

SCREEN TIME AND MENTAL HEALTH AMONG ADOLESCENTS

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ABSTRACT

Adolescence is a period of dynamic behavioural and emotional development that can increase young people's vulnerability to mental health problems. With 70% of mental disorders having their onset during childhood or adolescence, identifying modifiable factors of these disorders among adolescents can help inform future interventions aiming to improve mental health.

One of these factors is electronic technology which has become pervasive in our modern society, occupying an important portion of young people's days and changing their lifestyle. This has created serious concerns regarding the impact of heavy recreational screen use on adolescents' health, especially with the vast majority exceeding the sedentary recreational screen time recommendations of 2 hours or less per day. Evidence suggests that screen time can be associated with adolescent mental health problems. However, little is known about how the extent, nature, and types of recreational screen engagement among adolescents are associated with mental health problems as the body of evidence is very mixed, and many questions remain unanswered.

Accordingly, the aims of this dissertation were: i) to summarize the evidence regarding correlates of sedentary screen pursuits among youth, ii) to examine how different types of screens, incorporating their newer forms, are associated with adolescents' mental health cross-sectionally and longitudinally, iii) to examine the nature of screen use and its association with suicidal behaviours; and iv) to explore the moderating role of sex, age, and parental support in the association between screen time and different mental health problems.

To achieve these objectives, we completed four manuscripts, all prepared for submission to peer-reviewed scientific journals:

1. A narrative review on the psychological correlates of sedentary screen time behaviour among children and adolescents.
2. Heavy social media use and psychological distress among adolescents: the moderating role of sex, age, and parental support.
3. Problematic technology use, suicidal ideation, and suicide attempt among adolescents: the moderating role of sex.
4. Longitudinal associations between different types of screen use and depression and anxiety symptoms in adolescents.

Collectively, our results identified that high levels of sedentary screen behaviour are associated with more severe anxiety, depressive symptoms, and suicidality among adolescents. However, the strength of associations varied between some screen types. Additionally, the findings of this dissertation indicate that a further increase in screen time is associated with increased mental health problems. Lastly, an important role of sex and age in this association was identified. These results can be used to inform future research in this field and guide future interventions designed to manage screen use among adolescents and improve their mental health.

DEDICATION

I dedicate my dissertation to my children Mohammad, Manessa, and Zain who have filled my long journey with love and joy. You are the most valuable achievement of my life. I hope that this work inspires you to become the generation that makes change in the era of technology.

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LIST OF ABBREVIATIONS

BDNF	Brain-Derived Neurotrophic Factor
BMI	Body Mass Index
CESD-R-10	Center for Epidemiologic Studies Depression Scale (Revised)–10
CI	Confidence Interval
COVID-19	Coronavirus Disease 2019
DSM	Diagnostic and Statistical Manual of Mental Disorders
GAD-7	Generalized Anxiety Disorder scale-7
K6	Kessler 6-item Psychological Distress Scale
OR	Odds Ratio
OSDUHS	Ontario Student Drug Use and Health Survey
PTU	Problematic Technology Use
SD	Standard Deviation
SE	Standard Error
SES	Subjective Socioeconomic Status
TV	Television
USA	United States of America
WHO	World Health Organization

CHAPTER 1 INTRODUCTION

1.1 Thesis Overview and Rationale

This dissertation evaluates the association between different types of screen time and the duration and nature of use with different mental health problems such as anxiety, depression, and suicidal behaviour among adolescents.

The increase in global mental health problems among adolescents, coupled with a dramatic increase in sedentary screen pursuits in recent years, highlights the need to examine the association between types and duration of screen time with various mental health problems among adolescents. Adolescence is considered a critical period where mental health disorders tend to persist into adulthood, and when long-lasting health habits or risky behaviours are forming. Even though mental health is a complex, multifactorial issue, sedentary screen time pursuits are potential modifiable contributors. Therefore, the issue should be addressed preventatively during adolescence.

My dissertation will help to provide an improved understanding of the influences and associations of sedentary screen behaviour on adolescents' mental health and identifies the groups who are at greater risk. Such information may advise programs and policies that are needed to facilitate the reduction in sedentary screen pursuits among youth before unhealthy behaviours become imbedded and, ultimately, may help improve adolescents' mental health.

1.2 Conceptual Framework

This dissertation draws on two theoretical concepts from the Bronfenbrenner's ecological concept [1,2], and the displacement theory. These models can help make sense of the association between screen time and mental health, which in turn helps in providing valuable recommendations to reduce sedentary screen behaviour, promote mental health, and inform interventions [3].

Bronfenbrenner and colleagues' model suggests that ecological systems describe the relationship between individuals' direct and indirect environments, development, and social interactions. This model accounts for various system levels that include individual (age, sex, health, etc.), microsystem (family, peers, etc.), mesosystem (interactions between the individual's microsystems), exosystem (social and health services, socio-economic status (SES)), and macrosystem (culture, norms, laws, etc.). These systems are nested and interconnected to shape individuals' development [1,2,4]. By accounting for various systems, this framework captures the factors influencing certain health behaviours at various levels. In addition, this model can help understanding which individuals are more vulnerable to which types of screen depending on various system factors, thus it helps to inform tailored intervention approaches aiming to systematically influence factors involved in the mechanism of change at several levels. Therefore, in this dissertation, we examined factors from various levels of the ecological system to provide an in-depth understanding of their role in the association between screen use and mental health.

Another commonly used theory to explain the association between sedentary screen time and adolescents' mental health is the displacement hypothesis [5,6]. This theory began when television (TV) became popular in the mid-20th century, with increasing concerns about its

effects on children development. It proposes that watching TV can be associated with children's well-being by replacing activities that are critical and advantageous to the development [5]. In support of this concept, research showed that various types of sedentary screen consumption (e.g., social media, gaming, etc.) have been associated with indicators of poorer physical and mental health [7–9]. Furthermore, research indicated that screen time displacement affects sleep quality and quantity [10–12] and reduces physical activity [13,14]. These factors form the movement behaviours that pose important consequences for adolescents' mental and physical health [9,15–17]. It has been indicated that adhering to the Canadian 24-hour movement guidelines by limiting sedentary screen activities to 2 hours or less, getting 8-10 hours of good quality sleep, and engaging in physical activities for at least one hour per day for children and youth, [14,18] have a positive effects on mental health [13,19]. In addition to that, time spent in front of screens displaces social interactions with family and friends, which in turn negatively influences adolescent's mental health [20–23]. Accordingly, displacing health promoting activities can explain the negative association between sedentary pursuits and adolescent's mental health.

1.3 Research Objectives

The purpose of this dissertation was to examine how different types and behaviours of screen usage are associated with anxiety, depression, and other mental health problems in adolescents. To achieve this purpose, the following objectives were identified:

1. Perform a narrative review of the literature to identify the associations between screen-based sedentary behaviour and anxiety, depression, and other mental health problems among adolescents.

2. Examine how different types of screen pursuits (social media, TV viewing, video games, internet surfing, screen-based communication, etc.) are associated with anxiety and depression among adolescents cross-sectionally and longitudinally.
3. Examine how the problematic usage of technology is associated with suicidal ideation and suicide attempt among adolescents.
4. Determine the role of sex, age, and parental support in modifying the effect of screen time on mental health problems.

1.4 Dissertation Organization and Outline

This dissertation is organized in an article format as required in the University of Ottawa dissertation guidelines.

An overview of each chapter is provided below:

- Chapter 1 provides an introduction, theoretical framework, and rationale of the dissertation topic.
- Chapter 2 provides a literature review.
- Chapter 3 is the first manuscript of this dissertation, entitled: *Psychological Correlates of Sedentary Screen Time Behaviour Among Children and Adolescents: A Narrative Review*. This manuscript was published online in December 2020 in *Current Obesity Reports*.
- Chapter 4 is the second manuscript of this dissertation, entitled: *Heavy Social Media Use and Psychological Distress among Adolescents: The Moderating Role of Sex, Age, and Parental Support*. This manuscript was published online in June 2023 in *Frontiers in Public Health*.
- Chapter 5 is the third manuscript of this dissertation, entitled: *Problematic Technology Use, Suicidal Ideation, and Suicide Attempt among Adolescents: The Moderating Role of Sex*. This manuscript was accepted for publication in the *International Journal for Child and Adolescent Health*.

- Chapter 6 is the fourth manuscript of this dissertation, entitled: *Longitudinal associations between different types of screen use and depression and anxiety symptoms in adolescents*. This manuscript was published online in April 2023 in *Frontiers in Public Health*.
- Chapter 7 provides a general discussion, including the strengths, limitations, and future directions for research and future implications of the thesis results, and concluding remarks.

1.5 References

- [1] Bronfenbrenner U. Ecological systems theory. *Six Theor. Child Dev. Revis. Formul. Curr. Issues*, London, England: Jessica Kingsley Publishers; 1992, p. 187–249.
- [2] Bronfenbrenner U, Morris P. The bioecological model of human development. In: Lerner RM, Damon W, editors. *Theoretical Models Hum. Dev.*, New York: Wiley; 2006, p. 793–828.
- [3] Koehler SN, Parrell BR. *The Impact of Social Media On Mental Health: A Mixed-Methods Research Of Service Providers' Awareness*. 2020.
- [4] Eaton P. Viewing Digital Space(s) through Bronfenbrenner's Ecological Model. Paul William Eaton 2014. <https://profpeaton.com/2014/05/11/viewing-digital-spaces-through-bronfenbrenners-ecological-model/> (accessed February 17, 2022).
- [5] Neuman SB. The Displacement Effect: Assessing the Relation between Television Viewing and Reading Performance. *Read Res Q* 1988;23:414–40. <https://doi.org/10.2307/747641>.
- [6] Kraut R, Patterson M, Lundmark V, Kiesler S, Mukopadhyay T, Scherlis W. Internet paradox. A social technology that reduces social involvement and psychological well-being? *Am Psychol* 1998;53:1017–31. <https://doi.org/10.1037//0003-066x.53.9.1017>.
- [7] Asare M. Sedentary Behaviour and Mental Health in Children and Adolescents: A Meta-analysis. *J Child Adolesc Behav* 2015;03. <https://doi.org/10.4172/2375-4494.1000259>.
- [8] Biddle SJH, García Bengoechea E, Wiesner G. Sedentary behaviour and adiposity in youth: a systematic review of reviews and analysis of causality. *Int J Behav Nutr Phys Act* 2017;14:43. <https://doi.org/10.1186/s12966-017-0497-8>.
- [9] Carson V, Hunter S, Kuzik N, Gray CE, Poitras VJ, Chaput J-P, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth: an update.

- Appl Physiol Nutr Metab Physiol Appl Nutr Metab 2016;41:S240-265.
<https://doi.org/10.1139/apnm-2015-0630>.
- [10] Hale L, Guan S. Screen time and sleep among school-aged children and adolescents: a systematic literature review. *Sleep Med Rev* 2015;21:50–8.
<https://doi.org/10.1016/j.smr.2014.07.007>.
- [11] Cain N, Gradisar M. Electronic media use and sleep in school-aged children and adolescents: A review. *Sleep Med* 2010;11:735–42.
<https://doi.org/10.1016/j.sleep.2010.02.006>.
- [12] Sampasa-Kanyinga H, Hamilton HA, Chaput J-P. Use of social media is associated with short sleep duration in a dose-response manner in students aged 11 to 20 years. *Acta Paediatr Oslo Nor* 1992 2018;107:694–700. <https://doi.org/10.1111/apa.14210>.
- [13] Faulkner G, Weatherson K, Patte K, Qian W, Leatherdale ST. Are one-year changes in adherence to the 24-hour movement guidelines associated with flourishing among Canadian youth? *Prev Med* 2020;139:106179. <https://doi.org/10.1016/j.ypmed.2020.106179>.
- [14] Tremblay MS, Carson V, Chaput J-P, Connor Gorber S, Dinh T, Duggan M, et al. Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep. *Appl Physiol Nutr Metab* 2016;41:S311-327.
<https://doi.org/10.1139/apnm-2016-0151>.
- [15] Hoare E, Milton K, Foster C, Allender S. The associations between sedentary behaviour and mental health among adolescents: a systematic review. *Int J Behav Nutr Phys Act* 2016;13:108. <https://doi.org/10.1186/s12966-016-0432-4>.

- [16] Suchert V, Hanewinkel R, Isensee B. Sedentary behavior and indicators of mental health in school-aged children and adolescents: A systematic review. *Prev Med* 2015;76:48–57. <https://doi.org/10.1016/j.ypmed.2015.03.026>.
- [17] Mougharbel F, Goldfield GS. Psychological Correlates of Sedentary Screen Time Behaviour Among Children and Adolescents: a Narrative Review. *Curr Obes Rep* 2020;9:493–511. <https://doi.org/10.1007/s13679-020-00401-1>.
- [18] Tremblay MS, Leblanc AG, Janssen I, Kho ME, Hicks A, Murumets K, et al. Canadian sedentary behaviour guidelines for children and youth. *Appl Physiol Nutr Metab Physiol Appl Nutr Metab* 2011;36:59–64; 65–71. <https://doi.org/10.1139/H11-012>.
- [19] Weatherson K, Gierc M, Patte K, Qian W, Leatherdale S, Faulkner G. Complete mental health status and associations with physical activity, screen time, and sleep in youth. *Ment Health Phys Act* 2020;19:100354. <https://doi.org/10.1016/j.mhpa.2020.100354>.
- [20] Twenge JM, Campbell WK. Media Use Is Linked to Lower Psychological Well-Being: Evidence from Three Datasets. *Psychiatr Q* 2019;90:311–31. <https://doi.org/10.1007/s11126-019-09630-7>.
- [21] Nesi J. The Impact of Social Media on Youth Mental Health: Challenges and Opportunities. *N C Med J* 2020;81:116–21. <https://doi.org/10.18043/ncm.81.2.116>.
- [22] Rutter LA, Thompson HM, Howard J, Riley TN, Jesús-Romero RD, Lorenzo-Luaces L. Social Media Use, Physical Activity, and Internalizing Symptoms in Adolescence: Cross-sectional Analysis. *JMIR Ment Health* 2021;8:e26134. <https://doi.org/10.2196/26134>.
- [23] Twenge JM, Spitzberg BH, Campbell WK. Less in-person social interaction with peers among U.S. adolescents in the 21st century and links to loneliness. *J Soc Pers Relatsh* 2019;36:1892–913. <https://doi.org/10.1177/0265407519836170>.

CHAPTER 2 LITERATURE REVIEW

2.1 Adolescence and Mental Health

Adolescence is a critical transitional period in human life in which many complex changes in physical and mental growth occur from age 10-19 years [1–4]. Two phases/stages are introduced in the literature in this chapter. The first, early adolescence, ranges/spans the time from 10 to 14 years, in which significant physical, emotional and cognitive changes occur. During this phase, exploring ways of being independent begins; however, the ability for abstract thinking is still limited. The second phase, late adolescence, ranges/spans the time from 15-19 years and includes slower physical development among girls, whereas boys continue rapid physical development [3,4]. Furthermore, during this phase, adolescents begin to develop their capacity for abstract and more logical thinking, moral reasoning, and complex thoughts [5].

During this developmental transition from childhood to adulthood, normative and maladaptive patterns which shape future trajectories are established [4], especially since adolescents are particularly sensitive to influences from their environments [6–8]. Also, this phase of life is of interest given the high vulnerability of adolescents to mental health problems [1,9,10] and behavioral problems [11]. Thus, it is of a high importance to create the foundation of various healthy behaviours that positively impact health and well-being [12–14].

According to the World Health Organization (WHO), mental health is defined as ‘a state of wellbeing in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and can make a contribution to his or her community [15]. The WHO and UNICEF, in recent joint programs on mental health and

psychological well-being for children and adolescents, emphasize that mental health problems are a serious public health issue globally and an emerging priority [10,16].

Mental health problems in adolescence have consequences that lead to a cost to both the individuals and society [9,17]. More than 13% of adolescents are living with a diagnosed mental disorder worldwide [18–20]. It has been estimated that the economic loss in young people's human potential arising from mental health disorders among children and adolescents is \$387 billion a year, in addition to the intangible impact of mental health problems on young people and their families as a leading cause of disability and disease burden globally [9]. Approximately 70% of mental health problems have their onset during childhood [21], and they often persist into adulthood [22].

2.1.1 Depression and Anxiety

There are many forms of mental health problems, with depression and anxiety being the most common [9,16]. Even though symptoms of depression and anxiety overlap, it was indicated that depression and anxiety are not completely similar, nor are they two forms of one disorder [23,24]. Depression is characterized mainly by unhappiness and losing interest in most activities. It is described as experiencing five or more symptoms in the last two weeks according to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) [25]. Depressed mood, loss of interest in all activities, fatigue and physical complaints, inability to focus, feeling worthless, agitation, change in appetite and sleep, and recurrent thoughts of death are features of depression [25].

There are many types of anxiety, but Generalized Anxiety Disorder is the most common. Symptoms of GAD are characterized by experiencing pervasive, excessive, and uncontrollable

worry, irritability, feeling nervous, restlessness, trouble relaxing, and fear for at least two weeks and persist for many months [26].

Depression and anxiety contribute to 43% of mental health problems among adolescents aged 10-19 years, with approximately 31.4% of males and 56.3% of females being impacted [9]. In Canada, depression is considered the most common mental health problems, with 11% of young people aged 15 to 24 years having been depressed in their lifetime; among them, nearly 9% of males and 13% of females were affected [27]. Furthermore, according to the 2014 Ontario Child Health Study, 9.7% of youth met the criteria for anxiety disorders; among them, 6.3% of males and 13.3% of females were impacted [18]. This is very concerning, especially since research indicated that 70% of mental health problems start at early ages, and young people with symptoms of anxiety and depression are more likely to experience mental health problems in adulthood [22,28].

Anxiety and depression during adolescence can have detrimental short and long-term consequences, and are considered the leading causes of disability and disease burden among adolescents, worldwide [16,29–32]. They affect school attendance and educational achievement [33,34], and are associated with school dropout and substance use [35]. These disorders can also lead to social withdrawal which can exacerbate isolation and loneliness; it has been shown that depression and anxiety during adolescence are associated with a higher risk of other mental disorders, various additional psychosocial adjustment problems, and suicidality [36,37]. Furthermore, depression is recognized as one of the most profound and burdensome diseases globally.[38] It is estimated that depression will be the second leading cause of disease burden worldwide by 2030, and the first leading cause in high-income countries [10,39]. At its worst, depression can lead to suicide.

2.1.2 Suicidal Behaviour

Another significant public health concern discussed in this dissertation is suicide. An annual worldwide estimate of 700,000 deaths due to suicide was indicated in recent reports, with much more suicide attempts [40]. In Canada, suicide is considered an important cause of preventable death. In 2020, suicide rate for adolescents aged 15-19 years was 8.2 per 100,000, accounting for almost one-quarter of all deaths and ranking as the second leading cause of death among youth [41] and fourth globally [40] with a narrowing gap between boys and girls youth suicide according to recent reports [42].

In addition to suicide-related deaths, recent statistics from the 2021 Ontario Student Drug Use and Health Survey (OSDUHS, 2021) indicate that 18% of Ontarian students indicated serious suicidal thoughts in the past year and 5% reported experiencing suicide attempts. According to this report, suicidal ideation increased from 16% to 18% from 2019 to 2021, which is considered a record since these surveys began in 2001 (OSDUHS, 2019 – OSDUHS, 2021). The nationally representative Canadian Community Health Survey (n=4031) cited comparable findings and indicated that lifetime suicidal ideation was higher among females than males (16.2% vs 12%, respectively) [27].

These numbers indicate that not only adolescents who attempt suicide are of concern, but also those with suicidal ideation given the high prevalence of suicidal behaviour among this group, which indicates a major national and global concern [43]. Most of these events first occur from early to mid-adolescence [44] and are recognized to be associated with co-morbid mental disorders, poor educational outcomes, premature death and adult suicide [45–47]. Suicidal behaviours also go beyond individual harm and are associated with social, and economic burdens on family, peers and community [48–50].

With the high and increasing prevalence of anxiety, depression and suicidality among adolescents and with an annual economic burden of mental disorders in Canada of approximately \$50 billion [51,52]; adding to this, that half of all lifetime mental disorders are estimated to begin by age 14 [28], there is a critical need for more research that helps to identify and understand in more depth the pathways to mental disorders starting at early ages. This will help inform programs, policies and other interventions that help preventing and addressing mental disorders. This is of a high importance, especially after the enormous negative impact of the coronavirus disease 2019 (COVID-19) pandemic on adolescents' mental health [53–55].

Many variables have been identified in the literature as being correlates, or contributors to mental health problems, including but not limited to socioeconomic status [56–58], biological and genetic factors [59], stressful life events [60], physical health [61,62] social support, lifestyle [56,58,59].

While pharmacotherapy and cognitive behavioural therapies are considered as effective treatments for managing mental health problems [63–67], their efficacy during childhood is variable and often weak, whereas healthy behaviours are considered as important factors that could improve symptoms and have little to no side effects [68,69]. A number of modifiable risk factors for mental health problems can have a significant impact on the prevention or development of the disease. Recreational screen activities are one set of modifiable risk factors of interest in this thesis. [70,71]

2.2 Sedentary Behaviour

2.2.1 Definition

Sedentary behaviour refers to any waking activity that results in an energy expenditure ≤ 1.5 metabolic equivalents (METs), done in a sitting, lying, or reclining posture [72]. Sedentary

behaviour can be measured objectively through accelerometers, or subjectively through self-report questionnaires [73,74]. While many activities can be identified as types of sedentary behaviours, such as reading, writing, eating, using screen based devices, or viewing TV [75]; screen based behaviours represented by video gaming, leisure phone and computer use, and social media use are considered the most common forms of recreational sedentary behaviour among adolescents [76,77].

In recent decades, with the rapid technological advancements, digital devices became ubiquitous in the day-to-day lives of adolescents who are growing up being immersed in a media-saturated world and are highly knowledgeable and engaged with technology [78,79]. Accordingly, there has been an extensive rise in screen usage among adolescents, from smartphone use, television, video games, computer, and social media use [79–82]. For that reason, many Canadian and international guidelines emphasize the importance of decreasing the time spent sedentary [83–85]. For example, the World Health Organization strongly recommends in their 2020 guidelines for physical activity and sedentary behaviour that children and youth should limit the amount of recreational screen time [85]. Also, the Canadian 24-hour movement guidelines for children and adolescents recommend limiting recreational screen time to 2 hours or less for children and youth aged 5-17 years [83,86].

2.2.2 Prevalence of sedentary behaviour

With screens like smartphones and tablets being portable and accessible easily, screen use in excess of guidelines (≤ 2 hours per day) has been broadly reported worldwide [87–89]. In Canada, where nearly 100% of Canadian adolescents and young adults [90] have access to smartphones, data from the Canadian Health Measures Survey (CHMS) reported that 71.9% of adolescents (12-17 years) spent more than 2 hours per day in recreational screen-based pursuits

and their average daily screen time was 3.8 hours [91]. Another recent representative survey among Ontarian adolescents showed that an average of 83% of adolescents in grades 7-12 spend three or more hours of recreational screen time per day. The same survey indicated a significant change in screen time use between 2019 and 2021, with 31% of youth in grades 9-12 reporting more than 5 hours of daily screen usage compared to 21% in 2019; and 26% reporting more than 7 hours of daily screen use compared to 12% in 2019 [92].

While screen time activities are considered as one of the greatest tools to access information easily and connect people in positive ways [93–95], the high prevalence of adolescents not meeting screen time use recommendations raises concern based on evidence from recent studies and reviews which have shown an association between sedentary screen pursuits and mental health problems such as depression, anxiety, low self-esteem and suicidal behaviours [96–101].

2.3 Association between sedentary screen time and mental health

Several studies examined the potential impact of screen-based sedentary behaviour on adolescents' mental illnesses. Some evidence in the literature indicated that a moderate amount of screen use is not harmful and may even have some benefits [102,103], while various studies documented an association between higher levels of screen time and anxiety, depression, and suicidal behaviours [97–101,104–106]. For example, a narrative review of reviews [104] on screen use among youth indicated a negative association between higher levels of digital screen use, social media, and depressive symptoms. Also, in a review of reviews on the association between screen time and adolescent's mental health, Stiglic and Viner (2019) showed evidence of a positive association between screen time and depressive symptoms [107]. Similarly, other systematic reviews and meta-analyses [108–110] have indicated that higher levels of sedentary screen activities are associated with greater mental health problems among adolescents.

However, this association cannot be considered causal nor conclusive as the majority of studies were cross-sectional in nature; it is also not clear whether a longitudinal association is modified by other factors not considered in those studies [110–112]. Moreover, despite the evidence of high screen time being positively associated with mental health problems, very limited studies assessed the dose-response relationship between different types of screen and mental health problems [110,113].

In addition to the quantity and frequency of screen use, another important factor that needs more investigation is the relationship between mental health and the nature of screen interaction. This happens when technology use includes problematic elements and adolescents become unable to forego technology and have uncontrollable desire to use it [114]. This was conceptualized as addictive use or problematic technology use (PTU), which was found to be associated with mental health problems such as depression and anxiety [115–119]. Evidence regarding problematic technology use and mental health problems, especially suicidality, is mixed and inconclusive [120–123]. Furthermore, the evidence regarding the role of critical factors such as sex and age in this association is also mixed and inconclusive, which highlights the need for more work to understand how extensive and problematic screen usage is associated with mental health problems within strata of sex and age.

2.3.1 Different types of screen time and mental health

In addition to the duration and strength of screen use, research indicates that other factors such as the type of screen used and the moderating factors that might modify this association are very important to provide the overall picture about the association between screen time and mental health problems. Recent evidence suggested that duration alone is not enough to determine the benefits and harm of screen use on mental health [110–112].

Various work has been done on screen types and mental health and mixed results were revealed regarding this association. Liu and colleagues (2016) showed in their meta-analysis that high computer use, and TV watching is associated with an increased risk of depression among adolescents [113]. Similar results were provided by Stiglic and Viner (2019) in their review of reviews [107]. Nevertheless, these studies could not provide evidence on how other types of screens could impact mental health. More recent reviews indicated that this association may depend on the type of screen, although there are very few studies that examined the relationship between specific types of screen activities and mental health outcomes. In a recent systematic review of longitudinal studies, Tang and colleagues (2021) indicated that the association between screen time and mental health problems among young people varied between different types of screen use, with a stronger association found for computer and internet use compared to videogames and television [112]. Another systematic review of longitudinal studies suggested that TV viewing may have less negative impacts on mental health than other types of sedentary screen activities like computer and video games [111]. Similar results were revealed by a recent review of longitudinal studies [110], which indicated that the association between screen time and mental health appears in a dose-response manner, and suggests that more research that investigates the impact of different types of screen pursuits on mental health among adolescents should be conducted.

Social media

Evidence regarding the association between social media and mental health problems among adolescents is also inconclusive. For example, several studies and reviews found an association between high social media use and mental health problems such as depressive symptoms, suicidal ideation, and anxiety [124–130]. It was found that factors like social

comparison, increased isolation, and risky behaviours explain this association [128,131–133]. On the other hand, some studies found a positive association between social media use and mental wellbeing [134,135] through increased communication and social interaction [136,137]. In contrast, recent longitudinal studies reported mixed results, finding no association between social media use and subsequent anxiety [138], and depressive symptoms [139–141]. They also found a positive association between the frequency of social media use and depressive symptoms [142] and psychological distress [143,144], suggesting that the frequency of use matter more than the duration of use.

2.3.2 Potential moderators of the association between screen time and mental health

Although the evidence of studies on screen time and mental health is expanding, there are still many aspects to be examined and addressed in order to inform policy and practice.[98–101,104–106]

Previous reviews [110–112,116,125,126,145] indicated the need of examination of various factors and correlates that can help clarify the strength of the association between social media use and mental health.

Sex

It is well-known that sex is an important moderator to examine, as research indicated that types of sedentary screen activities differed by sex, with boys tending to prefer computer video games and girls tending to favour social media and communication-based screen types [146,147]. With respect to mental health, it is well-known that there are sex differences in the prevalence of mental health problems, with girls reporting significantly higher scores of depression, anxiety and psychological distress than boys [148–150].

While recent studies and reviews indicated that sex difference was the most common factor examined in previous work on screen time and mental health, evidence was very inconsistent with some studies found an association between screen time and mental health outcomes among males but not females, while other studies contradicted those findings.[110–112]. Inconsistent results might be due to methodological issues with the majority of studies stratified by sex without using proper interaction analysis to investigate the moderating role of sex on the association [111]. Another reason regarding mixed results might be due to sex differences in screen preferences; however very limited research examined the moderating role of sex in different types of screen for mental health [138,151–154]. Additionally, evidence regarding the moderating role of sex in the relationship of screen time with anxiety is lacking [110,112].

Therefore, it was highly suggested by recent reviews to examine properly the moderating role of sex with different types of screen time in order to further our understanding of the most vulnerable group [110–112,145]. This is important to guide future tailored interventions which aim to reduce high screen usage and improve mental health among at risk groups.

Age

Age was also another proposed factor that could modify the effect of media use on mental health. However, only few studies examined the moderating role of age [111,125,155–157], and results were mixed and inconsistent. Therefore, recent studies suggested to examine the modifying effect of age in the association between screen time and mental health [111,126] given that many brain changes occur during adolescence. It has been suggested that the influence of media use may be exacerbated during early adolescence; first, because during this period of life, youth have a lower capacity to control impulsivity compared to older adolescents, and

second, areas of the brain responsible for processing emotions are not well developed [158]. Therefore, examining this factor could help future interventions and programs aimed at reducing sedentary behaviour and improving mental health based on adolescent age and their brain developmental stage.

Parental support

Another factor that is worth examining as a moderator under the umbrella of social and psychological support is the role of parents [126]. Parents play a key role in shaping their child's health behaviour. They are considered as role models and positive influencers for adolescents screen viewing. Recent evidence suggested that good parenting practicing and guidance through co-participation, meaningful interaction and discussion, and establishing an environment which can restrict heavy screen usage can influence children's recreational screen behaviours [159,160]. On the other hand, it has been known that weak parent-child relationship makes adolescents feel disconnected, so they use different screen types especially social media platforms as a tool to meet needs for social-connectedness [161]. However, evidence regarding the role of parents in screen use and adolescent depression and anxiety is limited. One study found that solid parents-adolescents relationships and increased in-person interaction are associated with better adolescents' mental health problems [162]. Another study indicated that poor parent-child communication was associated with high media usage [163]. Given the results are heterogeneous and none of the studies examined in depth the moderating role of parental support on the relationship between media use and mental health, some recent studies recommended considering the role of parents in this association [126]. This information could help understanding in more depth the factors that influence behaviour change, which in turn,

helps identifying strategies that parents can employ to limit screen use and promote mental well-being.

2.4 Limitations and Gaps in the current knowledge

Based on what we know on this topic and the limitations found in previous studies, we could indicate where the gaps in the literature are:

First, the tendency in primary studies to rely on cross-sectional data with a lack of prospective research designs, which prevents any conclusion of direction between screen-based activities and mental health outcomes to be drawn [111,145]. Second, most studies have employed total screen time measures, which affect a clear investigation of the different types of screen activities associated with adolescents' mental health and which type of screen is more harmful [110–112,125]. Third, evidence for symptoms of anxiety and suicidality is very limited [107,110,112]. Fourth, very limited evidence on the role of parental support and socio-environmental determinants is found in available studies [111,125,126]. Finally, evidence on the factors potentially moderating the relationship between screen-based activities and mental health problems is sparse, and the majority of the evidence on moderators did not use formal statistical tests for interaction and was only based on stratified analyses [111,126].

With current evidence reporting a dramatic increase in sedentary screen pursuits and mental health problems among adolescents, it is critical to accurately examine how screen time is associated with their mental health. For instance, contemporary sedentary screen behaviour can only be well understood if its complexity is recognized. Therefore, further research is warranted to better understand the nature and contexts of screen use among adolescents. In this regard, timely analysis of the characteristics of different types of screens, and the role of different moderators in the association between screen time and mental health is necessary to mitigate the

possible harms of high screen usage. This knowledge will help inform intervention programs aimed at preventing mental health problems among the younger generation and address its problematic use.

2.5 References

- [1] WHO Adolescent mental health 2019. <https://www.who.int/news-room/fact-sheets/detail/adolescent-mental-health> (accessed November 20, 2019).
- [2] Mulye TP, Park MJ, Nelson CD, Adams SH, Irwin CE, Brindis CD. Trends in adolescent and young adult health in the United States. *J Adolesc Health Off Publ Soc Adolesc Med* 2009;45:8–24. <https://doi.org/10.1016/j.jadohealth.2009.03.013>.
- [3] Sawyer SM, Azzopardi PS, Wickremarathne D, Patton GC. The age of adolescence. *Lancet Child Adolesc Health* 2018;2:223–8. [https://doi.org/10.1016/S2352-4642\(18\)30022-1](https://doi.org/10.1016/S2352-4642(18)30022-1).
- [4] Sawyer SM, Afifi RA, Bearinger LH, Blakemore S-J, Dick B, Ezech AC, et al. Adolescence: a foundation for future health. *The Lancet* 2012;379:1630–40. [https://doi.org/10.1016/S0140-6736\(12\)60072-5](https://doi.org/10.1016/S0140-6736(12)60072-5).
- [5] Blakemore S-J, Mills K. Is Adolescence a Sensitive Period for Sociocultural Processing? *Annu Rev Psychol* 2013;65. <https://doi.org/10.1146/annurev-psych-010213-115202>.
- [6] Ciranka S, van den Bos W. Social Influence in Adolescent Decision-Making: A Formal Framework. *Front Psychol* 2019;10.
- [7] Tomé G, de Matos MG, Simões C, Camacho I, AlvesDiniz J. How Can Peer Group Influence the Behavior of Adolescents: Explanatory Model. *Glob J Health Sci* 2012;4:26–35. <https://doi.org/10.5539/gjhs.v4n2p26>.
- [8] Institute of Medicine (US) and National Research Council (US) Committee on the Science of Adolescence. *The Science of Adolescent Risk-Taking: Workshop Report*. Washington (DC): National Academies Press (US); 2011.
- [9] UNICEF, editor. *On my mind: promoting, protecting and caring for children’s mental health*. New York, NY: UNICEF; 2021.

- [10] United Nations Children’s Fund (UNICEF) and the World Health Organization. UNICEF and WHO joint programme on mental health and psychosocial well-being and development of children and adolescents n.d. <https://www.who.int/publications-detail-redirect/978924006176> (accessed December 29, 2022).
- [11] Paus T, Keshavan M, Giedd JN. Why do many psychiatric disorders emerge during adolescence? *Nat Rev Neurosci* 2008;9:947–57. <https://doi.org/10.1038/nrn2513>.
- [12] Paakkari O, Torppa M, Kannas L, Paakkari L. Subjective health literacy: Development of a brief instrument for school-aged children. *Scand J Public Health* 2016;44:751–7.
- [13] Patton GC, Viner R. Pubertal transitions in health. *The Lancet* 2007;369:1130–9. [https://doi.org/10.1016/S0140-6736\(07\)60366-3](https://doi.org/10.1016/S0140-6736(07)60366-3).
- [14] Sheehan P, Sweeny K, Rasmussen B, Wils A, Friedman HS, Mahon J, et al. Building the foundations for sustainable development: a case for global investment in the capabilities of adolescents. *The Lancet* 2017;390:1792–806. [https://doi.org/10.1016/S0140-6736\(17\)30872-3](https://doi.org/10.1016/S0140-6736(17)30872-3).
- [15] WHO. Mental health 2022. <https://www.who.int/news-room/fact-sheets/detail/mental-health-strengthening-our-response> (accessed February 21, 2023).
- [16] World Health Organization (WHO). Adolescent mental health 2021. <http://www.who.int/news-room/fact-sheets/detail/adolescent-mental-health> (accessed October 30, 2020).
- [17] World Health Organization. mhGAP Intervention Guide for mental, neurological and substance use disorders in non-specialized health settings. Version 2.0 2016. <https://www.who.int/publications-detail-redirect/9789241549790> (accessed December 29, 2022).

- [18] Georgiades K, Duncan L, Wang L, Comeau J, Boyle MH. Six-Month Prevalence of Mental Disorders and Service Contacts among Children and Youth in Ontario: Evidence from the 2014 Ontario Child Health Study. *Can J Psychiatry Rev Can Psychiatr* 2019;64:246–55. <https://doi.org/10.1177/0706743719830024>.
- [19] Shaffer D, Fisher P, Lucas CP, Dulcan MK, Schwab-Stone ME. NIMH Diagnostic Interview Schedule for Children Version IV (NIMH DISC-IV): description, differences from previous versions, and reliability of some common diagnoses. *J Am Acad Child Adolesc Psychiatry* 2000;39:28–38. <https://doi.org/10.1097/00004583-200001000-00014>.
- [20] Shaffer D, Fisher P, Dulcan MK, Davies M, Piacentini J, Schwab-Stone ME, et al. The NIMH Diagnostic Interview Schedule for Children Version 2.3 (DISC-2.3): description, acceptability, prevalence rates, and performance in the MECA Study. *Methods for the Epidemiology of Child and Adolescent Mental Disorders Study. J Am Acad Child Adolesc Psychiatry* 1996;35:865–77. <https://doi.org/10.1097/00004583-199607000-00012>.
- [21] Kessler RC, Crum RM, Warner LA, Nelson CB, Schulenberg J, Anthony JC. Lifetime co-occurrence of DSM-III-R alcohol abuse and dependence with other psychiatric disorders in the National Comorbidity Survey. *Arch Gen Psychiatry* 1997;54:313–21. <https://doi.org/10.1001/archpsyc.1997.01830160031005>.
- [22] Fryers T, Brugha T. Childhood Determinants of Adult Psychiatric Disorder. *Clin Pract Epidemiol Ment Health CP EMH* 2013;9:1–50. <https://doi.org/10.2174/1745017901309010001>.
- [23] Seligman LD, Ollendick TH. Comorbidity of anxiety and depression in children and adolescents: An integrative review. *Clin Child Fam Psychol Rev* 1998;1:125–44. <https://doi.org/10.1023/A:1021887712873>.

- [24] Nutt D. Anxiety and depression: individual entities or two sides of the same coin? *Int J Psychiatry Clin Pract* 2004;8 Suppl 1:19–24. <https://doi.org/10.1080/13651500410005513>.
- [25] American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders (DSM-5®)*. American Psychiatric Pub; 2013.
- [26] Spitzer RL, Kroenke K, Williams JBW, Löwe B. A Brief Measure for Assessing Generalized Anxiety Disorder: The GAD-7. *Arch Intern Med* 2006;166:1092–7. <https://doi.org/10.1001/archinte.166.10.1092>.
- [27] Findlay L. Depression and suicidal ideation among Canadians aged 15 to 24. *Health Rep* 2017;28:11.
- [28] Kessler RC, Berglund P, Demler O, Jin R, Merikangas KR, Walters EE. Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Arch Gen Psychiatry* 2005;62:593–602. <https://doi.org/10.1001/archpsyc.62.6.593>.
- [29] Copeland WE, Angold A, Shanahan L, Costello EJ. Longitudinal Patterns of Anxiety From Childhood to Adulthood: The Great Smoky Mountains Study. *J Am Acad Child Adolesc Psychiatry* 2014;53:21–33. <https://doi.org/10.1016/j.jaac.2013.09.017>.
- [30] Copeland WE, Shanahan L, Costello EJ, Angold A. Childhood and adolescent psychiatric disorders as predictors of young adult disorders. *Arch Gen Psychiatry* 2009;66:764–72. <https://doi.org/10.1001/archgenpsychiatry.2009.85>.
- [31] Woodward LJ, Fergusson DM. Life course outcomes of young people with anxiety disorders in adolescence. *J Am Acad Child Adolesc Psychiatry* 2001;40:1086–93. <https://doi.org/10.1097/00004583-200109000-00018>.

- [32] Reef J, Diamantopoulou S, van Meurs I, Verhulst F, van der Ende J. Child to adult continuities of psychopathology: a 24-year follow-up. *Acta Psychiatr Scand* 2009;120:230–8. <https://doi.org/10.1111/j.1600-0447.2009.01422.x>.
- [33] Gibb SJ, Fergusson DM, Horwood LJ. Burden of psychiatric disorder in young adulthood and life outcomes at age 30. *Br J Psychiatry* 2010;197:122–7. <https://doi.org/10.1192/bjp.bp.109.076570>.
- [34] Fergusson DM, Woodward LJ. Mental health, educational, and social role outcomes of adolescents with depression. *Arch Gen Psychiatry* 2002;59:225–31. <https://doi.org/10.1001/archpsyc.59.3.225>.
- [35] Esmaeizadeh S, Moraros J, Thorpe L, Bird Y. Examining the Association and Directionality between Mental Health Disorders and Substance Use among Adolescents and Young Adults in the U.S. and Canada—A Systematic Review and Meta-Analysis. *J Clin Med* 2018;7:543. <https://doi.org/10.3390/jcm7120543>.
- [36] Johnson D, Dupuis G, Piche J, Clayborne Z, Colman I. Adult mental health outcomes of adolescent depression: A systematic review. *Depress Anxiety* 2018;35:700–16. <https://doi.org/10.1002/da.22777>.
- [37] Clayborne ZM, Varin M, Colman I. Systematic Review and Meta-Analysis: Adolescent Depression and Long-Term Psychosocial Outcomes. *J Am Acad Child Adolesc Psychiatry* 2019;58:72–9. <https://doi.org/10.1016/j.jaac.2018.07.896>.
- [38] Guilbert J-J. The World Health Report 2002 – Reducing Risks, Promoting Healthy Life. *Educ Health Mumbai* 2003;16:230–230.
- [39] Mathers CD, Loncar D. Projections of global mortality and burden of disease from 2002 to 2030. *PLoS Med* 2006;3:e442. <https://doi.org/10.1371/journal.pmed.0030442>.

- [40] World Health Organization. Suicide - Fact Sheet 2021. <https://www.who.int/news-room/fact-sheets/detail/suicide> (accessed May 2, 2022).
- [41] Statista. Suicide rate Canada by age 2020. Statista 2022. <https://www.statista.com/statistics/437701/rate-of-suicide-canada-by-age-group/> (accessed May 2, 2022).
- [42] Ruch DA, Sheftall AH, Schlagbaum P, Rausch J, Campo JV, Bridge JA. Trends in Suicide Among Youth Aged 10 to 19 Years in the United States, 1975 to 2016. *JAMA Netw Open* 2019;2:e193886. <https://doi.org/10.1001/jamanetworkopen.2019.3886>.
- [43] Evans R, White J, Turley R, Slater T, Morgan H, Strange H, et al. Comparison of suicidal ideation, suicide attempt and suicide in children and young people in care and non-care populations: Systematic review and meta-analysis of prevalence. *Child Youth Serv Rev* 2017;82:122–9. <https://doi.org/10.1016/j.chilyouth.2017.09.020>.
- [44] Goodday SM, Bondy S, Sutradhar R, Brown HK, Rhodes A. The Cumulative Incidence of Self-Reported Suicide-Related Thoughts and Attempts in Young Canadians. *Can J Psychiatry* 2019;64:107–15. <https://doi.org/10.1177/0706743718787794>.
- [45] Brière FN, Rohde P, Seeley JR, Klein D, Lewinsohn PM. Adolescent Suicide Attempts and Adult Adjustment. *Depress Anxiety* 2015;32:270–6. <https://doi.org/10.1002/da.22296>.
- [46] Cox G, Hetrick S. Psychosocial interventions for self-harm, suicidal ideation and suicide attempt in children and young people: What? How? Who? and Where? *Evid Based Ment Health* 2017;20:35–40. <https://doi.org/10.1136/eb-2017-102667>.
- [47] Swanson SA, Colman I. Association between exposure to suicide and suicidality outcomes in youth. *CMAJ* 2013;185:870–7. <https://doi.org/10.1503/cmaj.121377>.

- [48] Doran CM, Kinchin I. Economic and epidemiological impact of youth suicide in countries with the highest human development index. *PLoS ONE* 2020;15:e0232940.
<https://doi.org/10.1371/journal.pone.0232940>.
- [49] Bilsen J. Suicide and Youth: Risk Factors. *Front Psychiatry* 2018;9.
- [50] Cha CB, Franz PJ, M. Guzmán E, Glenn CR, Kleiman EM, Nock MK. Annual Research Review: Suicide among youth – epidemiology, (potential) etiology, and treatment. *J Child Psychol Psychiatry* 2018;59:460–82. <https://doi.org/10.1111/jcpp.12831>.
- [51] Ferrari AJ, Charlson FJ, Norman RE, Patten SB, Freedman G, Murray CJL, et al. Burden of Depressive Disorders by Country, Sex, Age, and Year: Findings from the Global Burden of Disease Study 2010. *PLOS Med* 2013;10:e1001547.
<https://doi.org/10.1371/journal.pmed.1001547>.
- [52] Smetanin P, Stiff D, Briante C, Adair C, Ahmad, Khan. The Life and Economic Impact of Major Mental Illnesses in Canada: 2011 to 2041. Mental Health Commission of Canada; 2011.
- [53] Myhr A, Naper LR, Samarawickrema I, Vesterbekkmo RK. Impact of COVID-19 Pandemic Lockdown on Mental Well-Being of Norwegian Adolescents During the First Wave—Socioeconomic Position and Gender Differences. *Front Public Health* 2021;9.
- [54] Marques de Miranda D, da Silva Athanasio B, Sena Oliveira AC, Simoes-e-Silva AC. How is COVID-19 pandemic impacting mental health of children and adolescents? *Int J Disaster Risk Reduct* 2020;51:101845. <https://doi.org/10.1016/j.ijdr.2020.101845>.
- [55] Singh S, Roy D, Sinha K, Parveen S, Sharma G, Joshi G. Impact of COVID-19 and lockdown on mental health of children and adolescents: A narrative review with

- recommendations. *Psychiatry Res* 2020;293:113429.
<https://doi.org/10.1016/j.psychres.2020.113429>.
- [56] Fonseca-Pedrero E, Al-Halabí S, Pérez-Albéniz A, Debbané M. Risk and Protective Factors in Adolescent Suicidal Behaviour: A Network Analysis. *Int J Environ Res Public Health* 2022;19:1784. <https://doi.org/10.3390/ijerph19031784>.
- [57] Lemstra M, Neudorf C, D’Arcy C, Kunst A, Warren LM, Bennett NR. A Systematic Review of Depressed Mood and Anxiety by SES in Youth Aged 10–15 Years. *Can J Public Health Rev Can Santé Publique* 2008;99:125–9. <https://doi.org/10.1007/BF03405459>.
- [58] Ati NAL, Paraswati MD, Windarwati HD. What are the risk factors and protective factors of suicidal behavior in adolescents? A systematic review. *J Child Adolesc Psychiatr Nurs* 2021;34:7–18. <https://doi.org/10.1111/jcap.12295>.
- [59] Remes O, Mendes JF, Templeton P. Biological, Psychological, and Social Determinants of Depression: A Review of Recent Literature. *Brain Sci* 2021;11:1633.
<https://doi.org/10.3390/brainsci11121633>.
- [60] Mollica RF, Caridad KR, Massagli MP. Longitudinal study of posttraumatic stress disorder, depression, and changes in traumatic memories over time in Bosnian refugees. *J Nerv Ment Dis* 2007;195:572–9. <https://doi.org/10.1097/NMD.0b013e318093ed2c>.
- [61] Gunn JM, Ayton DR, Densley K, Pallant JF, Chondros P, Herrman HE, et al. The association between chronic illness, multimorbidity and depressive symptoms in an Australian primary care cohort. *Soc Psychiatry Psychiatr Epidemiol* 2012;47:175–84.
<https://doi.org/10.1007/s00127-010-0330-z>.

