolescents than in adults (O'Hagan et al., 2016).

In summary, the body of research investigating possible connections between screen device use and eye health is growing. There is however scarcity of experimental and longitudinal studies. No relevant systematic review or meta-analysis has been found.

COGNITIVE FUNCTIONING

There is a relatively large body of literature exploring the impact of screen media, especially television, on cognitive development. It may seem that prolonged exposure to television is associated with delayed language development and poor executive function, especially in infants and toddlers. For example, in a longitudinal 4-year study, Ennemoser and Schneider (2007) found that children who viewed television for 117 min per day showed lower reading achievements when compared to those who watched television for only 35 to 69 min per day. It is proposed that insufficient quantity and quality of parental interaction in the first years of a child's life may lead to a slower rate of language acquisition (Schmidt et al., 2009).

Furthermore, some research has linked viewing television for longer periods of time during childhood with attention problems, even long-lasting. For example, Christakis et al. (2004) have shown that one additional hour of watching television by children in the first year of life was associated with a 28% increase in the risk of attention problems at the age 7 years. However, the reanalysis of the same dataset revealed that such an effect was significant only for 10% of the children who watched television more than 7 hours per day. On the other hand, studies in older children have shown that watching television at ages 5, 7, 9,

and 11 years was associated with attention problems at ages 13 and 15 years (Landhuis et al., 2007). The authors suggested that watching television in the first years of life might contribute to some long-lasting attention problems. Therefore, it remains unresolved as to whether the attention problem comes from early exposure to television per se or because of the content of programmes watched. It might also be the case that viewing frequent shots and scene changes interferes with the development of attention.

Conversely, some studies have pointed to the positive effects of television, i.e. educational programmes for cognitive development (for review see: Schmidt and Anderson, 2009). It is suggested that even preschool-aged children might benefit by watching educational programmes for the development of literacy, mathematics, or problem solving. To summarise, the existing studies provide for both potential positive as well as negative effects of television on the cognitive functioning of children, depending on the age of the child and the type of programmes watched. According to the American Academy of Pediatrics (Council on Communications and Media 2016a, 2016b), parents or caregivers should watch programmes with children, especially those less than 3 years old. During such “co-viewing,” parents can focus the children’s attention on content, thus potentially increasing their ability to learn from screen media.

DEPRESSION AND ANXIETY

As the screen time among children and adolescents has been increasing alongside the prevalence of various mental health problems, a growing body of research attempts to establish whether there are any linkages between these phenomena. Paediatric population represents a developmental context predisposing to susceptibility to certain features of modern technology. Preschool children lack abilities based on the theory of mind e.g. to recognise persuasion and manipulation which may prompt sensitivity to advertising, marketing and abuse. Children and adolescents learn how to regulate emotions in an adaptive way while still being susceptible to addictive behaviours, such as excessive media use. Finally, the youth seems to be physiologically inclined to experience attachment anxieties as they start separation process and thus may be more vulnerable to social media dangers (susceptibility to addictive patterns of media use, abuse) (Council on Communications and Media, 2016a, 2016b; Reid Chassiakos et al., 2016).

Given the aforementioned developmental issues, research making preliminary inferences about the relationship between screen time and mental health problems in children and adolescents draw a lot of public attention. In fact, results from a population-based cohort study in children over 2 years old and adolescents and their parents support the evidence that excessive screen time (over 4–7 hours/day) is associated with greater risk of poor emotional regulation, poor executive functioning, anxiety, depression, and psychiatric treatment (Twenge and Campbell, 2018).

