Psychiatry Research 281 (2019) 112586

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

The association between excessive screen-time behaviors and insufficient sleep among adolescents: Findings from the 2017 youth risk behavior surveillance system

Philip Baiden[a,*], Savarra K. Tadeo[a], Kersley E. Peters[b]

[a] School of Social Work, The University of Texas at Arlington, 211 S. Cooper St., Arlington, TX, Box 19129, 76019, USA
[b] Toronto District School Board, 5050 Yonge St, North York, ON M2N 5N8, Canada

ARTICLE INFO

Keywords:
Insufficient sleep
Excessive screen-time behaviors
Depression
Adolescents

ABSTRACT

Although studies have examined the association between television viewing and poor sleep quality, few studies have considered the association between excessive screen-time behaviors and insufficient sleep among adolescents drawing on a large nationally representative sample. The objective of this study was to examine the association between excessive screen-time behaviors and insufficient sleep among adolescents. Data for this study came from the 2017 Youth Risk Behavior Survey. A sample of 14,603 adolescents aged 14–18 years (51.5% female) was analyzed using logistic regression with insufficient sleep as the outcome variable and excessive screen-time behaviors as the main explanatory variable. Of the 14,603 adolescents, almost three out of four (74.8%) had less than 8 h of sleep on an average school night, and about 43% engaged in excessive screen-time behaviors on an average school day. Controlling for all other predictors, odds were 1.34 times higher for adolescents who engaged in excessive screen-time behaviors to have insufficient sleep when compared to adolescents who did not engage in excessive screen-time behaviors ($AOR = 1.34$, $p < .001$, 95% CI = 1.22–1.48). School-based behavior interventions that focus on reduction in excessive screen-time and sedentary behaviors might be beneficial in reducing excessive screen-time behaviors and consequently improve sleep quality among adolescents.

1. Introduction

A good night's sleep is vital to the physical and mental health well-being of children and adolescents (Gerber, 2014; Maski and Owens, 2016; Ohayon et al., 2017). However, many adolescents in the United States do not get the recommended 8 h of sleep (Gruber et al., 2014; Meldrum et al., 2018; Owens and Adolescent Sleep Working Group, 2014; Wheaton et al., 2018). Singh and Kenney (2013) found that the percentage of US children and adolescents aged 6–17 years that got less than eight hours of sleep per night rose from 31.2% in 2003 to 41.9% in 2012. According to data from the 2017 Youth Risk Behavior Survey (YRBS), only 25% of adolescents in the US got the recommended eight or more hours of sleep on an average school night (Kann et al., 2018).

Insufficient sleep has been found to have adverse effects on health behaviors such as poor diet (Champion et al., 2017; Chaput and Dutil, 2016), obesity (Lechner et al., 2019; Li et al., 2017; Patel and Hu, 2008), substance use (Pieters et al., 2015; Sivertsen et al., 2015), mental health outcomes such as depression and anxiety (Blake et al., 2018; Ogawa et al., 2019; Shanahan et al., 2014), and suicidal behaviors (Baiden, Tadeo, et al., 2019; Stanley et al., 2017; Winsler et al., 2015). Insufficient sleep among adolescents has also been found to lead to a lack of concentration in class (Lufi et al., 2011) and poor academic performance (Dewald et al., 2010; Owens and Adolescent Sleep Working Group, 2014).

A burgeoning number of studies over the past decade have found that the use of electronic devices such as televisions and computers negatively affects sleep quality (Brockmann et al., 2016; Hart et al., 2017; Mireku et al., 2019; Thompson and Christakis, 2005). However, unlike these older stationary devices, new handled mobile and media devices such as smartphones and tablets with internet and social media capabilities are known to offer a different type of exposure as they allow real-time interaction for users (Carter et al., 2016). The presence of these handled mobile and media devices is so pervasive that, they are contributing substantially to poor sleep quality (Baer et al., 2012; Cabré-Riera et al., 2019; Johansson et al., 2016; Kenney and

* Corresponding author.
E-mail address: philip.baiden@uta.edu (P. Baiden).

https://doi.org/10.1016/j.psychres.2019.112586
Received 11 April 2019; Received in revised form 25 September 2019; Accepted 26 September 2019
Available online 27 September 2019

Gortmaker, 2017; National Sleep Foundation, 2014; Woods and Scott, 2016).