- [62] Narmandakh A, Roest AM, de Jonge P, Oldehinkel AJ. Psychosocial and biological risk factors of anxiety disorders in adolescents: a TRAILS report. *Eur Child Adolesc Psychiatry* 2021;30:1969–82. <https://doi.org/10.1007/s00787-020-01669-3>.
- [63] Feng C-Y, Chu H, Chen C-H, Chang Y-S, Chen T-H, Chou Y-H, et al. The effect of cognitive behavioral group therapy for depression: a meta-analysis 2000-2010. *Worldviews Evid Based Nurs* 2012;9:2–17. <https://doi.org/10.1111/j.1741-6787.2011.00229.x>.
- [64] Xiang Y, Cuijpers P, Teng T, Li X, Fan L, Liu X, et al. Comparative short-term efficacy and acceptability of a combination of pharmacotherapy and psychotherapy for depressive disorder in children and adolescents: a systematic review and meta-analysis. *BMC Psychiatry* 2022;22. <https://doi.org/10.1186/s12888-022-03760-2>.
- [65] Boaden K, Tomlinson A, Cortese S, Cipriani A. Antidepressants in Children and Adolescents: Meta-Review of Efficacy, Tolerability and Suicidality in Acute Treatment. *Front Psychiatry* 2020;11.
- [66] Kodish I, Rockhill C, Varley C. Pharmacotherapy for anxiety disorders in children and adolescents. *Dialogues Clin Neurosci* 2011;13:439–52.
- [67] Cipriani A, Furukawa TA, Salanti G, Geddes JR, Higgins JP, Churchill R, et al. Comparative efficacy and acceptability of 12 new-generation antidepressants: a multiple-treatments meta-analysis. *The Lancet* 2009;373:746–58. [https://doi.org/10.1016/S0140-6736\(09\)60046-5](https://doi.org/10.1016/S0140-6736(09)60046-5).
- [68] Das JK, Salam RA, Lassi ZS, Khan MN, Mahmood W, Patel V, et al. Interventions for Adolescent Mental Health: An Overview of Systematic Reviews. *J Adolesc Health* 2016;59:S49–60. <https://doi.org/10.1016/j.jadohealth.2016.06.020>.

- [69] Carney R, Firth J. Exercise interventions in child and adolescent mental health care: An overview of the evidence and recommendations for implementation. *JCPP Adv* 2021;1:e12031. <https://doi.org/10.1002/jcv2.12031>.
- [70] Rodriguez-Ayllon M, Cadenas-Sánchez C, Estévez-López F, Muñoz NE, Mora-Gonzalez J, Migueles JH, et al. Role of Physical Activity and Sedentary Behavior in the Mental Health of Preschoolers, Children and Adolescents: A Systematic Review and Meta-Analysis. *Sports Med* 2019;49:1383–410. <https://doi.org/10.1007/s40279-019-01099-5>.
- [71] Hoare E, Milton K, Foster C, Allender S. The associations between sedentary behaviour and mental health among adolescents: a systematic review. *Int J Behav Nutr Phys Act* 2016;13:108. <https://doi.org/10.1186/s12966-016-0432-4>.
- [72] Tremblay MS, Aubert S, Barnes JD, Saunders TJ, Carson V, Latimer-Cheung AE, et al. Sedentary Behavior Research Network (SBRN) – Terminology Consensus Project process and outcome. *Int J Behav Nutr Phys Act* 2017;14:75. <https://doi.org/10.1186/s12966-017-0525-8>.
- [73] Atkin AJ, Gorely T, Clemes SA, Yates T, Edwardson C, Brage S, et al. Methods of Measurement in epidemiology: Sedentary Behaviour. *Int J Epidemiol* 2012;41:1460–71. <https://doi.org/10.1093/ije/dys118>.
- [74] Byrom B, Stratton G, Mc Carthy M, Muehlhausen W. Objective measurement of sedentary behaviour using accelerometers. *Int J Obes* 2016;40:1809–12. <https://doi.org/10.1038/ijo.2016.136>.
- [75] Rivière F, Aubert S, Omorou AY, Ainsworth BE, Vuillemin A. Taxonomy-based content analysis of sedentary behavior questionnaires: A systematic review. *PLOS ONE* 2018;13:e0193812. <https://doi.org/10.1371/journal.pone.0193812>.

- [76] Hardy LL, Dobbins TA, Denney-Wilson EA, Okely AD, Booth ML. Descriptive epidemiology of small screen recreation among Australian adolescents. *J Paediatr Child Health* 2006;42:709–14. <https://doi.org/10.1111/j.1440-1754.2006.00956.x>.
- [77] Marshall SJ, Gorely T, Biddle SJH. A descriptive epidemiology of screen-based media use in youth: a review and critique. *J Adolesc* 2006;29:333–49. <https://doi.org/10.1016/j.adolescence.2005.08.016>.
- [78] Rideout V. The common sense census: media use by tweens and teens. Common Sense Media; 2015.
- [79] Rideout VJ, Foehr UG, Roberts DF. Generation M²: Media in the Lives of 8- to 18-Year-Olds. Henry J; 2010.
- [80] Anderson M, Jiang J. Teens, Social Media & Technology 2018. Pew Research Center; 2018.
- [81] Rideout V, Robb MB. The Common Sense census: Media use by tweens and teens. San Francisco, CA: Common Sense Media.; 2019.
- [82] Rideout V, Robb M. Social Media, Social Life: Teens Reveal Their Experiences. San Francisco, CA, US: Common Sense Media; 2018.
- [83] Tremblay MS, Carson V, Chaput J-P, Connor Gorber S, Dinh T, Duggan M, et al. Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep. *Appl Physiol Nutr Metab Physiol Appl Nutr Metab* 2016;41:S311-327. <https://doi.org/10.1139/apnm-2016-0151>.
- [84] Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (13-17 years): An Integration of Physical Activity, Sedentary Behaviour, and Sleep 2019:148.

- [85] World Health Organization. WHO guidelines on physical activity and sedentary behaviour 2020. <https://apps.who.int/iris/bitstream/handle/10665/336656/9789240015128-eng.pdf?sequence=1&isAllowed=y> (accessed December 3, 2020).
- [86] Tremblay MS, LeBlanc AG, Carson V, Choquette L, Connor Gorber S, Dillman C, et al. Canadian Physical Activity Guidelines for the Early Years (aged 0–4 years). *Appl Physiol Nutr Metab* 2012;37:345–56. <https://doi.org/10.1139/h2012-018>.
- [87] LeBlanc AG, Katzmarzyk PT, Barreira TV, Broyles ST, Chaput J-P, Church TS, et al. Correlates of Total Sedentary Time and Screen Time in 9–11 Year-Old Children around the World: The International Study of Childhood Obesity, Lifestyle and the Environment. *PLOS ONE* 2015;10:e0129622. <https://doi.org/10.1371/journal.pone.0129622>.
- [88] Atkin AJ, Sharp SJ, Corder K, van Sluijs EMF. Prevalence and Correlates of Screen Time in Youth: An International Perspective. *Am J Prev Med* 2014;47:803–7. <https://doi.org/10.1016/j.amepre.2014.07.043>.
- [89] Hill D, Ameenuddin N, Chassiakos Y (Linda) R, Cross C, Radesky J, Hutchinson J, et al. Media Use in School-Aged Children and Adolescents. *Pediatrics* 2016;138:e20162592. <https://doi.org/10.1542/peds.2016-2592>.
- [90] Statistics Canada. A Portrait of Canadian Youth: Today's Youth Are Unlike Any Generation Before!. 2019.
- [91] Roberts KC, Yao X, Carson V, Chaput J-P, Janssen I, Tremblay MS. Meeting the Canadian 24-Hour Movement Guidelines for Children and Youth. *Health Rep* 2017;28:3–7.
- [92] Boak A, Elton-Marshall T, Hamilton HA. The well-being of Ontario students: Findings from the 2021 Ontario Student Drug Use and Health Survey (OSDUHS). Toronto: Centre for Addiction and Mental Health; 2022.

- [93] Boyd D, Ellison N. Social Network Sites: Definition, History, and Scholarship. *J Comput-Mediat Commun* 2007;13:210–30. <https://doi.org/10.1111/j.1083-6101.2007.00393.x>.
- [94] Chan WS, Leung AY. Use of Social Network Sites for Communication Among Health Professionals: Systematic Review. *J Med Internet Res* 2018;20. <https://doi.org/10.2196/jmir.8382>.
- [95] Diomidous M, Chardalias K, Magita A, Koutonias P, Panagiotopoulou P, Mantas J. Social and Psychological Effects of the Internet Use. *Acta Inform Medica* 2016;24:66–8. <https://doi.org/10.5455/aim.2016.24.66-68>.
- [96] Carson V, Hunter S, Kuzik N, Gray CE, Poitras VJ, Chaput J-P, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth: an update. *Appl Physiol Nutr Metab Physiol Appl Nutr Metab* 2016;41:S240-265. <https://doi.org/10.1139/apnm-2015-0630>.
- [97] Twenge JM, Joiner TE, Rogers ML, Martin GN. Increases in Depressive Symptoms, Suicide-Related Outcomes, and Suicide Rates Among U.S. Adolescents After 2010 and Links to Increased New Media Screen Time. *Clin Psychol Sci* 2018;6:3–17. <https://doi.org/10.1177/2167702617723376>.
- [98] Mougharbel F, Goldfield GS. Psychological Correlates of Sedentary Screen Time Behaviour Among Children and Adolescents: a Narrative Review. *Curr Obes Rep* 2020. <https://doi.org/10.1007/s13679-020-00401-1>.
- [99] Vidal C, Lhaksampa T, Miller L, Platt R. Social media use and depression in adolescents: a scoping review. *Int Rev Psychiatry Abingdon Engl* 2020;32:235–53. <https://doi.org/10.1080/09540261.2020.1720623>.

- [100] Stanczykiewicz B, Banik A, Knoll N, Keller J, Hohl DH, Rosińczuk J, et al. Sedentary behaviors and anxiety among children, adolescents and adults: a systematic review and meta-analysis. *BMC Public Health* 2019;19:459. <https://doi.org/10.1186/s12889-019-6715-3>.
- [101] Zink J, Belcher BR, Imm K, Leventhal AM. The relationship between screen-based sedentary behaviors and symptoms of depression and anxiety in youth: a systematic review of moderating variables. *BMC Public Health* 2020;20. <https://doi.org/10.1186/s12889-020-08572-1>.
- [102] Przybylski AK, Weinstein N. A Large-Scale Test of the Goldilocks Hypothesis: Quantifying the Relations Between Digital-Screen Use and the Mental Well-Being of Adolescents. *Psychol Sci* 2017;28:204–15. <https://doi.org/10.1177/0956797616678438>.
- [103] Ferguson CJ. Everything in Moderation: Moderate Use of Screens Unassociated with Child Behavior Problems. *Psychiatr Q* 2017;88:797–805. <https://doi.org/10.1007/s11126-016-9486-3>.
- [104] Orben A. Teenagers, screens and social media: a narrative review of reviews and key studies. *Soc Psychiatry Psychiatr Epidemiol* 2020;55:407–14. <https://doi.org/10.1007/s00127-019-01825-4>.
- [105] Keles B, McCrae N, Grealish A. A systematic review: the influence of social media on depression, anxiety and psychological distress in adolescents. *Int J Adolesc Youth* 2020;25:79–93. <https://doi.org/10.1080/02673843.2019.1590851>.
- [106] Wang X, Li Y, Fan H. The associations between screen time-based sedentary behavior and depression: a systematic review and meta-analysis. *BMC Public Health* 2019;19. <https://doi.org/10.1186/s12889-019-7904-9>.

- [107] Stiglic N, Viner RM. Effects of screentime on the health and well-being of children and adolescents: a systematic review of reviews. *BMJ Open* 2019;9:e023191.
<https://doi.org/10.1136/bmjopen-2018-023191>.
- [108] Stanczykiewicz B, Banik A, Knoll N, Keller J, Hohl DH, Rosińczuk J, et al. Sedentary behaviors and anxiety among children, adolescents and adults: a systematic review and meta-analysis. *BMC Public Health* 2019;19:459. <https://doi.org/10.1186/s12889-019-6715-3>.
- [109] Allen MS, Walter EE, Swann C. Sedentary behaviour and risk of anxiety: A systematic review and meta-analysis. *J Affect Disord* 2019;242:5–13.
<https://doi.org/10.1016/j.jad.2018.08.081>.
- [110] Zhang J, Yang SX, Wang L, Han LH, Wu XY. The influence of sedentary behaviour on mental health among children and adolescents: A systematic review and meta-analysis of longitudinal studies. *J Affect Disord* 2022;306:90–114.
<https://doi.org/10.1016/j.jad.2022.03.018>.
- [111] Zink J, Belcher BR, Imm K, Leventhal AM. The relationship between screen-based sedentary behaviors and symptoms of depression and anxiety in youth: a systematic review of moderating variables. *BMC Public Health* 2020;20. <https://doi.org/10.1186/s12889-020-08572-1>.
- [112] Tang S, Werner-Seidler A, Torok M, Mackinnon AJ, Christensen H. The relationship between screen time and mental health in young people: A systematic review of longitudinal studies. *Clin Psychol Rev* 2021;86:102021.
<https://doi.org/10.1016/j.cpr.2021.102021>.

- [113] Liu M, Wu L, Yao S. Dose–response association of screen time-based sedentary behaviour in children and adolescents and depression: a meta-analysis of observational studies. *Br J Sports Med* 2016;50:1252–8. <https://doi.org/10.1136/bjsports-2015-095084>.
- [114] Addiction Center. Social Media Addiction. Addict Cent n.d. <https://www.addictioncenter.com/drugs/social-media-addiction/> (accessed February 23, 2023).
- [115] Seyrek S, Cop E, Sinir H, Ugurlu M, Şenel S. Factors associated with Internet addiction: Cross-sectional study of Turkish adolescents. *Pediatr Int* 2017;59:218–22. <https://doi.org/10.1111/ped.13117>.
- [116] Cheng Y-S, Tseng P-T, Lin P-Y, Chen T-Y, Stubbs B, Carvalho AF, et al. Internet Addiction and Its Relationship With Suicidal Behaviors: A Meta-Analysis of Multinational Observational Studies. *J Clin Psychiatry* 2018;79:17r11761. <https://doi.org/10.4088/JCP.17r11761>.
- [117] Chen L, Yan Z, Tang W, Yang F, Xie X, He J. Mobile phone addiction levels and negative emotions among Chinese young adults: The mediating role of interpersonal problems. *Comput Hum Behav* 2016;55:856–66. <https://doi.org/10.1016/j.chb.2015.10.030>.
- [118] Ha Y-M, Hwang WJ. Gender Differences in Internet Addiction Associated with Psychological Health Indicators Among Adolescents Using a National Web-based Survey. *Int J Ment Health Addict* 2014;12:660–9. <https://doi.org/10.1007/s11469-014-9500-7>.
- [119] Tripathi A. Impact of Internet Addiction on Mental Health: An Integrative Therapy Is Needed. *Integr Med Int* 2017;4:215–22. <https://doi.org/10.1159/000491997>.

- [120] Arrivillaga C, Rey L, Extremera N. Adolescents' problematic internet and smartphone use is related to suicide ideation: Does emotional intelligence make a difference? *Comput Hum Behav* 2020;110:106375. <https://doi.org/10.1016/j.chb.2020.106375>.
- [121] Guo L, Luo M, Wang W-X, Huang G-L, Xu Y, Gao X, et al. Association between problematic Internet use, sleep disturbance, and suicidal behavior in Chinese adolescents. *J Behav Addict* 2018;7:965–75. <https://doi.org/10.1556/2006.7.2018.115>.
- [122] Huang Y, Xu L, Mei Y, Wei Z, Wen H, Liu D. Problematic Internet use and the risk of suicide ideation in Chinese adolescents: A cross-sectional analysis. *Psychiatry Res* 2020;290:112963. <https://doi.org/10.1016/j.psychres.2020.112963>.
- [123] Alpaslan AH. The Association between Problematic Internet Use, Suicide Probability, Alexithymia and Loneliness among Turkish Medical Students. *J Psychiatry* 2015;18. <https://doi.org/10.4172/Psychiatry.1000208>.
- [124] McCrae N, Gettings S, Pursell E. Social Media and Depressive Symptoms in Childhood and Adolescence: A Systematic Review. *Adolesc Res Rev* 2017;2:315–30. <https://doi.org/10.1007/s40894-017-0053-4>.
- [125] Keles B, McCrae N, Grealish A. A systematic review: the influence of social media on depression, anxiety and psychological distress in adolescents. *Int J Adolesc Youth* 2020;25:79–93. <https://doi.org/10.1080/02673843.2019.1590851>.
- [126] Vidal C, Lhaksampa T, Miller L, Platt R. Social media use and depression in adolescents: a scoping review. *Int Rev Psychiatry Abingdon Engl* 2020;32:235–53. <https://doi.org/10.1080/09540261.2020.1720623>.

- [127] Best P, Manktelow R, Taylor B. Online communication, social media and adolescent wellbeing: A systematic narrative review. *Child Youth Serv Rev* 2014;41:27–36.
<https://doi.org/10.1016/j.childyouth.2014.03.001>.
- [128] Berryman C, Ferguson CJ, Negy C. Social Media Use and Mental Health among Young Adults. *Psychiatr Q* 2018;89:307–14. <https://doi.org/10.1007/s11126-017-9535-6>.
- [129] D'Arienzo MC, Boursier V, Griffiths MD. Addiction to Social Media and Attachment Styles: A Systematic Literature Review. *Int J Ment Health Addict* 2019;17:1094–118.
<https://doi.org/10.1007/s11469-019-00082-5>.
- [130] Kelly Y, Zilanawala A, Booker C, Sacker A. Social Media Use and Adolescent Mental Health: Findings From the UK Millennium Cohort Study. *EClinicalMedicine* 2018;6:59–68. <https://doi.org/10.1016/j.eclinm.2018.12.005>.
- [131] Barry C, Sidoti C, Briggs S, Reiter S, Lindsey R. Adolescent social media use and mental health from adolescent and parent perspectives. *J Adolesc* 2017;61:1–11.
<https://doi.org/10.1016/j.adolescence.2017.08.005>.
- [132] Vogel E, Rose J, Roberts L, Eckles K. Social comparison, social media, and self-esteem. *Psychol Pop Media Cult* 2014;3:206–22. <https://doi.org/10.1037/ppm0000047>.
- [133] O'Reilly M. Social media and adolescent mental health: the good, the bad and the ugly. *J Ment Health Abingdon Engl* 2020;29:200–6.
<https://doi.org/10.1080/09638237.2020.1714007>.
- [134] Erfani SS, Abedin B. Impacts of the use of social network sites on users' psychological well-being: A systematic review. *J Assoc Inf Sci Technol* 2018;69:900–12.
<https://doi.org/10.1002/asi.24015>.

- [135] Frost RL, Rickwood DJ. A systematic review of the mental health outcomes associated with Facebook use. *Comput Hum Behav* 2017;76:576–600.
<https://doi.org/10.1016/j.chb.2017.08.001>.
- [136] Spies Shapiro LA, Margolin G. Growing up wired: social networking sites and adolescent psychosocial development. *Clin Child Fam Psychol Rev* 2014;17:1–18.
<https://doi.org/10.1007/s10567-013-0135-1>.
- [137] Moorhead SA, Hazlett DE, Harrison L, Carroll JK, Irwin A, Hoving C. A new dimension of health care: systematic review of the uses, benefits, and limitations of social media for health communication. *J Med Internet Res* 2013;15:e85. <https://doi.org/10.2196/jmir.1933>.
- [138] Boers E, Afzali MH, Conrod P. Temporal Associations of Screen Time and Anxiety Symptoms Among Adolescents. *Can J Psychiatry* 2020;65:206–8.
<https://doi.org/10.1177/0706743719885486>.
- [139] Coyne SM, Rogers AA, Zurcher JD, Stockdale L, Booth M. Does time spent using social media impact mental health?: An eight year longitudinal study. *Comput Hum Behav* 2020;104:106160. <https://doi.org/10.1016/j.chb.2019.106160>.
- [140] Heffer T, Good M, Daly O, MacDonell E, Willoughby T. The Longitudinal Association Between Social-Media Use and Depressive Symptoms Among Adolescents and Young Adults: An Empirical Reply to Twenge et al. (2018). *Clin Psychol Sci* 2019;7:462–70.
<https://doi.org/10.1177/2167702618812727>.
- [141] Houghton S, Lawrence D, Hunter SC, Rosenberg M, Zadow C, Wood L, et al. Reciprocal Relationships between Trajectories of Depressive Symptoms and Screen Media Use during Adolescence. *J Youth Adolesc* 2018;47:2453–67. <https://doi.org/10.1007/s10964-018-0901-y>.

- [142] Frison E, Eggermont S. Browsing, Posting, and Liking on Instagram: The Reciprocal Relationships Between Different Types of Instagram Use and Adolescents' Depressed Mood. *Cyberpsychology Behav Soc Netw* 2017;20:603–9.
<https://doi.org/10.1089/cyber.2017.0156>.
- [143] Riehm KE, Feder KA, Tormohlen KN, Crum RM, Young AS, Green KM, et al. Associations Between Time Spent Using Social Media and Internalizing and Externalizing Problems Among US Youth. *JAMA Psychiatry* 2019;76:1266–73.
<https://doi.org/10.1001/jamapsychiatry.2019.2325>.
- [144] Viner RM, Gireesh A, Stiglic N, Hudson LD, Goddings A-L, Ward JL, et al. Roles of cyberbullying, sleep, and physical activity in mediating the effects of social media use on mental health and wellbeing among young people in England: a secondary analysis of longitudinal data. *Lancet Child Adolesc Health* 2019;3:685–96.
[https://doi.org/10.1016/S2352-4642\(19\)30186-5](https://doi.org/10.1016/S2352-4642(19)30186-5).
- [145] Mougharbel F, Goldfield GS. Psychological Correlates of Sedentary Screen Time Behaviour Among Children and Adolescents: a Narrative Review. *Curr Obes Rep* 2020;9:493–511. <https://doi.org/10.1007/s13679-020-00401-1>.
- [146] Raposo M, Martínez-Figueira M, CAMPOS S, Parrilla Á. Teens' Behavior Patterns on the Web: Surfing or Wrecking? *Digit Educ Rev* 2021:60–75.
<https://doi.org/10.1344/der.2021.39.60-75>.
- [147] Ferreiro SG, Gómez P, Harris S, Braña T, Boubeta A. Diferencias de sexo en el uso de internet en adolescentes españoles. *Behav Psychol Psicol Conduct* 2017;25:129–46.
- [148] Van Droogenbroeck F, Spruyt B, Keppens G. Gender differences in mental health problems among adolescents and the role of social support: results from the Belgian health

interview surveys 2008 and 2013. *BMC Psychiatry* 2018;18:6.

<https://doi.org/10.1186/s12888-018-1591-4>.

[149] Gariépy G, Elgar FJ. Trends in Psychological Symptoms among Canadian Adolescents from 2002 to 2014: Gender and Socioeconomic Differences. *Can J Psychiatry Rev Can Psychiatr* 2016;61:797–802. <https://doi.org/10.1177/0706743716670130>.

[150] Alloy LB, Hamilton JL, Hamlat EJ, Abramson LY. Pubertal Development, Emotion Regulatory Styles, and the Emergence of Sex Differences in Internalizing Disorders and Symptoms in Adolescence. *Clin Psychol Sci J Assoc Psychol Sci* 2016;4:867–81. <https://doi.org/10.1177/2167702616643008>.

[151] Grøntved A, Singhammer J, Froberg K, Møller NC, Pan A, Pfeiffer KA, et al. A prospective study of screen time in adolescence and depression symptoms in young adulthood. *Prev Med* 2015;81:108–13. <https://doi.org/10.1016/j.ypmed.2015.08.009>.

[152] Kim S, Kimber M, Boyle MH, Georgiades K. Sex Differences in the Association Between Cyberbullying Victimization and Mental Health, Substance Use, and Suicidal Ideation in Adolescents. *Can J Psychiatry Rev Can Psychiatr* 2019;64:126–35. <https://doi.org/10.1177/0706743718777397>.

[153] Ohannessian CM. Media Use and Adolescent Psychological Adjustment: An Examination of Gender Differences. *J Child Fam Stud* 2009;18:582–93. <https://doi.org/10.1007/s10826-009-9261-2>.

[154] Ohannessian CM. Video game play and anxiety during late adolescence: The moderating effects of gender and social context. *J Affect Disord* 2018;226:216–9. <https://doi.org/10.1016/j.jad.2017.10.009>.

- [155] Banjanin N, Banjanin N, Dimitrijevic I, Pantic I. Relationship between internet use and depression: Focus on physiological mood oscillations, social networking and online addictive behavior. *Comput Hum Behav* 2015;43:308–12.
<https://doi.org/10.1016/j.chb.2014.11.013>.
- [156] Tsitsika AK, Tzavela EC, Janikian M, Ólafsson K, Iordache A, Schoenmakers TM, et al. Online social networking in adolescence: patterns of use in six European countries and links with psychosocial functioning. *J Adolesc Health Off Publ Soc Adolesc Med* 2014;55:141–7. <https://doi.org/10.1016/j.jadohealth.2013.11.010>.
- [157] Ivie EJ, Pettitt A, Moses LJ, Allen NB. A meta-analysis of the association between adolescent social media use and depressive symptoms. *J Affect Disord* 2020;275:165–74.
<https://doi.org/10.1016/j.jad.2020.06.014>.
- [158] Steinberg L. A Social Neuroscience Perspective on Adolescent Risk-Taking. *Dev Rev* 2008;28:78–106. <https://doi.org/10.1016/j.dr.2007.08.002>.
- [159] Arundell L, Parker K, Timperio A, Salmon J, Veitch J. Home-based screen time behaviors amongst youth and their parents: familial typologies and their modifiable correlates. *BMC Public Health* 2020;20:1492. <https://doi.org/10.1186/s12889-020-09581-w>.
- [160] Goncalves WSF, Byrne R, de Lira PIC, Viana MT, Trost SG. Parental Influences on Physical Activity and Screen Time among Preschool Children from Low-Income Families in Brazil. *Child Obes* 2023;19:112–20. <https://doi.org/10.1089/chi.2021.0305>.
- [161] Hwang J, Toma CL. The Role of Mental Well-Being and Perceived Parental Supportiveness in Adolescents' Problematic Internet Use: Moderation Analysis. *JMIR Ment Health* 2021;8:e26203. <https://doi.org/10.2196/26203>.

- [162] Isarabhakdi P, Pewnil T. Engagement with family, peers, and Internet use and its effect on mental well-being among high school students in Kanchanaburi Province, Thailand. *Int J Adolesc Youth* 2016;21:15–26. <https://doi.org/10.1080/02673843.2015.1024698>.
- [163] Szwedo DE, Mikami AY, Allen JP. Qualities of Peer Relations on Social Networking Websites: Predictions from Negative Mother-Teen Interactions. *J Res Adolesc Off J Soc Res Adolesc* 2011;21:595–607. <https://doi.org/10.1111/j.1532-7795.2010.00692.x>.

CHAPTER 3 MANUSCRIPT 1

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Psychological Correlates of Sedentary Screen Time Behaviour Among Children and Adolescents: A Narrative Review.

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Abstract

Recent findings: Paralleling the rise of mental health issues in children and adolescents is ubiquitous overuse of screens, but it is unclear how screen time is related to important mental health outcomes and whether this association differs by gender, age and screen type.

Purpose: The aim of this narrative review was to (1) synthesize the literature on the relationship between screen time and important mental health outcomes; and (2) examine the underpinning factors that can influence this association.

Methods: Medline/PubMed, PsychINFO and google scholar databases were searched on December 2019 for articles published mainly in the last five years. The search focused on two main concepts: i) screen time; ii) mental health outcomes including anxiety, depression, psychological and psychosocial wellbeing and body image concerns.

Results: 60 studies were included in the review. Higher levels of screen time are associated with more severe depressive symptoms. We found moderate evidence for an association between screen time and poor psychological well-being and body dissatisfaction especially among females. Relationships between screen time and anxiety were inconsistent and somewhat gender specific. Social media use was consistently associated with poorer mental health.

Summary: Higher levels of screen time are generally associated with poorer mental health outcomes, but associations are influenced by screen type, gender and age. Practitioners, parents, policy makers and researchers should collectively identify and evaluate strategies to reduce screen time, or to use screens more adaptively, as a means of promoting better mental health among children and adolescents.

Keywords Screen time; depression; anxiety; psychological wellbeing; body image; children; adolescent

Introduction

Worldwide, 13.4% of children and adolescents experience mental health disorders [1], indicating that adolescents are at high risk. In fact, 70% of mental illnesses start in early ages [2], and many persist into adulthood [3]. These statistics are alarming given that mental disorders contribute 21.8% of the total burden of disease in high-income countries among children and adolescents aged 0–14 years [4] and can reduce life expectancy by 20 years [5], thus leading to premature mortality.

Sedentary behaviour is defined as any waking activities that result in an energy expenditure ≤ 1.5 metabolic equivalents (METs) while in either a sitting, lying or reclining posture [6]. It includes most sitting-based activities (e.g. reading, eating, listening to music, drawing, etc.) and screen-based leisure time activities (e.g. TV viewing, playing video games, use of computers, cellular phones, tablets and social media) [7–9]. Sedentary behaviour can be measured objectively using accelerometers, which offer an accurate measurement of total sedentary time, and subjectively using questionnaires and diaries which provide detailed information on the quality, context and type of sedentary behaviour [10, 11]. Sedentary behaviour, primarily in the form of screen use among children and adolescents, has increased dramatically in the past decade with the advent of mobile technology, with the majority of youth spending large proportions of the day (6–8 h) in this type of sedentary activity [12, 13].

It has been recognised that sedentary behaviour has detrimental health effects, including adverse cardiometabolic health outcomes, morbidity and premature mortality [14–17]. Indeed, high levels of sedentary behaviours are correlated with many adverse health outcomes in

children and adolescents, including physical and mental well-being [18], elevated body mass index (BMI) [19–21], cardiometabolic function [21, 22] and cognitive development [20]. In this context, Canadian and international guidelines established recommendations to limit the time spent engaged in sedentary pursuits [23–26]. For example, the Canadian 24-h movement guidelines for children and adolescents discourage screen time for children under 2 years old and suggest no more than 1 h daily for children 2–4 years and no more than 2 h for those aged 5–17 years old [27]. Despite these recommendations, the vast majority of children and adolescents do not meet these guidelines and engage in high levels of screen time, with many accruing between 6 and 8 h/day [9, 12, 13, 28–32].

Surprisingly, findings from a recent systematic review found limited evidence to show that objectively measured sedentary behaviour has a negative impact on mental health [33]. However, objectively measured sedentary behaviour combines screen time and many non-screen sedentary behaviours such as reading, homework, listening to music and other sedentary hobbies, so the effects of screen time on mental health have not been adequately isolated. There are many inherent aspects of spending long periods engaged in screen use that can lead to poor mental health, including feelings of social isolation or withdrawal, exposure to unrealistic ideals of beauty, unhealthy social comparisons, sleep reduction and cyberbullying [22, 34–37]. Moreover, there is evidence that different types of screen use may have different impacts on health [38], indicating that the type of screen matters, although this has not been well studied. Research has indicated that digital media users have different needs that impact the selection and the preference of media [39]. According to the differential-susceptibility model proposed by Valkenburg and Peter [40], the effects of media are dependent on a complex combination of cognitive (effort invested), physiological (stimulation received), behavioural (frequency/duration

of use) and personality characteristics, which collectively lead individual differences in susceptibility of harmful effects of media consumption [40].

Therefore, given the high prevalence of screen time and mental health problems among children and adolescents and their significant economic [41, 42] and health impact they pose [43, 44], it is timely to better understand how screen time among children and adolescents is related to important mental health outcomes, such as anxiety, depression, body image and psychological well-being. Accordingly, this narrative review aimed to synthesise research in this area, including research using both cross-sectional and longitudinal designs to establish an evidence base that can inform policy, practice and research regarding the psychological impacts that screen use has on children and adolescents.

Methods

Electronic databases of Medline/PubMed, PsychINFO and Google Scholar were searched on December 2019 for articles published in the last 5 years. The search mainly focused on the association between recreational screen time sedentary behaviour and mental health outcomes in children and adolescents including anxiety, depression, psychological and psychosocial well-being and body image concerns. Then the articles' titles and abstracts were screened, and full text of potentially relevant articles were retrieved according to eligibility criteria. Information was extracted from each article and summarized in tables categorised by to the study outcomes. A total of 60 articles met the inclusion criteria. Included studies were heterogeneous and varied in terms of the screen time activities including age, sample size and outcome measures.

Cross-sectional studies on the association between screen time and depressive symptoms

Depression and anxiety are considered to be among the leading causes of illness, disability and burden in youth according to the World Health Organization [45, 46]. The prevalence of depression increased by 18% [47] between 2005 and 2015, and up to 20% of children and adolescents to meet criteria for anxiety disorders [48]. This is highly concerning especially with emerging research indicating that the onset of depression and anxiety is occurring at younger ages [49–51].

Many cross-sectional studies [36, 52–73] (Table 1) have examined the relationship between screen time and symptoms of depression and/or anxiety among children and adolescents. Out of 23 cross-sectional studies, the majority of studies ($n = 17$) showed that high exposure to at least one type of screen use was associated with more severe depression and/or anxiety symptoms [36, 52, 53, 57, 59–64, 67•, 68–73], while only a few studies reported negative associations [58] or mixed associations based on gender [54, 55, 56•, 65, 66]. Research on preschooler's screen time and mental health such as depression and anxiety is lacking.

In cross-sectional studies, almost all types of screen use were significantly associated with a higher level of depressive symptoms among young people, especially adolescents, with aggregated time spent engaged in television, computer and mobile phone use showing the strongest associations, indicating an additive effect of screen use. For example, one of the largest cross-sectional studies ($n = 9702$) [53] on adolescents found that screen use was associated with an increased odds of moderate and severe symptoms of depression and anxiety. These results were similar to other large cross-sectional studies [60, 63]. Maras et al. demonstrated that higher levels of screen time, as measured by an aggregate of TV viewing,

recreational computer use and video gaming, were associated with more severe symptoms of depression and anxiety among the youth [60], consistent with cross-sectional findings from other studies among children and adolescents [52, 61, 75, 76].

Associations with emotional distress may differ by screen type, as leisure computer use was more highly associated with anxiety and depression outcomes than television viewing in some studies [52, 60], but cross-sectional findings from a longitudinal study found that high levels of TV viewing and not recreational computer use were more strongly associated with depressive symptoms in adolescents and children [74].

Internet-based video gaming has recently become a popular activity among adolescents, especially males, making it an important type of sedentary behaviour to investigate. A recent study on 578 adolescents reported that high use of internet video gaming was associated with more severe anxiety and depression among adolescents, with males being more affected than females [65]. These results are consistent with other studies showing a strong association between computer games and symptoms of depression [52, 60]. However, a recent European study on gaming among school children between 6 and 11 years found that gaming was not significantly associated with self-reported mental health problems such as depression and anxiety [58]. The conflicting findings may be due, in part, to differences in “dose” of video gaming and age, as the studies with adolescents reported much higher usage of gaming compared with those involving preadolescent samples.

In addition to online video gaming, new digital media like social media networking sites have also been recognised to be associated with mental health issues like depression and/or anxiety [36, 56•, 67•, 68–73]. A recent nationally representative study [56•] reported that adolescents who frequently use social media were more likely to have high levels of depressive

symptoms, with stronger correlations reported among females. The association between social networking sites (SNS), psychological distress and suicide attempts was found to be indirect and mediated by cyberbullying victimisation in a large study (N = 5126) of adolescents (aged 11–20 years) [36]. Insomnia was another mediating factor reported by Li et al., who found a positive association between Facebook addiction and depression among 1015 Chinese adolescents [72]. Furthermore, another cross-sectional study indicated that both active and passive use of Facebook were associated with an increased depressed mood. However, this association was influenced by gender where girls who use Facebook passively and boys who use Facebook actively in a public setting were more likely to develop depression. Also, this study indicated that perceived social support mediated the relationship between social media and depression [69]. The number of social media accounts and the frequency of checking were also found to be additional factors that impact the association between social media and depression and anxiety according to data from parents [70]. These factors and mediators require further investigation in future research.

Concerning the age group, the majority of studies assessed screen use and depression among adolescents, or combined children and adolescents without examining these populations separately, so associations in children are unclear. The greater inquiry in adolescents might be attributed to adolescents reporting higher screen use than children [89] or being more prone to experiencing depression than children [90].

Longitudinal Studies on Screen Use and Anxiety/Depressive Symptoms

Several longitudinal studies examined the association between screen time and depression and anxiety among children and adolescents [74–88] (Table 1). Some recent studies were in line with cross-sectional ones and found a positive association between screen use,

depression [74, 77•] and anxiety among adolescents [85, 88]. For example, a longitudinal study done on 3826 adolescents found a time-varying relationship between social media, television and depressive symptoms [77•]. Each additional hour spent on social media usage in a given year was linked to a 0.41-unit increase in depressive symptoms for that same year, indicating a dose–response relationship. Also, a similar within-person association was found with television watching [77•]. Furthermore, a large longitudinal study with 6595 adolescents aged 12 to 15 years old reported that spending more than 3 h daily on social media significantly increased the risk for mental health problems, particularly internalising problems such as depression and anxiety [85]. While 8 longitudinal studies [74, 77•, 79, 82, 85–88] found an association between some types of screen activities and depression and/or anxiety, other studies found little [78, 80, 81] or no evidence [75, 76, 83] that screen time is longitudinally associated with depression and/or anxiety. For example, a longitudinal study involving children and adolescents that examined the association between television watching and mental health indicated no significant association [83].

Interestingly, many cross-sectional and longitudinal studies found that the association between screen time and depression [54, 55, 56•] and anxiety [84•] differed by gender. Many studies found that females with high levels of screen time use reported the highest level of depressive symptoms, while weaker or even no associations were found in males [54, 55]. Another study found higher symptoms of anxiety with playing video games among girls and lower symptoms among boys [84•] which contradicts the findings from Wang et al. [65] who reported that high online video game use was related to higher symptoms of depression and anxiety among males. It should be noted that the sample of youth from the study by Wang et al.

engaged significantly in more time of online gaming, thereby highlighting that video gaming may be especially psychologically harmful with excessive use.

The difference in results and clear gender differences in longitudinal studies might be related to diverse types of screen use, dose, age and variation in the baseline level of anxiety and depression among adolescents. For example, a study by Kelly et al. in 2018 involved 10,904 adolescents, indicating that females spent a high proportion of their time on social media and that the magnitude of association between social media use and depressive symptoms was larger for females than for males [56•], consistent with the findings in similar studies and reviews [87•, 91]. Research has indicated that high social media use may confer an increased risk of depression in adolescent females due to interference in sleep habits [37], exposure to teasing or cyberbullying or unrealistic beauty ideals leading to unfavourable social comparisons and low self-esteem [92]. These gender differences might also be related, in part, to the higher baseline levels of anxiety/depression among adolescent females than males [93] as the prevalence of depression and anxiety after puberty is twice as high for females compared with males [94], as well as a higher prevalence of social media use among adolescent girls.

Although consistent gender differences emerged for social media use, a recent longitudinal study on video games and anxiety among older adolescents showed that while moderate use of video gaming was associated with higher anxiety symptoms among females, this was not the case in males [84•]. While the reason is still unclear, the authors hypothesize that boys may enjoy the social interaction and sense of competition between players more than girls. On the other hand, it is noteworthy that the degree of internet usage or video game “dose” may have an important impact on affective symptoms, as youth with extensive screen exposure in the

form of internet use/video gaming exhibited significantly more mental health issues than those with low usage, regardless of gender [95].

Very few studies have examined reciprocal relationships between screen time and depression and anxiety symptoms among children and adolescents. However, a large longitudinal study among adolescents showed a reciprocal relationship between computer and videogame usage and increased level of generalised anxiety disorders [88]. That is, youth with emotional distress characterised by anxiety may spend more time indoors and engage in various forms of screen time as a way of coping, and these media activities may further exacerbate their psychological distress, thereby creating a vicious cycle.

In summary, there is strong cross-sectional and moderate longitudinal evidence for an association between screen time and depressive symptoms among children and adolescents, but associations differ by age, type of screen use, gender and other moderators. Most of the studies focused on depressive symptoms, so further longitudinal studies are warranted to better understand the association between different types of screen time and anxiety.

Cross-sectional Studies on Screen Time and Psychological Well-being

Psychological well-being refers to satisfaction with life and experiencing positive emotions [96], including positive self-perceptions and positive relationships [97]. Research has linked psychological well-being with academic performance [98], physical health [99] and mental health. Thus, it is essential to understand how screen time is associated with psychological well-being among children and adolescents to effectively inform clinical practice, policy and research.

As shown in Table 2, several cross-sectional studies examined the role of screen time on childrens and adolescents' well-being [63, 64, 100–107]. Negative associations between digital

technology use and adolescents' and childrens' wellbeing were found in many studies [63, 64, 100, 101, 105–107], while a few found no relationship between the use of screen time and well-being [102–104]. A high-quality, large study (n = 120,115) in youth from the UK found that moderate digital technology use did not correlate strongly with mental well-being [103]. However, analysis of three large surveys of adolescents in the UK and USA (n = 221,096) [64] revealed that those who use screens for less than 1 h a day reported more favourable psychological well-being than high users (more than 5 h/day). Interestingly, this study indicated that individuals who did not engage in digital media activities at all had poorer well-being than light users [64].

While results were more consistent among adolescents, studies on young children reported mixed findings. A crosssectional study in China looked at the relationship between excessive screen time and psychological well-being in 20,324 children aged 3–4 years found a dose–response relationship whereby every additional hour of screen-based pursuits was associated with poorer psychosocial well-being. This association was mostly mediated by the parent–child interaction.

According to this study, excessive exposure to screen may have the strongest effect on the frequency of engagement in interactive activities between the parents and the child which in turn can be a risk factor for child psychosocial problems [106•]. On the other hand, null findings were reported in a smaller study examining the associations between moderate levels of TV viewing and psychological well-being among children aged 0–5 years [102]. Similarly, in a large cross-sectional study (n = 19,957), little or no evidence was found to support a link between screen use and psychological wellbeing among young children [104].

Longitudinal studies on Screen Time and Psychological Well-being

Several longitudinal studies (Table 2) have found that higher amounts of recreational screen time predicted lower psychological well-being among children and adolescents [87••, 107–112]. A study investigated possible dose–response associations between media use and later psychological wellbeing among children aged between 2 and 6 years. This study reported that higher levels of electronic media predicted lower psychological well-being, with television viewing being more strongly associated with well-being than e-games and computer use [110]. Another longitudinal study indicated that the high use of social media was associated with poorer wellbeing, and the relationship was stronger for females than males [87••, 109••]. This gender difference was also apparent in other studies examining the effect of excessive use of video gaming, also called video gaming disorder on psychological and psychosocial well-being. A recent longitudinal study found that video gaming disorder predicted a decrease in psychosocial well-being especially social competencies among boys compared to girls [112]. Similar to those stated above for anxiety and depression, mechanisms underpinning this gender difference might simply reflect differences in use between females and males [87••, 91] which leads to a higher risk of being exposed to cyberbullying [56•, 87••, 113, 114]. Also, the types of games chosen might be associated with gender differences as girls tend to choose puzzle and educational games while boys tend to choose fighting, strategy and action games which might increase their vulnerability to the negative impact of disordered gaming [115]. Another possible mechanism that may explain the association between screen time and mental well-being is sleep, as inadequate sleep is associated with higher use of screen time among children and adolescents [116]; thus, the displacement of sleep, especially among girls, can mediate the association between screen time and mental well-being [56•, 87••]. Furthermore, replacing direct interaction

with friends with low-quality, superficial communication of most online interaction online interaction may result in poor social connectedness and lower quality of relationships, which consequently may negatively affect psychological well-being [117].

Taken together, the majority of the reviewed studies, including those using longitudinal designs, indicate a negative association between screen time and psychological well-being, with most of the studies being conducted in adolescents. More inconsistent results emerged from large-scale cross-sectional studies, perhaps due to greater heterogeneity in study measures of well-being, data analyses and sample characteristics [102, 104]. The evidence base among pre-adolescents and young children is moderate, but we highly recommend further longitudinal examination of the relationship between screen time and psychological well-being is needed to gain a better understanding of this association.

Cross-Sectional Studies on Screen Time and Body Image

Body dissatisfaction Body dissatisfaction is defined as a negative attitude towards appearance, body weight, size or shape and is one the most robust aspects of the broader concept of body image. Body image concerns are highly prevalent during adolescence when one's body shape and weight strongly influence one's selfesteem, and these concerns are especially salient among females [118]. Body image concerns are well known to be detrimental contributors to well-being [119] and significant predictors of psychiatric conditions such as eating disorders and [118] and depression, as well as low self-esteem [120, 121]. With social media platforms such as Facebook, Snapchat and Instagram, body image has become an important target in these activities [122], where individuals post their most flattering photos and view those of others [123], creating an online environment that could be detrimental to body image [124]. Spending time on social media puts adolescents under a higher risk of comparing themselves to more

attractive peers [125], and as a result, these unfavourable social comparisons of physical appearance may elicit or exacerbate body image concerns [126, 127]. Screen time, mainly social media use, has received significant attention in research for its potential impact on body dissatisfaction [128]; therefore, it is highly essential to understand how the use of this and other forms of digital media may contribute to adolescents' body image.

As shown in Table 3, cross-sectional research indicated that screen time [56•, 126, 129–133] especially that spent on social media is associated with body image concerns among adolescents. For example, a large study comprised of high school girls ($n = 1087$) aged 13–15 years showed that those who use social media frequently reported significantly greater body image concerns such as internalization of the thin ideal, drive for thinness and body surveillance compared to non-users [131]. Another recent crosssectional study among adolescents [130] also indicated an association between social media and body dissatisfaction; however, this study found that this association was impacted by the social environment (e.g. relationship with the mother). Specifically, adolescents who reported positive relationships with their mothers had less body dissatisfaction in relation to social media use than those with more negative maternal relationships [130].

Longitudinal Studies on Screen Time and Body Image

Although many cross-sectional [126, 131–133] and longitudinal research [136] has focused on females who report high levels of body image concerns, some recent longitudinal studies included both genders [134, 135•]. For example, a study on 604 adolescents aged 11–18 years indicated that both genders experienced the same extent of body dissatisfaction when using social media networking sites frequently [134]. Another longitudinal study involving 1840 adolescents aged between 12 and 19 years showed that passive Facebook usage (consuming

information without direct exchanges like posting status or commenting) was associated with more social comparison among adolescent males and females over time [135•]. While social comparison has been clearly implicated in playing an important mechanistic role in the association between screen time and body image concerns, other factors were highlighted in the literature as indicated previously about the buffering effects of positive parent–adolescent relationships [130].

Interestingly, media literacy, which is about being able to think critically about media [137] and being able to assess whether a media content such as an image is realistic or not [138], was suggested as another important protective factor that attenuated the adverse effects on body image among adolescents when exposed to unrealistic thin-ideal media images [139]. Thus, media literacy programs should be examined in more depth using experimental and longitudinal designs as this may represent a promising strategy that protects youth from developing an unhealthy body image known to predict other psychiatric disorders.