On the other hand, a prospective cohort study conducted among adolescents in 2018 showed that Internet use was correlated with increased anxiety in young individuals who had already displayed higher levels of anxiety at baseline. There is an emerging evidence from the increasing number of meta-analyses that indicates no or very weak relationship between screen time and internalising symptoms. Moreover, scientists argue, based on conflicting conclusions that can be drawn from the same dataset, that studies in the area of behavioural science are prone to false positive results. Cross-sectional survey-based design of most of the studies in reference provides self-reported data prone to subjective bias and gives solely correlational evidence without knowledge on causality (Orben and Przybylski, 2019). Furthermore, some researchers add to the discussion a hypothesis that the association between screen time and mental health is nonlinear. Recently obtained results indicate that the actual relationship between screen time and mental health favours moderate users over non-users and excessive users of different devices (Przybylski and Weinstein, 2017). Although “everything in moderation” message seems compelling, an increasing number of scientists point out that focusing on screen time may not be the most productive in terms of preventive and therapeutic interventions both in the research area and counsel. They rather encourage focusing on how media are used – a more nuanced approach in comparison with a singular measurement of screen time. Research findings point to associations between lower anxiety and positive online interactions that enhance social support and facilitate socialising in person. Conversely, negative interactions and social comparison online as well as the reduction of face-to-face experiences appears to be connected with more internalizing symptoms (Odgers and Jensen, 2020).

Taking these substantial disagreements into consideration, caution and individual assessment of media use in each patient is likely the best approach for clinical practitioners to adopt (Odgers and Jensen, 2020).

AGGRESSIVE BEHAVIOURS

The influence of exposure to violent media content on children’s behaviour has been a topic of heated scientific debate. Some scholars claim that the relationship not only exists but displays cause and effect nature. They argue that playing violent video games may increase aggressive behaviours, cognition and affect, as well as decrease helping behaviours in dose-response manner. Authors of two meta-analyses concluded that these effects are statistically significant in experimental, cross-sectional and longitudinal studies irrespective of gender, culture and game type (Greitemeyer and Mügge, 2014). However, Ferguson et al. (2012) demonstrated results from their longitudinal study showing no links between playing violent games and escalation of violent behaviours. It has been argued that the aforementioned meta-analyses have methodological issues that limit their interpretability:

existing publication bias in favour of studies that show the relationship, omission of covariates, small effect sizes which, even if statistically significant, should not prompt premature conclusions (Ferguson, 2015). While the vigorous scientific debate continues, other scholars propose the consensus of a small, yet detrimental effect of playing violent games on aggressive behaviours (Mathur and VanderWeele, 2019).

CONCLUSIONS

1. Access to screen devices often begins as early as in the infancy. Both screen time and device ownership increase with age. Concerns arise whether there is a relationship between various health aspects and screen media use. Most of the areas discussed in this paper lack scientific consensus.
2. Contemporary recommendations advocate concrete limitation-based approach towards infants, toddlers and pre-school children while providing more general guidelines for older children and adolescents.
3. Obesity is the best-documented negative outcome of excessive screen media use.
4. Screen media use seems to affect both the quantity and the quality of sleep. Recommendations advise to discontinue the use of screen devices at least one hour before bedtime and preferably restrain from device placement in children's bedroom.
5. There is emerging evidence suggesting that screen media use may pose a risk to the musculoskeletal system by inducing tissue damage and pain.
6. As far as visual symptoms are concerned, no robust analysis investigating their association with screen media exposure were found. Preliminary results stemming mostly from cross-sectional studies imply an association between negative visual outcomes and screen device use, especially in infants and young children.
7. Most research in the area of mental health in the digital era is cross-sectional and survey-based in design. Therefore, even if statistically significant correlations were established, the matter of causality remains undetermined. Even though several cohort studies leveraged their statistically significant and correlational results to gain predominance in public opinion and research directions, they cannot provide clinically relevant evidence.
8. Moreover, it seems in regard to mental health that focusing solely on screen time may be futile in clinical practice since the nature of screen device use seems to be more relevant for comprehending mental health outcomes in children and adolescents. Offline experiences and intrinsic characteristics of a patient are likely more important contributing factors.
9. The existence and nature of the link between aggressive behaviours and media exposure to violence remains controversial. Certain scholars suggested a consensus of a small, yet detrimental effect.

Conflict of interest

The authors report no conflicts of interests.