There is growing empirical evidence that excessive screen-time behaviors such as texting, online video gaming, and use of smartphones and tablets may have deleterious effects on adolescent functioning (Cabré-Riera et al., 2019; Cain and Gradisar, 2010; Carter et al., 2016; Owens and Adolescent Sleep Working Group, 2014; Sami et al., 2018). As a result of this, the American Academy of Pediatrics in 2016 recommended limiting screen-time activities to not more than 2 h per day for adolescents (Chassiakos et al., 2016). However, estimates show that as much as one in two adolescents are exceeding this screen-time recommendation (Kann et al., 2018; Sisson et al., 2010). Excessive screen-time is defined as spending three or more hours a day on an electronic device for things not related to school or homework (Kann et al., 2014).

The extant literature suggests that excessive screen-time can lead to obesity and weight gain through binge eating while viewing (Cameron et al., 2016; Garcia et al., 2019; Wethington et al., 2013). Zink et al. (2019) recently examined the effects of screen-time on emotional disorder symptoms among 2525 adolescent high school students from Southern California and found that controlling for baseline screen-time sedentary behaviors and covariates, adolescents with excessive screen-time behaviors had 36% higher odds of developing symptoms of depression. Kenney and Gortmaker (2017) also found that adolescents who engaged in excessive screen-time behaviors were 1.78 times more likely to be obese, 1.98 times more likely to consume sugar-sweetened beverage, and 1.94 times more likely to be physically inactive. Although studies have examined the association between television viewing and poor sleep quality (e.g., Brockmann et al., 2016; Hart et al., 2017), few studies have examined the association between excessive screen-time and insufficient sleep among adolescents drawing on a large nationally representative sample.

Regarding the association between mental health factors such as depression and sleep difficulties, some scholars have found that poor sleep quality is as a result of symptoms of depression (Bennett et al., 2005; Lichstein, 2006), which have led other scholars to suggest that sleep will improve with improvements in mental health problems (Chorney et al., 2007). For instance, Pesonen et al. (2019) recently examined the association between depressive symptoms and Rapid Eye Movement (REM) sleep behavior among a sample of Finnish adolescents and found that those who were clinically depressed had a 2.9- and a 7.6-fold risk of experiencing REM sleep fragmentation. However, Alvaro et al. (2014) investigated the independent association between insomnia and depression among 318 high school students from Australia and found a bi-directional relationship between insomnia and depression. A meta-analysis conducted by Lovato and Gradisar (2014) also concluded that although sleep disturbance acts as a precursor to depression, there is evidence for a relationship in the opposite direction as well. In the present study, we postulate that controlling for the effects of other factors, depression will be associated with insufficient sleep.

In addition, other studies have found an association between suicidal ideation and poor sleep quality (Sami et al., 2018; Stanley et al., 2017) as well as body weight and poor sleep quality (Kohler and van den Heuvel, 2008; Turel et al., 2017; Walter et al., 2018). The prevalence of insufficient sleep among sexual minority adolescents is also known to be greater than that of their heterosexual counterparts (Crawford and Ridner, 2018). The extant literature has also found that adolescents who engage in regular physical activity are less likely to present with mental health problems (Baiden, Mengo, et al., 2019; McDowell et al., 2017; McMahon et al., 2017) and more likely to meet the recommended eight hours of sleep (Torstveit et al., 2018; Zink et al., 2019).

Excessive screen-time has been hypothesized to adversely affect insufficient sleep through two main mechanisms (Cain and Gradisar, 2010; Hale and Guan, 2015). First, excessive screen-time may negatively affect insufficient sleep by directly delaying bedtime and the onset of sleep. A study that investigated bedtime mobile phone use and sleep found that taking a mobile phone into the bedroom was associated with longer sleep latency, later rise time, fatigue, short sleep duration, and more daytime dysfunction (Exelmans and Van den Bulck, 2016). Second, exposure to radiofrequency electromagnetic fields (RF-EMF) and blue light screen emission from smartphones and tablets at night are known to disrupt the circadian rhythm, thereby resulting in decreased sleep time (Cabre-Riera et al., 2019; Cain and Gradisar, 2010; Hale and Guan, 2015; Heo et al., 2017; Tosini et al., 2016). Wood et al. (2013) in their study found that a 2-h exposure to self-luminous tablets with blue light-emitting diode (LED) conditions (Apple iPads set to full brightness) resulted in a statistically reliable suppression of melatonin. However, in exploring whether tablet screen light had a suppressive effect on sleep quality, Heath et al. (2014) found no effect of bright tablet screen light on sleep onset latency, number of slow-wave sleep, or REM minutes.