Limitations and Strengths

Although this narrative review is representative of key findings from a broad body of literature with the aim to examine the research objectives, there are a few limitations that are noteworthy. This study was not a systematic review of the literature, but rather a narrative review performed by a single reviewer. There may be relevant studies that have been excluded. However, the present review is unique in critically analysing both cross-sectional and longitudinal evidence from very recent studies (past 5 years) about the association between sedentary screen time and mental health, thus providing current evidence to inform future research, practice and policy reform designed to improve children's and adolescents' mental health

Summary, Conclusions and Recommendations

Findings from the present review suggest that screen time is generally associated with depressive symptoms among adolescents, especially females. Evidence on the association between screen time and anxiety among adolescents was mixed and inconclusive and somewhat screen and gender dependent. However, high screen use was consistently shown to be associated with poorer emotional well-being in longitudinal studies, although mixed evidence was found among cross-sectional studies, especially among young children. We also found that high screen time, especially social media use, was consistently associated with greater body image concerns among both male and female adolescents, although females appear more negatively affected. Media literacy and positive relationship with parents appear to attenuate the negative role of screen time on body image, likely by reducing internalisation of unrealistic beauty ideals. Due to the small number of studies in pre-adolescent children, especially preschoolers, it is not possible to determine with any degree of confidence the association between screen time and mental health indicators in this population.

This review highlights that some types of screens are more consistently problematic for mental health than others depending on the content of the media and the characteristics of individuals and their susceptibility levels to the effects of media. For example, social media usage was consistently shown to be associated with depressive and/or anxiety symptoms [36, 56•, 67•, 68–73, 82, 86], higher levels of body dissatisfaction [56•, 130–132, 134–136] and poorer psychological wellbeing [87••, 109••, 111, 112] among adolescents, with evidence showing that these relationships are sometimes stronger in girls than boys. Regarding mechanisms in which social media may negatively affect mental health, evidence suggests

this may occur through a process of unfavourable social comparison, poor sleep and/or cyberbullying [22, 34–36, 69, 72]. Although not well studied, the preliminary research among adolescents, especially males, suggests that high use of internet video gaming is associated with more severe anxiety and depressive symptoms. These findings are consistent with a growing body of evidence to suggest that excessive internet-based gaming can produce marked interference in youth’s emotional, familial, social and academic functioning and is being evaluated for inclusion as a behavioural addiction in the Diagnostic and Statistical Manual of Mental Disorders (DSM-V) [140]. Similarly, this review found evidence for associations between excessive computer/internet use and mental health difficulties in adolescents. These findings are consistent with the introduction of new concepts known as “internet addiction disorder” or “internet use disorder”, which are additional types of behavioural addictions characterised by compulsive or pathological internet use that result in marked impairment in functioning. These terms are also being considered for inclusion in the DSM-V [140].

Recommendations for Practice, Policy and Research

Given that childhood and adolescence are critical periods for physical and psychological development, and children and adolescents are spending excessive amounts of time in recreational screen use, the results of this review have significant implications. Based on evidence from this review, we recommend that parents and health practitioners who work with children and adolescents limit recreational screen use to that delineated in the Canadian 24-h movement behaviour guidelines [27]. The findings obtained here also support the new changes in school policy made by the Provincial Ministry of Education in Ontario, Canada, that banned the use of cell phones in schools. Given screen time is associated with an increased risk of obesity [19–21] and cardiometabolic disease [21, 22] in children and adolescence, and this review

provides robust evidence for detrimental associations with several mental health outcomes, further legislation by other provinces around banning cell phones may follow and these policy changes should be empirically evaluated to see if they have beneficial effects on mental health. There is encouraging evidence that media literacy may be an effective method in which parents, teachers and practitioners can attenuate the harmful effects of digital media use, although more intervention studies are needed. Moreover, developing and maintaining a strong parent–child relationship appears to buffer the negative effects of screen time on several mental health indicators, thus should be targeted in treatment and prevention studies.

Many of the studies used cross-sectional designs, so future longitudinal studies with longer follow-ups and inclusion of potential mediators and moderators including the individuals' cognitive and emotional statuses that happen during media exposure [40] are needed to gain a better understanding of how various forms of screen use impact children's and adolescents' risk of mental health problems over time, and whether effects and mechanisms differ between males and females. In addition, intervention studies designed to determine whether reducing either specific types or duration of screen time or promoting more adaptive use of screens are effective strategies that promote better mental health or prevent mental illness among children and adolescents are needed.

Compliance with Ethical Standards

Conflict of Interest Fatima Mougharbel declares that she has no conflict of interest. Gary Goldfield declares that he has no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest and recently published have been highlighted as important:

* = Of importance

** = Of outstanding importance

1. Polanczyk GV, Salum GA, Sugaya LS, Caye A, Rohde LA. Annual research review: a meta-analysis of the worldwide prevalence of mental disorders in children and adolescents. *J Child Psychol Psychiatry*. 2015;56:345–65.
2. The Human Face of Mental Health and Mental Illness in Canada, 2006: (611102012-001) [Internet]. American Psychological Association; 2006 [cited 2019 Dec 5]. Available from: <http://doi.apa.org/get-pe-doi.cfm?doi=10.1037/e611102012-001>
3. Kessler RC, Merikangas KR. The National Comorbidity Survey Replication (NCS-R): background and aims. *Int J Methods Psychiatr Res*. 2004;13:60–8.
4. Gore FM, Bloem PJN, Patton GC, Ferguson J, Joseph V, Coffey C, et al. Global burden of disease in young people aged 10-24 years: a systematic analysis. *Lancet*. 2011;377:2093–102.
5. Chesney E, Goodwin GM, Fazel S. Risks of all-cause and suicide mortality in mental disorders: a meta-review. *World Psychiatry*. 2014;13:153–60.
6. Sedentary Behaviour Research Network. Letter to the editor: standardized use of the terms “sedentary” and “sedentary behaviours.”. *Appl Physiol Nutr Metab*. 2012;37:540–2.
7. Pettee Gabriel KK, Morrow JR, Woolsey A-LT. Framework for physical activity as a complex and multidimensional behavior. *J Phys Act Health*. 2012;9(Suppl 1):S11–8.
8. Troiano RP, Pettee Gabriel KK, Welk GJ, Owen N, Sternfeld B. Reported physical activity and sedentary behavior: why do you ask? *J Phys Act Health*. 2012;9(Suppl 1):S68–75.

9. Arundell L, Fletcher E, Salmon J, Veitch J, Hinkley T. A systematic review of the prevalence of sedentary behavior during the after-school period among children aged 5-18 years. *Int J Behav Nutr Phys Act.* 2016;13:1–9. *Curr Obes Rep* (2020) 9:493–511 507
10. Lubans DR, Hesketh K, Cliff DP, Barnett LM, Salmon J, Dollman J, et al. A systematic review of the validity and reliability of sedentary behaviour measures used with children and adolescents. *Obes Rev.* 2011;12:781–99.
11. Atkin AJ, Gorely T, Clemes SA, Yates T, Edwardson C, Brage S, et al. Methods of measurement in epidemiology: sedentary behaviour. *Int J Epidemiol.* 2012;41:1460–71.
12. Bauman AE, Petersen CB, Blond K, Rangul V, Hardy LL. The descriptive epidemiology of sedentary behaviour. In: Leitzmann MF, Jochem C, Schmid D, editors. *Sedentary behaviour epidemiology* [internet]. Cham: Springer International Publishing; 2018 [cited 2019 Nov 19]. p. 73–106. https://doi.org/10.1007/978-3-319-61552-3_4.
13. Khan A, Uddin R, Lee E-Y, Tremblay MS. Sitting time among adolescents across 26 Asia–Pacific countries: a population-based study. *Int J Public Health.* 2019;64:1129–38.
14. Biswas A, Oh PI, Faulkner GE, Bajaj RR, Silver MA, Mitchell MS, et al. Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis. *Ann Intern Med.* 2015;162:123–32.
15. Patterson R, McNamara E, Tainio M, de Sá TH, Smith AD, Sharp SJ, et al. Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis. *Eur J Epidemiol.* 2018;33:811–29.
16. Hebestreit A, Thumann B, Wolters M, Bucksch J, Huybrechts I, Inchley J, et al. Road map towards a harmonized pan-European surveillance of obesity-related lifestyle behaviours and their determinants in children and adolescents. *Int J Public Health.* 2019;64: 615–23.

17. Pogrnilovic BK, O'Sullivan G, Milton K, Biddle SJH, Bauman A, Bull F, et al. A global systematic scoping review of studies analysing indicators, development, and content of national-level physical activity and sedentary behaviour policies. *Int J Behav Nutr Phys Act*. 2018;15:1–17.
18. LeBlanc AG, Spence JC, Carson V, Connor Gorber S, Dillman C, Janssen I, et al. Systematic review of sedentary behaviour and health indicators in the early years (aged 0–4 years). *Appl Physiol Nutr Metab*. 2012;37:753–72.
19. Fang K, Mu M, Liu K, He Y. Screen time and childhood overweight/obesity: a systematic review and meta-analysis. *Child Care Health Dev*. 2019;45:744–53.
20. Mitchell JA, Rodriguez D, Schmitz KH, Audrain-McGovern J. Greater screen time is associated with adolescent obesity: a longitudinal study of the BMI distribution from ages 14 to 18 2. *Obesity*. 2013;21:572–5.
21. Goldfield GS, Kenny GP, Hadjiyannakis S, Phillips P, Alberga AS, Saunders TJ, et al. Video game playing is independently associated with blood pressure and lipids in overweight and obese adolescents. *PLoS One*. 2011;6:e26643.
22. Saunders TJ, Chaput J-P, Tremblay MS. Sedentary behaviour as an emerging risk factor for cardiometabolic diseases in children and youth. *Can J Diabetes*. 2014;38:53–61.
23. WHO adolescent mental health [Internet]. 2019 [cited 2019 Nov 20]. Available from: <https://www.who.int/news-room/factsheets/detail/adolescent-mental-health>
24. Australia Co. Australian 24-Hour Movement Guidelines for Children (5–12 years) and Young People (13–17 years): An Integration of Physical Activity, Sedentary Behaviour, and Sleep. 2019. p. 148.
25. Tremblay MS, Chaput J-P, Adamo KB, Aubert S, Barnes JD, Choquette L, et al. Canadian 24-hour movement guidelines for the early years (0–4 years): an integration of physical activity,

- sedentary behaviour, and sleep. BMC Public Health [Internet]. 2017;17 [cited 2019 Feb 22]. Available from: <https://bmcpublihealth.biomedcentral.com/articles/10.1186/s12889-017-4859-6>.
26. Tremblay MS, LeBlanc AG, Carson V, Choquette L, Connor Gorber S, Dillman C, et al. Canadian physical activity guidelines for the early years (aged 0–4 years). *Appl Physiol Nutr Metab*. 2012;37:345–56.
 27. Tremblay MS, Carson V, Chaput J-P, Connor Gorber S, Dinh T, Duggan M, et al. Canadian 24-hour movement guidelines for children and youth: an integration of physical activity, sedentary behaviour, and sleep. *Appl Physiol Nutr Metab*. 2016;41:S311–27.
 28. Downing KL, Hnatiuk J, Hesketh KD. Prevalence of sedentary behavior in children under 2 years: a systematic review. *Prev Med*. 2015;78:105–14.
 29. Vanderloo LM. Screen-viewing among preschoolers in childcare: a systematic review. *BMC Pediatr*. 2014;14:205.
 30. O'Brien KT, Vanderloo LM, Bruijns BA, Truelove S, Tucker P. Physical activity and sedentary time among preschoolers in centrebased childcare: a systematic review. *Int J Behav Nutr Phys Activity* [Internet]. 2018;15 [cited 2019 Feb 22] Available from: <https://ijbnpa.biomedcentral.com/articles/10.1186/s12966-018-0745-6>.
 31. Pereira JR, Cliff DP, Sousa-Sá E, Zhang Z, Santos R. Prevalence of objectively measured sedentary behavior in early years: systematic review and meta-analysis. *Scand J Med Sci Sports*. 2019;29:308–28.
 32. Ferrari GL d M, Pires C, Solé D, Matsudo V, Katzmarzyk PT, Fisberg M. Factors associated with objectively measured total sedentary time and screen time in children aged 9–11 years. *J Pediatr*. 2019;95:94–105.

33. Cliff DP, Hesketh KD, Vella SA, Hinkley T, Tsiros MD, Ridgers ND, et al. Objectively measured sedentary behaviour and health and development in children and adolescents: systematic review and meta-analysis. *Obes Rev.* 2016;17:330–44.
34. Kraut R, Patterson M, Lundmark V, Kiesler S, Mukopadhyay T, Scherlis W. Internet paradox. A social technology that reduces social involvement and psychological well-being? *Am Psychol.* 1998;53:1017–31.
35. Sampasa-Kanyinga H, Hamilton HA, Chaput J-P. Use of social media is associated with short sleep duration in a dose-response manner in students aged 11 to 20 years. *Acta Paediatr.* 2018;107:694–700.
36. Sampasa-Kanyinga H, Hamilton HA. Social networking sites and mental health problems in adolescents: the mediating role of cyberbullying victimization. *Eur Psychiatry.* 2015;30:1021–7.
37. Sampasa-Kanyinga H, Chaput J-P, Hamilton HA, Colman I. Bullying involvement, psychological distress, and short sleep duration among adolescents. *Soc Psychiatry Psychiatr Epidemiol.* 2018;53:1371–80.
38. Sanders T, Parker PD, del Pozo-Cruz B, Noetel M, Lonsdale C. Type of screen time moderates effects on outcomes in 4013 children: evidence from the longitudinal study of Australian children. *Int J Behav Nutr Phys Act BioMed Central.* 2019;16:1–10.
39. Rentfrow PJ, Goldberg LR, Zilca RD. Listening, watching, and reading: the structure and correlates of entertainment preferences. *J Pers.* 2011;79:223–58.
40. Valkenburg PM, Peter J. The differential susceptibility to media effects model. *J Commun Oxford Academic.* 2013;63:221–43.

41. Kessler RC, Aguilar-Gaxiola S, Alonso J, Chatterji S, Lee S, Ormel J, et al. The global burden of mental disorders: an update from the WHO World Mental Health (WMH) surveys. *Epidemiol Psychiatr Soc.* 2009;18:23–33.
42. Snell T, Knapp M, Healey A, Guglani S, Evans-Lacko S, Fernandez J-L, et al. Economic impact of childhood psychiatric disorder on public sector services in Britain: estimates from national survey data. *J Child Psychol Psychiatry.* 2013;54:977–85.
43. Jokela M, Ferrie J, Kivimäki M. Childhood problem behaviors and death by midlife: the British National Child Development Study. *J Am Acad Child Adolesc Psychiatry.* 2009;48:19–24. 508
Curr Obes Rep (2020) 9:493–511
44. Knapp M, King D, Healey A, Thomas C. Economic outcomes in adulthood and their associations with antisocial conduct, attention deficit and anxiety problems in childhood. *J Ment Health Policy Econ.* 2011;14:137–47.
45. Patel V. Why adolescent depression is a global health priority and what we should do about it. *J Adolesc Health.* 2013;52:511–2.
46. Dick B, Ferguson BJ. Health for the world’s adolescents: a second chance in the second decade. *J Adolesc Health.* 2015;56:3–6.
47. World Health Organization. WHO | Depression: let’s talk [Internet]. WHO. 2017 [cited 2019 Dec 12]. Available from: http://www.who.int/mental_health/management/depression/en/
48. Costello EJ, Egger HL, Angold A. The developmental epidemiology of anxiety disorders: phenomenology, prevalence, and comorbidity. *Child Adolesc Psychiatr Clin N Am.* 2005;14:631–48.
49. Sorenson SB, Rutter CM, Aneshensel CS. Depression in the community: an investigation into age of onset. *J Consult Clin Psychol.* 1991;59:541–6.

50. Kessler RC, Berglund P, Demler O, Jin R, Merikangas KR, Walters EE. Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Arch Gen Psychiatry*. 2005;62:593–602.
51. Yalin N, Young A. *The Age of Onset of Unipolar Depression: Etiopathogenetic and Treatment Implications*. Springer, Cham, 2019. p. 111–24.
52. Goldfield GS, Murray M, Maras D, Wilson AL, Phillips P, Kenny GP, et al. Screen time is associated with depressive symptomatology among obese adolescents: a HEARTY study. *Eur J Pediatr*. 2016;175:909–19.
53. Bélair M-A, Kohen DE, Kingsbury M, Colman I. Relationship between leisure time physical activity, sedentary behaviour and symptoms of depression and anxiety: evidence from a population-based sample of Canadian adolescents. *BMJ Open*. 2018;8:e021119.
54. Hayward J, Jacka FN, Skouteris H, Millar L, Strugnell C, Swinburn BA, et al. Lifestyle factors and adolescent depressive symptomatology: associations and effect sizes of diet, physical activity and sedentary behaviour. *Aust N Z J Psychiatry*. 2016;50:1064–73.
55. Hoare E, Milton K, Foster C, Allender S. Depression, psychological distress and internet use among community-based Australian adolescents: a cross-sectional study. *BMC Public Health*. 2017;17:365.
56. • Kelly Y, Zilanawala A, Booker C, Sacker A. Social media use and adolescent mental health: findings from the UK Millennium Cohort Study. *EClinicalMedicine*. 2018;6:59–68 **A large representative study which examines various mechanisms which have been proposed as pathways for the association between social media and adolescent’s mental health. (online harassment, sleep quantity, self-esteem, body image).**

57. Khan A, Burton NW. Is physical inactivity associated with depressive symptoms among adolescents with high screen time? Evidence from a developing country. *Ment Health Phys Act.* 2017;12:94–9.
58. Kovess-Masfety V, Keyes K, Hamilton A, Hanson G, Bitfoi A, Golitz D, et al. Is time spent playing video games associated with mental health, cognitive and social skills in young children? *Soc Psychiatry Psychiatr Epidemiol.* 2016;51:349–57.
59. Li X, Buxton OM, Lee S, Chang A-M, Berger LM, Hale L. Sleep mediates the association between adolescent screen time and depressive symptoms. *Sleep Med.* 2019;57:51–60.
60. Maras D, Flament MF, Murray M, Buchholz A, Henderson KA, Obeid N, et al. Screen time is associated with depression and anxiety in Canadian youth. *Prev Med.* 2015;73:133–8.
61. Trinh L, Wong B, Faulkner GE. The independent and interactive associations of screen time and physical activity on mental health, school connectedness and academic achievement among a population-based sample of youth. *J Can Acad Child Adolesc Psychiatry.* 2015;24:17–24.
62. Twenge JM, Joiner TE, Rogers ML, Martin GN. Increases in depressive symptoms, suicide-related outcomes, and suicide rates among U.S. adolescents after 2010 and links to increased new media screen time. *Clin Psychol Sci.* 2018;6:3–17.
63. 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;12:271–83 **One of very few large studies to explore the association between screen time and mental health on children and adolescents from a very young age.**
64. Twenge JM, Campbell WK. Media use is linked to lower psychological well-being: evidence from three datasets. *Psychiatr Q.* 2019;90:311–31.

65. Wang J-L, Sheng J-R, Wang H-Z. The association between mobile game addiction and depression, social anxiety, and loneliness. *Front Public Health* [Internet]. 2019;7 [cited 2020 Jan 4]. Available from: <https://www.frontiersin.org/articles/10.3389/fpubh.2019.00247/full>.
66. Zhang J, Hu H, Hennessy D, Zhao S, Zhang Y. Digital media and depressive symptoms among Chinese adolescents: a crosssectional study. *Heliyon* [Internet]. 2019;5 [cited 2020 Jan 7] Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6514493/>.
67. Sampasa-Kanyinga H, Lewis RF. Frequent use of social networking sites is associated with poor psychological functioning among children and adolescents. *Cyberpsychol Behav Soc Netw*. 2015;18:380–5 **A very large representative study which examines mainly the mediating role of cyberbullying on adolescent’s mental health.**
68. Hanprathet N, Manwong M, Khumsri J, Yingyeun R, Phanasathit M. Facebook addiction and its relationship with mental health among Thai high school students. *J Med Assoc Thailand Chotmaihet thangphaet*. 2015;98:S81–90.
69. Frison E, Eggermont S. exploring the relationships between different types of Facebook use, perceived online social support, and adolescents’ depressed mood. *Soc Sci Comput Rev*. 2016;34: 153–171.
70. Barry C, Sidoti C, Briggs S, Reiter S, Lindsey R. Adolescent social media use and mental health from adolescent and parent perspectives. *J Adolesc*. 2017;61:1–11.
71. Yan H, Zhang R, Oniffrey T, Chen G, Wang Y, Wu Y, et al. Associations among screen time and unhealthy behaviors, academic performance, and well-being in Chinese adolescents. *Int J Environ Res Public Health*. 2017;14:596.

72. Li J-B, Lau JTF, Mo PKH, Su X-F, Tang J, Qin Z-G, et al. Insomnia partially mediated the association between problematic internet use and depression among secondary school students in China. *J Behav Addict Akademiai Kiado*. 2017;6:554–64.
73. Wang P, Wang X, Yingqiu W, Xie X, Wang X, Zhao F, et al. Social networking sites addiction and adolescent depression: a moderated mediation model of rumination and self-esteem. *Personal Individ Differ*. 2018;127:162–7.
74. Bickham DS, Hsuen Y, Rich M. Media use and depression: exposure, household rules, and symptoms among young adolescents in the USA. *Int J Public Health*. 2015;60:147–55.
75. Carter JS, Dellucci T, Turek C, Mir S. Predicting depressive symptoms and weight from adolescence to adulthood: stressors and the role of protective factors. *J Youth Adolesc*. 2015;44:2122–40.
76. Gunnell KE, Flament MF, Buchholz A, Henderson KA, Obeid N, Schubert N, et al. Examining the bidirectional relationship between physical activity, screen time, and symptoms of anxiety and depression over time during adolescence. *Prev Med*. 2016;88:147–52. *Curr Obes Rep* (2020) 9:493–511 509
77. • Boers E, Afzali MH, Newton N, Conrod P. Association of screen time and depression in adolescence. *JAMA Pediatr*. 2019;173: 853–9 **A large longitudinal study with a long term follow-up which examines various types of screen activities effects on adolescent's mental health.**
78. Etchells PJ, Gage SH, Rutherford AD, Munafò MR. Prospective investigation of video game use in children and subsequent conduct disorder and depression using data from the Avon longitudinal study of parents and children. *PLoS One*. 2016;11:e0147732.

79. Grøntved A, Singhammer J, Froberg K, Møller NC, Pan A, Pfeiffer KA, et al. A prospective study of screen time in adolescence and depression symptoms in young adulthood. *Prev Med*. 2015;81:108–13.
80. Houghton S, Lawrence D, Hunter SC, Rosenberg M, Zadow C, Wood L, et al. Reciprocal relationships between trajectories of depressive symptoms and screen media use during adolescence. *J Youth Adolesc*. 2018;47:2453–67.
81. Khouja JN, Munafò MR, Tilling K, Wiles NJ, Joinson C, Etchells PJ, et al. Is screen time associated with anxiety or depression in young people? Results from a UK birth cohort. *BMC Public Health* [Internet]. 2019;19 [cited 2019 Nov 17]. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6337855/>.
82. Li J, Mo P, Lau J, Su X-F, Zhang X, Wu A, et al. Online social networking addiction and depression: the results from a largescale prospective cohort study in Chinese adolescents. *J Behav Addict*. 2018;7:1–11.
83. McVeigh J, Smith A, Howie E, Straker L. Trajectories of television watching from childhood to early adulthood and their association with body composition and mental health outcomes in young adults. *PLoS One*. 2016;11:e0152879.
84. • Ohannessian CM. Video game play and anxiety during late adolescence: the moderating effects of gender and social context. *J Affect Disord*. 2018;226:216–9 A longitudinal study that considers gender and the social context of video game use on anxiety symptomatology.
85. Riehm KE, Feder KA, Tormohlen KN, Crum RM, Young AS, Green KM, et al. Associations between time spent using social media and internalizing and externalizing problems among US youth. *JAMA Psychiatry*. 2019;76:1266–73.

86. Vernon L, Modecki K, Barber B. Tracking effects of problematic social networking on adolescent psychopathology: the mediating role of sleep disruptions. *J Clin Child Adolesc Psychol*. 2016;46: 1–15.
- 87.♦♦ Viner R, Gireesh A, Stiglic N, Hudson L, Goddings A-L, Ward J, et al. Roles of cyberbullying, sleep, and physical activity in mediating the effects of social media use on mental health and wellbeing among young people in England: a secondary analysis of longitudinal data. *The Lancet Child & Adolescent Health*. 2019;3:685–696. **This study is the first longitudinal mediation analysis from a representative cohort which highlights that the impact of social media on is not directly associated with social media use but with the content or the displacement of sleep and physical activity.**
88. Zink J, Belcher BR, Kechter A, Stone MD, Leventhal AM. Reciprocal associations between screen time and emotional disorder symptoms during adolescence. *Prev Med Rep*. 2019;13:281– 8.
89. Brodersen NH, Steptoe A, Boniface DR, Wardle J. Trends in physical activity and sedentary behaviour in adolescence: ethnic and socioeconomic differences. *Br J Sports Med*. 2007;41:140–4.
90. Lack CW, Green AL. Mood disorders in children and adolescents. *J Pediatr Nurs*. 2009;24:13–25.
91. McCrae N, Gettings S, Purssell E. Social media and depressive symptoms in childhood and adolescence: a systematic review. *Adolescent Res Rev*. 2017;2:315–30.
92. Kim S, Kimber M, Boyle MH, Georgiades K. Sex differences in the association between cyberbullying victimization and mental health, substance use, and suicidal ideation in adolescents. *Can J Psychiatr*. 2019;64:126–35.
93. Sadler K, Vizard T, Ford T, Marchesell F, Pearce N, Mandalia D, et al. Mental health of children and young people in England, 2017. [Internet]. NHS Digital. 2017; [cited 2019 Dec 16].

Available from: <https://digital.nhs.uk/data-and-information/publications/statistical/mental-health-of-children-and-youngpeople-in-england/2017/2017>.

94. Giedd JN, Keshavan M, Paus T. Why do many psychiatric disorders emerge during adolescence? *Nat Rev Neurosci*. 2008;9:947– 57.
95. Yen J-Y, Ko C-H, Yen C-F, Chen S-H, Chung W-L, Chen C-C. Psychiatric symptoms in adolescents with internet addiction: comparison with substance use. *Psychiatry Clin Neurosci*. 2008;62:9– 16.
96. Diener E. Subjective well-being: the science of happiness and a proposal for a national index. *Am Psychol*. 2000;55:34–43.
97. Ryff CD, Keyes CLM. The structure of psychological well-being revisited. 1995;69:719.
98. Rodríguez-Fernández A, Ramos-Díaz E, Axpe-Saez I. The role of resilience and psychological well-being in school engagement and perceived academic performance: an exploratory model to improve academic achievement. *Health and Academic Achievement* [Internet]. 2018; [cited 2019 Dec 16]; Available from: <https://www.intechopen.com/books/health-and-academicachievement/the-role-of-resilience-and-psychological-well-beingin-school-engagement-and-perceived-academic-perf>.
99. Hernandez R, Bassett SM, Boughton SW, Schuette SA, Shiu EW, Moskowitz JT. Psychological well-being and physical health: associations, mechanisms, and future directions. *Emot Rev*. 2018;10:18–29.
100. Booker CL, Skew AJ, Kelly YJ, Sacker A. Media use, sports participation, and well-being in adolescence: cross-sectional findings from the UK Household Longitudinal Study. *Am J Public Health*. 2015;105:173–9.

101. Herman KM, Hopman WM, Sabiston CM. Physical activity, screen time and self-rated health and mental health in Canadian adolescents. *Prev Med.* 2015;73:112–6.
102. Lee E-Y, Carson V. Physical activity, sedentary behaviour, and psychosocial well-being among young south Korean children. *Child Care Health Dev.* 2018;44:108–16.
103. Przybylski AK, Weinstein N. A large-scale test of the Goldilocks hypothesis: quantifying the relations between digital-screen use and the mental well-being of adolescents. *Psychol Sci.* 2017;28: 204–15.
104. Przybylski AK, Weinstein N. Digital screen time limits and young children’s psychological well-being: evidence from a populationbased study. *Child Dev.* 2019;90:e56–65.
105. Suchert V, Hanewinkel R, Isensee B, läuft Study Group. Sedentary behavior, depressed affect, and indicators of mental well-being in adolescence: does the screen only matter for girls? *J Adolesc.* 2015;42:50–8.
106. • Zhao J, Zhang Y, Jiang F, Ip P, Ho FKW, Zhang Y, et al. Excessive screen time and psychosocial well-being: the mediating role of body mass index, sleep duration, and parent-child interaction. *J Pediatr.* 2018;202:157–162.e1 **This study is one of very few studies which examines screen time and psychological well-being among preschool children and the role of some mediators on this association such as the BMI, sleep, and parent-child interaction.**
107. Allen MS, Vella SA. Screen-based sedentary behaviour and psychosocial well-being in childhood: cross-sectional and longitudinal associations. *Ment Health Phys Act.* 2015;9:41–7. 510 *Curr Obes Rep* (2020) 9:493–511
108. Babic MJ, Smith JJ, Morgan PJ, Eather N, Plotnikoff RC, Lubans DR. Longitudinal associations between changes in screen-time and mental health outcomes in adolescents. *Ment Health Phys Act.* 2017;12:124–31.

- 109.●● Booker CL, Kelly YJ, Sacker A. Gender differences in the associations between age trends of social media interaction and wellbeing among 10-15 year olds in the UK. BMC Public Health. 2018;18:321 **This study examines longitudinal data from a large nationally representative sample and estimated models separately by gender. It suggests gender differences in the relationship between social media interaction and mental well-being.**
110. Hinkley T, Verbestel V, Ahrens W, Lissner L, Molnár D, Moreno LA, et al. Early childhood electronic media use as a predictor of poorer well-being: a prospective cohort study. JAMA Pediatr. 2014;168:485–92.
111. Kim HH. The impact of online social networking on adolescent psychological well-being (WB): a population-level analysis of Korean school-aged children. Int J Adolesc Youth. 2017;22: 364–76.
112. van den Eijnden R, Koning I, Doornwaard S, van Gorp F, ter Bogt T. The impact of heavy and disordered use of games and social media on adolescents' psychological, social, and school functioning. J Behav Addict. 2018;7:697–706.
113. Coyne SM, Padilla-Walker LM, Holmgren HG, Stockdale LA. Instagrowth: a longitudinal growth mixture model of social media time use across adolescence. J Res Adolesc. 2019;29:897–907.
114. Hamm MP, Newton AS, Chisholm A, Shulhan J, Milne A, Sundar P, et al. Prevalence and effect of cyberbullying on children and young people: a scoping review of social media studies. JAMA Pediatr. 2015;169:770–7.
115. Phan MH, Jardina JR, Hoyle S, Chaparro BS. Examining the Role of Gender in Video Game Usage, Preference, and Behavior. Proceedings of the Human Factors and Ergonomics Society Annual Meeting. Sage CA: Los Angeles, SAGE Publications Inc; 2012;56:1496–500.
116. Hale L, Guan S. Screen time and sleep among school-aged children and adolescents: a systematic literature review. Sleep Med Rev. 2015;21:50–8.

117. Valkenburg PM, Peter J. Online communication and adolescent well-being: testing the stimulation versus the displacement hypothesis. *J Comput-Mediat Commun.* 2007;12:1169–82.
118. Bucchianeri MM, Arikian AJ, Hannan PJ, Eisenberg ME, Neumark-Sztainer D. Body dissatisfaction from adolescence to young adulthood: findings from a 10-year longitudinal study. *Body Image.* 2013;10:1–7.
119. Stice E, Bearman SK. Body-image and eating disturbances prospectively predict increases in depressive symptoms in adolescent girls: a growth curve analysis. *Dev Psychol.* 2001;37:597–607.
120. Goldschmidt AB, Wall M, Choo T-HJ, Becker C, Neumark-Sztainer D. Shared risk factors for mood-, eating-, and weight-related health outcomes. *Health Psychol.* 2016;35:245–52.
121. Paxton SJ, Neumark-Sztainer D, Hannan PJ, Eisenberg ME. Body dissatisfaction prospectively predicts depressive mood and low self-esteem in adolescent girls and boys. *J Clin Child Adolesc Psychol.* 2006;35:539–49.
122. Siibak A. Constructing the self through the photo selection - visual impression management on social networking websites. *Cyberpsychology.* 2009;3 [cited 2020 Jan 3] Available from: <https://cyberpsychology.eu/article/view/4218>.
123. Espinoza G, Juvonen J. The pervasiveness, connectedness, and intrusiveness of social Network site use among young adolescents. *Cyberpsychol Behav Soc Netw.* 2011;14:705–9.
124. Chua THH, Chang L. Follow me and like my beautiful selfies: Singapore teenage girls' engagement in self-presentation and peer comparison on social media. *Comput Hum Behav.* 2016;55:190–7.
125. Vandenbroucke S, et al. Vieillir, mais pas tout seul. Une enquête sur la solitude et l'isolement social des personnes âgées en Belgique. Fondat Roi Baudouin [Internet]. 2012; [cited 2019 Sep

- 17] Available from: https://cdn.uclouvain.be/public/Exports%20reddot/aisbl-generations/documents/DocPart_Etud_VieillirMaisPasToutSeul_2012.pdf.
126. Meier EP, Gray J. Facebook photo activity associated with body image disturbance in adolescent girls. *Cyberpsychol Behav Soc Netw*. 2014;17:199–206. 1
27. Fardouly J, Vartanian LR. Negative comparisons about one's appearance mediate the relationship between Facebook usage and body image concerns. *Body Image*. 2015;12:82–8.
128. Holland G, Tiggemann M. A systematic review of the impact of the use of social networking sites on body image and disordered eating outcomes. *Body Image*. 2016;17:100–10.
129. Añez E, Fornieles-Deu A, Fauquet-Ars J, López-Guimerà G, Puntí-Vidal J, Sánchez-Carracedo D. Body image dissatisfaction, physical activity and screen-time in Spanish adolescents. *J Health Psychol*. 2018;23:36–47.
130. de Vries DA, Vossen HGM, Van der Kolk-van der Boom P. Social media and body dissatisfaction: investigating the attenuating role of positive parent–adolescent relationships. *J Youth Adolesc*. 2019;48:527–36.
131. Tiggemann M, Slater A. NetGirls: the internet, Facebook, and body image concern in adolescent girls. *Int J Eat Disord*. 2013;46:630–3.
132. Tiggemann M, Slater A. NetTweens: the internet and body image concerns in preteenage girls. *J Early Adolesc* SAGE Publications Inc. 2014;34:606–20.
133. Vandenberg L, Eggermont S. Understanding sexual objectification: a comprehensive approach toward media exposure and girls' internalization of beauty ideals, self-objectification, and body surveillance: media, adolescent girls, and self-objectification. *J Commun*. 2012;62:869–87.

134. de Vries DA, Peter J, de Graaf H, Nikken P. Adolescents' social network site use, peer appearance-related feedback, and body dissatisfaction: testing a mediation model. *J Youth Adolesc.* 2016;45:211–24.
135. • Rousseau A, Eggermont S, Frison E. The reciprocal and indirect relationships between passive Facebook use, comparison on Facebook, and adolescents' body dissatisfaction. *Comput Hum Behav.* 2017;73:336–44 **This study examines passive use of Facebook and its association with body image concerns reciprocally. It highlights that passive use of Facebook predicts comparison which in its turn predicts more body dissatisfaction.**
136. Tiggemann M, Slater A. Facebook and body image concern in adolescent girls: a prospective study: Facebook and body image concern. *Int J Eat Disord.* 2017;50:80–3.
137. Silverblatt A. *Media Literacy: Keys to Interpreting Media Messages.* Praeger; 2001.
138. Berel S, Irving LM. Media and disturbed eating: an analysis of media influence and implications for prevention. *J Prim Prev.* 1998;18:415–30.
139. McLean SA, Paxton SJ, Wertheim EH. Does media literacy mitigate risk for reduced body satisfaction following exposure to thinideal media? *J Youth Adolesc.* 2016;45:1678–95.
140. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders (DSM-5®).* American Psychiatric Pub; 2013.

Table 1. Characteristics of studies on depression and anxiety

Author, Year, Country of study	Study design	Sample characteristics	Screen time activities	Depression Measures and Findings	Anxiety Measures and Findings
Barry et al., 2017 [70] USA	Cross-sectional	226 (113 adolescent-parent dyads) Age : 14-17 years	Social media	Measures: DSM-V checklist. Findings: social media (number of accounts, frequency of checking) was moderately, positively associated with depression as reported by parents.	Measures: DSM-V checklist. Findings: social media (number of accounts, frequency of checking) was moderately, positively associated with anxiety as reported by parents.
Bélair et al. 2018 [53] Canada	Cross-sectional	9702 adolescents Age: 14-15 years	TV Videos DVDs Video games	Measures: Diagnostic and Statistical Manual of Mental Disorders (DSM-III-R). Findings: higher odds of having moderate and severe symptoms of depression among those who exceeded recommended sedentary screen time.	Measures: DSM-III-R. Findings: higher odds of having moderate and severe symptoms of anxiety among those who exceeded recommended sedentary screen time.
Frison & Eggermont 2015 [69] Belgium	Cross-sectional	910 adolescents Mean age: 15.44 years	Facebook	Measures: The Center for Epidemiological Studies Depression Scale for Children (CES-DC). Findings: positive correlation between passive Facebook use and depressed mood among girls, and active Facebook use and depressed mood among boys. Perceived online social support mediated this association.	-
Goldfield et al. 2016 [52] Canada	Cross-sectional	358 overweight and obese adolescents Age: 14-18 years Mean age 15.6 years	Computer Video games TV	Measures: Children's Depression Inventory (CDI). Findings: time spent playing video games and recreational computer time but not TV viewing was associated with depressive symptoms.	-

Hanprathet et al. 2015 [68] Thailand	Cross-sectional	832 adolescents Mean age: 16.7 years	Facebook addiction	Measures: The Thai General Health Questionnaire. Findings: Facebook addiction among adolescents could be associated with severe depression.	Measures: The Thai General Health Questionnaire. Findings: Facebook addiction among adolescents could be associated with anxiety.
Hayward et al. 2016 [54] Australia	Cross-sectional	3295 adolescents Mean age=15.1 years	TV Computer	Measures: Moods and Feelings Questionnaire– Short (SMFQ). Findings: positive association between screen time and depressive symptoms for girls only.	–
Hoare et al. 2017 [55] Australia	Cross-sectional	5500 adolescents Age 11-17 years Mean age: 14.5 years	Internet Social media	Measures: Diagnostic and Statistical Manual of Mental Disorders Version IV (DISC IV). Findings: spending more than 7 h/day on the internet was significantly associated with depressive symptoms among females.	–
Kelly et al. 2018 [56] UK	Cross-sectional	10,904 adolescents Age: 14 years	Social media	Measures: SMFQ. Findings: the magnitude of association between social media use and depressive symptoms was larger for girls than for boys.	–
Khan and Burton 2017 [57] Bangladesh	Cross-sectional	898 adolescents Age 12-17 years Mean age: 14.3 years	Computer TV DVD Social media	Measures: CESD. Findings: high recreational screen time and not meeting physical activity recommendations are associated with depressive symptoms.	–

Kovess-Masfety et al. 2016 [58] Europe	Cross-sectional	3195 Children Age: 6-11 years	Video games	Measures: Dominic Interactive (DI). Findings: High video game usage was associated with lower prevalence of mental health difficulties.	Measures: DI. Findings: high video game usage was associated with lower prevalence of mental health difficulties.
Li et al., 2017 [72] China	Cross-sectional	1015 adolescents Grade 7-9. Age not reported.	Social media	Measures: Chinese version of the Center for Epidemiological Studies Depression scale. Findings: A significant association was found between social media addiction and depression. Insomnia partially mediated this association.	-
Li et al. 2019 [59] USA	Cross-sectional	2865 adolescents Mean age: 15.53	Social messaging Web surfing TV/movie watching Gaming	Measures: CES-D. Findings: all four screen-based activities had direct associations with adolescent depressive symptoms.	-
Maras et al. 2015 [60] Canada	Cross-sectional	2482 adolescents. Grade 7 to 12	TV Computer Video games	Measures: Children's Depression Inventory (CDI). Findings: duration of screen time was associated with severity of depression. Video game playing and computer use but not TV viewing were associated with more severe depressive symptoms.	Measures: Multidimensional Anxiety Scale for Children-10 (MASC10). Findings: duration of screen time was associated with severity of anxiety. Video games playing was associated with severity of anxiety.
Sampasa & Lewis 2015 [67] Canada	Cross-sectional	753 adolescents Mean age = 14.1 years	SNS: Facebook Twitter Instagram MySpace	Measure: The Kessler (K-10) Scale (measures anxiety and depression) Findings: The use of SNSs more than 2 hours per day was associated with increased level of psychological distress.	Measures: K-10 Scale. Findings: The use of SNSs more than 2 hours per day was associated with increased level of psychological distress.

Sampasa & Hamilton 2015 [36] Canada	Cross-sectional	5126 Age: 11–20-year Mean age: 15.2 years	SNS: Facebook Twitter Instagram MySpace	Measure: K-10 Scale. Findings: The use of SNSs was associated with in increased level of psychological distress. Findings suggest that cyberbullying is a significant mediator which explains this association.	Measures: K-10 Scale. Findings: The use of SNSs was associated with in increased level of psychological distress. Findings suggest that cyberbullying is a significant mediator which explains this association.
Trinh et al. 2015 [61] Canada	Cross-sectional	2660 adolescents. Mean age: 15.8 years	TV Computer Mobile Games Internet	Measures: CES-D. Findings: exceeding screen time recommendations was significantly related to depressive symptoms especially in males.	–
Twenge & Campbell 2018 [63] USA	Cross-sectional	40337 children and adolescents Age: 2-17 years	Mobile Computer Electronic devices and games TV	Measures: US National Survey of Children’s Health (NSCH). Findings: among 14- to 17-year-olds, high users of screens (7+ h/day vs. low users of 1 h/day) were more than twice as likely to ever have been diagnosed with depression in the last 12 months.	Measures: NSCH. Findings: Among 14- to 17-year-olds, high users of screens (7+ h/day vs. low users of 1 h/day) were more than twice as likely to ever have been diagnosed with anxiety in the last 12 months.
Twenge et al. 2018 [62] USA	Cross-sectional	506820 adolescents Age: 13-18 years	Electronic devices Social media Internet TV	Measures: six items from the Bentler Medical and Psychological Functioning Inventory depression scale. Findings: new media screen time is increasing overtime and it is associated with depression.	–
Twenge & Campbell 2019 [64] UK and USA	Cross-sectional	221096 adolescents from a UK and USA samples Age: UK sample: 15 years US sample: 8 th , 10 th , and 12 th graders (age not reported)	Smartphones Computers Social media Gaming Internet	Measures: “During the past 12 months, did you ever feel so sad or hopeless almost every day for two weeks or more in a row that you stopped doing some usual activities?”. Findings: heavy users (vs. light) of digital media were 48% to 171% more likely to report being depressed.	–

Wang et al. 2018 [73] China	Cross-sectional	365 adolescents Age: 14-18 years	Social media	Measures: CES-D. Findings: social media addiction is positively associated with depression. Rumination mediated this association and self esteem moderated this mediation.	
Wang et al. 2019 [65] China	Cross-sectional	578 adolescents Mean age: 15 years	Mobile games addiction	Measures: Brief Symptom Inventory (BSI). Findings: mobile game addiction was positively associated with depression.	Measures: Child Social Anxiety Scale. Findings: mobile game addiction was positively associated with depression social anxiety especially among males.
Yan et al. 2017 [71] China	Cross-sectional	2656 adolescents Age: 13-18 years	Social media	-	Measures: Middle School Student Mental Health Scale to measure anxiety. Findings: a positive association was found between the time spent on social media and anxiety.
Zhang et al. 2019 [66] China	Cross-sectional	16205 adolescents Age: 12-18 years	TV Digital media	Measures: "have you felt depressed during the last seven days". Findings: adolescents who spent more time on screen pursuits are significantly more likely to have depressive symptoms. New digital media had a greater association among girls for depression.	-
Bickham et al. 2015 [74] USA	Cross-sectional and longitudinal T1: 2009 T2: 2010	126 adolescents Mean age at T1: 14 years	TV Computer Mobile	Measures: The Beck Depression Index (BDI). Findings: significant positive association between mobile use and depression. More TV and mobile use reported at baseline the higher participants' depression score was after one year.	-

Carter et al. 2015 [75] USA	Cross-sectional and longitudinal T1: 12–18 years T2: 13-19 years T3: 18–26 years	6504 adolescents Mean age at T1: 15.53 years	TV Computer Video games	Measures: Center for Epidemiological Studies Depression Scale (CES-D). Findings: positive association between screen time and depressive symptoms only at baseline. No longitudinal association found.	–
Gunnell et al. 2016 [76] Canada	Cross-sectional and Longitudinal Follow-up: every one to two years for sever years between 2006-2013	1160 adolescents Age 10-21 years Mean age=13.54 years at T1	TV Video games Computer	Measures: Children’s Depression Inventory (CDI). Findings: a cross-sectional association between screen time and depression, however initial screen time didn’t predict changes in depression over time.	Measures: MASC-10. Findings: a cross-sectional association between screen time and anxiety, however initial screen time didn’t predict changes in anxiety over time.
Boers et al., 2019 [77] Canada	Longitudinal Follow-up: annually for four years	3826 adolescents Mean age: 12.3	Video games Social media TV Computer	Measures: BSI. Findings: time-varying associations between social media, television, and depression.	–
Etchells et al. 2016 [78] UK	Longitudinal Follow up: at age 15	5400 Children and adolescents Age: 8/9-15 years	Video games	Measures: development and Well-Being Assessment (DAWBA). Findings: moderate levels of playing video games that are more likely to include violent content in childhood is weakly associated with an increased risk of depression.	–
Grontved et al. 2016 [79] Denmark	Longitudinal Follow-up: 6-years and 12 years follow up between 1997 and 2010	435 adolescents to young adults Mean age:8.8 at T1	TV Computer	Measure: Major Depression Inventory (MDI). Findings: prolonged TV viewing, but not computer use, was associated with more depression symptoms.	–

Houghton et al. 2018 [80] Australia	Longitudinal Follow up: 6 times in two years from 2013 to 2015	1,749 adolescents Age : 10-17 at T1	Social networking and web browsing Gaming TV	Measures: CDI. Findings: Small positive associations were evident between depressive symptoms and later screen use, and between screen use and later depressive symptoms.	-
Khouja et al. 2019 [81] UK	Longitudinal T1: 16 years T2: 18 years	14665 adolescents Age: 16 years at T1	TV Texting Computer	Measures: Clinical Interview Schedule (CIS-R). Findings: increased computer use at age 16 is associated with a small increased risk of depression at age 18.	Measures: CIS-R. Findings: increased computer use at age 16 is associated with a small increased risk of anxiety at age 18.
Li et al. 2018 [82] China	Longitudinal T1: March 2014 T2: after nine months	5365 adolescents at T1 Mean age: 13.9 years at T1.	Social networking sites	Measures: CES-D. Findings: a bidirectional association was found between online social networking addiction and depression.	-
McVeigh et al. 2016 [83] Australia	Longitudinal Follow-up: at ages 5, 8, 10, 14, 17, and 20 years	2441 children and adolescents	TV	Measures: Depression Anxiety Stress Scales (DASS-21). Findings: No association between TV watching and mental health.	Measures: DASS-21. Findings: No association between TV watching and mental health.
Ohannessian 2018 [84] USA	Longitudinal Follow up: one year after T1	441 adolescents Mean age: 17.14 at T1	Video games	-	Measures: Screen for Child Anxiety Related Disorders (SCARED). Findings: Boys who played video games the most had the lowest levels of anxiety, whereas girls who played video games the most had the highest levels of anxiety. Gender and social context moderated the association.
Riehm et al. 2019 [85] USA	Longitudinal Follow-up: annually for 3 waves	6595 adolescents Age: 12 to 15 years at T1	Social media	Measures: GAIN-SS. Findings: spending more than 3 hours per day using social media may increase the risk for	Measures: GAIN-SS. Findings: spending more than 3 hours per day using social media may increase the risk for

	from September 2013 to October 2016			mental health problems, particularly internalizing problems.	mental health problems, particularly internalizing problems.
Vernon et al. 2016 [86] Australia	Longitudinal Follow-up: annually for 3 years	874 adolescents at T1 Mean Age: 14.4 years at T1	Social networking sites	Measures: Depressed mood scale (adapted from the longitudinal Michigan Study of Adolescent Life Transitions). Findings: Increased investment in social media predicted higher depressed mood in adolescents, which was mediated by the higher levels of sleep disruptions.	–
Viner et al. 2019 [87] UK	Longitudinal Follow-up: three waves of follow ups from age 13 to 16	12866 adolescents Age: 13-14 years at T1	Social media	–	Measures: General Health Questionnaire (GHQ12) and National Statistics (ONS) wellbeing. Findings: frequent social media use was predictive of later anxiety especially among girls. This association isn't directly related to social media use but with the harmful content on social media or by displacement of healthy behaviours like sleep and physical activity.
Zink et al. 2019 [88] USA	Longitudinal Follow-up: 1 year after T1	2525 adolescents Mean age: 14.6 years at T1	TV Computer Video games	Measures: Revised Children's Anxiety and Depression Scale (RCADS). Findings: Screen time wasn't associated with major depressive disorders.	Measures: RCADS. Findings: reciprocal association between computer/ videogame use, and anxiety.