References

- Ben Ayed H, Yaich S, Trigui M et al.: Prevalence, risk factors and outcomes of neck, shoulders and low-back pain in secondary-school children. *J Res Health Sci* 2019; 19: e00440.
- Braune-Krickau K, Schneebeli L, Pehlke-Milde J et al.: Smartphones in the nursery: parental smartphone use and parental sensitivity and responsiveness within parent-child interaction in early childhood (0–5 years): a scoping review. *Infant Ment Health J* 2021; 42: 161–175.
- Canadian Paediatric Society, Digital Health Task Force, Ottawa, Ontario: Digital media: promoting healthy screen use in school-aged children and adolescents. *Paediatr Child Health* 2019; 24: 402–417.
- Canadian Paediatric Society, Digital Health Task Force, Ottawa, Ontario: Screen time and young children: promoting health and development in a digital world. *Paediatr Child Health* 2017; 22: 461–477.
- Carter B, Rees P, Hale L et al.: Association between portable screen-based media device access or use and sleep outcomes: a systematic review and meta-analysis. *JAMA Pediatr* 2016; 170: 1202–1208.
- Christakis DA, Zimmerman FJ, DiGiuseppe DL et al.: Early television exposure and subsequent attentional problems in children. *Pediatrics* 2004; 113: 708–713.
- Council on Communications and Media: Media and young minds. *Pediatrics* 2016a; 138: e20162591.
- Council on Communications and Media: Media use in school-aged children and adolescents. *Pediatrics* 2016b; 138: e20162592.
- Council on Communications and Media, Strasburger VC: Children, adolescents, obesity, and the media. *Pediatrics* 2011; 128: 201–208.
- Ennemoser M, Schneider W: Relations of television viewing and reading: findings from a 4-year longitudinal study. *J Educ Psychol* 2007; 99: 349–368.
- Fares J, Fares MY, Fares Y: Musculoskeletal neck pain in children and adolescents: risk factors and complications. *Surg Neurol Int* 2017; 8: 72.
- Ferguson CJ: Do angry birds make for angry children? A meta-analysis of video game influences on children's and adolescents' aggression, mental health, prosocial behavior, and academic performance. *Perspect Psychol Sci* 2015; 10: 646–666.
- Ferguson CJ, San Miguel C, Garza A et al.: A longitudinal test of video game violence influences on dating and aggression: a 3-year longitudinal study of adolescents. *J Psychiatr Res* 2012; 46: 141–146.
- Greitemeyer T, Mügge DO: Video games do affect social outcomes: a meta-analytic review of the effects of violent and prosocial video game play. *Pers Soc Psychol Bull* 2014; 40: 578–589.
- Gromada A, Rees G, Chzhen Y: UNICEF Innocenti: Worlds of Influence: Understanding What Shapes Child Well-being in Rich Countries. Innocenti Report Card 16, UNICEF Office of Research – Innocenti, Florence 2020.
- Hancox RJ, Milne BJ, Poulton R: Association between child and adolescent television viewing and adult health: a longitudinal birth cohort study. *Lancet* 2004; 364: 257–262.
- Huguet A, Tougas ME, Hayden J et al.: Systematic review with meta-analysis of childhood and adolescent risk and prognostic factors for musculoskeletal pain. *Pain* 2016; 157: 2640–2656.
- Hysing M, Pallesen S, Stormark KM et al.: Sleep and use of electronic devices in adolescence: results from a large population-based study. *BMJ Open* 2015; 5: e006748.
- Kılıç AO, Sari E, Yucel H et al.: Exposure to and use of mobile devices in children aged 1–60 months. *Eur J Pediatr* 2019; 178: 221–227.
- Landhuis CE, Poulton R, Welch D et al.: Does childhood television viewing lead to attention problems in adolescence? Results from a prospective longitudinal study. *Pediatrics* 2007; 120: 532–537.