Table 2. Characteristics of studies on psychological well-being

Author, Year Country of study	Study Design	Sample characteristics	Screen time activities	Psychological Wellbeing Measures and Findings
Booker et al. 2015 [100] UK	Cross-sectional	4899 adolescents Age: 10-15 years	SNS Game console Computer game use TV, DVDS	Measures: Happiness with six domains of life. SDQ Findings: Chatting on social networking sites and game console usage were associated with higher odds of socio-emotional problems. Higher total screen based media use was associated with lower odds of happiness and higher odds of socio-emotional difficulties.
Herman et al. 2015 [101] Canada	Cross-sectional	7725 adolescents Age: 12-17 years	Computer Video games TV, DVDs	Measures: Self-rated mental health: one item ‘would you say your mental health in general is excellent, very good, fair or poor?’ Findings: Adolescents who didn’t meet Canadian guidelines for sedentary behaviour and exceeded screen time were 30–50 % more likely to rate their mental health sub-optimally compared to those who met guidelines.
Lee & Carson 2018 [102] South Korea	Cross-sectional	1774 children Age: 0-5 Years	TV	Measures: happiness, and stress were used to measure psychological well-being. Findings: TV viewing was not associated with psychosocial well-being.
Przybylski and Weinstein 2017 [103] UK	Cross-sectional	120115 adolescents Age: 15 years	DVDs TV Games Computers Mobile Social networking Internet	Measures: Warwick Edinburgh Mental Well-Being Scale (WEMWBS) Findings: relationships between digital-screen time and mental well-being are nonlinear and that moderate engagement in digital activities is not harmful. although high levels of engagement may have a measurable, albeit small, negative influence
Przybylski & Weinstein 2019 [104] USA	Cross-sectional	19957 children Age: 2-5 years	Computer Mobile Video games TV Electronic devices	Measures: Questionnaire drafted by developmental specialists Findings: Evidence didn’t support an association between screen time and psychological well being

Suchert et al. 2015 [105] Germany	Cross-sectional	1296 adolescents. Mean age: 13.7 years	TV Mobile Video games Computer	Measures: CES-D. Findings: negative associations between sedentary screen time behaviour and mental wellbeing especially among adolescent girls.
Twenge & Campbell 2018 [63] USA	Cross-sectional	40337 children and adolescents Age: 2-17 years	Mobile Computer Electronic devices and games TV	Measures: NSCH Findings: after 1 h/day of use, more hours of daily screen time were associated with lower psychological well-being. This association is larger among adolescents. Among 14- to 17-year-olds, high users of screens (7+ h/day vs. low users of 1 h/day) were more than twice as likely to ever have been treated by a mental health profession or have taken medication for a psychological or behavioral issue in the last 12 months. Moderate use of screens (4 h/day) was also associated with lower psychological well-being.
Twenge & Campbell 2019 [64] UK and USA	Cross-sectional	221096 adolescents from a UK and USA samples Age: UK sample: 15 years US sample: 8th, 10th, and 12th graders (age not reported)	smartphones, computers, social media, gaming, Internet	Measures: 14-item Warwick-Edinburgh Mental Well-Being Scale Findings: Heavy users (vs. light) of digital media were 48% to 171% more likely to be in low psychological well-being.
Zhao et al. 2018 [106] China	China Cross-sectional	20324 Children Age: 3-4 years	Video programs Electronic games TV Computer Mobile iPad	Measures: SDQ Findings: Excessive screen exposure was associated with poor psychosocial well-being in preschool children via a number of mediators, like sleep, BMI and mostly by reducing parent-child interaction.
Allen and Vella 2015 [100] Australia	Cross sectional and Longitudinal T1: 2010 T2: 2012	7818 children 6 -10 years at T1	TV Video games	Measures: SDQ Findings: screen-based sedentary behaviour is related to the development of psychosocial difficulties in early and late childhood. Important moderators: household income, parental education level, and neighbourhood socioeconomic position.
Babic et al. [108] Australia	Longitudinal T1: between April and June 2014	322 adolescents Mean age 14.4 at T1	TV, DVDs, computer, and tablet/mobile	Measures: Flourishing Scale Findings: Changes in total recreational screen-time and computer use were negatively

	T2: between October and December 2014.			associated with psychological well-being. A positive association was found with TV/DVD use and psychological difficulties.
Booker et al.2018 [109] UK	Longitudinal Follow-up: 5 waves from age 10 to 15 years	9859 adolescents Age: 10 to 15 years	Social media	Measures: Happiness with six domains of life. Strengths and Difficulties Questionnaire (SDQ). Findings: significant correlation between interacting on social media and well-being among females. Higher social media interaction at age 10 was associated with declines in well-being thereafter for females, but not for males.
Hinkley et al. 2014 [110] Europe	Longitudinal T1: from September 1, 2007, to June 30, 2008, T2: from September 1, 2009, to May 31,2010	3604 children Age: 2-6 years	TV Computer Games	Measures: SDQ Questionnaire for Measuring Health-Related Quality of Life in Children and Adolescents–Revised Version (KINDLr) Findings: higher levels of early childhood electronic media use especially TV viewing are associated with children being at risk for poorer outcomes with some indicators of well-being.
Kim 2017 [111] Korea	Longitudinal T1:2007 T2:2008	2844 adolescents Age: 12-15 years	SNS and online communication	Measures: students self reported questionnaire Findings: strong negative relationship between online activities (chatting, e-mailing, participating in communities or clubs and using bulletin boards) and self-reported mental wellbeing.
van den Eijnden et al. 2018 [112] Netherlands	Longitudinal Follow-up: T1: February to March 2015 T2: 2016 T3: 2017	538 adolescents Age: 12-15 years Mean age: 12.9 years at T1	Social media disorder Internet gaming disorder	Measures: Perceived social competence: the 5-item Dutch version of the Harters' Self Perception Profile of Adolescents 5-item Satisfaction with Life Scale developed by Diener, Emmons, Larsen, and Griffin Findings: disordered use of social media and internet games predict a decrease in the psychosocial wellbeing of adolescents in terms of life satisfaction and perceived social competencies. More vulnerability among boys was

				found in terms of disordered gaming.
Viner et al. 2019 [87] UK	Longitudinal Follow-up: three waves of follow ups from age 13 to 16	12866 adolescents Age: 13-14 years at T1	Social media	Measures: General Health Questionnaire (GHQ12) and National Statistics (ONS) wellbeing Findings: frequent social media use was predictive of later lower well-being especially among girls.

Table 3. Characteristics of studies on body image

Author, Year, Country of study	Study Design	Sample characteristics	Screen time activities	Body image Measures and Findings
Añez et al 2018 [129] Spain	Cross-sectional	1501 adolescents Age: 13-17 years	TV Computer (leisure and homework)	Measures: Body Dissatisfaction subscale of the Eating Disorders Inventory-3 (EDI-3). Findings: Computer leisure time was negatively associated only with girls' body dissatisfaction.
De Vries et al 2019 [130] Netherland	Cross-sectional	404 adolescents Age: 12-19 years	Facebook Instagram	Measures: The body dissatisfaction subscale of the Body Attitude Test. Findings: social media use was positively associated with body dissatisfaction, but this relationship was weaker among adolescents who reported a more positive mother–adolescent relationship. Positive father–adolescent relationship did not moderate the association between social media use and body dissatisfaction.
Kelly et al. 2018 [56] UK	Cross-sectional	10,904 adolescents Age: 14 years	Social media	Measures: On a scale of 1 to 7 how do you feel about the way you look? Which of these do you think you are?" (underweight, about the right weight, slightly overweight, very overweight), "Have you ever exercised to lose weight or to avoid gaining weight?", "Have you ever eaten less food, fewer calories, or foods low in fat to lose weight or to avoid gaining weight?". Findings: social media screen time was associated with body image concerns among girls more than boys.
Meier and Gray 2014 [126] USA	Cross-sectional	103 female adolescents Age: 12-18 years	Social networking sites Facebook	Measures: The 5-item Sociocultural Internalization of Appearance Questionnaire for Adolescents (SIAQ—A). The Physical Appearance Comparison Scale (PACS). Weight Satisfaction subscale of the Body-Esteem Scale for Adolescents and Adults (BES). Self-Objectification Questionnaire.

				Findings: It is not the total time spent on FB or the Internet, but the amount of FB time allocated to photo activity that is associated with greater thin ideal internalization, self-objectification, weight dissatisfaction, and drive for thinness.
Tiggemann and Slater 2013 [131] Australia	Cross-sectional	1087 female adolescents Age: 13-15 years	Facebook	Measures: body surveillance drive for thinness and Internalization of beauty Ideals. Findings: Facebook users scored significantly more highly on all body image concern measures than non-users. Number of Facebook friends was significantly correlated with all body image concern measures.
Tiggemann and Slater 2014 [132] Australia	Cross-sectional	189 young female adolescents Age: 10-12 years	TV Magazine Facebook MySpace Other social networking sites	Measures: Sociocultural Internalization of Media Ideals Scale Body Surveillance Scale of the Objectified Body Consciousness Scale—Youth Body Esteem Scale for Children. Dieting: (“Do you watch exactly what you eat?” “Do you try to eat less at meal times than you would like to eat?”) “Have you ever been on a diet to lose weight?” Findings: SNS use correlated with internalization, body surveillance, and negative body esteem. Time spent on these social networking sites produced stronger correlations with body image concerns than did overall Internet exposure.
Vandenbosch and Eggermont 2012 [133] Belgium	Cross-sectional	558 female adolescents Age: 13-18 years	sexually objectifying music TV, primetime TV programs, Social networking sites	Measures: Noll and Fredrickson’s original Self-Objectification Questionnaire. Internalization subscale of the Sociocultural Attitudes Toward Appearance Scale. Body surveillance subscale from the Objectified Body Consciousness Scale for Adolescents. Findings: SNS use significantly predicted body surveillance. Direct relationships between

				internalization of beauty ideals and sexually objectifying media.
De Vries et al 2016 [134] Netherland	Cross-sectional and longitudinal T1: July through September 2008 T2: December 2009	604 adolescents 11-18 years at T1	Hyves.nl	Measures: Body dissatisfaction Peer appearance-related Feedback. Findings: SNS use predicted increased body dissatisfaction in both genders. SNS use predicted increased peer influence on body image via peer appearance-related feedback.
Rousseau et al. 2017 [135] Belgium	Cross-sectional and Longitudinal T1: March 2014 T2: October 2014	1840 adolescents Age: 12-19 years at T1	Facebook	Measures: The Body Dissatisfaction Subscale of the Body Attitude Test. Findings: adolescents who use Facebook in a passive manner would develop a stronger tendency to engage in social comparison on Facebook, which in turn leads to experiencing higher levels of body dissatisfaction, and vice versa
Tiggemann and Slater 2017 [136] Australia	Longitudinal T1: grade 8 and 9th T2 :2 years later	438 female adolescents Mean age 13.6 at T1	Facebook	Measures: Sociocultural Attitudes Toward Appearance Questionnaire. Objectified Body Consciousness Scale–Youth. Drive for Thinness Scale of the Eating Disorder Inventory. Findings: One aspect of Facebook use was associated with subsequent higher levels of aspects of body image concerns.

CHAPTER 4 MANUSCRIPT 2

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I am the first author on this article. I was responsible for designing the study, with guidance from my supervisors and co-authors. I performed all data analyses, created all of the tables, wrote the manuscript, submitted the final version for publication, and addressed reviewer comments.



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Heavy social media use and psychological distress among adolescents: The moderating role of sex, age, and parental support

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ABSTRACT

Background: Despite increasing evidence that social media use is associated with adolescents' mental well-being, little is known about the role of various factors in modifying the effect of this association during adolescence. This study examined the association between social media use and psychological distress among adolescents and explored whether sex, age, and parental support moderate this association.

Methods: Data came from a representative sample of middle and high school students in Ontario, Canada. Cross-sectional analyses included 6,822 students derived from the 2019 Ontario Student Drug Use and Health Survey.

Results: Our results showed that 48% of adolescents used social media for 3 h or more per day, and 43.7% had moderate to severe psychological distress, with a higher prevalence among females (54%) than males (31%). After adjustment for relevant covariates, heavy social media use (≥ 3 h/day) was associated with increased odds of severe psychological distress [odds ratio (OR): 2.01; 95% confidence interval (CI): 1.59–2.55]. The association of social media use with psychological distress was modified by age ($p < 0.05$) but not sex or parental support. The association was stronger among younger adolescents.

Conclusion: Heavy social media use is associated with higher levels of psychological distress, with younger adolescents being the most vulnerable. Longitudinal studies are recommended for future research to examine in more depth the role of sex, age, and parental support in the association between social media use and psychological distress to better determine the strength and of the association.

Keywords: social media, psychological distress, mental health, adolescents

Background

Adolescence is a critical and formative transitory period in which individuals shift from childhood to adulthood. With significant biological, developmental, and psychological changes taking place during adolescence, it is crucial to ensure that adolescents are fully supported to promote physical and mental well-being to set the stage for a healthy adulthood (1, 2). During this period of life, adolescents become more independent in making choices related to their lifestyle behaviors (3). Early adolescence involves pubertal changes that elicit substantial biological, cognitive, physical, social, and emotional changes making this a critical period for the development of mental health problems (4, 5). Furthermore, the period of late adolescence through which adolescents are transitioning to adulthood, is also considered to be a highly vulnerable period for mental health problems that can have profound effects into adulthood (6). Accordingly, it is crucial to examine how modifiable behaviors during adolescence impact mental health outcomes, in order to address them before they become rooted.

Mental health problems among adolescents have increased worldwide, with one in seven (14%) young people aged 10–19 years experiencing mental health problems (1), within which anxiety and depression make up about 43% (2) and are considered the leading causes of illness and disability for adolescents (1). Depression and anxiety are also considered risk factors for many adverse health outcomes, such as cardiovascular diseases, behavioral problems, and substance use disorder (7, 8). In addition to that, depression and anxiety can affect academic achievement and learning, and reduce quality of life. At its worst, depression can lead to suicide (1). Recent evidence suggests that girls have worse mental health outcomes such as psychological distress than boys (9–11). With mental health morbidity increasing significantly among adolescents (12), underpinning factors are still unclear, but are likely complex and influenced by many

environmental factors. Previous literature has suggested that increases in mental health problems may be associated with higher levels of social media use (13–16).

While the COVID-19 pandemic has accelerated the trend of social media use among adolescents when in-person interaction had been restricted (17–19), social media use had increased dramatically among adolescents and occupied a significant part of their daily lives even prior to the onset of the pandemic (20). Recently, the World Health Organization strongly recommended in their 2020 guidelines for physical activity and sedentary behavior that children and youth should limit the amount of recreational screen time (21). Furthermore, the Canadian 24-h movement guidelines for children and adolescents recommend limiting recreational screen time to 2 h or less for children and youth aged 5–17 years (22, 23). However, with the emergence of newer devices such as tablets and smartphones, social media was considered as one of the most used screen activities among youth, especially females (24, 25). In Canada, 86% of youth in Ontario use social media platforms every day, and more than 20% indicate they spend more than 5 h on social media daily (26). This raises concerns given that adolescence, especially at its onset, is considered a crucial time frame because it is the period at which there is an exponential increase in social media use (27) and increasing vulnerability to mental health problems (4). Accordingly, understanding the association between social media use and adolescents' mental health has become a priority.

Previous studies on social media use and adolescents' mental health provides some evidence regarding the nature of the association (13, 14, 16, 24, 28–31). However, results were mixed, resulting in an inconclusive understanding to date. Inconsistent findings could be attributed to many reasons, such as differences in research designs, populations sampled, and analytical plans. Also, while various factors of social media use and mental health have been identified in

previous research, most studies failed to examine whether this association differs by characteristics of individuals (16, 24, 32–34). For example, some studies reported sex differences in the association between social media use and mental health or performed stratified analyses by sex without statistically examining whether sex moderated the association (35–39), and in the few that considered the moderating role of sex on the relationship (13, 40, 41), results were inconsistent. Age has also been proposed as a factor that could modify the effect of social media use on mental health problems, yet, only one study examined the moderating role of age, and found that high social media use was associated with higher odds of internalizing problems among younger adolescents (42). Given the importance of the social media context during early adolescence, a period in which individuals give more values to peer acceptance, friendships, and identity exploration, early adolescents can be more vulnerable to harmful contents of social media (43, 44). In addition, recent research showed that females who use social media extensively at early ages had poorer mental health outcomes several years on (41). This suggests further examination of the role of age and sex in the association between social media use and mental health among adolescents (15, 16, 24).

In addition to the role of sex and age, research needs to better understand other factors such as the social and psychological support factors represented by the role of parents (24, 45). It has been suggested that weak parental supportiveness makes adolescents feel disconnected, so they use social media more frequently to find meaningful social interaction (45). However, very little is known about how parental support plays a role in social media use and adolescent depression and anxiety, and none of the studies examined the moderating role of parental support. Thus, considering the role of parents in this association is important and needed (24).

Since social media use is both highly prevalent among youth and a seemingly modifiable behavior, examining the variables that modify the effect of the association between social media use and psychological distress symptoms among youth is crucial to fill the knowledge gaps and inform future research and interventions. Accordingly, the objectives of this study were to (1) examine the association between social media use and psychological distress among adolescents, and (2) explore the moderating role of age, sex, and parental support on the association between social media use and psychological distress. We hypothesized that heavy social media use would be associated with psychological distress in adolescents. We also hypothesized that sex, age, and parental support would be moderators of this association with females, younger adolescents, and those who reported rare parental support being the most vulnerable for psychological distress when using social media heavily.

Design

The current study is a secondary data analysis of the 2019 Ontario Student Drug Use and Health Survey (OSDUHS) (46). This representative cross-sectional school-based survey included Ontarians in grades 7–12 from English and French public and Catholic schools ($n = 14,142$). Two hundred sixty-three schools from 47 public and Catholic school boards participated in this survey. Ethics approval was obtained from the Research Ethics Boards of the Center for Addiction and Mental Health (CAMH; 029/2016), York University (e2014-099), and 47 public and Catholic school boards' research review committees. Participation in the survey required active parental written consent and student assent. The survey was completed anonymously during school time.

Data were collected from November 2018 to June 2019. Four split ballot versions of the questionnaire were administered in classrooms in a paper booklet format (Form A and B for

Elementary Schools; Form A and B for Secondary Schools) where students completed one of two alternately distributed questionnaires in classrooms depending on the school level. Questionnaires used in elementary schools excluded certain topics (e.g., drug use screeners for problematic drug use). Form A and Form B were distributed alternatively to students in each classroom to accomplish two near-equal random samples completing each form. The overall completion rate was 59%, with reasons for not completing the survey including unreturned consents or refusal of participation (29%), and student absenteeism (12%). Further information about the survey is available elsewhere (46). For the present study, only those who completed the questionnaire with the mental health component (Form A, N = 7,617) were included.

Measures

Social media use

Students were asked to indicate how many hours they spend daily posting or browsing social media sites, such as Facebook, Twitter, and Instagram. Response options were as follows: less than 1 h a day, about 1 h a day, 2 h a day, 3–4 h a day, 5–6 h a day, 7 or more hours a day, not daily usage, do not use social media, and do not use the Internet. We created a scale variable as follows: the three latter response options represented no use of social media (coded 0), the “less than 1 h a day,” “about 1 h a day,” and “2 h a day” responses were collapsed and represented light to moderate use (coded 1), the “3–4 h a day,” “5–6 h a day,” and “seven or more hours a day” were collapsed and represented heavy use (coded 2). The cut-off was specified based on the recommended cut-off of 2 h or less for daily recreational screen time among adolescents from the Canadian sedentary behavior guidelines (22) and previous studies on similar topics (47, 48).

Psychological Distress

The Kessler Psychological Distress Scale (K-6) was used to measure the frequency of experiencing depression and anxiety in the past 4 weeks (49). Each of the six items included the following response options: “none of the time,” “a little of the time,” “some of the time,” “most of the time,” and “all of the time.” A total score ranging from 0 to 24 was created, with higher scores representing greater psychological distress. A score ranging from 0 to 7 represented no distress (coded 0), 8 to 12 represented moderate distress (coded 1), and a score of 13 and more indicated severe distress (coded 2) (50), consistent with other studies using the K6 measure (51–53). The K6 is a valid and reliable tool to measure symptoms of psychological distress among youth with a high internal consistency ($\alpha = 0.86$) (54). The internal reliability coefficient for the K-6 in this study was Cronbach’s $\alpha = 0.87$.

Potential Moderators

Sex, age, and parental support were potential moderators in our study. Sex is represented by a binary variable: females (coded 1) and males (coded 0). Age was also represented by a binary variable and grouped as “younger adolescents” (10–14 years old, coded 0) and “older adolescents” (15–20 years old, coded 1) based on early adolescence and middle and late adolescence phases reported in the literature (55). Parental support was assessed by the following question: “How often do you talk about your problems and feelings with at least one of your parents?” The response options were: “always,” “usually,” “sometimes,” “rarely,” and “never.” We collapsed the first two categories into one category that represented good parental support (coded = 0). Responses of “sometimes” (coded = 1) remained a separate category, and the last two categories were collapsed to represent poor parental support (coded = 2).

Covariates

Covariates included sex and age (if not moderators), ethnicity, subjective socioeconomic status (SES), and body mass index (BMI) z-score. Covariates were selected based on their availability in the dataset and their association with the independent and dependent variables (56–60).

Ethnicity was measured through self-identification from the following categories: White, Chinese, Filipino, South East Asian, Japanese, Korean, South Asian, West Asian, Black, Aboriginal, Latino, and Other. We dichotomized this variable as follows: White (coded 0) in a separate category, and all multiple selections on the ethnicity groups included in another category (coded 1). SES was assessed using the MacArthur Subjective Socioeconomic Status Ladder (61). Students were asked to indicate on the 1–10 rungs ladder what best described their parents' SES: "Imagine this ladder below shows how Canadian society is set up. At the top of the ladder are people who are the 'best off'—they have the most money, the most education, and the jobs that bring the most respect. At the bottom are the people who are 'worst off'—they have the least money, little education, no job or jobs that no one wants. Now think about your family. Please check off the numbered box that best shows where you think your family would be on this ladder." Rungs higher on the ladder indicate higher perceived SES. This variable was treated as a continuous variable in our analyses. We also calculated BMI (kg/m^2) from students' self-reported weight (in kilograms) and height (in meters), and we transformed it into z-scores following the reference data issued by the World Health Organization (62).

Statistical analysis

In our analysis, we used Taylor series linearization methods to account for the complexity of the sample design of the survey and to attain unbiased variances and point estimates using Stata 16.1 (Stata Corporation, College Station, TX, United States). Analyses included complete information on all variables, reducing the sample size from 7,617 to 6,822. Pearson's chi-square

tests and adjusted Wald tests were used for categorical and continuous variables, respectively, to test the statistical differences between excluded data (missing data) and those included in our analyses for all the variables. Compared to the included participants, those who were excluded were more likely to be males, aged 15–20 years, less likely to be of white ethnicity, and more likely to use social media heavily.

Participant characteristics were described by proportions and means. Correlations between all variables of interest included in the study were examined using Spearman correlation for ordinal and continuous variables and Pearson chi-square adjusted for the survey design and transformed into an F-statistic for categorical variables because of the complex sampling. Ordinal logistic regression was used to estimate the odds ratios (OR) for the psychological distress outcome with all independent variables of interest. Furthermore, crude and adjusted ordered regression models were used to examine associations between social media use and psychological distress among adolescents. Covariates included age, sex, ethnicity, subjective SES, and BMI z-score. In order to test if the associations between social media and psychological distress varied by sex, age, and parental support, two-way interactions were examined in separate models. In cases where interaction terms were significant, stratified results were presented.

Results

Sample characteristics

Table 1 provides the descriptive characteristics of the sample. About 57% of the sample were females, 58% of the students were 15 years or older, and 56% were white. About 48% of the sample used social media heavily (≥ 3 h daily). The prevalence of moderate and severe psychological distress was 23.4% and 20.3%, respectively.

Among the younger students (11–14 years), 38.7% used social media heavily, 32.6% reported rare parental support, 19.8% were moderately distressed, and 16% were severely distressed. However, among older students, 54.6% reported using social media heavily, 37.2% reported rare parental support, 26% were moderately distressed, and 23.6% were severely distressed. Regarding parental support, among those who reported having usual parental support ($N = 2,745$), 14% reported not using social media, 43.6% reported using social media moderately, and 42.4% reported heavy use of social media. Also, among the same group, 20.1% reported having moderate distress, and 11.8% reported having severe distress. However, among those who reported having rare parental support ($N = 2,410$), 11.5% reported not using social media, 34.5% reported using social media moderately, and 54% reported heavy use of social media. In addition to that, of participants who reported having rare parental support, 24.7% reported having moderate distress, and 31.3% reported having severe distress.

Bivariate analysis

Bivariate correlations for all variables of interest are shown in Table 2. The chi-square results indicate that being a male was correlated with lower psychological distress and less social media use. Being older (15–20-year-old) was correlated with higher psychological distress and more social media use. Non-white ethnicity was associated with higher psychological distress.

Spearman correlation results indicate that higher SES was associated with lower psychological distress. Also, higher psychological distress was associated with more use of social media and less parental support. Furthermore, less parental support was associated with more social media use.

Multivariable Ordinal Regression Modeling of the Association Between Social Media Use and Psychological Distress Among Adolescents Adjusted for All Variables of Interest

Results of multivariable ordinal regression analysis examining the association between social media use and psychological distress are summarized in Table 3. Heavy social media use was associated with psychological distress (OR: 1.44; 95% CI: 1.12–1.85). Also, adolescents who reported parental support was rare had higher odds of psychological distress compared to those with good parental support (OR: 2.41; 95% CI: 2.04–2.84). Adolescents who felt sometimes supported also had higher odds of psychological distress compared to those with good parental support (OR: 1.57; 95% CI: 1.31–1.87). Males were less likely than females to experience high psychological distress levels (OR: 0.41; 95% CI: 0.36–0.46).

Crude and Adjusted Multivariable Ordinal Regression Modeling with Interaction terms of the Association of Social Media Use on Psychological Distress Among Adolescents

Results of multivariable ordinal regression analysis examining the association between social media use and psychological distress with interaction terms are summarized in Table 4.

Interactions were statistically significant for age by heavy social media use for distress [Model 3 two-way interaction terms (OR: 0.54; CI: 0.33–0.90, $p < 0.05$)]. Interaction terms for sex (Model 2) and parental support (Model 4) by social media were not significant.

Our unadjusted models show that the interaction terms for parental support by heavy social media for psychological distress are significant for those who reported having parental support sometimes and those who reported rare parental support (OR: 0.51; CI: 0.27–0.94, $p < 0.05$ and OR: 0.53; CI: 0.31–0.91, $p < 0.05$, respectively). However, the moderating role of parental support became insignificant after adjusting for covariates. Thus, subsequent analyses examining the association between social media use and psychological distress were stratified by age.

Crude and Adjusted Multivariate Ordinal Regression Modeling of Social Media Use on Psychological Distress Among Adolescents Stratified by Age

Results of the multivariable ordinal regression analysis examining the association between social media use stratified by age are presented in Table 5. After adjusting for covariates, younger students who use social media heavily had higher odds of psychological distress (OR = 2.32; CI: 1.67–3.21).

Discussion

This study examined the association between social media use and psychological distress in a large and representative sample of adolescents in Ontario (Canada) and explored whether sex, age, and parental support would moderate this relationship. Heavy use of social media was moderately associated with higher levels of psychological distress among adolescents, and the effect of the association was modified by age, but not sex or parental support.

Even though the cross-sectional design of this study cannot determine the direction of the associations, our findings regarding the positive correlation between time spent on social media and high levels of psychological distress align with previous cross-sectional (42, 63–67), experimental and prospective studies (68–71), and reviews (24, 34, 73, 74), which provided implicit causation regarding the direction of the association that moves from heavy social media use to mental health problems. Numerous mechanisms could contribute to the direction and nature of the relationship between social media use and depression and anxiety. Adolescents involved in high levels of social media may experience poor quality of sleep, which plays a mediating role in the pathway to depression and anxiety (75, 76). Furthermore, time spent on social media may increase the risk of exposure to unrealistic societal ideal images and an over representation of positive experiences and posts (77, 78). Thus, adolescents who make frequent unfavorable social comparisons with other users are more likely to experience negative feelings about body image and encounter envy, guilt, and regret (66, 79). These feelings can be

detrimental to their self-esteem and have been identified as significant contributors to internalizing problems such as depression and anxiety (25, 79–83). Also, more time spent on social media increases the chances of experiencing cyberbullying, which has strong ties with depressive symptoms (47, 84). In addition, the displacement theory posits the lack of social and in-person interaction and family communication displaced by frequent time on social media can contribute to symptoms of depression and anxiety (85). These associations between social media and mental distress should be explored prospectively to help determine the temporality of the associations identified.

This study also found that younger adolescents have higher odds of distress when using social media heavily than their older counterparts (42). Our results could be explained by early adolescence, as a vulnerable stage for mental health issues (4, 5, 86, 87) in which social media was indicated as a potential risk factor (88, 89). This phase involves significant pubertal changes, and biological, neurological, and social transformation (5, 90, 91), in which adolescents start to experience an increase in self-consciousness, inner conflict, stress, and disorientation (91). At the social and contextual level, peer relationships become more central to self-worth, and family can become disoriented as youths strive for independence, and this may spark greater reliance on social media as a source of social support, autonomy, seeking peers' feedback, and exploring identity (43, 92–94). As such, early adolescence is distinguished by a significant increase in internalizing and externalizing problems (4, 5, 86, 87). Young adolescents' brain regions that are engaged in social interaction endure extensive changes, which make them vulnerable to being impacted by media use that contributes to low self-esteem, upward social comparison, emotion-loaded communications (25, 92), and cyberbullying which can all trigger mental health symptoms (37, 95–97). In addition to that, heavy use of social media can interfere with the time

adolescents use to do other beneficial activities like in-person interaction or physical activity which can increase their chance to experience mental health issues (14, 98).

While males were less likely than females to experience psychological distress, and tend to use social media less heavily, no moderating role of sex was found in the extent to which social media use subgroups are associated with psychological distress, aligning with previous work (40). These results may be attributed to the way social media use was measured, which only focused on the social media use time and could not represent how social media was used.

However, our study showed that females spent more time on social media and reported greater psychological distress symptoms than males, results in line with previous studies (4, 10, 40, 42, 88, 99–101). We hypothesized that females would be more negatively affected psychologically by greater social media use because they are more emotionally and interested in friendships, and body appearance (102, 103), and tend to be more involved in self-disclosure (102) and are more likely than males to experience low emotional self-efficacy and lack of negative emotional management (104, 105). This might make females more vulnerable to experience social media-related upward social comparison (106), cyberbullying (36, 47), and body dissatisfaction (89), all factors known to be linked with depression and anxiety.

The finding that adjustment for SES and sex reduced the moderating effect of parental support to non-significance suggests that parental support's role in the association between social media use and psychological distress among adolescents is impacted by sex and SES. This supports the need for future longitudinal studies to evaluate further these factors and other unexamined factors that may underlie the moderating effects of parental support in the social media–mental health relationship. In further consideration of our findings, the simplicity of the parental support variable, which only measured to what extent adolescents discuss their problems with parents,

could be one reason why parental support did not moderate the association after adjustment for such a finding. Research has indicated that the role of parents is indeed very important and includes multiple levels of involvement, in addition to having their children discuss their problems with them (24, 45). Parents can be both gatekeepers (107) and influencers of their adolescents' social media use experience especially during early adolescence (108–110).

On the other hand, our results showed that those with rare parental support used social media more frequently and had higher odds for psychological distress, consistent with previous work. It has been known that parents play a significant role in their adolescents' social media use and behavior, which can impact mental well-being (111–114). Adolescents who reported having unsupportive parents felt disconnected, and used social media more frequently to find meaningful social interaction (45). That being said, in-person communication and support offline from parents are all factors that can shape adolescents' media use and experience, which in turn impact mental well-being. Therefore, we highly recommend that future research investigate through large longitudinal studies the role of parental support, taking into consideration the impact of other important covariates in this association.

This study has several limitations worth mentioning. Our findings are based on cross-sectional data; thus, the bidirectional relationship between social media use and psychological distress could not be determined. Therefore, it is still unclear whether social media experiences shape mental health problems or vice versa. For example, those in distress may seek comfort, support or satisfy other psychological needs through social media (115). Also, data measured only the time spent on social media and not the quality of the time, which is a critical factor (29, 37). In addition, self-reported instruments are subject to inaccuracies and residual confounding by

unmeasured variables is always possible in observational studies (e.g., medication use and history of mental health problems). Finally, as in all large studies, missing values are inevitable, and we had 10%. Case analyses showed that those with missing data were more likely to be males, to use social media more heavily and were more distressed, so it is uncertain how these missing cases would have impacted the observed associations had they been included in the analysis.

The results of our study may offer valuable implications for tailored preventative interventions to help minimize heavy and unhealthy social media use. As our results indicated, younger adolescents are more likely to experience psychological distress when using social media heavily; as such, it is important to educate parents and caregivers to help their young children and adolescents to decrease their time on social media and promote appropriate behavioral regulation. Also, discussions with adolescents about their social media behavior, the risks and benefits of platforms, and promoting safe and effective social media strategies are warranted (116, 117). Furthermore, longitudinal studies that capture specific types, quality, and context of social media use are highly recommended to better understand the strength and the directional impact of the relationship between social media and mental health.

Conclusion

Our results show that heavy social media use is moderately associated with psychological distress among adolescents, and this association is modified by age, with younger adolescents being more vulnerable. As such, future studies would benefit from longitudinal designs with larger, more representative samples that examine the bidirectional association and investigate in more depth the role of sex, age, and parental support. Furthermore, future studies that investigate the mechanisms of this association taking into consideration the quality and quantity of social

media use, are warranted. Addressing these points will help to design media literacy programs, policies, and approaches for parents, mental health providers, teachers, and adolescents to promote mental health and educate adolescents, especially younger ones, on the negative psychological impacts of heavy social media consumption.

Data availability statement

The datasets presented in this research article cannot be made available in the manuscript, supplemental files, or a public repository due to the Centre for Addiction and Mental Health's and The Ontario Public and Catholic School Board's institutional Research Ethics Board agreements. Requests to access the datasets should be directed to the Centre for Addiction and Mental Health at info@camh.ca.

Ethics statement

The studies involving human participants were reviewed and approved by the Research Ethics Boards of the Centre for Addiction and Mental Health (CAMH), York University, and 47 public and Catholic school boards' research review committees. Written informed consent to participate in this study was provided by the participants' legal guardian.

Author contributions

FM, J-PC, and GG participated in the conception of the study. FM and HS-K conducted statistical analyses. FM wrote the first version of the manuscript. J-PC and GG substantially contributed to the methods and interpretation of results. J-PC, GG, HS-K, IC, SL, and HH critically reviewed the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

1. WHO Adolescent mental health. (2019). Available at: <https://www.who.int/news-room/fact-sheets/detail/adolescent-mental-health> (Accessed November 20, 2019).

[Google Scholar](#)

2. UNICEF. *On My Mind: Promoting, Protecting and Caring for Children's Mental Health*. New York, NY: UNICEF (2021).

[Google Scholar](#)

3. Spear, HJ, and Kulbok, P. Autonomy and adolescence: a concept analysis. *Public Health Nurs Boston Mass.* (2004) 21:144–52. doi: 10.1111/j.0737-1209.2004.021208.x

[CrossRef Full Text](#) | [Google Scholar](#)

4. McLaughlin, KA, and King, K. Developmental trajectories of anxiety and depression in early adolescence. *J Abnorm Child Psychol.* (2015) 43:311–23. doi: 10.1007/s10802-014-9898-1

[CrossRef Full Text](#) | [Google Scholar](#)

5. Tottenham, N, and Galván, A. Stress and the adolescent brain: amygdala-prefrontal cortex circuitry and ventral striatum as developmental targets. *Neurosci Biobehav Rev.* (2016) 70:217–27. doi: 10.1016/j.neubiorev.2016.07.030

[CrossRef Full Text](#) | [Google Scholar](#)

6. Kessler, RC, Berglund, P, Demler, O, Jin, R, Merikangas, KR, and Walters, EE. Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Arch Gen Psychiatry.* (2005) 62:593–602. doi: 10.1001/archpsyc.62.6.593

[CrossRef Full Text](#) | [Google Scholar](#)

7. Scott, KM. Depression, anxiety and incident cardiometabolic diseases. *Curr Opin Psychiatry*. (2014) 27:289–93. doi: 10.1097/YCO.0000000000000067

[CrossRef Full Text](#) | [Google Scholar](#)

8. Wolitzky-Taylor, K, Bobova, L, Zinbarg, RE, Mineka, S, and Craske, MG. Longitudinal investigation of the impact of anxiety and mood disorders in adolescence on subsequent substance use disorder onset and vice versa. *Addict Behav*. (2012) 37:982–5. doi: 10.1016/j.addbeh.2012.03.026

[CrossRef Full Text](#) | [Google Scholar](#)

9. Campbell, OLK, Bann, D, and Patalay, P. The gender gap in adolescent mental health: a cross-national investigation of 566,829 adolescents across 73 countries. *SSM Popul Health*. (2021) 13:100742. doi: 10.1016/j.ssmph.2021.100742

[CrossRef Full Text](#) | [Google Scholar](#)

10. Albert, PR. Why is depression more prevalent in women? *J Psychiatry Neurosci*. (2015) 40:219–21. doi: 10.1503/jpn.150205

[CrossRef Full Text](#) | [Google Scholar](#)

11. Van Droogenbroeck, F, Spruyt, B, and Keppens, G. Gender differences in mental health problems among adolescents and the role of social support: results from the Belgian health interview surveys 2008 and 2013. *BMC Psychiatry*. (2018) 18:6. doi: 10.1186/s12888-018-1591-4

[CrossRef Full Text](#) | [Google Scholar](#)

12. Twenge, JM, Cooper, AB, Joiner, TE, Duffy, ME, and Binau, SG. Age, period, and cohort trends in mood disorder indicators and suicide-related outcomes in a nationally representative dataset, 2005-2017. *J Abnorm Psychol*. (2019) 128:185–99. doi: 10.1037/abn0000410

[CrossRef Full Text](#) | [Google Scholar](#)

13. Riehm, KE, Feder, KA, Tormohlen, KN, Crum, RM, Young, AS, Green, KM, et al. Associations between time spent using social media and internalizing and externalizing problems among US youth. *JAMA Psychiat.* (2019) 76:1266–73. doi: 10.1001/jamapsychiatry.2019.2325

[CrossRef Full Text](#) | [Google Scholar](#)

14. Twenge, JM, Martin, GN, and Campbell, WK. Decreases in psychological well-being among American adolescents after 2012 and links to screen time during the rise of smartphone technology. *Emot Wash DC.* (2018) 18:765–80. doi: 10.1037/emo0000403

[CrossRef Full Text](#) | [Google Scholar](#)

15. Ivie, EJ, Pettitt, A, Moses, LJ, and Allen, NB. A meta-analysis of the association between adolescent social media use and depressive symptoms. *J Affect Disord.* (2020) 275:165–74. doi: 10.1016/j.jad.2020.06.014

[CrossRef Full Text](#) | [Google Scholar](#)

16. Keles, B, McCrae, N, and Grealish, A. A systematic review: the influence of social media on depression, anxiety and psychological distress in adolescents. *Int J Adolesc Youth.* (2020) 25:79–93. doi: 10.1080/02673843.2019.1590851

[CrossRef Full Text](#) | [Google Scholar](#)

17. Nilsson, A, Rosendahl, I, and Jayaram-Lindström, N. Gaming and social media use among adolescents in the midst of the COVID-19 pandemic. *Nordic Stud Alcohol Drugs.* (2022) 39:347–61. doi: 10.1177/14550725221074997

[CrossRef Full Text](#) | [Google Scholar](#)

18. Zhang, S, Liu, M, Li, Y, and Chung, JE. Teens' social media engagement during the COVID-19 pandemic: a time series examination of posting and emotion on Reddit. *Int J Environ Res Public Health*. (2021) 18:10079. doi: 10.3390/ijerph181910079

[CrossRef Full Text](#) | [Google Scholar](#)

19. Wiederhold, BK. Social media use during social distancing. *Cyberpsychol Behav Soc Netw*. (2020) 23:275–6. doi: 10.1089/cyber.2020.29181.bkw

[CrossRef Full Text](#) | [Google Scholar](#)

20. Rideout, V, and Robb, M. *Social Media, Social Life: Teens Reveal Their Experiences*. San Francisco, CA, US: Common Sense Media (2018).

[Google Scholar](#)

21. World Health Organization WHO guidelines on physical activity and sedentary behavior. (2020) Available at: <https://apps.who.int/iris/bitstream/handle/10665/336656/9789240015128-eng.pdf?sequence=1&isAllowed=y> (Accessed December 3, 2020).

[Google Scholar](#)

22. Tremblay, MS, Carson, V, Chaput, J-P, Connor Gorber, S, Dinh, T, Duggan, M, et al. Canadian 24-hour movement guidelines for children and youth: an integration of physical activity, sedentary behavior, and sleep. *Appl Physiol Nutr Metab Physiol*. (2016) 41:S311–27. doi: 10.1139/apnm-2016-0151

[CrossRef Full Text](#) | [Google Scholar](#)

23. Tremblay, MS, LeBlanc, AG, Carson, V, Choquette, L, Connor Gorber, S, Dillman, C, et al. Canadian physical activity guidelines for the early years (aged 0–4 years). *Appl Physiol Nutr Metab*. (2012) 37:345–56. doi: 10.1139/h2012-018

[CrossRef Full Text](#) | [Google Scholar](#)

24. Vidal, C, Lhaksampa, T, Miller, L, and Platt, R. Social media use and depression in adolescents: a scoping review. *Int Rev Psychiatry Abingdon Engl.* (2020) 32:235–53. doi: 10.1080/09540261.2020.1720623

[CrossRef Full Text](#) | [Google Scholar](#)

25. Nesi, J, and Prinstein, MJ. Using social Media for Social Comparison and Feedback-Seeking: gender and popularity moderate associations with depressive symptoms. *J Abnorm Child Psychol.* (2015) 43:1427–38. doi: 10.1007/s10802-015-0020-0

[CrossRef Full Text](#) | [Google Scholar](#)

26. Boak, A, Hamilton, HA, Adlaf, EM, Beitchman, J, Wolfe, D, and Mann, RE. The mental health and well-being of Ontario students, 1991–2017: Detailed findings from the Ontario student drug use and health survey (OSDUHS). (2018)

[Google Scholar](#)

27. OFCOM. *Children and Parents: Media Use and Attitudes* London, England: OFCOM (2021).

[Google Scholar](#)

28. Thorisdottir, IE, Sigurvinsdottir, R, Kristjansson, AL, Allegrante, JP, Lilly, CL, and Sigfusdottir, ID. Longitudinal association between social media use and psychological distress among adolescents. *Prev Med.* (2020) 141:106270. doi: 10.1016/j.ypmed.2020.106270

[CrossRef Full Text](#) | [Google Scholar](#)

29. Thorisdottir, IE, Sigurvinsdottir, R, Asgeirsdottir, BB, Allegrante, JP, and Sigfusdottir, ID. Active and passive social media use and symptoms of anxiety and depressed mood among Icelandic adolescents. *Cyberpsychol Behav Soc Netw.* (2019) 22:535–42. doi: 10.1089/cyber.2019.0079

[CrossRef Full Text](#) | [Google Scholar](#)

30. Heffer, T, Good, M, Daly, O, MacDonell, E, and Willoughby, T. The longitudinal association between social-media use and depressive symptoms among adolescents and Young adults: an empirical reply to Twenge et al. (2018). *Clin Psychol Sci.* (2019) 7:462–70. doi: 10.1177/2167702618812727

[CrossRef Full Text](#) | [Google Scholar](#)

31. Jensen, M, George, MJ, Russell, MR, and Odgers, CL. Young adolescents' digital technology use and mental health symptoms: little evidence of longitudinal or daily linkages. *Clin Psychol Sci.* (2019) 7:1416–33. doi: 10.1177/2167702619859336

[CrossRef Full Text](#) | [Google Scholar](#)

32. McCrae, N, Gettings, S, and Purssell, E. Social media and depressive symptoms in childhood and adolescence: a systematic review. *Adolesc Res Rev.* (2017) 2:315–30. doi: 10.1007/s40894-017-0053-4

[CrossRef Full Text](#) | [Google Scholar](#)

33. Seabrook, EM, Kern, ML, and Rickard, NS. Social networking sites, depression, and anxiety: a systematic review. *JMIR Ment Health.* (2016) 3:e5842. doi: 10.2196/mental.5842

[CrossRef Full Text](#) | [Google Scholar](#)

34. Huang, C. Time spent on social network sites and psychological well-being: a meta-analysis. *CyberPsychol Behav Soc Netw.* (2017) 20:346–54. doi: 10.1089/cyber.2016.0758

[CrossRef Full Text](#) | [Google Scholar](#)

35. Boers, E, Afzali, MH, and Conrod, P. Temporal associations of screen time and anxiety symptoms among adolescents. *Can J Psychiatr.* (2020) 65:206–8. doi: 10.1177/0706743719885486

[CrossRef Full Text](#) | [Google Scholar](#)

36. Kim, S, Kimber, M, Boyle, MH, and Georgiades, K. Sex differences in the association between cyberbullying victimization and mental health, substance use, and suicidal ideation in adolescents. *Can J Psychiatr Rev Can Psychiatr*. (2019) 64:126–35. doi: 10.1177/0706743718777397

[CrossRef Full Text](#) | [Google Scholar](#)

37. Frison, E, and Eggermont, S. Exploring the relationships between different types of Facebook use, perceived online social support, and adolescents' depressed mood. *Soc Sci Comput Rev*. (2015) 34:153–71. doi: 10.1177/0894439314567449

[CrossRef Full Text](#) | [Google Scholar](#)

38. Banjanin, N, Banjanin, N, Dimitrijevic, I, and Pantic, I. Relationship between internet use and depression: focus on physiological mood oscillations, social networking and online addictive behavior. *Comput Hum Behav*. (2015) 43:308–12. doi: 10.1016/j.chb.2014.11.013

[CrossRef Full Text](#) | [Google Scholar](#)

39. Barry, C, Sidoti, C, Briggs, S, Reiter, S, and Lindsey, R. Adolescent social media use and mental health from adolescent and parent perspectives. *J Adolesc*. (2017) 61:1–11. doi: 10.1016/j.adolescence.2017.08.005

[CrossRef Full Text](#) | [Google Scholar](#)

40. Kelly, Y, Zilanawala, A, Booker, C, and Sacker, A. Social media use and adolescent mental health: findings from the UK millennium cohort study. *EClinicalMedicine*. (2018) 6:59–68. doi: 10.1016/j.eclinm.2018.12.005

[CrossRef Full Text](#) | [Google Scholar](#)

41. Booker, CL, Kelly, YJ, and Sacker, A. Gender differences in the associations between age trends of social media interaction and well-being among 10-15 year olds in the UK. *BMC Public Health*. (2018) 18:321. doi: 10.1186/s12889-018-5220-4

[CrossRef Full Text](#) | [Google Scholar](#)

42. Tsitsika, AK, Tzavela, EC, Janikian, M, Ólafsson, K, Iordache, A, Schoenmakers, TM, et al. Online social networking in adolescence: patterns of use in six European countries and links with psychosocial functioning. *J Adolesc Health Off Publ Soc Adolesc Med*. (2014) 55:141–7. doi: 10.1016/j.jadohealth.2013.11.010

[CrossRef Full Text](#) | [Google Scholar](#)

43. Gerwin, RL, Kaliebe, K, and Daigle, M. The interplay between digital media use and development. *Child Adolesc Psychiatr Clin N Am*. (2018) 27:345–55. doi: 10.1016/j.chc.2017.11.002

[CrossRef Full Text](#) | [Google Scholar](#)

44. Nesi, J, Miller, AB, and Prinstein, MJ. Adolescents' depressive symptoms and subsequent technology-based interpersonal behaviors: a multi-wave study. *J Appl Dev Psychol*. (2017) 51:12–9. doi: 10.1016/j.appdev.2017.02.002

[CrossRef Full Text](#) | [Google Scholar](#)

45. Hwang, J, and Toma, CL. The role of mental well-being and perceived parental supportiveness in adolescents' problematic internet use: moderation analysis. *JMIR Ment Health*. (2021) 8:e26203. doi: 10.2196/26203

[CrossRef Full Text](#) | [Google Scholar](#)

46. Boak, A, Hamilton, HA, Adlaf, EM, and Mann, RE. Drug use among Ontario students, 1977–2019: Detailed findings from the Ontario student drug use and health survey. (2019)

[Google Scholar](#)

47. Sampasa-Kanyinga, H, and Hamilton, HA. Social networking sites and mental health problems in adolescents: the mediating role of cyberbullying victimization. *Eur Psychiatry J Assoc Eur Psychiatr.* (2015) 30:1021–7. doi: 10.1016/j.eurpsy.2015.09.011

[CrossRef Full Text](#) | [Google Scholar](#)

48. Sampasa-Kanyinga, H. Link to external site this link will open in a new window, Chaput J-P, Hamilton HA. Social media use, school connectedness, and academic performance among adolescents. *J Prim Prev N Y.* (2019) 40:189–211. doi: 10.1007/s10935-019-00543-6

[CrossRef Full Text](#) | [Google Scholar](#)

49. Kessler, RC, Andrews, G, Colpe, LJ, Hiripi, E, Mroczek, DK, Normand, SLT, et al. Short screening scales to monitor population prevalences and trends in non-specific psychological distress. *Psychol Med.* (2002) 32:959–76. doi: 10.1017/s0033291702006074

[CrossRef Full Text](#) | [Google Scholar](#)

50. Yiengprugsawan, V, Kelly, M, and Tawatsupa, B. Kessler Psychological Distress Scale In: AC Michalos, editor. *Encyclopedia of Quality of Life and Well-Being Research.* Dordrecht: Springer Netherlands (2014). 3469–70.

[Google Scholar](#)

51. Prochaska, J, Sung, H-Y, Max, W, Shi, Y, and Ong, M. Validity study of the K6 scale as a measure of moderate mental distress based on mental health treatment need and utilization. *Int J Methods Psychiatr Res.* (2012) 21:88–97. doi: 10.1002/mpr.1349

[CrossRef Full Text](#) | [Google Scholar](#)

52. Okoro, CA, Dhingra, SS, and Li, C. A triple play: psychological distress, physical comorbidities, and access and use of health services among U.S. adults with disabilities. *J Health Care Poor Underserved*. (2014) 25:814–36. doi: 10.1353/hpu.2014.0103

[CrossRef Full Text](#) | [Google Scholar](#)

53. Frajerman, A, Rolland, F, Falissard, B, Bertschy, G, Diquet, B, and Marra, D. COVID-19 pandemic's impact on French health students: a cross-sectional study during the third wave. *J Affect Disord*. (2022) 311:165–72. doi: 10.1016/j.jad.2022.05.087

[CrossRef Full Text](#) | [Google Scholar](#)

54. Ferro, MA. The psychometric properties of the Kessler psychological distress scale (K6) in an epidemiological sample of Canadian youth. *Can J Psychiatr*. (2019) 64:647–57. doi: 10.1177/0706743718818414

[CrossRef Full Text](#) | [Google Scholar](#)

55. Kipke, MD. *Risks and Opportunities: Synthesis of Studies on Adolescence*. Washington, D.C.: National Academies Press (1999).

[Google Scholar](#)

56. Fang, K, Mu, M, Liu, K, and He, Y. Screen time and childhood overweight/obesity: a systematic review and meta-analysis. *Child Care Health Dev*. (2019) 45:744–53. doi: 10.1111/cch.12701

[CrossRef Full Text](#) | [Google Scholar](#)

57. Mazur, A, Caroli, M, Radziewicz-Winnicki, I, Nowicka, P, Weghuber, D, Neubauer, D, et al. Reviewing and addressing the link between mass media and the increase in obesity among European children: the European academy of Paediatrics (EAP) and the European childhood obesity group (ECOG) consensus statement. *Acta Paediatr*. (2018) 107:568–76. doi: 10.1111/apa.14136

[CrossRef Full Text](#) | [Google Scholar](#)

58. Kinge, JM, Øverland, S, Flatø, M, Dieleman, J, Røgeberg, O, Magnus, MC, et al. Parental income and mental disorders in children and adolescents: prospective register-based study. *Int J Epidemiol.* (2021) 50:1615–27. doi: 10.1093/ije/dyab066

[CrossRef Full Text](#) | [Google Scholar](#)

59. van Vuuren, CL, Wachter, GG, Veenstra, R, Rijnhart, JJM, van der Wal, MF, Chinapaw, MJM, et al. Associations between overweight and mental health problems among adolescents, and the mediating role of victimization. *BMC Public Health.* (2019) 19:612. doi: 10.1186/s12889-019-6832-z

[CrossRef Full Text](#) | [Google Scholar](#)

60. Silva, M, Loureiro, A, and Cardoso, G. Social determinants of mental health: a review of the evidence. *Eur J Psychiatry.* (2016) 30:259–92.

[Google Scholar](#)

61. Goodman, E, Adler, NE, Kawachi, I, Frazier, AL, Huang, B, and Colditz, GA. Adolescents' perceptions of social status: development and evaluation of a new indicator. *Pediatrics.* (2001) 108:E31. doi: 10.1542/peds.108.2.e31

[CrossRef Full Text](#) | [Google Scholar](#)

62. World Health Organization WHO Anthro and Macros—Version 3.2.2 2011. Geneva, Switzerland. Available at: <https://www.nutritioncluster.net/node/4825> (Accessed February 9, 2022).

[Google Scholar](#)

63. Oberst, U, Wegmann, E, Stodt, B, Brand, M, and Chamarro, A. Negative consequences from heavy social networking in adolescents: the mediating role of fear of missing out. *J Adolesc.* (2017) 55:51–60. doi: 10.1016/j.adolescence.2016.12.008

[CrossRef Full Text](#) | [Google Scholar](#)

64. Woods, HC, and Scott, H. #Sleepyteens: social media use in adolescence is associated with poor sleep quality, anxiety, depression and low self-esteem. *J Adolesc.* (2016) 51:41–9. doi: 10.1016/j.adolescence.2016.05.008

[CrossRef Full Text](#) | [Google Scholar](#)

65. Akkın Gürbüz, HG, Demir, T, Gökalp Özcan, B, Kadak, MT, and Poyraz, BÇ. Use of social network sites among depressed adolescents. *Behav Inform Technol.* (2017) 36:517–23. doi: 10.1080/0144929X.2016.1262898

[CrossRef Full Text](#) | [Google Scholar](#)

66. Marengo, D, Longobardi, C, Fabris, MA, and Settanni, M. Highly-visual social media and internalizing symptoms in adolescence: the mediating role of body image concerns. *Comput Hum Behav.* (2018) 82:63–9. doi: 10.1016/j.chb.2018.01.003

[CrossRef Full Text](#) | [Google Scholar](#)

67. Twenge, JM, and Martin, GN. Gender differences in associations between digital media use and psychological well-being: evidence from three large datasets. *J Adolesc.* (2020) 79:91–102. doi: 10.1016/j.adolescence.2019.12.018

[CrossRef Full Text](#) | [Google Scholar](#)

68. Hunt, MG, Marx, R, Lipson, C, and Young, J. No more FOMO: limiting social media decreases loneliness and depression. *J Soc Clin Psychol.* (2018) 37:751–68. doi: 10.1521/jscp.2018.37.10.751

[CrossRef Full Text](#) | [Google Scholar](#)

69. Murray, M, Maras, D, and Goldfield, GS. Excessive Time on Social Networking Sites and Disordered Eating Behaviors Among Undergraduate Students: Appearance and Weight Esteem as Mediating Pathways. *Cyberpsychol Behav Soc Netw.* (2016) 19:709–715. doi: 10.1089/cyber.2016.0384

[CrossRef Full Text](#) | [Google Scholar](#)

70. Thai, H, Davis, CG, Mahboob, W, Perry, S, Adams, A, and Goldfield, GS. *Reducing Social Media Use Improves Appearance and Weight Esteem in Youth with Emotional Distress*. Washington, DC: Psychology of Popular Media (2023).

[Google Scholar](#)

71. Thai, H, Davis, C, Stewart, N, Gunnell, K, and Goldfield, GS. The effects of reducing social media use on body esteem among transitional-aged youth. *J Soc Clin Psychol.* (2021) 40:481–507. doi: 10.1521/jscp.2021.40.6.481

[CrossRef Full Text](#) | [Google Scholar](#)

72. Mougharbel, F, and Goldfield, GS. Psychological correlates of sedentary screen time behavior among children and adolescents: a narrative review. *Curr Obes Rep.* (2020) 9:493–511. doi: 10.1007/s13679-020-00401-1

[CrossRef Full Text](#) | [Google Scholar](#)

73. Schønning, V, Hjetland, GJ, Aarø, LE, and Skogen, JC. Social media use and mental health and well-being among adolescents—a scoping review. *Front Psychol.* (2020) 11:1949. doi: 10.3389/fpsyg.2020.01949

[CrossRef Full Text](#) | [Google Scholar](#)

74. Yang, Q, Liu, J, and Rui, J. Association between social network sites use and mental illness: a meta-analysis. *Cyberpsychol J Psychosoc Res Cyberspace.* (2022) 16. doi: 10.5817/CP2022-1-1

[CrossRef Full Text](#) | [Google Scholar](#)

75. Li, X, Buxton, OM, Lee, S, Chang, A-M, Berger, LM, and Hale, L. Sleep mediates the association between adolescent screen time and depressive symptoms. *Sleep Med.* (2019) 57:51–60. doi: 10.1016/j.sleep.2019.01.029

[CrossRef Full Text](#) | [Google Scholar](#)

76. Sampasa-Kanyinga, H, Chaput, J-P, Hamilton, HA, and Colman, I. Bullying involvement, psychological distress, and short sleep duration among adolescents. *Soc Psychiatry Psychiatr Epidemiol.* (2018) 53:1371–80. doi: 10.1007/s00127-018-1590-2

[CrossRef Full Text](#) | [Google Scholar](#)

77. Vogel, EA, and Rose, JP. Self-reflection and interpersonal connection: making the most of self-presentation on social media. *Transl Issues Psychol Sci.* (2016) 2:294–302. doi: 10.1037/tps0000076

[CrossRef Full Text](#) | [Google Scholar](#)

78. Pera, A. Psychopathological processes involved in social comparison, depression, and envy on Facebook. *Front Psychol.* (2018) 9:22. doi: 10.3389/fpsyg.2018.00022

[CrossRef Full Text](#) | [Google Scholar](#)

79. Blomfield Neira, CJ, and Barber, BL. Social networking site use: linked to adolescents' social self-concept, self-esteem, and depressed mood. *Aust J Psychol.* (2014) 66:56–64. doi: 10.1111/ajpy.12034

[CrossRef Full Text](#) | [Google Scholar](#)

80. McCarthy, PA, and Morina, N. Exploring the association of social comparison with depression and anxiety: a systematic review and meta-analysis. *Clin Psychol Psychother.* (2020) 27:640–71. doi: 10.1002/cpp.2452

[CrossRef Full Text](#) | [Google Scholar](#)

81. Paxton, SJ, Neumark-Sztainer, D, Hannan, PJ, and Eisenberg, ME. Body dissatisfaction prospectively predicts depressive mood and low self-esteem in adolescent girls and boys. *J Clin Child Adolesc Psychol Off J Soc Clin Child Adolesc Psychol Am Psychol Assoc Div.* (2006) 53:539–49. doi: 10.1207/s15374424jccp3504_5

[CrossRef Full Text](#) | [Google Scholar](#)

82. Shin, NY, and Shin, MS. Body dissatisfaction, self-esteem, and depression in obese Korean children. *J Pediatr.* (2008) 152:502–6. doi: 10.1016/j.jpeds.2007.09.020

[CrossRef Full Text](#) | [Google Scholar](#)

83. Steg, L, Keizer, K, Buunk, AP, and Rothengatter, T. *Applied Social Psychology*. Cambridge, United Kingdom: Cambridge University Press (2017).

[Google Scholar](#)

84. Bottino, SMB, Bottino, CMC, Regina, CG, Correia, AVL, and Ribeiro, WS. Cyberbullying and adolescent mental health: systematic review. *Cad Saude Publ.* (2015) 31:463–75. doi: 10.1590/0102-311x00036114

[CrossRef Full Text](#) | [Google Scholar](#)

85. Hoge, E, Bickham, D, and Cantor, J. Digital media, anxiety, and depression in children. *Pediatrics.* (2017) 140:S76–80. doi: 10.1542/peds.2016-1758G

[CrossRef Full Text](#) | [Google Scholar](#)

86. Petersen, IT, Bates, JE, Dodge, KA, Lansford, JE, and Pettit, GS. Describing and predicting developmental profiles of externalizing problems from childhood to adulthood. *Dev Psychopathol.* (2015) 27:791–818. doi: 10.1017/S0954579414000789

[CrossRef Full Text](#) | [Google Scholar](#)

87. Magis-Weinberg, L, Ballonoff Suleiman, A, and Dahl, RE. Context, development, and digital media: implications for very Young adolescents in LMICs. *Front Psychol.* (2021) 12:632713. doi: 10.3389/fpsyg.2021.632713

[CrossRef Full Text](#) | [Google Scholar](#)

88. Calandri, E, Graziano, F, and Rollé, L. Social media, depressive symptoms and well-being in early adolescence. The moderating role of emotional self-efficacy and gender. *Front Psychol.* (2021) 12:660740. doi: 10.3389/fpsyg.2021.660740

[CrossRef Full Text](#) | [Google Scholar](#)

89. Charmaraman, L, Richer, AM, Liu, C, Lynch, AD, and Moreno, MA. Early adolescent social media-related body dissatisfaction: associations with depressive symptoms, social anxiety, peers, and celebrities. *J Dev Behav Pediatr JDBP.* (2021) 42:401–7. doi: 10.1097/DBP.0000000000000911

[CrossRef Full Text](#) | [Google Scholar](#)

90. Dahl, RE, Allen, NB, Wilbrecht, L, and Suleiman, AB. Importance of investing in adolescence from a developmental science perspective. *Nature.* (2018) 554:441–50. doi: 10.1038/nature25770

[CrossRef Full Text](#) | [Google Scholar](#)

91. Brinthaup, T, and Lipka, R. *Understanding Early Adolescent Self and Identity: Applications and Interventions.* (2002) Albany, New York: Suny Press.

[Google Scholar](#)

92. Crone, EA, and Konijn, EA. Media use and brain development during adolescence. *Nat Commun.* (2018) 9:9. doi: 10.1038/s41467-018-03126-x

[CrossRef Full Text](#) | [Google Scholar](#)

93. Somerville, LH. Special issue on the teenage brain: sensitivity to social evaluation. *Curr Dir Psychol Sci.* (2013) 22:121–7. doi: 10.1177/0963721413476512

[CrossRef Full Text](#) | [Google Scholar](#)

94. Fitton, VA, Ahmedani, BK, Harold, RD, and Shifflet, ED. The role of technology on Young adolescent development: implications for policy, research and practice. *Child Adolesc Soc Work J.* (2013) 30:399–413. doi: 10.1007/s10560-013-0296-2

[CrossRef Full Text](#) | [Google Scholar](#)

95. Camerini, A-L, Marciano, L, Carrara, A, and Schulz, PJ. Cyberbullying perpetration and victimization among children and adolescents: a systematic review of longitudinal studies. *Telematics Inform.* (2020) 49:101362. doi: 10.1016/j.tele.2020.101362

[CrossRef Full Text](#) | [Google Scholar](#)

96. Hamm, MP, Newton, AS, Chisholm, A, Shulhan, J, Milne, A, Sundar, P, et al. Prevalence and effect of cyberbullying on children and Young people: a scoping review of social media studies. *JAMA Pediatr.* (2015) 169:770–7. doi: 10.1001/jamapediatrics.2015.0944

[CrossRef Full Text](#) | [Google Scholar](#)

97. Nesi, J. The impact of social media on youth mental health: challenges and opportunities. *N C Med J.* (2020) 81:116–21. doi: 10.18043/ncm.81.2.116

[CrossRef Full Text](#) | [Google Scholar](#)

98. Rutter, LA, Thompson, HM, Howard, J, Riley, TN, Jesús-Romero, RD, and Lorenzo-Luaces, L. Social media use, physical activity, and internalizing symptoms in adolescence: cross-sectional analysis. *JMIR Ment Health.* (2021) 8:e26134. doi: 10.2196/26134

[CrossRef Full Text](#) | [Google Scholar](#)

99. Viner, RM, Gireesh, A, Stiglic, N, Hudson, LD, Goddings, A-L, Ward, JL, et al. Roles of cyberbullying, sleep, and physical activity in mediating the effects of social media use on mental health and wellbeing among young people in England: a secondary analysis of longitudinal data. *Lancet Child Adolesc Health*. (2019) 3:685–96. doi: 10.1016/S2352-4642(19)30186-5

[CrossRef Full Text](#) | [Google Scholar](#)

100. Calandri, E, Graziano, F, Cattelino, E, and Testa, S. Depressive symptoms and loneliness in early adolescence: the role of empathy and emotional self-efficacy. *J Early Adolesc*. (2021) 41:369–93. doi: 10.1177/0272431620919156

[CrossRef Full Text](#) | [Google Scholar](#)

101. Rideout, V. *The Common Sense Census: Media Use by Tweens and Teens*. San Francisco, California: Common Sense Media (2015).

[Google Scholar](#)

102. Rose, AJ, and Rudolph, KD. A review of sex differences in peer relationship processes: potential trade-offs for the emotional and behavioral development of girls and boys. *Psychol Bull*. (2006) 132:98–131. doi: 10.1037/0033-2909.132.1.98

[CrossRef Full Text](#) | [Google Scholar](#)

103. Vannucci, A, and McCauley, OC. Self-competence and depressive symptom trajectories during adolescence. *J Abnorm Child Psychol*. (2018) 46:1089–109. doi: 10.1007/s10802-017-0340-3

[CrossRef Full Text](#) | [Google Scholar](#)

104. Bandura, A, Caprara, GV, Barbaranelli, C, Gerbino, M, and Pastorelli, C. Role of affective self-regulatory efficacy in diverse spheres of psychosocial functioning. *Child Dev*. (2003) 74:769–82. doi: 10.1111/1467-8624.00567

[CrossRef Full Text](#) | [Google Scholar](#)

105. Grazzani, I, Corti, I, Ornaghi, V, Antoniotti, C, and Pepe, A. Regolazione delle emozioni, autoefficacia emotiva ed empatia: una ricerca in preadolescenza. *Psicol Clin Dello Sviluppo*. (2015) 19:429–48. doi: 10.1449/81775

[CrossRef Full Text](#) | [Google Scholar](#)

106. Verduyn, P, Ybarra, O, Résibois, M, Jonides, J, and Kross, E. Do social network sites enhance or undermine subjective well-being? A critical review. *Soc Issues Policy Rev*. (2017) 11:274–302. doi: 10.1111/sipr.12033

[CrossRef Full Text](#) | [Google Scholar](#)

107. Vaala, SE, and Bleakley, A. Monitoring, mediating, and modeling: parental influence on adolescent computer and internet use in the United States. *J Child Media*. (2015) 9:40–57. doi: 10.1080/17482798.2015.997103

[CrossRef Full Text](#) | [Google Scholar](#)

108. de Ayala, L, López, MC, Sendín Gutierrez, JC, and García, JA. Problematic internet use among Spanish adolescents: the predictive role of internet preference and family relationships. *Eur. J Commun*. (2015) 30:470–85. doi: 10.1177/0267323115586725

[CrossRef Full Text](#) | [Google Scholar](#)

109. Schmuck, D. Following social media influencers in early adolescence: fear of missing out, social well-being and supportive communication with parents. *J Comput-Mediat Commun*. (2021) 26:245–64. doi: 10.1093/jcmc/zmab008

[CrossRef Full Text](#) | [Google Scholar](#)

110. Sampasa-Kanyinga, H, Lalande, K, and Colman, I. Cyberbullying victimisation and internalising and externalising problems among adolescents: the moderating role of parent–child relationship and child’s sex. *Epidemiol Psychiatr Sci.* (2018) 29:e8. doi: 10.1017/S2045796018000653

[CrossRef Full Text](#) | [Google Scholar](#)

111. Bloemen, N, and De Coninck, D. Social media and fear of missing out in adolescents: the role of family characteristics. *Soc Media Soc.* (2020) 6:2056305120965517. doi: 10.1177/2056305120965517

[CrossRef Full Text](#) | [Google Scholar](#)

112. Chang, F-C, Chiu, C-H, Miao, N-F, Chen, P-H, Lee, C-M, Chiang, J-T, et al. The relationship between parental mediation and internet addiction among adolescents, and the association with cyberbullying and depression. *Compr Psychiatry.* (2015) 57:21–8. doi: 10.1016/j.comppsy.2014.11.013

[CrossRef Full Text](#) | [Google Scholar](#)

113. Kerr, M, and Stattin, H. What parents know, how they know it, and several forms of adolescent adjustment: further support for a reinterpretation of monitoring. *Dev Psychol.* (2000) 36:366–80. doi: 10.1037/0012-1649.36.3.366

[CrossRef Full Text](#) | [Google Scholar](#)

114. Kerr, M, Stattin, H, and Burk, WJ. A reinterpretation of parental monitoring in longitudinal perspective. *J Res Adolesc.* (2010) 20:39–64. doi: 10.1111/j.1532-7795.2009.00623.x

[CrossRef Full Text](#) | [Google Scholar](#)

115. Przybylski, AK, Murayama, K, DeHaan, CR, and Gladwell, V. Motivational, emotional, and behavioral correlates of fear of missing out. *Comput Hum Behav.* (2013) 29:1841–8. doi: 10.1016/j.chb.2013.02.014

[CrossRef Full Text](#) | [Google Scholar](#)

116. Bahramian, E, Mazaheri, MA, and Hasanzadeh, A. The relationship between media literacy and psychological well-being in adolescent girls in Semirom city. *J Educ Health Promot.* (2018) 7:148. doi: 10.4103/jehp.jehp_41_18

[CrossRef Full Text](#) | [Google Scholar](#)

117. Kurz, M, Rosendahl, J, Rodeck, J, Muehleck, J, and Berger, U. School-based interventions improve body image and media literacy in youth: a systematic review and Meta-analysis. *J Prev Dent.* (2022) 43:5–23. doi: 10.1007/s10935-021-00660-1

[CrossRef Full Text](#) | [Google Scholar](#)

Table 1. Descriptive characteristics of the full sample and stratified by variables of interest.

Characteristics	Total sample N=6822	11-14 years N=2880	15-20 years N=3942	Males N=2951	Females N=3871	Parental support Always or usually N=2745	Parental support Sometimes N=1667	Parental support Rarely or never N=2410
Sex								
Males	43.2	43.8	42.8	—	—	36.1	42.6	51.8
Females	56.8	56.2	57.2	—	—	63.9	57.4	48.2
Age								
11-to-14-year-olds	42.2	—	—	42.8	41.8	45.5	41.4	39.0
15-to-20-year-olds	57.8	—	—	57.2	58.2	54.5	58.6	61.0
Ethnicity								
White	55.5	55.0	56.0	55.0	56.5	60.0	54.4	51.3
Other	44.5	45.0	44.0	45.0	43.5	40.0	45.6	48.7
Subjective SES								
Mean	6.94	7.14	6.83	6.98	6.89	7.17	7.17	6.74
(SD)	(1.68)	(1.75)	(1.62)	(1.55)	(1.80)	(1.61)	(1.61)	(1.68)
BMI Z-score								
Mean	0.33	0.37	0.31	0.35	0.31	0.33	0.33	0.34
(SD)	(1.11)	(1.21)	(1.05)	(0.97)	(1.26)	(1.13)	(1.13)	(1.08)
Social media use								
No use	12.5	22.0	5.6	16.0	9.9	14.0	11.6	11.5
Light to moderate use (≤ 2 h/day)	39.5	39.3	39.8	46.0	34.6	43.6	40.2	34.5
Heavy use (≥ 3 h/day)	48.0	38.7	54.6	38.0	55.5	42.4	48.2	54.0
Parental support								
Always/usually	40.2	43.4	38.0	33.6	45.3	14.0	11.6	12.5
Sometimes	24.5	24.0	24.8	24.1	24.7	43.6	40.2	34.5
Rarely/never	35.3	32.6	37.2	42.3	30.0	42.4	48.2	54.0
Psychological distress								
No distress	56.3	64.2	50.4	69.9	46.0	68.1	54.5	44.0
Moderate distress	23.4	19.8	26.0	19.2	27.0	20.1	27.0	24.7
Severe distress	20.3	16.0	23.6	10.9	27.0	11.8	18.5	31.3

Note: Data are shown as percentages or mean (standard deviation).

SES, socioeconomic status; SD, standard deviation; BMI, body mass index.

Table 2. Spearman correlation results of the association between psychological distress, sociodemographic characteristics, and social media use among adolescents (n=6,822).

	1.	2.	3.	4.	5.	6.	7.	8.
1. Sex	—	—	—	—	—	—	—	—
2. Age	0.085 [†]	—	—	—	—	—	—	—
3. Ethnicity	1.021 [†]	1.066 [†]	—	—	—	—	—	—
4. SES	0.018 [‡]	-0.107*** [‡]	-0.091*** [‡]	—	—	—	—	—
5. BMI z-score	-0.002 [‡]	-0.005 [‡]	0.003 [‡]	-0.063*** [‡]	—	—	—	—
6. Social media use	57.40*** [†]	95.019*** [†]	9.408*** [†]	-0.055*** [‡]	0.039*** [‡]	—	—	—
7. Parental support	41.174*** [†]	7.665*** [†]	6.018*** [†]	-0.189***	0.017 [‡]	0.100*** [‡]	—	—
8. Psychological distress	179.200*** [†]	30.906*** [†]	1.833 [†]	- 0.223***	0.055*** [‡]	0.200*** [‡]	0.232*** [‡]	—

Note: Sex (male/female), ethnicity (white/non-white), subjective SES, social media use (no use, moderate use, heavy use), parental support (usually, sometimes, rarely), and psychological distress (no distress, moderate distress, severe distress)

SES, socioeconomic status; SD, standard deviation; BMI, body mass index.

[†] Pearson chi-square adjusted for the survey design and transformed into an F-statistic.

[‡] Spearman Correlation.

*p < 0.05; **p < 0.01; ***p < 0.001.

Table 3. Results of the ordered regression analysis of the association between social media use and psychological distress adjusted for all variables of interest (n = 6,822).

Model	Psychological distress OR (95% CI)
Social media use	
No use	1
Light to moderate use (≤ 2 h/day)	1.11 (0.88 – 1.41)
Heavy use (≥ 3 h/day)	1.44 (1.12 – 1.85)**
Sex	
Female	1
Male	0.41 (0.36 – 0.46)***
Age	
11-to-14-year-olds	1
15-to-20-year-olds	1.36 (1.18 – 1.58)***
SES	0.83 (0.80 – 0.86)***
Race	
White	1
Non-white/ other	0.90 (0.78 – 1.05)
BMI Z-score	1.03 (0.97 – 1.08)
Parental support	
Usually/ always	1
Sometimes	1.57 (1.31 – 1.87)***
Rarely/ never	2.41 (2.04 – 2.84)***

Note: Data are shown as odds ratio and 95% confidence interval. OR: odds ratio; CI: confidence interval. Model is adjusted for sex, age, subjective SES, ethnicity, BMI z-score, and parental support.

SES, socioeconomic status; SD, standard deviation; BMI, body mass index.

*p < 0.05; **p < 0.01; ***p < 0.001.

Table 4. Results of the crude and adjusted ordered regression analysis with interaction terms of the associations between social media use and psychological distress among adolescents (n = 6,822).

Models	Crude	Adjusted'
Model 1		
No use	1	1
Light to moderate use (≤ 2 h/day)	1.21 (0.97 – 1.51)	1.29 (1.02 – 1.62)*
Heavy use (≥ 3 hours/day)	2.28 (1.82-2.85)***	2.01 (1.59-2.55)***
Model 2 – Interaction term between social media use and sex		
Light to moderate use x sex	1.34 (0.87-2.06)	1.29 (0.82 -2.03)
Heavy use social media use x sex	1.29 (0.86-1.93)	1.29 (0.85 -1.95)
Model 3 - Interaction term between social media use and age		
Light to moderate use x age	0.70 (0.43 – 1.15)	0.71 (0.43 – 1.16)
Heavy social media use x age	0.56 (0.34 -0.93)*	0.54 (0.33 -0.90)*
Model 4 - Interaction term between social media use and parental support		
Light to moderate use x sometimes parental support	0.70 (0.36-1.32)	0.75 (0.38 – 1.50)
Light to moderate use x rare parental support	0.75 (0.43-1.29)	1.01 (0.58 – 1.77)
Heavy social media use x sometimes parental support	0.51 (0.27-0.94)*	0.53 (0.27 – 1.03)
Heavy social media use x rare parental support	0.53 (0.31-0.91)*	0.69 (0.39 – 1.21)

Note: Data are shown as odds ratio and 95% confidence interval. OR: odds ratio; CI: confidence interval. 'Adjusted models: Model 1 is adjusted for sex, ethnicity, subjective socioeconomic status, BMI z-score and age. Model 2 is Model 1 + interaction term between social media use and sex; Model 3 is Model 1 + interaction term between social media use and age; Model 4 is Model 1 + interaction term between social media use and parental support. *p < 0.05; **p < 0.01; ***p < 0.001.

Table 5. Results of the crude and adjusted ordered regression analysis of the associations between social media use and psychological distress among adolescents, stratified by age (n = 6,822).

Characteristics	11- to 14- year-old N = 2880	15- to 20- year-old N = 3942
Model 1 – Crude		
No use	1	1
Light to moderate use (≤ 2 hours/day)	1.17 (0.88-1.54)	0.82 (0.59-1.24)
Heavy use (≥ 3 hours/day)	2.50 (1.83-3.42)***	1.45 (1.01-2.13)*
Model 2 - Adjusted		
No use	1	1
Light to moderate use (≤ 2 hours/day)	1.27 (0.95-1.70)	0.86 (0.58-1.26)
Heavy use (≥ 3 hours/day)	2.32 (1.67-3.21)***	1.24 (0.86-1.78)

Note: Data are presented as odds ratio and 95% confidence interval. OR: odds ratio; CI: confidence interval.

Model 1 is unadjusted. Model 2 is adjusted for sex, ethnicity, subjective socioeconomic status, and BMI z-score.

*p < 0.05; **p < 0.01; ***p < 0.001.

CHAPTER 5 MANUSCRIPT 3

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Problematic Technology Use, Suicidal Ideation, and Suicide Attempt among Adolescents: The Moderating Role of Sex

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Abstract

This study examined the associations between problematic technology use (PTU) and suicidal ideation and suicide attempt among adolescents and explored whether sex moderates these associations. Data used for this study were from a representative sample of middle and high school students in Ontario, Canada. Analyses included 4,390 students derived from the 2019 Ontario Student Drug Use and Health Survey. Our results showed that 19% of adolescents experienced symptoms of moderate-to-serious PTU, 16.8% had suicidal ideation, and 4.1% had suicide attempt. Females reported higher symptoms of moderate-to-serious PTU than males and reported a higher prevalence of suicidal ideation and suicide attempt. The association of PTU with suicidal ideation and suicide attempt was modified by sex. Having moderate-to-serious symptoms of PTU was associated with higher odds of suicidal ideation among males than females (OR = 3.72, 95% CI = 2.53–5.49 vs OR = 1.74, 95% CI = 1.35-2.26, respectively). Also, having moderate-to-serious symptoms of PTU was associated with higher odds of suicide attempt among males than females (OR = 6.25, 95% CI = 2.87-13.60 vs OR = 2.03, 95% CI = 1.28-3.23, respectively). In conclusion, PTU is a modifiable risk factor associated with increased odds of suicidal ideation and attempt among adolescents, with male adolescents being the most vulnerable. Further research is warranted to explore this association in more depth and to fully understand the role of sex and other potential moderators on the relationship between problem technology use and suicidality among adolescents. **Keywords:** Problematic Technology Use, screen time, suicidal ideation, suicide attempt, mental health, adolescents

Introduction

Every year over 700,000 individuals die due to suicide worldwide and many more attempt suicide (1). Among adolescents aged 15-19 years, suicide is considered the fourth leading cause of death globally (1). In 2020, the suicide rate in Canada for adolescents aged 15-19 years was 8.2 per 100,000, accounting for 24% of all deaths, and ranking second as a leading cause of death in this age group (2). Suicidal thoughts and suicide attempt manifesting in adolescence are significant predictors of suicide and represent a serious public health issue (3,4), as most of these events first occur from early to mid-adolescence (5). The nationally representative Canadian Community Health Survey (n=4031) showed that the prevalence of lifetime suicidal ideation and attempt among youth and emerging adults (15-24 years) is 14.1% and 5.8%, respectively. Furthermore, this survey indicated that lifetime suicidal ideation was higher among females than males (16.2% vs 12%, respectively) (6). While suicide is often perceived principally as a mental health problem, mainly resulting from depression (7), there is evidence indicating that suicidality can be strongly influenced by environmental and behavioral factors, including problematic technology use (PTU) (8). For this study, PTU is defined as excessive time spent on digital technology with an uncontrollable desire to use it in a way that negatively impacts an individual's daily routines and activities (9,10).

Technology use has become an essential part of adolescents' daily lives, with 95% of youth in the United States having access to a smartphone and almost half of them using internet regularly (11–13). Recent evidence showed that Canadian youth use technology more than any other generation with nearly 100% of individuals aged 15-24 years using the internet every day or having a smartphone (14). Furthermore, current evidence shows that the majority of secondary school students use electronic devices for three hours or more hours daily and almost 35% use them for

five hours or more during leisure time (15). Adolescence is considered a critical period in which adolescents encounter rapid changes in physical, mental, and cognitive functions, and they tend to be more involved in risky behaviors for exploration and emotional relief (16,17), a phenomenon that may be exacerbated by increasingly easy access to various types of technology (11,12,18). While technology offers many benefits, problem technology use is concerning as it has been recognized that excessive time spent on technology is emerging as a serious public health issue due to its association with adverse health outcomes among youth (19,20). This is evidenced by PTU being considered as an addictive behavior disorder in the International Classification of Diseases (ICD 11) (21). Similar to other non-substance-related addictive disorders (i.e. gambling, internet gaming disorder) that are recognized by the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), problematic technology shares similar typology. This includes excessive use of technology, anxiety or distress upon cessation that is followed by a strong desire to reuse it, emotional relief when reusing it, interference with sleep, inability to complete school work effectively, and causes conflict with parents, or peer-relationships (22,23).

Previous studies have found that symptoms of PTU are associated with psychosocial and mental health problems such as depression and anxiety (24–27). Among these detrimental outcomes associated with heavy technology use, suicidal behavior has gained increasing attention from researchers who found a positive association between excessive technology use and suicidal ideation and suicide attempt (28–32). However, another study found no association between problem internet use and suicidal ideation and suicide attempt among adolescents (33).

Although many studies examined the sex differences in PTU and the association to suicidal ideation and suicide attempt, to date there are inconsistent results. While some studies showed that males were more likely than females to report symptoms of PTU (24,32,34,35), other studies

contradicted those findings and reported that females were more likely than males to experience symptoms of PTU (36–38). Moreover, other studies have indicated no sex differences (23,39,40). These studies did not examine the association between PTU and both suicidal ideation and suicide attempt, taking into consideration the moderating role of sex in this association.

Given the high prevalence of technology use among adolescents (11,13,14), particularly during the COVID-19 pandemic (41), it is very important to understand the association between PTU and suicidal ideation and suicide attempt among adolescents, and identify which sub-groups of youth are at highest risk. This will help to inform future interventions and suicide-prevention strategies. Accordingly, building upon previous research, this study examined: 1) the associations between PTU and suicidal ideation and suicide attempt and 2) whether these associations differed by sex.

Methods

The current study is a secondary analysis of data from the 2019 Ontario Student Drug Use and Health Survey (OSDUHS) (15). This representative school-based survey is cross-sectional, it collects information related to physical and mental health, drug use, and other risk behaviours among students in grades 7–12 (n=14,142) from 263 English and French public and Catholic schools in Ontario. The Research Ethics Board at the Centre for Addictions and Mental Health (CAMH), York University, and Public and Catholic school boards' research review committees approved the 2019 OSDUHS protocol. Participation in the survey required parental consent and student assent and the survey was completed anonymously during school time.

Data were collected from November 2018 to June 2019. Students aged 11 to 20 years old completed anonymously self-administered questionnaires. Four split ballot versions of the questionnaire were assigned in classrooms (Form A and B for Elementary Schools; Form A and B

for Secondary Schools). Elementary school questionnaires excluded some topics (e.g., problem drug use; PTU, gambling problem). Form A and Form B were distributed alternately to students in each classroom to achieve two near-equal random samples completing each form. The completion rate was 59%, with reasons for not completing the survey including unreturned consents or refusal of participation (29%), and student absenteeism (12%). Further information about the survey is available elsewhere (15). For the present study, adolescents who completed the questionnaire A, (administered to students in grades 9 to 12; n=5273), and examined PTU, mental health, and substance use were included in our analyses.

Measures

Problematic technology use was assessed using the 6-item Short Problem Internet Use Test (SPIUT) (42). It consists of six items as follows: “How often do you find that you are staying on electronic devices longer than you intended?”, “How often do you neglect homework because you are spending more time on electronic devices?”, “How often are you criticized by your parents or your friends about how much time you spend on electronic devices?”, “How often do you lose sleep because you use electronic devices late at night?”, “How often do you feel nervous when you are not using electronic devices and feel relieved when you do go back to using them?”, and “How often do you choose to spend more time on electronic devices rather than go out with your friends?”. Responses rated on a 5-point Likert scale ranged from “never” (coded 0) to “very often” (coded 4) and scores across items were summed to provide a total score ranging from 0 to 24 with higher values indicative of more severe PTU. For this study, the individual symptoms of problem technology use, moderate-to-serious PTU (scores of 14 or higher) and serious PTU (scores of 19 or higher) (42). This tool is valid (42), and it represents a representing high internal reliability with Polychoric Cronbach’s alpha of 0.78 (43).

Suicidal ideation

Suicidal ideation was assessed by the following question: “In the last 12 months, did you ever seriously consider attempting suicide?” The response options were “Yes” (coded 1) or “No” (coded 0).

Suicide attempt

Suicide attempt was assessed by the following question: “In the last 12 months, did you actually attempt suicide?” The response options were “Yes” (coded 1) or “No” (coded 0).

Covariates

Covariates included in the statistical models were age, ethnoracial background, subjective socioeconomic status (SES), tobacco cigarette smoking, cannabis use, and alcohol consumption. These covariates were selected based on their association with the dependent and independent variables. Ethnoracial background was assessed through self-identification as follows: White, Chinese, Filipino, Southeast Asian, Japanese, Korean, South Asian, West Asian, Black, Aboriginal, Latino, and Other. We created five categories, based on distribution, as follows: White, Black, East/South-East Asian, South Asian, and Other. SES was assessed using an updated version of the MacArthur Subjective Socioeconomic Status Ladder (44,45), which is considered a reliable assessment of subjective social status (44). Students were asked to indicate on the 1 to 10 rungs ladder what best described their parents’ SES: “Imagine this ladder below shows how Canadian society is set up. At the top of the ladder are people who are the “best off”—they have the most money, the most education, and the jobs that bring the most respect. At the bottom are the people who are “worst off”—they have the least money, little education, no job or jobs that no one wants. Now think about your family. Please check off the numbered box that best shows

where you think your family would be on this ladder.’’ Rungs higher on the ladder indicate higher perceived SES. This variable was treated as a continuous variable in the analysis.

Regarding substance use variables, tobacco use was measured by asking the students how often they smoked cigarettes over the past 12 months. Cannabis use was assessed by asking the students how often they used cannabis over the past 12 months. Alcohol use was assessed by asking the students how often they drank alcohol (liquor, wine, beer, coolers) over the past 12 months. All substance use variables in this study were treated as scale variables ranging from 1 to 10 for tobacco use, 1 to 7 for cannabis use, and 1 to 9 for alcohol use, with higher numbers indicating more use.

Statistical analysis

All analyses were performed using Taylor series linearization methods to account for the complexity of the sample design of the survey and to achieve unbiased variances and point estimates using Stata 16.1 (Stata Corporation, College Station, TX, USA). Given that sex interaction with moderate-to-serious PTU was significant ($p < 0.05$), analyses including this independent variable were stratified by sex. Participant characteristics were described by proportions and means. We then examined the prevalence of symptoms of PTU and suicidal ideation and suicide attempt. Finally, we conducted univariable and multivariable logistic regression analyses to examine the associations for individual symptoms, and two different categories of PTU with suicidal ideation and suicide attempt. Covariates included age, ethnoracial background, subjective SES, tobacco cigarette smoking, cannabis use, and alcohol consumption. Results are expressed as odds ratios (OR) and their 95% confidence intervals (CI). Among the 5,273 eligible participants, 4,390 were included in the analytical sample. Participants with missing data on at least one variable were excluded. Comparing those excluded with those included in the

analysis, students with missing data were more likely to be of other ethnoracial background and to report less substance use and more PTU.

Results

Table 1 presents the characteristics of the study sample. 58% of the sample was female and 57.5 % were White. The prevalence of suicidal ideation and suicide attempt were 16.8 % and 4.1 %, respectively. About 19% of students reported symptoms of moderate-to-serious PTU and 3% reported symptoms of serious PTU. Females were more likely than males to report experiencing symptoms of moderate-to-serious PTU (21.8 % and 14.2%, respectively) and serious technology use (3.8% and 1.7%, respectively). Females were also more likely than males to report higher suicidal ideation (21.6 % and 12%, respectively) and suicide attempt (5.7 % and 3%, respectively).

Results of logistic regression analyses of the associations of moderate-to-serious symptoms of PTU with suicidal ideation and suicide attempt among adolescents are summarized in table 2. In the adjusted model, having moderate-to-serious symptoms of PTU was associated with higher odds of suicidal ideation among males than females (OR = 3.72, 95% CI = 2.53–5.49 vs OR = 1.74, 95% CI = 1.35-2.26, respectively) and suicide attempt (OR = 6.25, 95% CI = 2.87-13.60 vs OR = 2.03, 95% CI = 1.28-3.23, respectively). Individual symptoms of PTU were also associated with higher odds of suicidal ideation and suicide attempt among males and females with some exceptions. Staying on devices longer than intended was not associated with suicidal ideation in females or with suicide attempt in both sexes. Neglected homework because spending more time on devices was not associated with suicide attempt in both sexes. Getting criticized by parents or friends about time spent on electronic devices was associated with higher odds of suicide attempt in males only (OR = 1.93, 95% CI = 1.36–2.76). Also, choosing to spend more time on electronic

devices rather than go out with friends was associated with higher odds of suicide attempt in females only (OR = 1.59, 95% CI = 1.26–2.01).

Results of logistic regression analyses examining the associations of serious symptoms of PTU with suicidal ideation and suicide attempt among adolescents are summarized in table 3. No significant PTU by sex interaction was found, therefore we did not stratify the analyses by sex. Serious symptoms of PTU were associated with higher odds of suicidal ideation and suicide attempt (OR = 4.15, 95% CI = 2.36-7.30; and OR = 4.76, 95% CI = 1.18-12.52, respectively). Also, individual symptoms of PTU were associated with higher odds of suicidal ideation and suicide attempt, except for staying on devices longer than intended, and neglecting homework because spending more time on devices were associated with suicidal ideation only.

Discussion

The results of the present study showed a high prevalence of moderate-to-serious PTU in a sample of secondary school students in Ontario, Canada. Sex was also a significant moderator of the associations of PTU with suicidal ideation and suicide attempt. Having moderate-to-serious symptoms of PTU was associated with higher odds of suicidal ideation and suicide attempt in males and females, with males being the most vulnerable. To the best of our knowledge, this is the first study that aimed to examine the association between PTU and two key cognitive-behavioral indicators of suicidality in a large and representative school-based sample of adolescents and to explore the moderating effect of sex.

Our results indicated that both moderate-to-serious and serious symptoms of PTU were associated with higher odds of suicidal ideation and suicide attempt, with higher odds among males who reported moderate-to-serious symptoms of PTU. Our findings are in agreement with previous studies (32,39,46–48). Although the underlying mechanism of the association between PTU and

suicidal behavior is not fully understood, some relevant factors were discussed in the literature. First, adolescents experience more frequent strong and intense emotions than adults, with higher instability, making them more vulnerable and sensitive to emotionally charged situations (49). Thus, individuals having challenges recognizing and understanding their emotions are more prone to facing negative experiences with technology use and experiencing suicidal behavior (50). Accordingly, PTU may expose adolescents to violence, cyberbullying (51), inappropriate or unrealistic contents that trigger social comparison (52), and may further lead to developing negative emotions (53), low self-esteem (54), low tolerance to frustration, and weak emotional regulation than corresponding counterparts, as well as high impulsivity (55,56). All of these factors are associated with higher chances of depression and suicidal behaviors (51,57–61).