- LeBourgeois MK, Hale L, Chang AM et al.: Digital media and sleep in childhood and adolescence. *Pediatrics* 2017; 140 (Suppl 2): S92–S96.
- Magee L, Hale L: Longitudinal associations between sleep duration and subsequent weight gain: a systematic review. *Sleep Med Rev* 2012; 16: 231–241.
- Mathur MB, VanderWeele TJ: Finding common ground in meta-analysis “wars” on violent video games. *Perspect Psychol Sci* 2019; 14: 705–708.
- Mojtabai R, Olfson M, Han B: National trends in the prevalence and treatment of depression in adolescents and young adults. *Pediatrics* 2016; 138: e20161878.
- Moon JH, Lee MY, Moon NJ: Association between video display terminal use and dry eye disease in school children. *J Pediatr Ophthalmol Strabismus* 2014; 51: 87–92.
- Odgers CL, Jensen MR: Annual Research Review: Adolescent mental health in the digital age: facts, fears, and future directions. *J Child Psychol Psychiatry* 2020; 61: 336–348.
- O'Hagan JB, Khazova M, Price LLA: Low-energy light bulbs, computers, tablets and the blue light hazard. *Eye (Lond)* 2016; 30: 230–233.
- Orben A, Przybylski AK: The association between adolescent well-being and digital technology use. *Nat Hum Behav* 2019; 3: 173–182.
- Przybylski AK, Weinstein N: A large-scale test of the goldilocks hypothesis. *Psychol Sci* 2017; 28: 204–215.
- Rechichi C, De Mojà G, Aragona P: Video game vision syndrome: a new clinical picture in children? *J Pediatr Ophthalmol Strabismus* 2017; 54: 346–355.
- Reid Chassiakos YL, Radesky J, Christakis D et al.; Council on Communications and Media: Children and adolescents and digital media. *Pediatrics* 2016; 138: e20162593.
- Rideout V, Robb MB: The Common Sense Census: Media Use by Tweens and Teens. 2019. Common Sense Media, San Francisco, CA 2019. Available from: <https://www.commonsensemedia.org/sites/default/files/research/report/2019-census-8-to-18-full-report-updated.pdf>.
- Robinson TN: Reducing children's television viewing to prevent obesity: a randomized controlled trial. *JAMA* 1999; 282: 1561–1567.
- Schmidt ME, Anderson DR: The impact of television on cognitive development and educational achievement. In: Pecora N, Murray JP, Wartella EA (eds.): *Children and Television: Fifty Years of Research*. Erlbaum, Mahwah, NJ 2009.
- Schmidt ME, Rich M, Rifas-Shiman SL et al.: Television viewing in infancy and child cognition at 3 years of age in a US cohort. *Pediatrics* 2009; 123: e370–e375.
- Toh SH, Coenen P, Howie EK et al.: A prospective longitudinal study of mobile touch screen device use and musculoskeletal symptoms and visual health in adolescents. *Appl Ergon* 2020; 85: 103028.
- Turner PL, Mainster MA: Circadian photoreception: ageing and the eye's important role in systemic health. *Br J Ophthalmol* 2008; 92: 1439–1444.
- Twenge JM: *iGen: Why Today's Super-Connected Kids Are Growing Up Less Rebellious, More Tolerant, Less Happy– and Completely Unprepared for Adulthood (and What That Means for the Rest of Us)*. Atria Books, New York, NY 2017.
- Twenge JM, Campbell WK: Associations between screen time and lower psychological well-being among children and adolescents: evidence from a population-based study. *Prev Med Rep* 2018; 12: 271–283.
- World Health Organization: *Guidelines on Physical Activity, Sedentary Behaviour and Sleep for Children Under 5 Years of Age*. World Health Organization, Geneva 2019. Available from: <https://apps.who.int/iris/handle/10665/311664>.
- Yang GY, Huang LH, Schmid KL et al.: Associations between screen exposure in early life and myopia amongst Chinese preschoolers. *Int J Environ Res Public Health* 2020; 17: 1056.