Another interesting finding of this study was about the sex differences in the association between PTU and suicidal ideation and suicide attempt. Our descriptive results indicate that females reported a higher prevalence of PTU and suicidal ideation and suicide attempt than males. However, the association between PTU and suicidal ideation and suicide attempt showed that males are more vulnerable than females. Females and males may demonstrate different behavioral patterns and motivations for technology use (62,63). Females like socializing more than males online, evidenced by spending more time using social media platforms, smartphones, and online chatting; males spend more time in online gaming (12,40). Also, evidence showed that males tend to be involved more than females in online risky behaviors known to be associated with suicidal ideation and suicide attempt, such as pornography, violent video games, and gambling (64–68), which increase their vulnerability to suicidal behavior (8,69,70). Additionally, it has been suggested that males have lower levels than females in their emotional intelligence (71), a factor known to play a critical role in protecting against suicidal behavior (72). Given that the motivation,

quality and nature of types of technology use and how they were used was not measured in the survey, it is important to consider those measures in future studies to provide a better understanding of the underlying reasons for the observed sex differences that place males with PTU at higher risk of suicidal ideation and attempt.

It is important to note that our cross-sectional findings do not preclude a reverse causation hypothesis or bidirectionality. In fact, according to other evidence, depression was found to predict technology addiction as a way to cope with stressful life events and underlying psychological problems, which in turn could make the symptoms of depression worse and increase odds of suicidality (73,74). Also, it was suggested that victimization and social exclusion make adolescents feel isolated and rejected so they tend to use technology excessively as a coping mechanism, which makes them more vulnerable to online harmful content, such as cyberbullying (75,76). Consequently, they become more isolated by reducing their in-person communication and social network, which in turn can trigger their depression and suicidality (77–79).

Additional mechanisms that may explain the link between PTU and suicidality include the displacement of physical activity, and in-person communication or offline social interaction with family and peers, which have been shown to buffer against psychosocial and emotional problems (53,61,80). Therefore, extensive technology use may lead to poor interpersonal relationships with family and friends (81), and consequently lead adolescents to choose an avoidant maladaptive coping style to confront stressful situations which in turn increase psychosocial maladjustment such as emotional distress, problem coping, and loneliness (82), factors known to increase the risk of suicidal behavior among adolescents (83).

Third, sleep disturbances and insomnia are well known factors associated with poor mental health including suicidal ideation and suicide attempt (84). Also, it has been reported that sleep

mediates the association between heavy technology use and suicidal behavior among adolescents (32). This aligns with our results that showed that losing sleep because of late night use of devices was associated with higher odds of suicidal ideation and suicide attempt. Thus, late night use of electronic devices can reduce quantity and quality of sleep, which in turn is associated with increased risk of suicidal ideation and attempt among adolescents.

Additionally, the present study showed that 19% of students reported moderate-to-serious problematic technology symptoms, and 3% met the criteria for serious problematic use. It has been suggested that the high prevalence of PTU among adolescents (9,85) can be explained by their psychological immaturity (86), lacking self-regulation ability and coping strategies, as well as the elevated tendency for impulsivity and risk-taking behavior. There is evidence this is related to the prefrontal cortex, responsible for executive functions such as logical thinking, decision making, problem solving and impulsive control, that is not yet fully developed during adolescence (87–89). All these factors contribute to the high vulnerability among adolescents to addictive behavior (17,89,90).

Moreover, our study found that females were more likely than males to report PTU, consistent with previous studies (36,37,91–93), and contradictory with other studies which reported a higher prevalence of problematic technology internet use among males (24,35). Inconsistency in findings in various parts of the world might be attributed to methodological heterogeneity, such as the types and quantity of technology measured. The sex difference regarding the prevalence of technology use indicated in the present study might be explained by technology preferences. For example, evidence showed that females' favorite media activities are social media, chatting, listening to music, and reading while males are more likely to enjoy all types of video gaming including mobile and computer games and watching online videos (11,13,94,95).

Therefore, the high prevalence of PTU among females might be explained by the increased usage of the internet for communication purposes, which in turn can be associated with the higher smartphone use among females than males (37,96).

This study has several strengths. First, we used a large and representative sample of adolescents, considered many important covariates such as substance use in our analyses, and examined the moderating role of sex on the association between PTU and suicidal ideation and suicide attempt. Furthermore, the examination of each criterion of PTU was useful to provide a clearer interpretation of the results. Despite the several strengths, our study has some limitations that should be acknowledged. First, the cross-sectional nature of the study prohibited us from making any causal relationship between PTU, suicidal ideation, and suicide attempt. Second, the lack of measures of quality of technology use limited our ability to examine in more depth the sex differences which might be explained by how this technology was used. Third, this study includes high school students in grades 9 to 12 attending publicly funded schools in Ontario and is not representative of all students in Canada. Fourth, the low participation rate. Also, our data are based on self-reported measures which might contribute to recall bias. Longitudinal studies are needed to examine the directionality of the association between PTU and suicidal ideation and suicide attempt among adolescents.

Conclusion and Future Directions

Our present study indicates that PTU is very common among adolescents, especially females, and is associated with an increased risk of suicidal ideation and suicide attempt, with males being more vulnerable. Our results highlight the need for further research to understand the precise causal relationship between PTU and suicidal behaviour which can help to develop effective multidisciplinary interventions as a part of suicide prevention programs targeting youth

and their families. These interventions would help to provide media literacy, promote healthy digital media behaviours and increase awareness of the adverse effects of PTU.

Acknowledgements

The datasets presented in this research article cannot be made available in the manuscript, supplemental files, or a public repository due to the Centre for Addiction and Mental Health's and The Ontario Public and Catholic School Board's institutional Research Ethics Board agreements. Requests for accessing the datasets should be directed to the Centre for Addiction and Mental Health at info@camh.ca. The authors would like to thank the school boards, schools, and students who participated in the OSDUHS study. **Ethics statement:** The studies involving human participants were reviewed and approved by the Research Ethics Boards of the Centre for Addiction and Mental Health (CAMH), York University, and 47 public and Catholic school boards' research review committees. Written informed consent to participate in this study was provided by the participants' legal guardian. **Consent to participate:** All students attending participating schools were invited to participate using active-information passive-consent parental permission protocols. Parents were informed of the study and could withdraw their child by contacting study staff. Students not withdrawn from the study by their parents were considered eligible to participate. **Funding:** The Ontario Student Drug Use and Health Survey, a Centre for Addiction and Mental Health initiative, was funded in part through ongoing support from the Ontario Ministry of Health and Long-Term Care, as well as targeted funding from several provincial agencies.

Table 1. Descriptive characteristics of the full sample and stratified by sex.

Characteristics	Total sample N=4390	Females N=2549	Males N=1841	<i>p</i> -value ^a
Age (years) Mean (SD) (Min: 12, Max: 20)	15.9 (1.3)	15.8 (1.4)	15.9 (1.2)	0.282
Ethnoracial background	–	–	–	–
White	57.5	55.2	53.2	0.707
Black	7.3	8.8	9.0	–
East/South-East Asian	12.0	11.5	13.1	–
South Asian	8.3	9.0	8.8	–
Other	14.9	15.5	16.0	–
Subjective socioeconomic status Mean (SD) (Min: 1, Max: 10)	6.9 (1.7)	6.9 (1.8)	6.9 (1.6)	0.228
Tobacco cigarette smoking Mean (SD) (Min: 1, Max: 10)	1.2 (0.8)	1.2 (0.8)	1.3 (0.8)	0.274
Cannabis use Mean (SD) (Min: 1, Max: 7)	1.9 (1.8)	1.8 (1.8)	2.1 (1.8)	< 0.001
Alcohol consumption Mean (SD) (Min: 1, Max: 9)	2.7 (1.6)	2.8 (1.7)	2.7 (1.5)	0.371
Suicidal ideation				
No	83.2	78.4	88.0	< 0.001
Yes	16.8	21.6	12.0	
Suicide attempt				
No	95.9	94.3	97.0	< 0.01
Yes	4.1	5.7	3.0	
Moderate-to-serious PTU (score≥14)				
No				< 0.001
Yes	81.0 19.0	78.2 21.8	85.8 14.2	
Serious PTU (score≥19)				
No	97.0	96.2	98.3	< 0.01
Yes	3.0	3.8	1.7	
PTU score Mean (SD) (Min: 1, Max: 24)	9.2 (4.6)	10 (5.0)	8.5 (4.1)	< 0.001

Data are shown as weighted column % unless otherwise indicated. SD: standard deviation. ^a *p*-value of difference between males and females.

Table 2. Associations of moderate-to-serious symptoms of PTU with suicidal ideation and suicide attempt among adolescents.

Characteristics	Suicidal ideation Female N=2549	Suicidal ideation Male N=1841	Suicide attempt Female N=2549	Suicide attempt Male N=1841
Model 1	OR (95% CI)	OR (95% CI)	(OR 95% CI)	(OR 95% CI)
Stayed on devices longer than intended	1.23 (1.08-1.41)**	1.25 (1.05-1.49)*	1.09 (0.81-1.46)	1.34 (0.81-1.46)
Neglected homework because spending more time on devices	1.35 (1.20-1.52)***	1.49 (1.27-1.75)***	1.16 (0.92-1.47)	1.47 (0.99-2.18)
Criticized by parents/friends about time spent on electronic devices	1.25 (1.14-1.38)***	1.31 (1.12-1.54)***	1.29 (1.05-1.57)**	1.87 (1.29-2.27)***
Lose sleep because you use devices late at night	1.32 (1.16-1.50)***	1.35 (1.15-1.59)***	1.47 (1.18-1.84)***	1.73 (1.18-2.54)**
Felt nervous when not using devices and felt relieved when using them	1.47 (1.35-1.62)***	1.57 (1.34-1.84)***	1.71 (1.41-2.08)***	1.81 (1.39-2.37)***
Choose to spend more time on electronic devices rather than go out with friends	1.38 (1.24-1.55)***	1.38 (1.18-1.61)***	1.57 (1.26-1.95)***	1.37 (0.94-1.98)
Model 2	OR (95% CI)	OR (95% CI)	(OR 95% CI)	(OR 95% CI)
Moderate-to-serious symptoms				
No	1	1	1	1
Yes	2.18 (1.74-2.73)***	3.84 (2.61-5.64)***	2.72 (1.73-4.27)***	7.32 (3.27-16.40)***
Model 3	OR (95% CI)	OR (95% CI)	(OR 95% CI)	(OR 95% CI)
Stayed on devices longer than intended	1.11 (0.98-1.26)	1.22 (1.03-1.46)*	0.93 (0.69-1.25)	1.20 (0.74-1.94)
Neglected homework because spending more time on devices	1.23 (1.09-1.39)***	1.44 (1.21-1.70)***	0.99 (0.77-1.26)	1.26 (0.93-1.73)
Criticized by parents/friends about time spent on electronic devices	1.20 (1.08-1.35)***	1.34 (1.14-1.57)***	1.17 (0.96-1.44)	1.93 (1.36-2.76)***
Lose sleep because you use devices late at night	1.23 (1.08-1.41)**	1.31 (1.11-1.54)***	1.35 (1.08-1.69)**	1.60 (1.11-2.30)*
Felt nervous when not using devices and felt relieved when using them	1.33 (1.20-1.48)***	1.47 (1.24-1.75)***	1.51 (1.23-1.86)***	1.61 (1.16-2.25)**
Choose to spend more time on electronic devices rather than go out with friends	1.37 (1.31-1.56)***	1.40 (1.21-1.63)***	1.59 (1.26-2.01)***	1.38 (1.00-1.90)
Model 4	OR (95% CI)	OR (95% CI)	(OR 95% CI)	(OR 95% CI)
Moderate-to-serious symptoms				
No	1	1	1	1
Yes	1.74 (1.35-2.26)***	3.72 (2.53-5.49)***	2.03 (1.28-3.23)**	6.25 (2.87-13.60)***

Data are presented as odds ratio and 95% confidence interval. OR: odds ratio; CI: confidence interval. Models 1 and 2 are unadjusted. Models 3 and 4 are adjusted for age, ethnoracial background, subjective socioeconomic status, tobacco cigarette smoking, alcohol consumption, and cannabis use. *p < 0.05; **p < 0.01; ***p < 0.001.

Table 3. Associations of serious symptoms of PTU with suicidal ideation and suicide attempt among adolescents.

Characteristics	Suicidal ideation	Suicide attempt
Model 1	OR (95% CI)	OR (95% CI)

Stayed on devices longer than intended	1.32 (1.18-1.48)***	1.27 (0.98-1.65)
Neglected homework because spending more time on devices	1.44 (1.30-1.59)***	1.30 (1.03-1.64)**
Criticized by parents/friends about time spent on electronic devices	1.29 (1.18-1.42)***	1.49 (1.20-1.84)***
Lose sleep because you use devices late at night	1.34 (1.21-1.50)***	1.57 (1.28-1.94)***
Felt nervous when not using devices and felt relieved when using them	1.56 (1.43-1.69)***	1.80 (1.51-2.14)***
Choose to spend more time on electronic devices rather than go out with friends	1.38 (1.25-1.53)***	1.50 (1.25-1.81)***
Model 2	OR (95% CI)	OR (95% CI)
Serious symptoms		
No	1	1
Yes	6.14 (3.62-10.52)***	7.97 (3.19-19.9)***
Model 3	OR (95% CI)	OR (95% CI)
Stayed on devices longer than intended	1.16 (1.04-1.29)**	1.03 (0.77-1.36)
Neglected homework because spending more time on devices	1.31 (1.18-1.45)***	1.08 (0.85-1.36)
Criticized by parents/friends about time spent on electronic devices	1.25 (1.13-1.39)***	1.38 (1.10-1.74)**
Lose sleep because you use devices late at night	1.26 (1.13-1.40)***	1.43 (1.17-1.75)***
Felt nervous when not using devices and felt relieved when using them	1.37 (1.25-1.51)***	1.50 (1.22-1.85)***
Choose to spend more time on electronic devices rather than go out with friends	1.39 (1.25-1.53)***	1.51 (1.25-1.82)***
Model 4	OR (95% CI)	OR (95% CI)
Serious symptoms		
No	1	1
Yes	4.15 (2.36-7.30)***	4.76 (1.81-12.52)***

Data are presented as odds ratio and 95% confidence interval. OR: odds ratio; CI: confidence interval. Models 1 and 2 are unadjusted. Models 3 and 4 are adjusted for sex, age, ethnicity, subjective socioeconomic status, tobacco cigarette smoking, alcohol consumption, and cannabis use. *p < 0.05; **p < 0.01; ***p < 0.00

References

1. World Health Organization. Suicide - Fact sheet. URL: <https://www.who.int/news-room/fact-sheets/detail/suicide>.

2. Statista. Suicide rate Canada by age 2020. Statista, 2022. URL:
<https://www.statista.com/statistics/437701/rate-of-suicide-canada-by-age-group/>.
3. Silverman MM, Berman AL, Sanddal ND, O'carroll PW, Joiner TE. Rebuilding the tower of Babel: A revised nomenclature for the study of suicide and suicidal behaviors. Part 2: Suicide-related ideations, communications, and behaviors. *Suicide Life Threat Behav* 2007;37(3):264–77.
4. World Health Organization. Preventing suicide: A global imperative. Geneva: World Health Organization, 2014. URL:
https://apps.who.int/iris/bitstream/handle/10665/131056/9789241564779_eng.pdf;jsessionid=669AE1E93D31DC0CCEDB4BFD8D54CE4B?sequence=1.
5. Goodday SM, Bondy S, Sutradhar R, Brown HK, Rhodes A. The cumulative incidence of self-reported suicide-related thoughts and attempts in young Canadians. *Can J Psychiatry* 2019];64(2):107–15.
6. Findlay L. Depression and suicidal ideation among Canadians aged 15 to 24. *Health Rep* 2017;28(82):11.
7. Bilsen J. Suicide and youth: Risk factors. *Front Psychiatry* 2018;9:540.
8. Cheng YS, Tseng PT, Lin PY, Chen TY, Stubbs B, Carvalho AF, et al. Internet addiction and its relationship with suicidal behaviors: A meta-analysis of multinational observational studies. *J Clin Psychiatry* 2018;79(4):9291.
9. Aboujaoude E. Problematic Internet use: An overview. *World Psychiatry* 2010;9(2):85–90.
10. Addiction Centre. Social media addiction. Addiction Center, 2022. URL:
<https://www.addictioncenter.com/drugs/social-media-addiction/>.

11. Anderson M, Jiang J. Teens, social media and technology. Washington, DC: Pew Research Center, 2018:10.
12. Rideout V, Robb MB. The common sense census: Media use by tweens and teens. San Francisco, CA: Common Sense Media, 2019. URL: <https://www-commonsensemedia-org.proxy.bib.uottawa.ca/sites/default/files/research/report/2019-census-8-to-18-full-report-updated.pdf>.
13. Rideout V, Fox S, Trust WB. Digital health practices, social media use, and mental well-being among teens and young adults in the US, 2018. URL: <https://digitalcommons.psjhealth.org/publications/1093>.
14. Statistics Canada. A portrait of Canadian youth: Today's youth are unlike any generation before! URL: <http://www.deslibris.ca/ID/10103314>.
15. Boak A, Hamilton HA, Adlaf EM, Mann RE. Drug use among Ontario students, 1977–2019: Detailed findings from the Ontario Student Drug Use and Health Survey. Toronto, ON: Centre for Addiction and Mental Health, 2019. URL: https://www.camh.ca/-/media/files/pdf---osduhs/drugusereport_2019osduhs-pdf.pdf.
16. Hammond CJ, Mayes LC, Potenza MN. Neurobiology of adolescent substance use and addictive behaviors: Prevention and treatment implications. *Adolesc Med State Art Rev* 2014;25(1):15–32.
17. Crews F, He J, Hodge C. Adolescent cortical development: A critical period of vulnerability for addiction. *Pharmacol Biochem Behav* 2007;86(2):189–99.
18. Lopez-Fernandez O, Honrubia-Serrano L, Freixa-Blanxart M, Gibson W. Prevalence of problematic mobile phone use in British adolescents. *Cyberpsychology Behav Soc Netw* 2014;17(2):91–8.

19. Ho RC, Zhang MW, Tsang TY, Toh AH, Pan F, Lu Y, et al. The association between internet addiction and psychiatric co-morbidity: A meta-analysis. *BMC Psychiatry* 2014;14(1):1–10.
20. Derbyshire KL, Lust KA, Schreiber LRN, Odlaug BL, Christenson GA, Golden DJ, et al. Problematic Internet use and associated risks in a college sample. *Compr Psychiatry* 2013;54(5):415–22.
21. World Health Organization. International classification of diseases (ICD 11), 2018. URL: [https://www.who.int/news/item/18-06-2018-who-releases-new-international-classification-of-diseases-\(icd-11\)](https://www.who.int/news/item/18-06-2018-who-releases-new-international-classification-of-diseases-(icd-11)).
22. American Psychiatric Association. Diagnostic and statistical manual of mental disorders (DSM-5®). Washington, DC: American Psychiatric Association, 2013.
23. Park S, Hong KEM, Park EJ, Ha KS, Yoo HJ. The association between problematic internet use and depression, suicidal ideation and bipolar disorder symptoms in Korean adolescents. *Aust NZ J Psychiatry* 2013;47(2):153–9.
24. Ha YM, Hwang WJ. Gender differences in internet addiction associated with psychological health indicators among adolescents using a national web-based survey. *Int J Ment Health Addict* 2014;12(5):660–9.
25. Seyrek S, Cop E, Sinir H, Ugurlu M, Şenel S. Factors associated with internet addiction: Cross-sectional study of Turkish adolescents. *Pediatr Int* 2017;59(2):218–22.
26. Tripathi A. Impact of internet addiction on mental health: An integrative therapy is needed. *Integr Med Int* 2017;4(3–4):215–22.

27. Chen L, Yan Z, Tang W, Yang F, Xie X, He J. Mobile phone addiction levels and negative emotions among Chinese young adults: The mediating role of interpersonal problems. *Comput Hum Behav* 2016;55:856–66.
28. Huang Y, Xu L, Mei Y, Wei Z, Wen H, Liu D. Problematic internet use and the risk of suicide ideation in Chinese adolescents: A cross-sectional analysis. *Psychiatry Res* 2020;290:112963.
29. Yoo YS, Cho OH, Cha KS. Associations between overuse of the internet and mental health in adolescents. *Nurs Health Sci* 2014;16(2):193–200.
30. Arrivillaga C, Rey L, Extremera N. Adolescents' problematic internet and smartphone use is related to suicide ideation: Does emotional intelligence make a difference? *Comput Hum Behav* 2020;110:106375.
31. Lee SY, Park EC, Han KT, Kim SJ, Chun SY, Park S. The association of level of internet use with suicidal ideation and suicide attempts in South Korean adolescents: A focus on family structure and household economic status. *Can J Psychiatry* 2016;61(4):243–51.
32. Guo L, Luo M, Wang WX, Huang GL, Xu Y, Gao X, et al. Association between problematic Internet use, sleep disturbance, and suicidal behavior in Chinese adolescents. *J Behav Addict* 2018;7(4):965–75.
33. Alpaslan AH. The Association between problematic internet use, suicide probability, alexithymia and loneliness among Turkish medical students. *J Psychiatry* 2015;18(1): 34881.
34. Lam LT, Peng Z wen, Mai J cheng, Jing J. Factors associated with internet addiction among adolescents. *Cyberpsychol Behav* 2009;12(5):551–5.

35. Durkee T, Kaess M, Carli V, Parzer P, Wasserman C, Floderus B, et al. Prevalence of pathological internet use among adolescents in Europe: Demographic and social factors. *Addiction* 2012;107(12):2210–22.
36. Liu TC, Desai RA, Krishnan-Sarin S, Cavallo DA, Potenza MN. Problematic internet use and health in adolescents: data from a high school survey in Connecticut. *J Clin Psychiatry* 2011;72(6):836–45.
37. Mihara S, Osaki Y, Nakayama H, Sakuma H, Ikeda M, Itani O, et al. Internet use and problematic Internet use among adolescents in Japan: A nationwide representative survey. *Addict Behav Rep* 2016;4:58–64.
38. Bousoño Serrano M, Al-Halabí S, Burón P, Garrido M, Díaz-Mesa EM, Galván G, et al. Substance use or abuse, internet use, psychopathology and suicidal ideation in adolescents. *Adicciones* 2017;29(2):97–104.
39. Kim K, Ryu E, Chon MY, Yeun EJ, Choi SY, Seo JS, et al. Internet addiction in Korean adolescents and its relation to depression and suicidal ideation: A questionnaire survey. *Int J Nurs Stud* 2006;43(2):185–92.
40. Dufour M, Brunelle N, Tremblay J, Leclerc D, Cousineau MM, Khazaaal Y, et al. Gender difference in internet use and internet problems among Quebec high school students. *Can J Psychiatry Rev Can Psychiatr* 2016;61(10):663–8.
41. Lopez-Fernandez O. Emerging health and education issues related to internet technologies and addictive problems. *Int J Environ Res Public Health* 2021;18(1):E321.
42. Siciliano V, Bastiani L, Mezzasalma L, Thanki D, Curzio O, Molinaro S. Validation of a new short problematic internet use test in a nationally representative sample of adolescents. *Comput Hum Behav* 2015;45:177–84.

43. Taber KS. The use of Cronbach's alpha when developing and reporting research instruments in science education. *Res Sci Educ* 2018;48(6):1273–96.
44. Goodman E, Adler NE, Kawachi I, Frazier AL, Huang B, Colditz GA. Adolescents' perceptions of social status: Development and evaluation of a new indicator. *Pediatrics* 2001;108(2):E31.
45. Goodman E, Huang B, Schafer-Kalkhoff T, Adler NE. Perceived socioeconomic status: A new type of identity that influences adolescents' self-rated health. *J Adolesc Health* 2007;41(5):479–87.
46. Peng C, Wang M, Cheng J, Tan Y, Huang Y, Rong F, et al. Association between internet addiction and suicidal ideation, suicide plans, and suicide attempts among Chinese adolescents with and without parental migration. *Comput Hum Behav* 2021;125:106949.
47. Marchant A, Hawton K, Stewart A, Montgomery P, Singaravelu V, Lloyd K, et al. A systematic review of the relationship between internet use, self-harm and suicidal behaviour in young people: The good, the bad and the unknown. *PLoS One* 2017;12(8):e0181722.
48. Lin IH, Ko CH, Chang YP, Liu TL, Wang PW, Lin HC, et al. The association between suicidality and Internet addiction and activities in Taiwanese adolescents. *Compr Psychiatry* 2014;55(3):504–10.
49. Bailen NH, Green LM, Thompson RJ. Understanding emotion in adolescents: A review of emotional frequency, intensity, instability, and clarity. *Emot Rev* 2019;11(1):63–73.
50. Miller AB, McLaughlin KA, Busso DS, Brueck S, Peverill M, Sheridan MA. Neural correlates of emotion regulation and adolescent suicidal ideation. *Biol Psychiatry Cogn Neurosci Neuroimaging* 2018;3(2):125–32.

51. Sampasa-Kanyinga H, Lalande K, Colman I. Cyberbullying victimisation and internalising and externalising problems among adolescents: the moderating role of parent–child relationship and child’s sex. *Epidemiol Psychiatr Sci* 2018;29:e8.
52. Appel H, Gerlach AL, Crusius J. The interplay between facebook use, social comparison, envy, and depression. *Curr Opin Psychol* 2016;9:44–9.
53. Yu L, Zhou X. Emotional competence as a mediator of the relationship between internet addiction and negative emotion in young adolescents in Hong Kong. *Appl Res Qual Life* 2021;16(6):2419–38.
54. Fortes L da S, Fernandes DM. The effect of mobile and internet addiction on self-esteem among adolescents. *Int J English Language Literat Human* 2016;4(9):200–9.
55. Zhang Y, Liu Z, Zhao Y. Impulsivity, social support and depression are associated with latent profiles of internet addiction among male college freshmen. *Front Psychiatry* 2021;12:642914.
56. Chandiramani K. Internet Addiction and Impulsivity among Adolescents. *Indian J Health Wellbeing* 2014;5(7):64–7.
57. Seok JW, Lee KH, Sohn S, Sohn JH. Neural substrates of risky decision making in individuals with Internet addiction. *Aust NZ J Psychiatry* 2015;49(10):923–32.
58. van den Eijnden R, Koning I, Doornwaard S, van Gorp F, Ter Bogt T. The impact of heavy and disordered use of games and social media on adolescents’ psychological, social, and school functioning. *J Behav Addict* 2018;7(3):697–706.
59. Soto-Sanz V, Piqueras JA, Rodríguez-Marín J, Pérez-Vázquez MT, Rodríguez-Jiménez T, Castellvi P, et al. Self-esteem and suicidal behaviour in youth: A meta-analysis of longitudinal studies. *Psicothema* 2019;(31.3):246–54.

60. Carballo JJ, Llorente C, Kehrmann L, Flamarique I, Zuddas A, Purper-Ouakil D, et al. Psychosocial risk factors for suicidality in children and adolescents. *Eur Child Adolesc Psychiatry* 2020;29(6):759–76.
61. Brunborg GS, Burdzovic Andreas J. Increase in time spent on social media is associated with modest increase in depression, conduct problems, and episodic heavy drinking. *J Adolesc* 2019;74:201–9.
62. Liang L, Zhou D, Yuan C, Shao A, Bian Y. Gender differences in the relationship between internet addiction and depression: A cross-lagged study in Chinese adolescents. *Comput Hum Behav* 2016;63:463–70.
63. Ferguson CJ, Coulson M, Barnett J. A meta-analysis of pathological gaming prevalence and comorbidity with mental health, academic and social problems. *J Psychiatr Res* 2011;45(12):1573–8.
64. Andrie EK, Sakou II, Tzavela EC, Richardson C, Tsitsika AK. Adolescents' online pornography exposure and its relationship to sociodemographic and psychopathological correlates: A cross-sectional study in six European countries. *Children* 2021;8(10):925.
65. Hartmann T, Möller I, Krause C. Factors underlying male and female use of violent video games. *New Media Soc* 2015;17(11):1777–94.
66. Leonhardt M, Overå S. Are there differences in video gaming and use of social media among boys and girls?—A mixed methods approach. *Int J Environ Res Public Health* 2021;18(11):6085.
67. Valenciano-Mendoza E, Fernández-Aranda F, Granero R, Gómez-Peña M, Moragas L, Mora-Maltas B, et al. Prevalence of suicidal behavior and associated clinical correlates in patients with behavioral Addictions. *Int J Environ Res Public Health* 2021;18(21):11085.

68. Wardle H, McManus S. Suicidality and gambling among young adults in Great Britain: results from a cross-sectional online survey. *Lancet Public Health* 2021;6(1):e39–49.
69. Yu Y, Yang X, Wang S, Wang H, Chang R, Tsamlag L, et al. Serial multiple mediation of the association between internet gaming disorder and suicidal ideation by insomnia and depression in adolescents in Shanghai, China. *BMC Psychiatry* 2020;20:460.
70. Erevik EK, Landrø H, Mattson ÅL, Kristensen JH, Kaur P, Pallesen S. Problem gaming and suicidality: A systematic literature review. *Addict Behav Rep* 2022;15:100419.
71. D’Amico A, Geraci A. Sex differences in emotional and meta-emotional intelligence in pre-adolescents and adolescents. *Acta Psychol (Amst)* 2022;227:103594.
72. Domínguez-García E, Fernández-Berrocal P. The association between emotional intelligence and suicidal behavior: A systematic review. *Front Psychol* 2018;9:2380.
73. Yi X, Li G. The longitudinal relationship between internet addiction and depressive symptoms in adolescents: A random-intercept cross-lagged panel model. *Int J Environ Res Public Health* 2021;18(24):12869.
74. Lau J, Walden D, Wu A, Cheng KM, Lau M, Mo P. Bidirectional predictions between internet addiction and probable depression among Chinese adolescents. *J Behav Addict* 2018;7:1–11.
75. Durkee T, Hadlaczky G, Westerlund M, Carli V. Internet pathways in suicidality: A review of the evidence. *Int J Environ Res Public Health* 2011;8(10):3938–52.
76. Gansner M, Belfort E, Cook B, Leahy C, Colon-Perez A, Mirda D, et al. Problematic internet use and associated high-risk behavior in an adolescent clinical sample: Results from a survey of psychiatrically hospitalized youth. *Cyberpsychology Behav Soc Netw* 2019;22(5):349–54.

77. Herrero J, Urueña A, Torres A, Hidalgo A. Socially connected but still isolated: Smartphone addiction decreases social support over time. *Soc Sci Comput Rev* 2019;37(1):73–88.
78. Santini ZI, Jose PE, Cornwell EY, Koyanagi A, Nielsen L, Hinrichsen C, et al. Social disconnectedness, perceived isolation, and symptoms of depression and anxiety among older Americans (NSHAP): A longitudinal mediation analysis. *Lancet Public Health* 2020;5(1):e62–70.
79. Calati R, Ferrari C, Brittner M, Oasi O, Olié E, Carvalho AF, et al. Suicidal thoughts and behaviors and social isolation: A narrative review of the literature. *J Affect Disord* 2019;245:653–67.
80. El Asam A, Samara M, Terry P. Problematic internet use and mental health among British children and adolescents. *Addict Behav* 2019;90:428–36.
81. Milani L, Osualdella D, Di Blasio P. Quality of Interpersonal relationships and problematic internet use in adolescence. *Cyberpsychol Behav* 2009;12(6):681–4.
82. Cheng C, Sun P, Mak KK. Internet addiction and psychosocial maladjustment: Avoidant coping and coping inflexibility as psychological mechanisms. *Cyberpsychology Behav Soc Netw* 2015;18(9):539–46.
83. Wong A, Lai CCS, Shum AKY, Yip PSF. From the hidden to the obvious: Classification of primary and secondary school student suicides using cluster analysis. *BMC Public Health* 2022;22(1):693.
84. Liu JW, Tu YK, Lai YF, Lee HC, Tsai PS, Chen TJ, et al. Associations between sleep disturbances and suicidal ideation, plans, and attempts in adolescents: A systematic review and meta-analysis. *Sleep* 2019;42(6):054.

85. Chung TWH, Sum SMY, Chan MWL. Adolescent internet addiction in Hong Kong: Prevalence, psychosocial correlates, and prevention. *J Adolesc Health* 2019;64(6 Suppl):S34–43.
86. Yang X, Zhou Z, Liu Q, Fan C. Mobile phone addiction and adolescents' anxiety and depression: The moderating role of mindfulness. *J Child Fam Stud* 2019;28(3):822–30.
87. Grant JE, Lust K, Chamberlain SR. Problematic smartphone use associated with greater alcohol consumption, mental health issues, poorer academic performance, and impulsivity. *J Behav Addict* 2022;8(2):335–42.
88. Cerniglia L, Zoratto F, Cimino S, Laviola G, Ammaniti M, Adriani W. Internet addiction in adolescence: Neurobiological, psychosocial and clinical issues. *Neurosci Biobehav Rev* 2017;76(Pt A):174–84.
89. Chambers RA, Taylor JR, Potenza MN. Developmental neurocircuitry of motivation in adolescence: A critical period of addiction vulnerability. *Am J Psychiatry* 2003;160(6):1041–52.
90. Morese R, Longobardi C. Suicidal ideation in adolescence: A perspective view on the role of the ventromedial prefrontal cortex. *Front Psychol* 2020;11:713. Available from:
91. Procházka R, Suchá J, Dostál D, Dominik T, Dolejš M, Šmahaj J, et al. Internet addiction among Czech adolescents. *PsyCh J* 2021;10(5):679–87.
92. Morioka H, Itani O, Osaki Y, Higuchi S, Jike M, Kaneita Y, et al. The association between alcohol use and problematic internet use: A large-scale nationwide cross-sectional study of adolescents in Japan. *J Epidemiol* 2017;27(3):107–11.

93. Peris M, de la Barrera U, Schoeps K, Montoya-Castilla I. Psychological risk factors that predict social networking and internet addiction in adolescents. *Int J Environ Res Public Health* 2020;17(12):E4598.
94. Jackson LA, Zhao Y, Kolenic A, Fitzgerald HE, Harold R, Von Eye A. Race, gender, and information technology use: The new digital divide. *Cyberpsychol Behav* 2008;11(4):437–42.
95. Twenge JM, Martin GN. Gender differences in associations between digital media use and psychological well-being: Evidence from three large datasets. *J Adolesc* 2020;79:91–102.
96. Cha SS, Seo BK. Smartphone use and smartphone addiction in middle school students in Korea: Prevalence, social networking service, and game use. *Health Psychol Open* 2018;5(1):2055102918755046.

CHAPTER 6 MANUSCRIPT 4

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I am the first author on this article. I was responsible for designing the study, with guidance from my supervisors and co-authors. I performed all data analyses, created all of the tables, wrote the manuscript, submitted the final version for publication, and addressed reviewer comments.



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Longitudinal associations between different types of screen use and depression and anxiety symptoms in adolescents

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Abstract

Background: Evidence examining the longitudinal associations between different types of screen behaviours and mental health among adolescents is limited. The present study examined the association between five types of screen behaviours and symptoms of anxiety and depression one year later. This study also assessed how changes in screen time were associated with changes

in anxiety and depressive symptoms and whether the observed relationships were moderated by sex.

Methods: Longitudinal data of 17,174 students in grades 9–12 (53.5% females; mean age: 15.1 ± 0.9 years) attending high schools in Canada from two waves (year 6: 2017/18, year 7: 2018/19) of the COMPASS study were analyzed. Leisure screen time and mental health measures were self-reported. To test if the associations between screen time and anxiety, and depression vary by sex, two-way interactions were examined for sex. Analyses accounted for school clustering, race/ethnicity, sex, age, income, body mass index z-score, and previous year anxiety and depression symptoms.

Results: There were significant longitudinal associations between time spent on each type of screen and subsequent anxiety and depression symptoms. The strength of the associations varied by type of screen behaviour. Interaction analysis indicated a sex difference for television viewing and anxiety and depression symptoms, and internet surfing and anxiety symptoms. A dose-response relationship was observed between phone talking and anxiety symptoms. Beta estimates indicated that an increase in screen duration was associated with a further increase in anxiety and depression symptoms.

Conclusion: Higher screen time was longitudinally associated with higher anxiety and depression symptoms at one-year follow-up in adolescents. Time-change associations between screen usage and depressive and anxiety symptoms were observed. Also, associations differed based on sex and screen type, whereby greater increases in screen use predicted greater emotional distress. Findings from this prospective analysis suggest that screen time is an important determinant of anxiety and depressive symptoms among adolescents. Future studies

are recommended to help inform programs promoting screen time reduction with a goal to enhance adolescents' mental health.

Keywords: screen time, depression, anxiety, adolescents, public health

Background

Mental disorders among youth have become a serious public health problem worldwide, with one in seven adolescents aged 10–19 years experiencing mental disorders (1). Up to 70% of mental disorders start before the age of 18 years (2), and many persist into adulthood. Mental disorders are a leading cause of disability and disease burden globally, of which anxiety and depression are the main contributors (3, 4). It has been estimated that anxiety and depression

make up 43% of mental disorders among adolescents aged 10–19 years, within which nearly 31.4% of males and 56.3% of females were affected (5). Given the early onset and substantial societal, health, and economic burden of anxiety and depression (6–9), it is critical to examine the modifiable risk factors for the prevention and early intervention of mental disorders.

In recent years, excessive time spent on screens among adolescents has been recognized as a concerning issue associated with mental disorders, including anxiety and depression, especially with the widespread accessibility of digital devices and platforms (10–14). It has been indicated that 95% of United States adolescents (15) and 100% of Canadian adolescents and young adults (16) have access to smartphones, with the majority of them using the internet regularly (15, 17). Canadian representative data (18) show that youth are the greatest leisure users of screens with a daily screen time ranging from 3.1–7.6 h per day, exceeding the Canadian and World Health Organization sedentary behaviour guidelines of two hours or less of daily sedentary recreational screen usage (19, 20). Most adolescents spend more than three hours a day (35% spend five hours daily) on leisure screen time (21). This is very concerning considering the strong associations between screen time and anxiety and depression among adolescents (22–24); however, additional longitudinal evidence is required as suggested by recent reviews (11–14).

It has been suggested that different types of screen behaviours are associated differently with anxiety and depression, though results are not consistent (12–14, 22). For example, television viewing was shown to be more weakly associated with depression than other types of screen use, such as using a computer or video gaming (13, 14, 24). On the other hand, all screen types were found to be associated with anxiety (13). Other results indicated that video gaming and television viewing have stronger associations with depression and anxiety when compared to internet surfing and mobile phone use (12). Given the ongoing changes in screen types and how youth

engage in screen time behaviour, it is important to prospectively examine whether each type of screen behaviour is differently or similarly related to depression and anxiety to better inform research, policy and practice.

Previous studies suggest that recreational screen time can vary between males and females.

While adolescent males report playing more computer and video games, females report spending more time on social media and chatting online (15, 17, 25, 26). However, results on the moderating role of sex on the association between screen time and anxiety and depression were examined in only a few studies and with mixed results (12, 13). One study found that watching television was negatively associated with depressive symptoms one year later in males and positively associated with depressive symptoms one year later in females (27). Another study indicated that males who played video games the most at baseline had the lowest level of anxiety after one year, though females who played video games the most at baseline had the highest level of anxiety one year later (28). Another study found no sex difference between different types of screen and depressive symptoms (29, 30).

Given limited longitudinal research has examined how changes in different types of screen time could be associated with changes in anxiety and depressive symptoms over time and how sex moderates these associations, there is a critical need for more research in this field, especially that the majority of adolescents exceeding screen time guidelines. Such insight could help inform educational programs and the development of targeted interventions designed to reduce screen time and displace it with more beneficial activities for adolescents' mental health. Therefore, the objectives of this study are threefold: (1) examining the longitudinal associations between five types of screen time (including communication-based screen time such as instant messaging, chatting, and texting) and symptoms of anxiety and depression among adolescents; (2) assessing

how changes in screen time are associated with changes in anxiety and depressive symptoms one year later; and (3) evaluating whether the observed relationships between screen time and symptoms of anxiety and depression are moderated by sex.

Design

The COMPASS study is a designed to collect hierarchical longitudinal data annually (2012–2027) from a rolling cohort of grade 9 to 12 (Secondary I–V in Quebec) students from a convenience sample of secondary schools in British Columbia, Alberta, Ontario, and Quebec, Canada. School boards and schools were purposefully selected based on whether they permitted active information passive-consent parental permission protocols. All students attending participating schools and not withdrawn by their parents were eligible to participate. All participating students provided assent at the time of data collection. During the waves of data used here, all data were self-reported using a paper-and-pencil questionnaire completed during class time. All COMPASS procedures were approved by the University of Waterloo Office of Research Ethics (ORE #: 30118) and appropriate school board committees. A full description of the COMPASS host study is available elsewhere (31).

Participants

For the current study, we used linked student-level data from year 6 (2017/18; Y6—time 1) and year 7 (2018/19; Y7—time 2) of the COMPASS host study.¹ A one-year follow up was chosen because year 6 (2016/17) was the first year that the mental health measures were included in all participating schools and year 8 (2019/20) was interrupted by the start of the COVID-19 pandemic school closures.

In year 6, 66,501 students from 117 secondary schools participated, with a participation rate of 81.9%. In year 7, 74,501 students from 136 secondary schools participated in the study, with a participation rate of 84.2%. Each school was assigned a unique identifier, and student data were linked through a unique, self-generated anonymous code (32). Non-linkage was primarily due to student absences on one of the two data collection dates for reasons related to scheduled study periods, graduation, school transferring, dropping out of school, school field trips, and sports events, or for inaccurate data given on the data linkage measures. Further information on the COMPASS design is available elsewhere (31).

Of the 23,557 grade 9 to 12 students who were successfully linked for their participation in COMPASS in year 6 [considered here as time 1 (T1)] and year 7 [considered here as time 2 (T2)], 17,310 had complete data regarding depressive and anxiety symptoms at both time points. Among them, 17,147 students had complete data for all variables included in our analyses at both time points and constituted our analytical sample.

Measures

Screen time

Screen time was measured by asking the participants the following question: “how much time per day do you usually spend doing the following activities?,” where the five items of interest were: (1) “watching/streaming television shows or movies”; (2) “playing video/computer games”; (3) “talking on the phone”; (4) “surfing the internet”; and (5) “texting, messaging, emailing.” Individuals reported their screen time in hours (ranging from 0 to 9) and minutes (ranging from 0 to 45) for each item. This measure has been validated for use among adolescents (33). To assess a possible dose-response gradient and allow for good distribution across

categories, we categorized each item in 5 categories as follows: [0 to 29 min/d (coded 0—reference category); 30 to 59 min/d (coded 1), 1 to <2 h/d (coded 2); 2 to <3 h/d (coded 3); $\geq$ 3 h/d (coded 4)].

Anxiety

General anxiety symptoms were measured using the generalized anxiety disorder 7-item scale (GAD-7), a tool widely used in both clinical practice and research, which has been validated for use in youth (34, 35). The self-reported scale assesses generalized anxiety symptoms that include difficulty controlling feelings of worry, feeling afraid, trouble relaxing, nervousness, irritability, and restlessness over the last 2 weeks. Response options were as follows: “not at all,” “several days,” “over half the days,” or “nearly every day.” Responses were scored from 0 to 3 and summed to calculate a total anxiety score that ranged from 0 to 21, with higher scores indicating higher levels of anxiety symptoms. For the purpose of the present study, two forms of this variable were used in the analysis: (1) the total score was used as a continuous variable, and, (2) a dichotomous variable with a binary coding system to categorize participants with (coded 1) and without (coded 0—reference category) clinically-relevant anxiety symptoms with a cut-off score ≥ 10 was used (36).

Depression

Depressive symptoms were measured using the Center for Epidemiologic Studies Depression Scale (Revised)—10 (CESD-R-10) (37). This self-report scale was designed to assess clinical depressive symptoms that include feelings of sadness, hopelessness, amotivation, difficulty concentrating, difficulty sleeping, and irritability within the last seven days. Response options were as follows: “none or less than 1 day,” “1–2 days,” “3–4 days,” or “5–7 days.” Responses were scored from 0 to 3 and summed to calculate a total score that ranged from 0 to 30, with

higher scores indicating higher levels of depression symptoms. The CESD-R-10 scale has demonstrated validity among adolescents and adults (37–39). Two forms of this variable were used in the analysis. The total score was used as both a continuous variable and as a dichotomous variable with a binary coding system to categorize participants with (coded 1) and without (coded 0—reference category) clinically-relevant depressive symptoms using a cut-off score ≥ 10 (37).

Covariates

Individual-level covariates included age (years), race/ethnicity, body mass index (BMI) (age and sex adjusted BMI based on the WHO classifications using participant reported height and weight,[40] school-area median average household income, previous year anxiety and depressive symptoms, and sex. Race/ethnicity was assessed through self-identification and categorized as follows: White, Black, Asian, Hispanic/Latin American, and Other. BMI was categorized as follows: underweight (coded 1), normal weight (coded 0 – reference category), overweight (coded 2), and obesity (coded 3). Missing BMI was included as a category, given the high frequency of nonresponse to height/weight that cannot be excluded as missing completely at random [41] (coded 4). Weight and height measures in COMPASS were validated.[42] Average household income was used after cross-referencing school postal codes with Statistics Canada data. Income categories were as follows: \$25,000-50,000; \$50,001-75,000; \$75,001-100,000 and >\$100,000. Sex was identified based on the answer to the question “Are you female or male?” Only two response options were provided in these years of the survey: “female” (coded 0 – reference category) and “male” (coded 1).

Change in screen time and anxiety and depression symptoms

Change in screen time was determined by subtracting the time spent on each type of screen at T1 from the time spent at T2. Possible scores ranged from -5 to 5, with a positive score indicating that an individual increased their screen time at T2 compared to T1, and a negative score indicating that an individual decreased their screen time at T2 compared to T1. Scores were treated as scale variables.

Change in symptoms was determined by subtracting anxiety and depression scores at T1 from anxiety and depression scores at T2. Scores ranged from -21 to 21 for change in anxiety scores, and from -26 to 30 for change in depression scores. Positive scores indicate an increase in symptoms and negative score indicate an improvement in symptoms. Scores were treated as continuous variables.

Data processing and analyses

Analyses included complete information on all variables ($N = 17,147$). Pearson's chi-square tests and adjusted Wald tests were used for categorical and continuous variables, respectively, to test the statistical differences between missing data and those included in our analyses for all the variables. Compared to the included participants, those who were excluded were more likely to be male, aged 15-to-20-years, and more likely to use screen more frequently at both T1 and T2, and more likely to report clinically relevant anxiety symptoms at T1 and depression symptoms at T2.

Descriptive statistics, including frequencies, means, and standard deviations, were used to characterize the sample. Mixed models were used to account for school clustering by adding random intercepts at the school level. Odds ratios and 95% confidence intervals (CI) were used to estimate the longitudinal associations between daily time spent on each type of screen and

anxiety and depression symptoms. We computed the two-way interactions (sex by each type of screen) on the association between screen time and anxiety and depression. A significant two-way interaction ($p \leq 0.05$) would indicate significant moderation and models were stratified accordingly. Data are presented based on unadjusted models and models adjusted for year 6 covariates, including anxiety and depression symptoms, and sex when models were not stratified. Given that sex interactions with television viewing and anxiety and depression and internet surfing with anxiety were statistically significant, analyses for these associations were stratified by sex. A sensitivity analysis was conducted using the total anxiety and depression scores (continuous) and the pattern of results was similar (data not shown). Therefore, only analyses with dichotomous anxiety and depression scores are presented for clarity.

Conditional change models were conducted to examine whether longitudinal changes in daily time spent on each type of screen predict changes in anxiety and depressive symptoms at follow-up. The beta coefficients for change in each type of screen were presented to describe how change in screen time was associated with changes in anxiety and depressive symptoms. Models were adjusted for Y6 covariates, anxiety and depression, and sex when models were not stratified. A sensitivity analysis was conducted using the continuous screen time variable form, and results were similar (data not shown). All analyses were carried out in STATA/SE 16.1.

Results

Study Sample

This study included a total of 17,174 (53.5% females) participants with a mean age of 15.1 years at T1. Characteristics of the participants at T1 and T2 are summarized in Table 1. Females reported more internet surfing per day than any other screen time behaviour at T1 (mean = 126 min) and T2 (mean = 130 min). On the other hand, males reported more time

playing video games at T1 (mean = 142 min) and T2 (mean = 130) than any other screen time behaviour. Concerning mental health characteristics, 24.4% of the sample indicated having clinically-relevant anxiety symptoms (cut-off score ≥ 10) and 34.2% indicated having clinically-relevant depressive symptoms (cut-off score ≥ 10). Females reported more clinically relevant anxiety and depressive symptoms compared to males.

Longitudinal association between time spent on each type of screen and symptoms of anxiety

Odds ratios for the association between time spent watching television/movies, playing video games, talking on the phone, surfing the internet, and screen-based communication and anxiety are presented in Table 2. After adjusting for covariates and previous year anxiety, we found a positive association between time spent playing video games and anxiety (OR for 1–2 h = 1.13, 95% CI: 1.00 to 1.28; OR for 3+ hours = 1.27, 95% CI 1.12 to 1.45). In addition, we found a dose-response association between time spent talking on the phone and anxiety (OR for 30 min—less than 1 h = 1.22, 95% CI: 1.06 to 1.40; OR for 1—less than 2 h = 1.18, 95% CI: 1.05 to 1.33; OR for 2 to <3 h = 1.25, 95% CI 1.06 to 1.48, OR for 3+ hours = 1.36, 95% CI 1.17 to 1.57). Also, communication-based screen time was associated with anxiety symptoms (OR for 2 to <3 h = 1.18, 95% CI 1.04 to 1.34, 3+ hours = 1.40, 95% CI 1.25 to 1.57). Regarding sex differences, we found an association between watching television /movies for three or more hours and anxiety symptoms for females (OR for 3+ hours = 1.27, 95% CI 1.06 to 1.53) but not in males. Surfing the internet for three or more hours was also associated with anxiety symptoms among females (OR for 3+ hours = 1.20, 95% CI 1.03 to 1.40). Higher odds ratios were found among males who/surfed the internet for one to two hours or three or more (OR for 1–2 h = 1.41, 95% CI: 1.17 to 1.69; OR for 3+ hours = 1.49, 95% CI 1.22 to 1.82).

Longitudinal association between time spent on each type of screen and symptoms of depression

Odds ratios for the association between watching television/movies, playing video games, talking on the phone, surfing the internet, and screen-based communication and depression after one year are presented in Table 3. After adjusting for covariates and previous year depression, we found a positive association between time spent playing video games and subsequent depression (OR for 1–2 h = 1.14, 95% CI: 1.02 to 1.28; OR for 3+ hours = 1.29, 95% CI 1.15 to 1.46). As for anxiety there was evidence of an association between internet use and subsequent depression (OR 3+ hours = 1.24, 95% CI: 1.11 to 1.38). In addition, our results indicated an association between time spent talking on the phone (OR for 3+ hours = 1.33, 95% CI 1.15 to 1.53) and communication-based screen time and symptoms of subsequent depression (OR for 3+ hours = 1.32, 95% CI 1.19 to 1.46). Sex differences were also found in the association between television viewing and subsequent depression. Females who spent 3 or more hours watching television a day had symptoms of depression one year later (OR for 3+ hours = 1.30, 95% CI 1.09 to 1.55) but no association was found among males.

Longitudinal association between change in time spent on screen-based behaviour and changes in anxiety and depressive symptoms at follow-up

Table 4 summarizes the results of analyses examining the longitudinal association between changes in time spent on screen-based pursuits and change in subsequent anxiety and depressive symptoms, adjusting for all covariates and prior year anxiety and depression scores. Beta estimates showed a positive association between changes in screen duration for talking on the phone and screen-based communication with subsequent anxiety; no association was found for time change in video games and subsequent anxiety. Also, a positive association was found

between increase in screen duration for video gaming, talking on the phone, internet surfing, and screen-based communication and increase in subsequent depressive symptoms for the whole sample. That is, students who increased their screen usage at T2 compared to T1 had higher anxiety and depressive symptoms and those who reduced their screen usage had lower anxiety and depressive symptoms at follow-up. Regarding sex differences, increase in television usage was associated with further increase in subsequent anxiety symptoms for females only and in subsequent depressive symptoms for males only. Duration increase in television usage was associated with increase in subsequent anxiety symptoms for females but not for males, and with increase in subsequent depressive symptoms for males and not for females. Furthermore, increase duration in internet usage was associated with more increase in subsequent anxiety symptoms for females than males.

Discussion

We found that higher screen use is associated with increases in symptoms of depression and anxiety one year later among a large linked-longitudinal sample of Canadian adolescents. Dose-response relationships were observed with talking on the phone and anxiety symptoms and sex differences were observed with television/movie viewing and both anxiety and depression and with internet surfing and anxiety. The association between screen usage and mental disorders varied by the time spent in various screen behaviours and the type of screen behaviour, especially with anxiety. Lastly, our conditional change models indicated a positive linear association between change in the time spent on screens and symptoms of anxiety and depression one year later.

We found that all types of screen behaviours were associated with higher levels of anxiety and depression longitudinally among youth in our sample. While the effect sizes were small,

adjusting for the previous year's anxiety and depression, which is considered an analytical strength, likely attenuated the association and the dose-response pattern. In addition, when escalating the small effect to the population level, we believe the burden increase suggests a high importance of the results. Our results may be explained, in part, by the displacement theory (43, 44). While some evidence in the literature suggested that a moderate level of screen use is not harmful, high screen usage could displace time spent engaging in other beneficial pursuits, such as physical activity, sleep, and in person interaction, which are known to reduce anxiety and depression symptoms (45–49). Many movement guidelines for children and youth, including the Canadian 24-h movement guidelines, discussed the importance of limiting recreational sedentary screen behaviours to no more than 2 h per day, accumulating at least 60 min of moderate to vigorous physical activity daily, and sleeping 9–11 h per night (for those aged 5–13 years) or 8–10 h per night (for those aged 14–17 years) (19, 20). When doing an extensive amount of screen pursuits daily, it is more likely that this time interferes with other important health behaviours (30, 50, 51).

Although, we did not analyze how physical activity, screen time, and sleep, all combined are associated with mental health, previous studies showed that meeting all three recommendations was associated with lower odds of mental health problems (52, 53).

In addition to that, a systematic review (54) suggested that independent of physical activity levels, screen time-based sedentary behaviours are associated with increased psychological problems. Therefore, to maximize mental health benefits, a holistic approach that includes but not limited to screen time reduction is recommended.

In line with previous work (12, 13), we found that the strength of the association between screen time and mental disorders varied by the type of screen used. These findings were more evident

for anxiety symptoms. Screen-based communication and talking on the phone were associated with the highest levels of anxiety and depressive symptoms, followed by video gaming. While mixed results were reported in the literature, a recent systematic review of the association between screen time and mental health found little evidence of a positive association between television viewing or videogaming compared to internet use (12). Evidently, the relationship between screen use and depression and anxiety is complex, with many contributing factors and mechanisms. For example, in addition to the displacement hypothesis, talking on the phone and using screen-based communication for an extended period of time could affect mental health by disrupting sleep. It has been estimated that 36% of teens wake up at least once at night to check their phones (55), with the majority of adolescents bringing their phone to their bedrooms (56), which can delay their sleep time (57). Lack of sleep and poor quality sleep are associated with anxiety and depressive symptoms (58).

We also found that spending excessive time on video games was associated with anxiety and depressive symptoms. The effects of videogaming should be approached in regards of several interacting dimensions such as the age of the player, the time spent, personality attributes, and whether gaming alone or with friends (59). Evidence suggest that excessive video gaming, especially playing games that contain violence, is associated with an alteration in frontolimbic and subcortical regions of the brain that are connected to emotion regulation (60–62). This alteration occurred with responses to emotional stimuli that are exaggerated in the amygdala and known to be associated with symptoms of anxiety and depression (63–65).

Our results revealed several differences between sexes. Females spent more time surfing the internet but the association between surfing the internet and anxiety indicates that females had fewer anxiety symptoms than males. The association between frequent use of internet use and

anxiety among females could be related to the types and platforms used online. For example, it had been well known that females spend more time using social media platforms, and online chatting which can be beneficial to connect with friends when used moderately and mindfully (15, 66). However, excessive time spent on social networking sites and the passive use of these sites is known to be associated with more exposure to unrealistic content and posts (67, 68) that could lead to upward social comparisons, and envy which in turn can trigger internalizing problems such as anxiety and depression (69–72). On the other hand, sex differences in the strength of the association between time spent on the internet and subsequent anxiety symptoms could be explained by content preferences and how the internet was used (e.g., passive vs. active use). A recent study (73) examined teen's behaviour on the web and found sex differences regarding internet behaviour, where females are more inclined towards communication and information and show more awareness and caution regarding risky behaviours. This was also confirmed elsewhere (74, 75). Males tend to be less cautious when surfing the web, which may lead to more risky situations (73) such as gambling (76, 77), pornography, and sexting (78). These behaviours may increase their vulnerability to mental disorders like depression and anxiety (78, 79). Cyberbullying was indicated as another mechanism that have particularly negative impacts on anxiety and depression (80–82). Some studies also suggest that higher rates of cyberbullying were found among males (83, 84).

A sex difference was also found in the association between television usage and depression and anxiety symptoms. We found that only females who watched television excessively experienced increased levels of depression and anxiety one year later. As with social media, some television shows or media could expose adolescents to ideal images that promote upward social

comparison through ideal body image advertisements (85), another factor contributing to depression and anxiety (86, 87).

Recent studies (12–14) reported inconsistent evidence of sex moderating the association between total screen time or different types of screen use and both depressive symptoms and anxiety among adolescents. This inconsistency could be related to the content of the screen and how it is being used (active vs. passive), which was not well explored in previous work. Since few studies beside the present one analyzed the longitudinal effect by sex, it is hard to draw a conclusion regarding sex differences. Given that the content, quality, and nature of screen use and the way they are used were not measured in the survey, it is critical to consider additional measures in the future to better understand the underlying factors for the observed results, especially sex differences.

Lastly, regarding results from conditional change analyses, the current study is among the first to longitudinally examine conditional change in various types of screen time and anxiety and depression by sex. Our results suggest that increased time spent talking on the phone and screen-based communication were associated with increased depressive and anxiety symptoms. Also, increased in time spent on video games was associated with increased levels of depression with no significant results for anxiety. More time spent on television viewing was associated with higher anxiety symptoms among females and higher depressive symptoms among males. A similar association was observed between the time change in internet surfing, and symptoms of anxiety and depression with higher levels of anxiety found among females. While it is hard to draw a conclusion from these results, more research is warranted to explore these associations in more depth.

Our study includes many strengths. The longitudinal study design and measures of time spent using five different types of screens in a large sample of adolescents add a unique contribution to the literature. We also examined the moderating role of sex on the associations and included both anxiety and depressive symptoms. All measures of screen time and mental health have demonstrated validity in adolescents, including within the COMPASS host study. A significant strength is the adjustment for previous anxiety and depressive symptoms, given that the majority of studies on this topic were cross-sectional. Furthermore, our study contributes to the literature by using a rigorous conditional change analysis model which better establishes directionality given that most previous studies simply examined the longitudinal association between screen time and mental health fixed at each time point.

Although our study provides important insights, there are some limitations that could inform future research. First, we could not examine the screen use content, context, and motives, which are important to determine why various types of screens affect mental health differently and why sex differences occur. Examining those factors can help to maximize the benefits and opportunities adolescents can get from technology and protect them from risks that could occur with certain context when using the screen excessively. Second, although we controlled for baseline levels of anxiety and depression in all models, the possibility of residual confounding may have influenced results. Finally, future studies should rely on longer follow-up periods and assess a broader spectrum of mental health indicators such as, emotional, psychosocial, and cognitive health.

Conclusion

With high daily screen time exposure reported in the present study, our findings provide longitudinal evidence in a population-based sample of adolescents that more time spent on

screens is associated with more anxiety and depressive symptoms. The relationship between some types of screens such as talking on the phone and anxiety appears to follow a dose-response pattern. Sex differences in longitudinal associations were observed between types of screen use (i.e., television viewing and internet surfing) and anxiety and depression. Moreover, our results established that greater increases in screen time were associated with greater increases in depression and anxiety symptoms, and these observations occurred over one year and when controlling for baseline levels of anxiety and depression. More studies are warranted to examine the content and nature of screen usage. These studies can help inform public health programs, tailored with sex-specific and screen-specific considerations in mind, focusing on reducing screen time could contribute to the prevention of anxiety and depression among adolescents.

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Ethics Statement

All procedures received ethics approval from the University of Waterloo (ORE#30118), Brock University (REB#18-099), CIUSSS de la Capitale-Nationale–Université Laval (#MP-13-2017-1264), and participating school boards, including the use of active-information passive-consent parental permission protocols.

Author Contributions

FM, J-PC, and GG participated in the conception of the study. FM and HS-K conducted statistical analyses. FM wrote the first version of the manuscript. J-PC and GG substantially contributed to the methods and interpretation of results. J-PC, GG, HS-K, IC, SL, and KP

critically reviewed the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

1. World Health Organization (WHO) . Adolescent mental health. (2021). Available at: <http://www.who.int/news-room/fact-sheets/detail/adolescent-mental-health> (Accessed October 30, 2020).

[Google Scholar](#)

2. Merikangas, KR, He, J-P, Burstein, M, Swanson, SA, Avenevoli, S, Cui, L, et al. Lifetime prevalence of mental disorders in U.S. adolescents: results from the National Comorbidity Survey Replication—Adolescent Supplement (NCS-A). *J Am Acad Child Adolesc Psychiatry*. (2010) 49:980–9. doi: 10.1016/j.jaac.2010.05.017

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

3. Rehm, J, and Shield, KD. Global burden of disease and the impact of mental and addictive disorders. *Curr Psychiatry Rep*. (2019) 21:10. doi: 10.1007/s11920-019-0997-0

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

4. GBD 2019 Mental Disorders Collaborators . Global, regional, and national burden of 12 mental disorders in 204 countries and territories, 1990–2019: a systematic analysis for the global burden of disease study 2019. *Lancet Psychiatry*. (2022) 9:137–50. doi: 10.1016/S2215-0366(21)00395-3

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

5. UNICEF . *On My Mind: Promoting, Protecting and Caring for Children’s Mental Health*. New York, NY: UNICEF (2021).

[Google Scholar](#)

6. Naicker, K, Galambos, NL, Zeng, Y, Senthilselvan, A, and Colman, I. Social, demographic, and health outcomes in the 10 years following adolescent depression. *J Adolesc Health*. (2013) 52:533–8. doi: 10.1016/j.jadohealth.2012.12.016

[CrossRef Full Text](#) | [Google Scholar](#)

7. Friedrich, MJ . Depression is the leading cause of disability around the world. *JAMA*. (2017) 317:1517. doi: 10.1001/jama.2017.3826

[CrossRef Full Text](#) | [Google Scholar](#)

8. Chisholm, D, Sweeny, K, Sheehan, P, Rasmussen, B, Smit, F, Cuijpers, P, et al. Scaling-up treatment of depression and anxiety: a global return on investment analysis. *Lancet Psychiatry*. (2016) 3:415–24. doi: 10.1016/S2215-0366(16)30024-4

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

9. Marcus, M, Yasamy, MT, van Ommeren, M, Chisholm, D, and Saxena, S. *Depression: A Global Public Health Concern*. Geneva, Switzerland: World Health Organization (2012).

[Google Scholar](#)

10. Suchert, V, Hanewinkel, R, and Isensee, B. Sedentary behavior and indicators of mental health in school-aged children and adolescents: a systematic review. *Prev Med*. (2015) 76:48–57. doi: 10.1016/j.ypmed.2015.03.026

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

11. Mougharbel, F, and Goldfield, GS. Psychological correlates of sedentary screen time behaviour among children and adolescents: a narrative review. *Curr Obes Rep*. (2020) 9:493–511. doi: 10.1007/s13679-020-00401-1

[CrossRef Full Text](#) | [Google Scholar](#)

12. Tang, S, Werner-Seidler, A, Torok, M, Mackinnon, AJ, and Christensen, H. The relationship between screen time and mental health in young people: a systematic review of longitudinal studies. *Clin Psychol Rev.* (2021) 86:102021. doi: 10.1016/j.cpr.2021.102021

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

13. Zhang, J, Yang, SX, Wang, L, Han, LH, and Wu, XY. The influence of sedentary behaviour on mental health among children and adolescents: a systematic review and meta-analysis of longitudinal studies. *J Affect Disord.* (2022) 306:90–114. doi: 10.1016/j.jad.2022.03.018

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

14. Zink, J, Belcher, BR, Imm, K, and Leventhal, AM. The relationship between screen-based sedentary behaviors and symptoms of depression and anxiety in youth: a systematic review of moderating variables. *BMC Public Health.* (2020) 20:472. doi: 10.1186/s12889-020-08572-1

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

15. Rideout, V, and Robb, MB. *The Common Sense Census: Media Use By Tweens and Teens*. San Francisco, CA: Common Sense Media (2019).

[Google Scholar](#)

16. Statistics Canada . *A Portrait of Canadian Youth: Today's Youth Are Unlike Any Generation Before!* Geneva, Switzerland: Statistics Canada (2019).

[Google Scholar](#)

17. Anderson, M, and Jiang, J. *Teens, Social Media & Technology 2018*. Washington, D.C: Pew Research Center (2018).

[Google Scholar](#)

18. Prince, SA, Melvin, A, Roberts, KC, Butler, GP, and Thompson, W. Sedentary behaviour surveillance in Canada: trends, challenges and lessons learned. *Int J Behav Nutr Phys Act.* (2020) 17:34. doi: 10.1186/s12966-020-00925-8

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

19. Tremblay, MS, Carson, V, Chaput, J-P, Connor Gorber, S, Dinh, T, Duggan, M, et al. Canadian 24-hour movement guidelines for children and youth: an integration of physical activity, sedentary behaviour, and sleep. *Appl Physiol Nutr Metab.* (2016) 41:S311–27. doi: 10.1139/apnm-2016-0151

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

20. World Health Organization . *WHO Guidelines on Physical Activity and Sedentary Behaviour*. Geneva, Switzerland: World Health Organization (2020).

[Google Scholar](#)

21. Boak, A, Elton-Marshall, T, Mann, RE, Henderson, JL, and Hamilton, HA. *The Mental Health and Well-Being of Ontario Students, 1991–2019: Detailed Findings from the Ontario Student Drug Use and Health Survey (OSDUHS)*. Toronto, ON: Centre for Addiction and Mental Health (2020).

[Google Scholar](#)

22. Hoare, E, Milton, K, Foster, C, and Allender, S. The associations between sedentary behaviour and mental health among adolescents: a systematic review. *Int J Behav Nutr Phys Act.* (2016) 13:108. doi: 10.1186/s12966-016-0432-4

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

23. Khouja, JN, Munafò, MR, Tilling, K, Wiles, NJ, Joinson, C, Etchells, PJ, et al. Is screen time associated with anxiety or depression in young people? Results from a UK birth cohort. *BMC Public Health.* (2019) 19:82. doi: 10.1186/s12889-018-6321-9

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

24. Liu, M, Wu, L, and Yao, S. Dose-response association of screen time-based sedentary behaviour in children and adolescents and depression: a meta-analysis of observational studies. *Br J Sports Med*. (2016) 50:1252–8. doi: 10.1136/bjsports-2015-095084

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

25. Leonhardt, M, and Overå, S. Are there differences in video gaming and use of social media among boys and girls?—a mixed methods approach. *Int J Environ Res Public Health*. (2021) 18:6085. doi: 10.3390/ijerph18116085

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

26. Twenge, JM, and Martin, GN. Gender differences in associations between digital media use and psychological well-being: evidence from three large datasets. *J Adolesc*. (2020) 79:91–102. doi: 10.1016/j.adolescence.2019.12.018

[CrossRef Full Text](#) | [Google Scholar](#)

27. Ohannessian, CM . Media use and adolescent psychological adjustment: an examination of gender differences. *J Child Fam Stud*. (2009) 18:582–93. doi: 10.1007/s10826-009-9261-2

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

28. Ohannessian, CM . Video game play and anxiety during late adolescence: the moderating effects of gender and social context. *J Affect Disord*. (2018) 226:216–9. doi: 10.1016/j.jad.2017.10.009

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

29. Ma, L, Evans, B, Kleppang, AL, and Hagquist, C. The association between screen time and reported depressive symptoms among adolescents in Sweden. *Fam Pract*. (2021) 38:773–9. doi: 10.1093/fampra/cmab029

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

30. Boers, E, Afzali, MH, Newton, N, and Conrod, P. Association of screen time and depression in adolescence. *JAMA Pediatr.* (2019) 173:853–9. doi: 10.1001/jamapediatrics.2019.1759

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

31. Leatherdale, ST, Brown, KS, Carson, V, Childs, RA, Dubin, JA, Elliott, SJ, et al. The COMPASS study: a longitudinal hierarchical research platform for evaluating natural experiments related to changes in school-level programs, policies and built environment resources. *BMC Public Health.* (2014) 14:331. doi: 10.1186/1471-2458-14-331

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

32. Qian, W, Battista, K, Bredin, C, Brown, K, and Leatherday, S. *Assessing Longitudinal Data Linkage Results in the Compass Study*. Waterloo, ON: University of Waterloo (2015).

[Google Scholar](#)

33. Leatherdale, S, Laxer, R, and Faulkner, G. *Reliability and Validity of the Physical Activity and Sedentary Behaviour Measures in the COMPASS Study*. Waterloo, ON: University of Waterloo (2015).

[Google Scholar](#)

34. Mossman, SA, Luft, MJ, Schroeder, HK, Varney, ST, Fleck, DE, Barzman, DH, et al. The generalized anxiety disorder 7-item scale in adolescents with generalized anxiety disorder: signal detection and validation. *Ann Clin Psychiatry.* (2017) 29:227–234A.

[Google Scholar](#)

35. Romano, I, Ferro, MA, Patte, KA, and Leatherdale, ST. Measurement invariance of the GAD-7 and CESD-R-10 among adolescents in Canada. *J Pediatr Psychol.* (2022) 47:585–94. doi: 10.1093/jpepsy/jsab119

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

36. Spitzer, RL, Kroenke, K, Williams, JBW, and Löwe, B. A brief measure for assessing generalized anxiety disorder: the GAD-7. *Arch Intern Med.* (2006) 166:1092–7. doi: 10.1001/archinte.166.10.1092

[CrossRef Full Text](#) | [Google Scholar](#)

37. Andresen, EM, Malmgren, JA, Carter, WB, and Patrick, DL. Screening for depression in well older adults: evaluation of a short form of the CES-D. *Am J Prev Med.* (1994) 10:77–84. doi: 10.1016/S0749-3797(18)30622-6

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

38. Bradley, KL, Bagnell, AL, and Brannen, CL. Factorial validity of the center for epidemiological studies depression 10 in adolescents. *Issues Ment Health Nurs.* (2010) 31:408–12. doi: 10.3109/01612840903484105

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

39. Haroz, EE, Ybarra, ML, and Eaton, WW. Psychometric evaluation of a self-report scale to measure adolescent depression: the CESDR-10 in two national adolescent samples in the United States. *J Affect Disord.* (2014) 158:154–60. doi: 10.1016/j.jad.2014.02.009

[CrossRef Full Text](#) | [Google Scholar](#)

40. World Health Organization: Geneva, Switzerland . *WHO Anthro and Macros*. Version 3.2.2. Geneva, Switzerland: World Health Organization (2011).

[Google Scholar](#)

41. Aceves-Martins, M, Whitehead, R, Inchley, J, Giralt, M, Currie, C, and Solà, R. Self-reported weight and predictors of missing responses in youth. *Nutrition.* (2018) 53:54–8. doi: 10.1016/j.nut.2018.01.003

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

42. Leatherdale, ST, and Laxer, RE. Reliability and validity of the weight status and dietary intake measures in the COMPASS questionnaire: are the self-reported measures of body mass index (BMI) and Canada's food guide servings robust? *Int J Behav Nutr Phys Act.* (2013) 10:42. doi: 10.1186/1479-5868-10-42

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

43. NIE, NH . Sociability, interpersonal relations, and the internet: reconciling conflicting findings. *Am Behav Sci.* (2001) 45:420–35. doi: 10.1177/00027640121957277

[CrossRef Full Text](#) | [Google Scholar](#)

44. Kraut, R, Patterson, M, Lundmark, V, Kiesler, S, Mukopadhyay, T, and Scherlis, W. Internet paradox. A social technology that reduces social involvement and psychological well-being? *Am Psychol.* (1998) 53:1017–31. doi: 10.1037/0003-066X.53.9.1017

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

45. Philippot, A, Dubois, V, Lambrechts, K, Grogna, D, Robert, A, Jonckheer, U, et al. Impact of physical exercise on depression and anxiety in adolescent inpatients: a randomized controlled trial. *J Affect Disord.* (2022) 301:145–53. doi: 10.1016/j.jad.2022.01.011

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

46. Wang, X, Cai, Z, Jiang, W, Fang, Y, Sun, W, and Wang, X. Systematic review and meta-analysis of the effects of exercise on depression in adolescents. *Child Adolesc Psychiatry Ment Health.* (2022) 16:16. doi: 10.1186/s13034-022-00453-2

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

47. Rodriguez-Ayllon, M, Cadenas-Sánchez, C, Estévez-López, F, Muñoz, NE, Mora-Gonzalez, J, Migueles, JH, et al. Role of physical activity and sedentary behavior in the mental health of preschoolers,

children and adolescents: a systematic review and meta-analysis. *Sports Med.* (2019) 49:1383–410. doi: 10.1007/s40279-019-01099-5

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

48. Nakshine, VS, Thute, P, Khatib, MN, and Sarkar, B. Increased screen time as a cause of declining physical, psychological health, and sleep patterns: a literary review. *Cureus.* (2022) 14:e30051. doi: 10.7759/cureus.30051

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

49. Cook, K . Mental health, relationships & cognition In: K Cook , editor. *The Psychology of Silicon Valley: Ethical Threats and Emotional Unintelligence in the Tech Industry*. Cham: Springer International Publishing (2020). 197–233.

[Google Scholar](#)

50. Boers, E, Afzali, MH, and Conrod, P. Temporal associations of screen time and anxiety symptoms among adolescents. *Can J Psychiatr.* (2020) 65:070674371988548–208. doi: 10.1177/0706743719885486

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

51. Brannigan, R, Gil-Hernández, CJ, McEvoy, O, Cronin, F, Stanistreet, D, and Layte, R. Digital engagement and its association with adverse psychiatric symptoms: a longitudinal cohort study utilizing latent class analysis. *Comput Hum Behav.* (2022) 133:107290. doi: 10.1016/j.chb.2022.107290

[CrossRef Full Text](#) | [Google Scholar](#)

52. Sampasa-Kanyinga, H, Chaput, J-P, Goldfield, GS, Janssen, I, Wang, J, Hamilton, HA, et al. The Canadian 24-hour movement guidelines and psychological distress among adolescents: Les Directives

canadiennes en matière de mouvement sur 24 heures et la détresse psychologique chez les adolescents. *Can J Psychiatry*. (2021) 66:624–33. doi: 10.1177/0706743720970863

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

53. Sampasa-Kanyinga, H, Colman, I, Dumuid, D, Janssen, I, Goldfield, GS, Wang, JL, et al. Longitudinal association between movement behaviours and depressive symptoms among adolescents using compositional data analysis. *PLoS One*. (2021) 16:e0256867. doi: 10.1371/journal.pone.0256867

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

54. Tremblay, MS, LeBlanc, AG, Kho, ME, Saunders, TJ, Larouche, R, Colley, RC, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth. *Int J Behav Nutr Phys Act*. (2011) 8:98. doi: 10.1186/1479-5868-8-98

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

55. Robb, MB . *The New Normal: Parents, Teens, Screens, and Sleep in the United States*. San Francisco, CA: Common Sense Media (2019).

[Google Scholar](#)

56. Pacheco, D How screen time may cause insomnia in teens. *Sleep Found* (2021). Available at: <https://www.sleepfoundation.org/teens-and-sleep/screen-time-and-insomnia-for-teens> (Accessed October 25, 2022).

[Google Scholar](#)

57. Amra, B, Shahsavari, A, Shayan-Moghadam, R, Mirheli, O, Moradi-Khaniabadi, B, Bazukar, M, et al. The association of sleep and late-night cell phone use among adolescents. *J Pediatr*. (2017) 93:560–7. doi: 10.1016/j.jpeds.2016.12.004

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

58. Medic, G, Wille, M, and Hemels, ME. Short- and long-term health consequences of sleep disruption. *Nat Sci Sleep*. (2017) 9:151–61. doi: 10.2147/NSS.S134864

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

59. Anderson, CA, and Warburton, WA. The impact of violent video games: an overview In: *Growing Up Fast and Furious: Reviewing the Impacts of Violent and Sexualised Media on Children*. Annandale, NSW, Australia: The Federation Press (2012). 56–84.

[Google Scholar](#)

60. Schettler, L, Thomasius, R, and Paschke, K. Neural correlates of problematic gaming in adolescents: a systematic review of structural and functional magnetic resonance imaging studies. *Addict Biol*. (2022) 27:e13093. doi: 10.1111/adb.13093

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

61. Király, O, Potenza, MN, and Demetrovics, Z. Gaming disorder: current research directions. *Curr Opin Behav Sci*. (2022) 47:101204. doi: 10.1016/j.cobeha.2022.101204

[CrossRef Full Text](#) | [Google Scholar](#)

62. Chun, J-W, Choi, J, Cho, H, Lee, S-K, and Kim, DJ. Dysfunction of the frontolimbic region during swear word processing in young adolescents with internet gaming disorder. *Transl Psychiatry*. (2015) 5:e624. doi: 10.1038/tp.2015.106

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

63. Yoon, L, Rohrsetzer, F, Battel, L, Anés, M, Manfro, PH, Rohde, LA, et al. Frontolimbic network topology associated with risk and presence of depression in adolescents: a study using a composite risk score in Brazil. *Biol Psychiatry: Cogn Neurosci*. (2022) 8:426–35. doi: 10.1016/j.bpsc.2022.03.008

[CrossRef Full Text](#) | [Google Scholar](#)

64. Pandya, M, Altinay, M, Malone, D, and Anand, A. Where in the brain is depression? *Curr Psychiatry Rep.* (2012) 14:634–42. doi: 10.1007/s11920-012-0322-7

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

65. Xie, S, Zhang, X, Cheng, W, and Yang, Z. Adolescent anxiety disorders and the developing brain: comparing neuroimaging findings in adolescents and adults. *Gen Psychiatry.* (2021) 34:e100411. doi: 10.1136/gpsych-2020-100411

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

66. Christensen, SP . *Social Media Use and Its Impact on Relationships and Emotions*. Provo, Utah: Brigham Young University (2018):73.

[Google Scholar](#)

67. Vogel, EA, and Rose, JP. Self-reflection and interpersonal connection: making the most of self-presentation on social media. *Transl Issues Psychol Sci.* (2016) 2:294–302. doi: 10.1037/tps0000076

[CrossRef Full Text](#) | [Google Scholar](#)

68. Pera, A . Psychopathological processes involved in social comparison, depression, and envy on Facebook. *Front Psychol.* (2018) 9:22. doi: 10.3389/fpsyg.2018.00022

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

69. Thorisdottir, IE, Sigurvinsdottir, R, Asgeirsdottir, BB, Allegrante, JP, and Sigfusdottir, ID. Active and passive social media use and symptoms of anxiety and depressed mood among Icelandic adolescents. *Cyberpsychol Behav Soc Netw.* (2019) 22:535–42. doi: 10.1089/cyber.2019.0079

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

70. Blomfield Neira, CJ, and Barber, BL. Social networking site use: linked to adolescents' social self-concept, self-esteem, and depressed mood. *Aust J Psychol.* (2014) 66:56–64. doi: 10.1111/ajpy.12034

[CrossRef Full Text](#) | [Google Scholar](#)

71. Nesi, J, and Prinstein, MJ. Using social media for social comparison and feedback-seeking: gender and popularity moderate associations with depressive symptoms. *J Abnorm Child Psychol.* (2015) 43:1427–38. doi: 10.1007/s10802-015-0020-0

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

72. McCarthy, PA, and Morina, N. Exploring the association of social comparison with depression and anxiety: a systematic review and meta-analysis. *Clin Psychol Psychother.* (2020) 27:640–71. doi: 10.1002/cpp.2452

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

73. Raposo, M, Martínez-Figueira, M, Campos, S, and Parrilla, Á. Teens' behavior patterns on the web: surfing or wrecking? *Digit Educ Rev.* (2021) 39:60–75. doi: 10.1344/der.2021.39.60-75

[CrossRef Full Text](#) | [Google Scholar](#)

74. Kim, D, Nam, JK, Oh, J, and Kang, MC. A latent profile analysis of the interplay between PC and smartphone in problematic internet use. *Comput Hum Behav.* (2016) 56:360–8. doi: 10.1016/j.chb.2015.11.009

[CrossRef Full Text](#) | [Google Scholar](#)

75. Ferreiro, SG, Gómez, P, Harris, S, Braña, T, and Boubeta, A. Diferencias de sexo en el uso de internet en adolescentes españoles. *Behav Psychol.* (2017) 25:129–46.

[Google Scholar](#)

76. Dowling, K, Simpkin, AJ, and Barry, MM. A cluster randomized-controlled trial of the MindOut social and emotional learning program for disadvantaged post-primary school students. *J Youth Adolesc.* (2019) 48:1245–63. doi: 10.1007/s10964-019-00987-3

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

77. Montiel, I, Ortega-Barón, J, Basterra-González, A, González-Cabrera, J, and Machimbarrena, JM. Problematic online gambling among adolescents: a systematic review about prevalence and related measurement issues. *J Behav Addict.* (2021) 10:566–86. doi: 10.1556/2006.2021.00055

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

78. Andrie, EK, Sakou, II, Tzavela, EC, Richardson, C, and Tsitsika, AK. Adolescents' online pornography exposure and its relationship to sociodemographic and psychopathological correlates: a cross-sectional study in six European countries. *Children.* (2021) 8:925. doi: 10.3390/children8100925

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

79. González-Cabrera, J, Machimbarrena, JM, Beranuy, M, Pérez-Rodríguez, P, Fernández-González, L, and Calvete, E. Design and measurement properties of the online gambling disorder questionnaire (OGD-Q) in Spanish adolescents. *J Clin Med.* (2020) 9:120. doi: 10.3390/jcm9010120

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

80. Li, J, Wu, Y, and Hesketh, T. Internet use and cyberbullying: impacts on psychosocial and psychosomatic wellbeing among Chinese adolescents. *Comput Hum Behav.* (2023) 138:107461. doi: 10.1016/j.chb.2022.107461

[CrossRef Full Text](#) | [Google Scholar](#)

81. Zhu, C, Huang, S, Evans, R, and Zhang, W. Cyberbullying among adolescents and children: a comprehensive review of the global situation, risk factors, and preventive measures. *Front Public Health.* (2021) 9:634909. doi: 10.3389/fpubh.2021.634909

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

82. Sampasa-Kanyinga, H, Lalande, K, and Colman, I. Cyberbullying victimisation and internalising and externalising problems among adolescents: the moderating role of parent–child relationship and child’s sex. *Epidemiol Psychiatr Sci.* (2018) 29:e8. doi: 10.1017/S2045796018000653

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

83. Li, J, Sidibe, AM, Shen, X, and Hesketh, T. Incidence, risk factors and psychosomatic symptoms for traditional bullying and cyberbullying in Chinese adolescents. *Child Youth Serv Rev.* (2019) 107:104511. doi: 10.1016/j.chilyouth.2019.104511

[CrossRef Full Text](#) | [Google Scholar](#)

84. Hong, JS, Kim, DH, Thornberg, R, Kang, JH, and Morgan, JT. Correlates of direct and indirect forms of cyberbullying victimization involving south Korean adolescents: an ecological perspective. *Comput Hum Behav.* (2018) 87:327–36. doi: 10.1016/j.chb.2018.06.010

[CrossRef Full Text](#) | [Google Scholar](#)

85. Cattarin, JA, Thompson, JK, Thomas, C, and Williams, R. Body image, mood, and televised images of attractiveness: the role of social comparison. *J Soc Clin Psychol.* (2000) 19:220–39. doi: 10.1521/jscp.2000.19.2.220

[CrossRef Full Text](#) | [Google Scholar](#)

86. Tiggemann, M, and Kuring, JK. The role of body objectification in disordered eating and depressed mood. *Br J Clin Psychol.* (2004) 43:299–311. doi: 10.1348/0144665031752925

[PubMed Abstract](#) | [CrossRef Full Text](#) | [Google Scholar](#)

87. Dakanalis, A, Clerici, M, Caslini, M, Favagrossa, L, Prunas, A, Volpato, C, et al. Internalization of sociocultural standards of beauty and disordered eating behaviours: the role of body surveillance, shame and social anxiety. *J Psychopathol.* (2014) 20:33–7.

Table 1. Descriptive characteristics among Canadian secondary school students that participated in Year 6 (Time 1: 2017-18) and Year 7 (Time 2: 2018-19) of the COMPASS study

Characteristics	Total population Time 1 N= 17,174	Females Time 1 N= 9,173	Males Time 1 N= 7,974	Total population Time 2 N= 17,174	Females Time 2 N= 9,173	Males Time 2 N= 7,974
Age (mean (SD))	15.1 (0.9)	15.1 (0.9)	15.1 (0.9)	16.1 (0.9)	16.1 (0.9)	16.1 (0.9)
Race/ethnicity (%)*						
White	68.3	68.0	68.6	68.3	68.9	68.2
Black	02.5	02.3	02.8	02.5	02.4	03.2
Asian	12.6	12.8	12.6	12.6	12.9	12.5
Latin American/Hispanic	02.8	02.9	02.7	02.8	02.9	03.1
Other and mixed	13.8	14.0	13.3	13.8	12.9	13.0
BMI Classification*						
Underweight	01.8	01.5	01.9	01.6	01.2	02.1
Normal weight	57.1	60.0	53.7	60.4	63.3	56.8
Overweight	12.5	11.0	14.3	13.2	12.3	14.3
Obesity	05.6	04.0	07.6	06.1	04.4	08.1
Missing BMI	23.0	23.5	22.5	18.7	18.8	18.7
School-area household median income*						
\$ 25,000-50,000	12.6	13.3	11.6	12.6	13.3	11.6
\$50,001-75,000	55.8	55.1	56.6	55.8	55.1	56.7
\$75,001-100,000	26.6	26.4	26.9	26.6	26.5	26.9
> \$ 100,000	05.0	05.2	04.9	05.0	05.2	04.8
Screen time (mean (SD))						
television *	112.36 (87.04)	121.46 (87.74)	101.88 (85.04)	113.47 (87.26)	117.63 (86.25)	108.69 (88.17)
Video games*	81.43 (109.31)	29.16 (64.94)	141.56 (118.68)	74.55 (105.20)	26.48 (61.05)	129.93 (117.45)
Talking on the phone*	38.02 (75.57)	45.71 (81.62)	29.18 (66.87)	44.15 (80.39)	50.14 (84.11)	37.25 (75.30)
Internet surfing*	112.37 (111.98)	126.25 (116.56)	96.41 (104.22)	118.74 (108.29)	130.32 (110.18)	105.39 (104.50)
Texting/ messaging/ emailing*	94.20 (111.84)	110.38 (119.32)	75.58 (99.37)	99.32 (109.89)	111.98 (114.07)	84.73 (102.96)
Screen time						
television viewing*						
0-29 min/d	12.6	09.2	16.6	12.0	09.5	15.0
30-59 min/d	09.1	09.5	08.7	09.4	10.4	08.3
1-2 h/d	28.3	26.7	30.0	27.2	27.0	27.3
2-3 h/d	25.4	26.4	24.2	26.6	26.9	26.2
3+ h/d	24.6	28.2	20.5	24.8	26.2	23.2
Video games*						
0-29 min/d	45.4	72.2	14.6	47.8	74.2	17.5
30-59 min/d	07.3	07.5	07.0	07.4	07.3	07.5
1-2 h/d	15.5	10.8	20.9	15.8	10.0	22.6
2-3 h/d	12.2	04.6	20.9	11.4	04.0	19.7
3+ h/d	19.6	04.9	36.6	17.6	04.5	32.7
Talking on the phone*						
0-29 min/d	70.0	62.0	76.0	62.9	58.0	68.6
30-59 min/d	08.0	09.2	06.5	08.8	10.0	07.6
1-2 h/d	11.0	14.3	09.5	14.0	15.5	12.4
2-3 h/d	05.0	06.5	04.0	06.7	08.0	05.2
3+ h/d	06.0	08.0	05.0	07.6	08.5	06.2
Internet Surfing*						
0-29 min/d	19.5	16.0	23.7	15.0	12.2	18.2
30-59 min/d	13.0	11.7	14.0	12.0	10.8	13.3
1-2 h/d	25.5	24.3	27.0	26.3	24.8	28.0
2-3 h/d	17.0	18.0	16.0	19.4	20.5	18.3
3+ h/d	25.0	30.0	19.3	27.3	31.7	22.2
Texting/ messaging/ emailing*						
0-29 min/d	29.7	22.0	38.5	24.5	18.5	31.5
30-59 min/d	16.3	17.0	15.5	16.0	16.4	15.5
1-2 h/d	21.5	22.6	20.2	24.2	24.3	24.0
2-3 h/d	13.0	14.4	11.4	14.7	16.7	12.5

3+ h/d	19.5	24.0	14.4	20.6	24.1	16.5
Anxiety symptoms score* (mean (SD))	6.27 (5.53)	7.77 (5.73)	4.55 (4.74)	6.82 (5.67)	8.42 (5.73)	4.99 (5.02)
Anxiety symptoms*						
Yes	24.4	33.5	14.0	27.5	36.9	16.7
No	75.6	66.5	86.0	72.5	63.1	83.3
Depressive symptoms score * (mean (SD))	8.45 (5.84)	9.67 (6.23)	7.05 (5.01)	9.20 (6.04)	10.47 (6.27)	7.74 (5.40)
Depressive symptoms *						
Yes	34.2	42.9	24.2	40.0	49.6	29.4
No	65.8	57.1	75.8	60.0	50.4	70.6

Data are shown as percentages or mean (standard deviation).

SD, standard deviation; BMI, body mass index.

Starred variables represent statistically significant p-values for the sex differences (< 0.05).

Anxiety and depression symptoms assessed by the GAD-7 and CESD-10-R, respectively, with scores ≥ 10 used to indicate the presence of clinically-relevant symptoms.

Table 2. Longitudinal association between types of screen at Time 1 (2017-18) and anxiety symptoms at Time 2 (2018-19) among adolescents in the COMPASS study.

Television viewing - Females	Crude OR (95% CI)	Adjusted OR (95% CI)
0-29 min/d	1	1
30-59 min/d	0.99 (0.81 – 1.22)	0.99 (0.79 – 1.25)
1-2 h/d	1.08 (0.91 – 1.28)	1.10 (0.92 – 1.33)
2-3 h/d	1.18 (0.99 – 1.39)	1.16 (0.96 – 1.40)
3+ h/d	1.42 (1.20 – 1.67) ***	1.27 (1.06 – 1.53)**
Television viewing - Males	Crude OR (95% CI)	Adjusted OR (95% CI)
0-29 min/d	1	1
30-59 min/d	0.76 (0.58-0.99)*	0.80 (0.60 – 1.06)
1-2 h/d	0.84 (0.70-1.01)	0.83 (0.68 – 1.01)
2-3 h/d	1.05 (0.87-1.27)	0.98 (0.80 – 1.20)
3+ h/d	1.13 (0.93-1.37)	1.00 (0.81 – 1.23)
Video games	Crude OR (95% CI)	Adjusted OR (95% CI)
0-29 min/d	1	1
30-59 min/d	0.65 (0.57-0.75)***	0.86 (0.73-1.01)
1-2 h/d	0.68 (0.62-0.75)***	1.13 (1.00-1.28)*
2-3 h/d	0.54 (0.48-0.60)***	1.14 (0.99-1.32)
3+ h/d	0.57 (0.52-0.63)***	1.27 (1.12-1.45)***
Talking on the phone	Crude OR (95% CI)	Adjusted OR (95% CI)
0-29 min/d	1	1
30-59 min/d	1.42 (1.24-1.61)***	1.22 (1.06-1.40)**
1-2 h/d	1.49 (1.34-1.65)***	1.18 (1.05-1.33)**
2-3 h/d	1.62 (1.40-1.87)***	1.25 (1.06-1.48)**
3+ h/d	1.91 (1.67-2.17)***	1.36 (1.17-1.57)***
Internet surfing- females	Crude OR (95% CI)	Adjusted OR (95% CI)
0-29 min/d	1	1
30-59 min/d	0.91 (0.76-1.08)	0.94 (0.78-1.14)
1-2 h/d	1.06 (0.92-1.23)	1.03 (0.88-1.20)
2-3 h/d	1.12 (0.96-1.30)	1.04 (0.88-1.24)
3+ h/d	1.42 (1.24-1.63)***	1.20 (1.03-1.40)*
Internet surfing- males	Crude OR (95% CI)	Adjusted OR (95% CI)
0-29 min/d	1	1
30-59 min/d	1.01 (0.81-1.26)	1.00 (0.79-1.27)
1-2 h/d	1.46 (1.23-1.74)***	1.41 (1.17-1.69)***
2-3 h/d	1.41 (1.15-1.72)***	1.23 (0.99-1.29)
3+ h/d	1.79 (1.49-2.15)***	1.49 (1.22-1.82)***
Texting/ messaging/ emailing	Crude OR (95% CI)	Adjusted OR (95% CI)
0-29 min/d	1	1
30-59 min/d	1.29 (1.15-1.43)***	1.07 (0.95-1.21)
1-2 h/d	1.29 (1.16-1.42)***	1.01 (0.90-1.13)
2-3 h/d	1.58 (1.42-1.77)***	1.18 (1.04-1.34)**
3+ h/d	2.21 (2.01-2.44)***	1.40 (1.25-1.57)***

OR: odds ratio; CI: confidence interval. Models are adjusted for school clustering, age, race/ethnicity, BMI z-score, income, and prior year anxiety. *p < 0.05; **p < 0.01; ***p < 0.001

Data from Canadian secondary school students linked across year 6 (2017-18) and 7 (2018-19) of the COMPASS study.

Table 3. Longitudinal association between each type of screen at Time 1 (2017-18) and depressive symptoms at Time 2 (2018-19) among adolescents in the COMPASS study.

Screen time	Television viewing - Females	Crude OR (95% CI)	Adjusted OR (95% CI)
0-29 min/d	0-29 min/d	1	1
30-59 min/d	30-59 min/d	0.94 (0.78-1.14)	1.03 (0.83-1.28)
1-2 h/d	1-2 h/d	1.02 (0.87-1.20)	1.12 (0.94 – 1.34)
2-3 h/d	2-3 h/d	1.11 (0.95-1.31)	1.15 (0.96-1.38)
3+ h/d	3+ h/d	1.44 (1.23-1.69)***	1.30 (1.09-1.55)**
Screen time	Television viewing - males	Crude OR (95% CI)	Adjusted OR (95% CI)
0-29 min/d	0-29 min/d	1	1
30-59 min/d	30-59 min/d	0.79 (0.64-0.97)*	0.82 (0.66 – 1.03)
1-2 h/d	1-2 h/d	0.83 (0.72-0.97)*	0.81 (0.68 – 0.95)
2-3 h/d	2-3 h/d	0.91 (0.78-1.07)	0.87 (0.73 – 1.03)
3+ h/d	3+ h/d	1.06 (0.91-1.24)	0.91 (0.77 – 1.08)
Screen time	Video games	Crude OR (95% CI)	Adjusted OR (95% CI)
0-29 min/d	0-29 min/d	1	1
30-59 min/d	30-59 min/d	0.78 (0.69-0.88)***	1.06 (0.91-1.22)
1-2 h/d	1-2 h/d	0.75 (0.69-0.82)***	1.14 (1.02-1.28)*
2-3 h/d	2-3 h/d	0.62 (0.56-0.69)***	1.11 (0.98-1.27)
3+ h/d	3+ h/d	0.72 (0.66-0.78)***	1.29 (1.15-1.46)***
Screen time	Talking on the phone	Crude OR (95% CI)	Adjusted OR (95% CI)
0-29 min/d	0-29 min/d	1	1
30-59 min/d	30-59 min/d	1.34 (1.19-1.50)***	1.13 (0.99-1.29)
1-2 h/d	1-2 h/d	1.37 (1.25-1.51)***	1.07 (0.96-1.20)
2-3 h/d	2-3 h/d	1.56 (1.36-1.79)***	1.16 (0.99-1.36)
3+ h/d	3+ h/d	1.97 (1.74-2.24)***	1.33 (1.15-1.53)***
Screen time	Internet surfing	Crude OR (95% CI)	Adjusted OR (95% CI)
0-29 min/d	0-29 min/d	1	1
30-59 min/d	30-59 min/d	0.97 (0.86-1.09)	0.90 (0.79-1.03)
1-2 h/d	1-2 h/d	1.18 (1.08-1.30)***	1.00 (0.90-1.11)
2-3 h/d	2-3 h/d	1.35 (1.22-1.50)***	1.03 (0.91-1.16)
3+ h/d	3+ h/d	1.92 (1.75-2.11)***	1.24 (1.11-1.38)***
Screen time	Texting/ messaging/ emailing	Crude OR (95% CI)	Adjusted OR (95% CI)
0-29 min/d	0-29 min/d	1	1
30-59 min/d	30-59 min/d	1.21 (1.10-1.33)***	1.07 (0.96-1.20)
1-2 h/d	1-2 h/d	1.28 (1.17-1.40)***	1.07 (0.96-1.18)
2-3 h/d	2-3 h/d	1.45 (1.31-1.61)***	1.11 (0.99-1.25)
3+ h/d	3+ h/d	1.99 (1.82-2.18)***	1.32 (1.19-1.46)***

OR: odds ratio; CI: confidence interval. Models are adjusted for school clustering, age, race/ethnicity, BMI z-score, income, and prior year depression. *p < 0.05; **p < 0.01; ***p < 0.001

Table 4. Association between one-year change in screen time and changes in anxiety and depressive symptoms among adolescents in the COMPASS study (2017-18 to 2018-19).

One-year change in screen time and changes in depression	Est.	SE	95% CI	p-value
Television viewing - Females	0.046	0.017	(0.011-0.080)	0.008
Television viewing - Males	0.018	0.017	(-0.015-0.052)	0.269
Video games	0.017	0.014	(-0.010-0.045)	0.216
Talking on the phone	0.087	0.017	(0.051-0.119)	0.000
Internet surfing - Females	0.071	0.016	(0.039-0.102)	0.000
Internet surfing - Males	0.053	0.016	(0.019-0.086)	0.001
Texting/ messaging/ emailing	0.067	0.012	(0.043-0.092)	0.000
One-year change in screen time and changes in depression	Est.	SE	95% CI	p-value
Television viewing - Females	0.030	0.019	(-0.006-0.068)	0.109
Television viewing - Males	0.068	0.018	(0.032-0.104)	0.000
Video games	0.041	0.015	(0.011-0.071)	0.007
Talking on the phone	0.084	0.017	(0.050-0.118)	0.000
Internet surfing	0.070	0.012	(0.045-0.095)	0.000
Texting/ messaging/ emailing	0.100	0.013	(0.071-0.124)	0.000

Note: Models are adjusted for school clustering, age, race/ethnicity, BMI z-score, income, prior year anxiety, and depressive symptoms. Est.:

Beta coefficient, SE: Standard Error, CI: confidence interval.

CHAPTER 7 GENERAL DISCUSSION

7.1 Summary of Main Findings

The aim of this dissertation was to identify and address knowledge gaps in the scientific literature on the relationship between sedentary screen time and mental health symptoms such as anxiety, depressive symptoms, and suicidal behaviour among adolescents. To achieve this purpose, I conducted four research studies (one narrative review, two cross-sectional studies, and one longitudinal study) using two large datasets that included a diverse sample of Canadian youth.

Collectively, the results showed (1) a positive association between heavy and problematic use of sedentary screen activities and mental health symptoms cross-sectionally and subsequent symptoms longitudinally; (2) time-change associations between screen usage and depressive and anxiety symptoms; (3) the relationship between social media use and psychological distress was stronger among younger adolescents; (4) the relationship between problematic technology use and suicidal ideation and suicide attempt and between internet surfing and anxiety was stronger among males, while TV viewing was associated with higher anxiety and depressive symptoms among females; and (5) the strength of the association varied slightly between some types of screen use, with stronger relationships for screen-based communication, talking on the phone, and video gaming compared to TV viewing.

In this chapter, I will provide a summary of key findings from these studies, then I will outline the key strengths and limitations of the dissertation, important implications and future directions for research, and a conclusion will be provided.

In Chapter 3, we identified gaps in literature through a narrative review that was used to guide the dissertation structure. We examined the relationship between screen time and anxiety, depression, psychological well-being, and body image concerns in 60 recent cross-sectional and longitudinal studies. We found evidence for a positive association between duration of screen time and high depressive symptoms, poor psychological well-being, and body dissatisfaction. Evidence on anxiety was scarce and inconsistent. This study also found that the association between sedentary screen behaviour and mental health was influenced by sex, age and screen types.

In Chapter 4, we examined the cross-sectional association between heavy social media use and psychological distress among Ontarian adolescents ($N = 6,822$), and whether the effect of this association was modified by sex, age, and parental support. Results from this study showed a positive association between heavy social media use and psychological distress, with young adolescents being the most vulnerable. Although sex and parental support were not shown to be significant moderators of this association, our results suggest further work examining the effect modifying role of sex and parental support in large longitudinal trials with better measurement of parental support to better understand the role of these factors in the association between social media use and psychological distress.

In Chapter 5, we shed light on the association between heavy screen use and mental health by examining the association between problematic technology use and suicidal ideation and suicide attempt among adolescents. Using recent data from the OSDUHS ($N = 4,390$; mean age: 15.9 ± 1.3 years), our results showed that females have higher symptoms of problematic technology use and a higher prevalence of suicidal behaviour than males; however, males with moderate-to-serious symptoms of PTU had higher odds of both suicidal ideation and suicide

attempt. These results might be driven by the quality and nature of the types of technology used and are worth further investigation in the future.

In recognizing the importance of longitudinal studies to examine the dose-response association between different types of screen usage and mental health problems, we examined in Chapter 6 the longitudinal associations between five different types of screen pursuits and anxiety and depression using longitudinal data from 17,174 Canadian students (mean age: 15.1 ± 0.9 years). We also examined whether this association is modified by sex. Our results showed a significant association between time spent on each type of screen and anxiety and depression symptoms one year later. The strength of the associations was influenced by the type of screen pursuit and sex. Also, our results showed that more screen usage was associated with a further increase in anxiety and depressive symptoms.

7.2 Comparison with other relevant literature

7.2.1 Frequency of recreational screen use and mental health outcomes

The results of the frequency of screen use and mental health outcomes from the three original studies in this dissertation indicated that heavy screen use is associated with higher mental health symptoms, with more use over time being associated with worse mental health symptoms. Furthermore, adolescents with severe symptoms of problematic technology use reported higher odds of suicidal ideation and suicide attempts.

The results in this thesis are consistent with previous studies that showed that high and heavy recreational screen time is a strong predictor of mental health indicators among adolescents, which provides support that limiting screen time can be beneficial in reducing mental health problems [1–4]. Also, previous studies found a non-linear dose-response or U-shaped association between sedentary screen activities and mental health outcomes [1, 5–8],

suggesting that moderate use of screens is not harmful. These findings could be explained by the Digital Goldilocks Hypothesis suggesting that screen time in moderation might be beneficial, while too little use can deprive individuals from important social opportunities [6], and “overuse” displaces other beneficial activities that are important for good mental health. Though we did not notice a U-shaped association in our results, the findings of this dissertation align with what the theory implies in terms of finding the right balance between recreational screen time and other important health behaviours for maintaining a healthy relationship with screen use.

The results regarding the association between high screen time and mental health problems appear to be driven by many proposed mechanisms such as reduction of face-to-face interaction with family and friends [9]; reduction in physical activity [10], poor sleep quality, or lack of sleep [10–15]; cyberbullying [10, 16–18]; and/or upward social comparison [19–21]. In addition to that, several biological mechanisms have been proposed, with one study showing the screen time was associated with lower serum brain derived neurotrophic factor (BDNF), which is a neurotrophin that is associated with mental wellbeing [22]. Moreover, a recent review of results from observations in humans and experiments in mice provides evidence that excessive media exposure is associated with adverse brain structure and function, as well as lower executive functioning, possibly through over stimulation [23]. Further research is warranted to explore potential factors that could untangle the mechanisms contributing to the relationship between each type of screen time and mental health outcomes in adolescents to fully understand the complex and nuanced association between sedentary screen activities and mental health outcomes.

7.2.2 Different types of screen and mental health outcomes

Our longitudinal study also demonstrated that the relationship between screen time and anxiety and depressive symptoms varied slightly between different screen types, with more evidence for anxiety. For instance, texting, messaging, emailing and talking on the phone were associated with more anxiety and depressive symptoms than TV viewing. This is consistent with previous work demonstrating that the association between screen time and mental health outcomes differs between screen types [2, 24]. This might suggest a moderating role of screen types and is worth further examination in the future [2, 3]. A possible explanation regarding the difference in the association by screen type is related to the screen content and activity. Therefore, it is important to examine not only the types of screens used but also the content and the way the technology is being used by adolescents.

Our findings regarding the association between social media use and psychological distress align with previous work which found a positive association between high social media use and symptoms of anxiety and depression and psychological distress among adolescents [25, 26]. It has been suggested that social media use might expose young people to upward social comparison [21, 27], which can trigger low self-esteem [28–30] and body image concerns [29, 31], factors known to be associated with psychological distress [27, 31, 32]. Also, the way social media has been used by adolescents matters as previous work [33, 34] indicated that passive use of social media is associated with higher levels of depressive symptoms. One more explanation related to the association between social media use and mental health problems is that more screen time replaces in person social interaction, which can lead to loneliness [9]. In summary, our findings suggest that future research is needed that investigates the type and nature of social media use to better understand the association with mental health.

7.2.3 Moderators of screen time and mental health outcomes

We observed sex and age differences across studies; however, no moderating role of parental support was found in our results.

Regarding age as moderator between social media use and psychological distress, we found that older adolescents reported more social media usage than their younger counterparts. However, younger groups presented higher odds of psychological distress when using social media heavily, in agreement with previous work [35, 36] and in contrast with another [37]. While mixed results could be related to different study designs, one explanation of our findings could be related to the phase of early adolescence as a high-risk period for mental health problems [38–41] during which social media use could be a potential trigger [42, 43]. Future longitudinal studies with further investigation of the age and sex differences in this association are needed.

Our findings on sex as a moderator varied between studies. The association between problematic technology use and suicidal ideation and suicide attempt reported a positive association between higher symptoms of problematic technology use and suicidal ideation and suicide attempt with higher odds among males.

Our results regarding sex differences between each type of screen use and mental health outcomes longitudinally indicate that females reported more of surfing the internet than males however males had higher anxiety symptoms. On the other hand, our results indicated that only females with heavy TV viewing reported increased levels of anxiety and depression after one year. Mixed results were provided in previous work regarding the moderating role of sex on the association between screen time and mental health [2, 3, 24]. The sex difference could also be related to the content and preferences of screen types, therefore it is highly recommended that future longitudinal studies assess preferences and content among males and females separately to

understand the sex differences in screen preferences and also examine the mechanism underpinning sex differences among adolescents [2, 3].

Regarding parental support as a moderator, our findings from the cross-sectional study suggest no moderating effect of parental support after adjusting for SES and sex. This indicates an important role of these covariates in the association between social media use and mental health. Also, the quality and depth of measurement of parental support in the survey is very vague and does not inform about the role of parents in role modeling, guidance, and support of their teens. Previous work indicated that the role of parents is very critical in influencing teens screen behaviours by using open communication, setting rules, supervision and monitoring [44–46]. Therefore, we highly recommend that future research examines with more methodological rigour the role of parents, taking into consideration the impact of other important factors as covariates in this relationship.

7.3 Strengths and Limitations

7.3.1 Strengths

The present dissertation has several strengths. First, it included a thorough narrative review that examined more than 60 articles that summarize the impact of different screen types on mental health illnesses such as body dissatisfaction, psychological well-being, depression, and anxiety in children and youth. This review provided one of the most current piece of evidence on this topic and identified gaps in the literature that guided our subsequent studies.

Second, this dissertation included various study designs, cross-sectional and longitudinal. It is well known that longitudinal designs provide stronger evidence about the direction of association between screen time and mental health. Third, our data for the studies were driven from large datasets on Canadian adolescents. The OSDUHS and the COMPASS datasets are

large, samples that allowed us to produce robust models, control for many covariates, assess different types of screen use, and examine moderators that are related to mental health outcomes. Fourth, most of the screen time and mental health outcomes measures were validated tools. Fifth, this dissertation examined many moderators, such as age, sex, and parental support, using proper statistical tests of interaction. In contrast, many previous studies generated pooled analyses or stratified analyses without performing tests of interaction for effect modification [3, 24]. Finally, this dissertation examined many mental health indicators, such as anxiety, depression, and suicidal behaviours whereas previous research demonstrated a lack of a thorough examination of these indicators [2, 3, 24, 47].

7.3.2 Limitations

Findings from this dissertation contribute important information to a growing body of literature. However, several limitations must be noted. First, our review of the literature was not a systematic review, but rather a narrative review performed by a single reviewer. Therefore, the absence of predefined selection criteria and a formal critical appraisal of data quality are considered limitations.

Second, despite the work from one longitudinal study, our results from the two cross-sectional studies limited the causality inference about the direction of the relationships between screen time and mental health outcomes. Furthermore, due to the cross-sectional nature of this study, we were unable to determine whether adolescents' characteristics or mental health trigger them to spend much time on the screen or if screen time impacts their mental health.

Third, the present dissertation did not account for the numerous types of media content adolescents engaged in, which limited our ability to understand how quality and content can explain this association between screen time and mental health. Fourth, variables were measured

using a variety of self-report questionnaires, which can make the study design susceptible to information bias through the potential for participants to over or underreport screen time or over or underestimate mental health symptoms, probably to avoid perceived stigmas or judgment. It also must be noted that depressive symptoms and anxiety do not represent clinical diagnoses in these studies.

Fifth, self-reported data in the OSDUHS and COMPASS are not nationally representative, especially the OSDHS sample, which was restricted to Ontario, therefore the generalizability of our findings to all adolescents in Canada is limited. Also, enrolled students who do not participate in the surveys for lack of consent or absenteeism may bias the results if those who did not participate differ from participating students on variables of interest. Sixth, the approaches we used to select covariates included identifying potential confounders based on prior knowledge and existing literature and performing statistical tests to assess the association between potential confounders and the exposure or outcome variables. We did not employ a directed acyclic graph (DAG) which is considered a thorough approach for better understanding relations between the variables and to determine the minimum set of variables that should enter the adjusted model, which could reduce the chances of under or over-adjustment and collider bias [48–50]. Finally, due to the limited data, potential important moderators such as parent-adolescent interactions could not be examined in adequate depth.

7.4 Implications and Recommendations for Practice

The findings of this dissertation have important implications for policymakers, schools, practitioners, and parents. Evidence suggests that interventions that are based on theory are more effective than non-theoretical approaches [51, 52]. Thus, it is essential to consider multiple levels of the ecological model that influence the association between sedentary screen behaviour and

mental health among adolescents to inform the design of evidence-based strategies to foster screen time reduction. That being said, the following implications involve the individual, interpersonal (e.g., relationships, family), institutional and community (e.g., schools) and societal (e.g., policies, regulations, resource allocation) levels.

Policymakers should increase funding for research on screen time and mental health among adolescents that includes implementation of interventions aiming to influence a better, responsible and healthy use of recreational screen time. In addition to that policymakers are encouraged to allocate more funding to help employ an efficient and adequate response program starting by public awareness campaigns targeting caregivers, parents and adolescents to shed light on screen time guidelines and empower those in need of mental health services by connecting them to appropriate resources. Policymakers should also use more strict regulations for social media use through more efficient age verification, and safety features restricting minor from accessing these platforms [53], and requiring parental consent for adolescents to access their apps. Recently the U.S. Surgeon General Vivek Murthy indicated that age 13 is too early for young people to be using social media, highlighting some of the potential impacts to young people physical and mental well-being. He advised parents to keep teens off social media until they are 16, 17, or 18 years old [54]. Murthy called for data transparency and safety standard to have in place by social media companies to prevent these platforms from causing mental health harms to young people [55]. This is especially important given findings from the dissertation that the associations between screens time and mental health is stronger in younger ages, making this population more vulnerable.

The results of this dissertation hold important implications for potential media literacy plans for the integration of healthy screen use into the whole family environment and in schools.

The media literacy framework consists of the ability to access, use, understand, and engage with all types of media in a critical, effective and responsible way to become active rather than passive media consumers. It also allows individuals to authenticate information, manage privacy, address cyberbullying, and access online platforms safely [56–59].

Additionally, increased awareness regarding a modifiable risk factor like screen use can help to promote healthy screen time use and adherence to the recommended sedentary screen time recommendations in the 24-hour movement guidelines to protect adolescents' mental health. Some experimental and prospective studies looking at the effects of limiting recreational digital use showed improvement in depression, anxiety, loneliness, and emotional distress among youth [60–63]. In addition to that, interventions aiming at reducing screen time, especially social media use, and encouraging youth to use media more moderately could have promising results on mental health outcomes [64–66]. Recently, the Canadian Pediatric Society (2019) launched the Digital Health Task Force, through which they recommended healthcare providers discuss with families essential principles to promote healthy screen use among children and adolescents. These recommendations included strategies on managing screen time in a healthy meaningful way, encouraging parents to model healthy screen use, and employing balanced and informed digital monitoring of problematic technology use [66].

Given that technology use increases during adolescence, many validated and short screening tools [67–70] may be helpful in clinical practice for the use of primary care clinicians to conduct early screening for problematic technology use. This could help clinicians to understand the risk profile and improve the detection of problematic technology use among adolescents, which informs early treatment and prevention. Also, clinicians should encourage

and inform parents and caregivers to implement a healthy media use plan for the whole family [58].

Finally, as primary caregivers, parents can play an important role in positively influencing children screen access behaviour by setting rules and monitoring screen use, and establishing at home behavioural control. Previous work has shown that some interventions, such as setting time limits, use parental control apps, displacing screen time with other health promoting activities, and developing screen time contracts or plans help reduce sedentary behaviour among children and young adolescents [71, 72].

7.5 Implications and Directions for Future Research

The results of this dissertation are helpful in guiding future research aiming to assess the association between screen time and mental health among adolescents.

First, future research is warranted to examine in more depth the association between different types of screen and mental health problems using large, high-quality studies and validated and objective measures (e.g., smartphones and device monitoring apps) that help understand the exact nature of this association. Longitudinal and representative samples with extended follow-up periods and repeated measures of different screen use behaviours with various mental health outcomes will provide clear answers regarding the direction and strength of this association.

Second, future studies are warranted to investigate in more depth the moderating effect of different types of screens, sex and various age groups on the association between screen time and mental health outcomes. Such investigations may provide insight into whether there are age, screen type, or sex differences and what underpinning mechanisms influence these differences in the association between screen time and mental health.

Third, more research is needed to expand the work on examining potential mechanisms pertaining to the effect of sedentary screen time on mental health among adolescents to better explain the neurobiological and psychosocial pathways. For instance, future studies should explore the nature, content, and context of screen usage and how this can play a role in the causal pathway between screen time and mental health outcomes.

Fourth, this dissertation focused on the unidirectional association between screen time and mental health outcomes. It is important in the future to disentangle the bi-directional association between screen time and mental health to provide a stronger conclusion regarding the directionality of this relationship. Finally, few experimental studies exist, thus research using randomized controlled trial designs are warranted to determine if reducing sedentary screen use has a positive impact on mental health outcomes in children and youth, as well as identify how age, sex, and screen type and intensity impact treatment response.

7.6 Conclusion

The association between high sedentary pursuits among adolescents and its association with mental health outcomes has gained significant attention from researchers, academics, and stakeholders. Despite the fact that mental health among adolescents is a complex issue and it is interconnected with many individual and environmental factors, as indicated in the theoretical framework, the findings of this dissertation suggest that high levels of sedentary screen behaviour appear to be significantly associated with various mental health problems such as anxiety, depressive symptoms, and suicidality among adolescents.

Our results identified important moderators for the association between screen time and mental health outcomes, such as sex and age, and the strength of the association varied between some screen types. It is critical for the research on screen time and mental health to further

explore other aspects of screen use like the content and context of screen usage and their relationship to adolescent mental health. Now that screens are a ubiquitous part of everyone's day-to-day life, researchers, policymakers, and clinicians should go beyond individuals to the wider context like family to understand and address the effects of screen time on adolescents' mental health and provide practical guidance on how to use sedentary screen-based technologies more responsibly.

Additionally, further research with a strong longitudinal design and especially randomized trials is highly recommended to better understand the causal association and the strength and direction of the relationship between different types of screen use and mental health problems among adolescents. Also, the results of this dissertation can be used as a guide for future research to investigate further moderating variables in relation to each type of screen and adolescent mental health longitudinally.

Furthermore, in line with Canadian 24-Hour Movement Behaviour Guidelines [73], the findings of this dissertation also have important public health and clinical implications given the high screen use among adolescents and that screen time is associated with many mental health outcomes, suggesting that parents be involved to limit screen time and clinical practitioners should employ valid screening tools in efforts at improving the mental health of adolescents.

7.7 References

1. Hoare E, Milton K, Foster C, Allender S (2016) The associations between sedentary behaviour and mental health among adolescents: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity* 13:108
2. Tang S, Werner-Seidler A, Torok M, Mackinnon AJ, Christensen H (2021) The relationship between screen time and mental health in young people: A systematic review of longitudinal studies. *Clinical Psychology Review* 86:102021
3. Zink J, Belcher BR, Imm K, Leventhal AM (2020) The relationship between screen-based sedentary behaviors and symptoms of depression and anxiety in youth: a systematic review of moderating variables. *BMC Public Health*. <https://doi.org/10.1186/s12889-020-08572-1>
4. Liu M, Wu L, Yao S (2016) Dose–response association of screen time-based sedentary behaviour in children and adolescents and depression: a meta-analysis of observational studies. *Br J Sports Med* 50:1252–1258
5. Ferguson CJ (2017) Everything in Moderation: Moderate Use of Screens Unassociated with Child Behavior Problems. *Psychiatr Q* 88:797–805
6. Przybylski AK, Weinstein N (2017) A Large-Scale Test of the Goldilocks Hypothesis: Quantifying the Relations Between Digital-Screen Use and the Mental Well-Being of Adolescents. *Psychol Sci* 28:204–215
7. Suchert V, Hanewinkel R, Isensee B (2015) Sedentary behavior and indicators of mental health in school-aged children and adolescents: A systematic review. *Preventive Medicine* 76:48–57
8. Kim JY (2012) The Nonlinear Association Between Internet Using Time for Non-Educational Purposes and Adolescent Health. *J Prev Med Public Health* 45:37–46

9. Twenge JM, Spitzberg BH, Campbell WK (2019) Less in-person social interaction with peers among U.S. adolescents in the 21st century and links to loneliness. *Journal of Social and Personal Relationships* 36:1892–1913
10. Viner RM, Gireesh A, Stiglic N, Hudson LD, Goddings A-L, Ward JL, Nicholls DE (2019) Roles of cyberbullying, sleep, and physical activity in mediating the effects of social media use on mental health and wellbeing among young people in England: a secondary analysis of longitudinal data. *The Lancet Child & Adolescent Health* 3:685–696
11. Martin A, Pugmire J, Wells V, Riddell J, Skivington K, Simpson S, McDaid L (2020) Systematic literature review of the relationship between adolescents' screen time, sleep and mental health.
12. Li X, Buxton OM, Lee S, Chang A-M, Berger LM, Hale L (2019) Sleep mediates the association between adolescent screen time and depressive symptoms. *Sleep Med* 57:51–60
13. Vernon L, Modecki K, Barber B (2016) Tracking Effects of Problematic Social Networking on Adolescent Psychopathology: The Mediating Role of Sleep Disruptions. *Journal of Clinical Child & Adolescent Psychology* 46:1–15
14. Shadzi MR, Salehi A, Vardanjani HM (2020) Problematic Internet Use, Mental Health, and Sleep Quality among Medical Students: A Path-Analytic Model. *Indian Journal of Psychological Medicine* 42:128–135
15. Li J-B, Lau JTF, Mo PKH, Su X-F, Tang J, Qin Z-G, Gross DL (2017) Insomnia partially mediated the association between problematic Internet use and depression among secondary school students in China. *Journal of Behavioral Addictions* 6:554–564

16. Sampasa-Kanyinga H, Lewis RF (2015) Frequent Use of Social Networking Sites Is Associated with Poor Psychological Functioning Among Children and Adolescents. *Cyberpsychol Behav Soc Netw* 18:380–385
17. Gansner M, Belfort E, Cook B, Leahy C, Colon-Perez A, Mirda D, Carson N (2019) Problematic Internet Use and Associated High-Risk Behavior in an Adolescent Clinical Sample: Results from a Survey of Psychiatrically Hospitalized Youth. *Cyberpsychol Behav Soc Netw* 22:349–354
18. Li J, Wu Y, Hesketh T (2023) Internet use and cyberbullying: Impacts on psychosocial and psychosomatic wellbeing among Chinese adolescents. *Computers in Human Behavior* 138:107461
19. Vogel EA, Rose JP (2016) Self-reflection and interpersonal connection: Making the most of self-presentation on social media. *Translational Issues in Psychological Science* 2:294–302
20. Boers E, Afzali MH, Newton N, Conrod P (2019) Association of Screen Time and Depression in Adolescence. *JAMA Pediatr* 173:853–859
21. Nesi J, Prinstein MJ (2015) Using Social Media for Social Comparison and Feedback-Seeking: Gender and Popularity Moderate Associations with Depressive Symptoms. *J Abnorm Child Psychol* 43:1427–1438
22. Goldfield GS, Cameron JD, Sigal RJ, et al (2021) Screen time is independently associated with serum brain-derived neurotrophic factor (BDNF) in youth with obesity. *Appl Physiol Nutr Metab* 46:1083–1090
23. Christakis DA, Ramirez JSB, Ferguson SM, Ravinder S, Ramirez J-M (2018) How early media exposure may affect cognitive function: A review of results from observations in

humans and experiments in mice. *Proceedings of the National Academy of Sciences* 115:9851–9858

24. Zhang J, Yang SX, Wang L, Han LH, Wu XY (2022) The influence of sedentary behaviour on mental health among children and adolescents: A systematic review and meta-analysis of longitudinal studies. *Journal of Affective Disorders* 306:90–114
25. Keles B, McCrae N, Grealish A (2020) A systematic review: the influence of social media on depression, anxiety and psychological distress in adolescents. *International Journal of Adolescence and Youth* 25:79–93
26. McCrae N, Gettings S, Purssell E (2017) Social Media and Depressive Symptoms in Childhood and Adolescence: A Systematic Review. *Adolescent Res Rev* 2:315–330
27. McCarthy PA, Morina N (2020) Exploring the association of social comparison with depression and anxiety: A systematic review and meta-analysis. *Clinical Psychology & Psychotherapy* 27:640–671
28. Blomfield neira CJ, Barber BL (2014) Social networking site use: Linked to adolescents' social self-concept, self-esteem, and depressed mood. *Australian Journal of Psychology* 66:56–64
29. Meshioye A (2016) Influences social media has on body image, anxiety and self-esteem in young adults.
30. Nihill GFJ, Lubans DR, Plotnikoff RC (2013) Associations between sedentary behavior and self-esteem in adolescent girls from schools in low-income communities. *Mental Health and Physical Activity* 6:30–35

31. Marengo D, Longobardi C, Fabris MA, Settanni M (2018) Highly-visual social media and internalizing symptoms in adolescence: The mediating role of body image concerns. *Computers in Human Behavior* 82:63–69
32. Twenge JM, Campbell WK (2019) Media Use Is Linked to Lower Psychological Well-Being: Evidence from Three Datasets. *Psychiatr Q* 90:311–331
33. Frison E, Eggermont S (2016) Exploring the Relationships Between Different Types of Facebook Use, Perceived Online Social Support, and Adolescents' Depressed Mood. *Social Science Computer Review* 34:153–171
34. Thorisdottir IE, Sigurvinsdottir R, Asgeirsdottir BB, Allegrante JP, Sigfusdottir ID (2019) Active and Passive Social Media Use and Symptoms of Anxiety and Depressed Mood Among Icelandic Adolescents. *Cyberpsychology, Behavior, and Social Networking* 22:535–542
35. Tsitsika AK, Tzavela EC, Janikian M, Ólafsson K, Iordache A, Schoenmakers TM, Tzavara C, Richardson C (2014) Online social networking in adolescence: patterns of use in six European countries and links with psychosocial functioning. *J Adolesc Health* 55:141–147
36. Kremer P, Elshaug C, Leslie E, Toumbourou JW, Patton GC, Williams J (2014) Physical activity, leisure-time screen use and depression among children and young adolescents. *J Sci Med Sport* 17:183–187
37. Banjanin N, Banjanin N, Dimitrijevic I, Pantic I (2015) Relationship between internet use and depression: Focus on physiological mood oscillations, social networking and online addictive behavior. *Computers in Human Behavior* 43:308–312
38. McLaughlin KA, King K (2015) Developmental trajectories of anxiety and depression in early adolescence. *J Abnorm Child Psychol* 43:311–323

39. Petersen IT, Bates JE, Dodge KA, Lansford JE, Pettit GS (2015) Describing and predicting developmental profiles of externalizing problems from childhood to adulthood. *Dev Psychopathol* 27:791–818
40. Tottenham N, Galván A (2016) Stress and the Adolescent Brain: Amygdala-Prefrontal Cortex Circuitry and Ventral Striatum as Developmental Targets. *Neurosci Biobehav Rev* 70:217–227
41. Magis-Weinberg L, Ballonoff Suleiman A, Dahl RE (2021) Context, Development, and Digital Media: Implications for Very Young Adolescents in LMICs. *Frontiers in Psychology* 12:
42. Calandri E, Graziano F, Rollé L (2021) Social Media, Depressive Symptoms and Well-Being in Early Adolescence. The Moderating Role of Emotional Self-Efficacy and Gender. *Frontiers in Psychology* 12:
43. Charmaraman L, Richer AM, Liu C, Lynch AD, Moreno MA (2021) Early adolescent social media-related body dissatisfaction: Associations with depressive symptoms, social anxiety, peers, and celebrities. *J Dev Behav Pediatr* 42:401–407
44. Arundell L, Parker K, Timperio A, Salmon J, Veitch J (2020) Home-based screen time behaviors amongst youth and their parents: familial typologies and their modifiable correlates. *BMC Public Health* 20:1492
45. Walch R, Sabey A (2019) Parental Monitoring of Adolescent Social Media Use and Emotional Regulation. *Family Perspectives* 1:
46. Wallace LN (2022) Associations between parental monitoring and parents' social media use and social media perceptions. *Social Sciences & Humanities Open* 6:100294

47. Stiglic N, Viner RM (2019) Effects of screentime on the health and well-being of children and adolescents: a systematic review of reviews. *BMJ Open* 9:e023191
48. Shrier I, Platt RW (2008) Reducing bias through directed acyclic graphs. *BMC Medical Research Methodology* 8:70
49. Hernán MA, Hernández-Díaz S, Robins JM (2004) A structural approach to selection bias. *Epidemiology* 15:615–625
50. Diemer EW, Hudson JI, Javaras KN (2021) More (Adjustment) Is Not Always Better: How Directed Acyclic Graphs Can Help Researchers Decide Which Covariates to Include in Models for the Causal Relationship between an Exposure and an Outcome in Observational Research. *Psychotherapy and Psychosomatics* 90:289–298
51. Kok G, Gottlieb NH, Peters G-JY, Mullen PD, Parcel GS, Ruiter RAC, Fernández ME, Markham C, Bartholomew LK (2016) A taxonomy of behaviour change methods: an Intervention Mapping approach. *Health Psychol Rev* 10:297–312
52. Abraham C (2015) Mapping modifiable mechanisms in health promotion research: a commentary on Sniehotta, Pesseau, and Araújo-Soares. *Health Psychol Rev* 9:160–164
53. Barkley T (2023) What Should Policymakers Do about Social Media and Minors? The Center for Growth and Opportunity
54. CNN (2023) Surgeon General says 13 is “too early” to join social media.
55. Common Sense Media (2023) Healthy Young Minds: A Conversation with U.S. Surgeon General Dr. Vivek Murthy Part 1: “This is a crisis.” | Common Sense Media.
<https://www.commonsensemedia.org/videos/healthy-young-minds-a-conversation-with-us-surgeon-general-dr-vivek-murthy-part-1-this-is-a-crisis>. Accessed 1 Apr 2023

56. American Academy of Child and Adolescent Psychiatry (2020) Screen Time and Children.
https://www.aacap.org/AACAP/Families_and_Youth/Facts_for_Families/FFF-Guide/Children-And-Watching-TV-054.aspx. Accessed 27 Feb 2023
57. American Academy of Pediatrics Family Media Plan. In: HealthyChildren.org.
https://www.healthychildren.org/English/fmp/Pages/MediaPlan.aspx?_ga=2.56796202.184777083.1654274841-1551370823.1652023829&_gl=1*1otxvyz*_ga*MTU1MTM3MDgyMy4xNjUyMDIzODI15*_ga_FD9D3XZVQQ*MTY1NDM1OTQ3Ny40LjAuMTY1NDM1OTQ3Ny4w.
 Accessed 27 Feb 2023
58. Reid Chassiakos Y (Linda), Radesky J, Christakis D, Moreno MA, Cross C, COUNCIL ON COMMUNICATIONS AND MEDIA (2016) Children and Adolescents and Digital Media. *Pediatrics* 138:e20162593
59. MediaSmarts (2023) Young Canadians in a Wireless World, Phase IV: Digital Media Literacy and Digital Citizenship.
60. Tromholt M (2016) The Facebook Experiment: Quitting Facebook Leads to Higher Levels of Well-Being. *Cyberpsychology, Behavior, and Social Networking* 19:661–666
61. Kandola A, del Pozo Cruz B, Hayes J, Owen N, Dunstan D, Hallgren M (2022) Impact on adolescent mental health of replacing screen-use with exercise: A prospective cohort study. *Journal of Affective Disorders*. <https://doi.org/10.1016/j.jad.2021.12.064>
62. Hunt MG, Marx R, Lipson C, Young J (2018) No more FOMO: Limiting social media decreases loneliness and depression. *Journal of Social and Clinical Psychology* 37:751–768

63. Thai H, Davis C, Stewart N, Gunnell K, Goldfield G (2021) The Effects of Reducing Social Media Use on Body Esteem Among Transitional-Aged Youth. *Journal of Social and Clinical Psychology* 40:481–507
64. Bell BT, Taylor C, Paddock D, Bates A (2022) Digital Bodies: A controlled evaluation of a brief classroom-based intervention for reducing negative body image among adolescents in the digital age. *Br J Educ Psychol* 92:280–298
65. McLean SA, Wertheim EH, Masters J, Paxton SJ (2017) A pilot evaluation of a social media literacy intervention to reduce risk factors for eating disorders. *Int J Eat Disord* 50:847–851
66. Canadian Paediatric Society, Digital Health Task Force, Ottawa, Ontario (2019) Digital media: Promoting healthy screen use in school-aged children and adolescents. *Paediatr Child Health* 24:402–417
67. Moreno MA, Arseniev-Koehler A, Selkie E (2016) Development and testing of a 3-item screening tool for Problematic Internet Use. *J Pediatr* 176:167-172.e1
68. Besser B, Rumpf H-J, Bischof A, Meerkerk G-J, Higuchi S, Bischof G (2017) Internet-Related Disorders: Development of the Short Compulsive Internet Use Scale. *Cyberpsychol Behav Soc Netw* 20:709–717
69. Demetrovics Z, Király O, Koronczai B, Griffiths MD, Nagygyörgy K, Elekes Z, Tamás D, Kun B, Kökönyei G, Urbán R (2016) Psychometric Properties of the Problematic Internet Use Questionnaire Short-Form (PIUQ-SF-6) in a Nationally Representative Sample of Adolescents. *PLOS ONE* 11:e0159409

70. Siciliano V, Bastiani L, Mezzasalma L, Thanki D, Curzio O, Molinaro S (2015) Validation of a new Short Problematic Internet Use Test in a nationally representative sample of adolescents. *Computers in Human Behavior* 45:177–184
71. Nguyen P, Le LK-D, Nguyen D, Gao L, Dunstan DW, Moodie M (2020) The effectiveness of sedentary behaviour interventions on sitting time and screen time in children and adults: an umbrella review of systematic reviews. *Int J Behav Nutr Phys Act* 17:117
72. Biddle SJH, Petrolini I, Pearson N (2014) Interventions designed to reduce sedentary behaviours in young people: a review of reviews. *Br J Sports Med* 48:182–186
73. Canadian Society for Exercise Physiology (2019) Canadian 24-Hour Movement Guidelines: An Integration of Physical Activity, Sedentary Behaviour, and Sleep.

APPENDIX. Research Ethics Boards Approval from the University of Ottawa

10/05/2021

Université d'Ottawa
Bureau d'éthique et d'intégrité de la recherche

University of Ottawa
Office of Research Ethics and Integrity

CERTIFICAT D'APPROBATION ÉTHIQUE | CERTIFICATE OF ETHICS APPROVAL

Numéro du dossier / Ethics File Number

H-05-21-8921

Titre du projet / Project Title

Longitudinal association and changes between daily hours of different types of screens and anxiety and depression in youth and the moderating role of sex and age

Type de projet / Project Type

Thèse de doctorat / Doctoral thesis

Statut du projet / Project Status

Approuvé / Approved

Date d'approbation (jj/mm/aaaa) / Approval Date (dd/mm/yyyy)

10/05/2021

Date d'expiration (jj/mm/aaaa) / Expiry Date (dd/mm/yyyy)

09/05/2022

Équipe de recherche / Research Team

Chercheur / Researcher	Affiliation	Role
Fatima MOUGHARBEL	École interdisciplinaire des sciences de la santé / Interdisciplinary School of Health Sciences	Chercheur Principal / Principal Investigator
Gary GOLDFIELD	Département de pédiatrie / Department of Pediatrics	Superviseur / Supervisor
Jean-Philippe CHAPUT	Département de pédiatrie / Department of Pediatrics	Co-superviseur / Co-supervisor
Ian COLMAN	Département d'épidémiologie et santé publique / Department of Epidemiology and Public Health	Collaborateur / Collaborator
Karen PATTE	Brook University	Collaborateur / Collaborator
Hugues SAMPASA-KANYINGA	Département d'épidémiologie et santé publique / Department of Epidemiology and Public Health	Collaborateur / Collaborator
SCOTT LEATHERDALE	UW	Collaborateur / Collaborator

Conditions spéciales ou commentaires / Special conditions or comments

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Université d'Ottawa

Bureau d'éthique et d'intégrité de la recherche

University of Ottawa

Office of Research Ethics and Integrity

Le Comité d'éthique de la recherche (CÉR) de l'Université d'Ottawa, opérant conformément à l'*Énoncé de politique des Trois conseils* (2014) et toutes autres lois et tous règlements applicables, a examiné et approuvé la demande d'éthique du projet de recherche ci-nommé.

L'approbation est valide pour la durée indiquée plus haut et est sujette aux conditions énumérées dans la section intitulée "Conditions Spéciales ou Commentaires". Le formulaire « Renouvellement ou Fermeture de Projet » doit être complété quatre semaines avant la date d'échéance indiquée ci-haut afin de demander un renouvellement de cette approbation éthique ou afin de fermer le dossier.

Toutes modifications apportées au projet doivent être approuvées par le CÉR avant leur mise en place, sauf si le participant doit être retiré en raison d'un danger immédiat ou s'il s'agit d'un changement ayant trait à des éléments administratifs ou logistiques du projet. Les chercheurs doivent aviser le CÉR dans les plus brefs délais de tout changement pouvant augmenter le niveau de risque aux participants ou pouvant affecter considérablement le déroulement du projet, rapporter tout événement imprévu ou indésirable et soumettre toute nouvelle information pouvant nuire à la conduite du projet ou à la sécurité des participants.

The University of Ottawa Research Ethics Board, which operates in accordance with the *Tri-Council Policy Statement* (2014) and other applicable laws and regulations, has examined and approved the ethics application for the above-named research project.

Ethics approval is valid for the period indicated above and is subject to the conditions listed in the section entitled "Special Conditions or Comments". The "Renewal/Project Closure" form must be completed four weeks before the above-referenced expiry date to request a renewal of this ethics approval or closure of the file.

Any changes made to the project must be approved by the REB before being implemented, except when necessary to remove participants from immediate endangerment or when the modification(s) only pertain to administrative or logistical components of the project. Investigators must also promptly alert the REB of any changes that increase the risk to participant(s), any changes that considerably affect the conduct of the project, all unanticipated and harmful events that occur, and new information that may negatively affect the conduct of the project or the safety of the participant(s).

Kim THOMPSON

Responsable d'éthique en recherche / Protocol Officer

Pour/For Daniel LAGAREC Président(e) du/ Chair of the Comité d'éthique de la recherche en sciences de la santé et sciences / Health Sciences and Sciences Research Ethics Board

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CERTIFICAT D'APPROBATION ÉTHIQUE | CERTIFICATE OF ETHICS APPROVAL

Numéro du dossier / Ethics File Number
Titre du projet / Project Title

H-05-21-6937
Cross-sectional association between social media use and psychological distress and suicidality in adolescents: the moderating role of sex, parental support, and unmet mental health needs.

Type de projet / Project Type

Thèse de doctorat / Doctoral thesis

Statut du projet / Project Status
Date d'approbation (jj/mm/aaaa) / Approval Date (dd/mm/yyyy)
Date d'expiration (jj/mm/aaaa) / Expiry Date (dd/mm/yyyy)

Approuvé / Approved
30/05/2021
29/05/2022

Équipe de recherche / Research Team

Chercheur / Researcher	Affiliation	Role
Fatima MOUGHARBEL	École interdisciplinaire des sciences de la santé / Interdisciplinary School of Health Sciences	Chercheur Principal / Principal Investigator
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Jean-Philippe CHAPUT	Département de pédiatrie / Department of Pediatrics	Co-superviseur / Co-supervisor
SCOTT LEATHERDALE	UW	Collaborateur / Collaborator
Ian COLMAN	Département d'épidémiologie et santé publique / Department of Epidemiology and Public Health	Collaborateur / Collaborator
Hugues SAMPASA-KANYINGA	Département d'épidémiologie et santé publique / Department of Epidemiology and Public Health	Collaborateur / Collaborator
Hayley HAMILTON	Centre for Addiction and Mental Health	Collaborateur / Collaborator

Conditions spéciales ou commentaires / Special conditions or comments

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Riana MARCOTTE

Responsable d'éthique en recherche / Protocol Officer

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L'approbation est valide pour la durée indiquée plus haut et est sujette aux conditions énumérées dans la section intitulée "Conditions Spéciales ou Commentaires". Le formulaire « Renouvellement ou Fermeture de Projet » doit être complété quatre semaines avant la date d'échéance indiquée ci-haut afin de demander un renouvellement de cette approbation éthique ou afin de fermer le dossier.

Toutes modifications apportées au projet doivent être approuvées par le CÉR avant leur mise en place, sauf si le participant doit être retiré en raison d'un danger immédiat ou s'il s'agit d'un changement ayant trait à des éléments administratifs ou logistiques du projet. Les chercheurs doivent aviser le CÉR dans les plus brefs délais de tout changement pouvant augmenter le niveau de risque aux participants ou pouvant affecter considérablement le déroulement du projet, rapporter tout événement imprévu ou indésirable et soumettre toute nouvelle information pouvant nuire à la conduite du projet ou à la sécurité des participants.

The University of Ottawa Research Ethics Board, which operates in accordance with the *Tri-Council Policy Statement* (2014) and other applicable laws and regulations, has examined and approved the ethics application for the above-named research project.

Ethics approval is valid for the period indicated above and is subject to the conditions listed in the section entitled "Special Conditions or Comments". The "Renewal/Project Closure" form must be completed four weeks before the above-referenced expiry date to request a renewal of this ethics approval or closure of the file.

Any changes made to the project must be approved by the REB before being implemented, except when necessary to remove participants from immediate endangerment or when the modification(s) only pertain to administrative or logistical components of the project. Investigators must also promptly alert the REB of any changes that increase the risk to participant(s), any changes that considerably affect the conduct of the project, all unanticipated and harmful events that occur, and new information that may negatively affect the conduct of the project or the safety of the participant(s).

Safaa LAMHOUEB

Coordonnateur de l'éthique / Ethics Coordinator

Pour/For Daniel LAGAREC Président(e) du/ Chair of the Comité d'éthique de la recherche en sciences de la santé et sciences / Health Sciences and Sciences Research Ethics Board

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CERTIFICAT D'APPROBATION ÉTHIQUE | CERTIFICATE OF ETHICS APPROVAL

Numéro du dossier / Ethics File Number
Titre du projet / Project Title

H-05-21-6937
Cross-sectional association between social media use and psychological distress and suicidality in adolescents: the moderating role of sex, parental support, and unmet mental health needs.

Type de projet / Project Type

Thèse de doctorat / Doctoral thesis

Statut du projet / Project Status
Date d'approbation (jj/mm/aaaa) / Approval Date (dd/mm/yyyy)
Date d'expiration (jj/mm/aaaa) / Expiry Date (dd/mm/yyyy)

Renouvelé / Renewed
30/05/2021
29/05/2023

Équipe de recherche / Research Team

Chercheur / Researcher	Affiliation	Role
Fatima MOUGHARBEL	École interdisciplinaire des sciences de la santé / Interdisciplinary School of Health Sciences	Chercheur Principal / Principal Investigator
Gary GOLDFIELD	Département de pédiatrie / Department of Pediatrics	Superviseur / Supervisor
Jean-Philippe CHAPUT	Département de pédiatrie / Department of Pediatrics	Co-superviseur / Co-supervisor
SCOTT LEATHERDALE	UW	Collaborateur / Collaborator
Ian COLMAN	Département d'épidémiologie et santé publique / Department of Epidemiology and Public Health	Collaborateur / Collaborator
Hugues SAMPASA-KANYINGA	Département d'épidémiologie et santé publique / Department of Epidemiology and Public Health	Collaborateur / Collaborator
Hayley HAMILTON	Centre for Addiction and Mental Health	Collaborateur / Collaborator

Conditions spéciales ou commentaires / Special conditions or comments

Université d'Ottawa

Bureau d'éthique et d'intégrité de la recherche

University of Ottawa

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