1.1. Current study

Drawing on a large nationally representative sample, the objective of this study was to examine the association between excessive screen-time behaviors and insufficient sleep among adolescents. We hypothesized that there would be an association between excessive screen-time behaviors and insufficient sleep after adjusting for the effects of demographic characteristics, depression, suicidal ideation, overweight, and physical activity.

2. Methods

2.1. Data source and participants

Data for this study came from the 2017 YRBS. The YRBS is a school-based national survey that is conducted by the Centers for Disease Control and Prevention (CDC) every two years to examine health-risk behaviors that contribute to the leading causes of death and disability among adolescents in the US. The YRBS recruited 9th-12th graders from both public and private schools to complete self-administered surveys. The YRBS utilized a three-stage cluster sample design to create a nationally representative sample of high school students. Detailed information about the YRBS including the objectives, methodology, and sampling procedure are available at www.cdc.gov/yrbss and in other publications (Baiden, Graaf, et al., 2019; Baiden, Mengo, et al., 2019; Baiden and Tadeo, 2019; Baiden, Tadeo, et al., 2019; Baiden et al., 2019; Brener et al., 2013; Kann et al., 2018). The study protocol for conducting the YRBS was approved by the CDC's Institutional Review Board (IRB), and the publicly available data has been de-identified (Brener et al., 2013); hence, no additional IRB approval was required. There were 14,765 respondents in the 2017 YRBS of which 14,603 were aged 14–18 years old. Missing data analyses were conducted to assess the pattern of missing data, and we found that data were missing at random. Due to the fact that data were missing at random, Multiple Imputation using Chained Equations (MICE) was chosen as the most appropriate technique to impute the complete data (Van Buuren and Oudshoorn, 2000). Multiple imputation is a simulation-based approach for analyzing missing data that replaces missing values with multiple sets of simulated values to complete the dataset and adjust for missing data uncertainty (Rubin, 1996). With MICE, imputed datasets are based on a set of imputation models, one for each variable with missing values.

2.2. Variables

2.2.1. Outcome variable

The outcome variable investigated in this study was insufficient sleep and was measured as a binary variable. The original question asked respondents “On an average school night, how many hours of sleep do you get?” with the following response options “4 or less

hours", "5 h", "6 h", "7 h", "8 h" "9 h" and "10 or more hours". Following the recommendations of CDC (CDC, 2017) and the American Academy of Sleep Medicine (Paruthi et al., 2016), adolescents who had less than eight hours of sleep on an average school night were considered as having insufficient sleep and were recoded as 1 whereas adolescents who had eight or more hours of sleep on an average school night were considered as having sufficient sleep and were recoded as 0.

2.2.2. Explanatory variables

The main explanatory variable examined in this study was excessive screen-time behaviors and was measured based on the question "On an average school day, how many hours do you play video or computer games or use a computer for something that is not schoolwork? (Count time spent on things such as Xbox, PlayStation, an iPad or other tablet, a smartphone, texting, YouTube, Instagram, Facebook, or other social media)." Response options for this item included: "none", "Less than 1 h per day", "1 h per day", "2 h per day", "3 h per day", "4 h per day", and "5 or more hours per day". Following the recommendations of the American Academy of Pediatrics (Chassiakos et al., 2016) and prior studies (Berchtold et al., 2018; Kann et al., 2018; Twenge et al., 2018), responses were dichotomized into "0 = <3 h per day per" versus "1 = ≥3 h per day". The YRBS item assessing excessive screen-time behaviors have been found to have adequate psychometric properties (Brener et al., 2013; Kann et al., 2018).

2.2.3. Covariates

Based on the findings of previous studies (Biggs et al., 2017; Kovess-Masfety et al., 2016; Mazzer et al., 2019; Pieters et al., 2015; Zink et al., 2019), we included the following health-risk behaviors and mental health factors as covariates in the logistic regression model: depression, suicidal ideation, overweight, and physical activity. These health-risk behaviors and mental health factors have also been found to be associated with excessive screen-time behaviors and sleep difficulties (Kann et al., 2018). Depression was measured based on response to the question "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?" Adolescents who answered "yes" were coded as 1; whereas those who answered "no" were coded as 0. Suicidal ideation was measured based on response to the question "During the past 12 months, did you ever seriously consider attempting suicide?" Adolescents who answered "yes" were coded as 1; whereas those who answered "no" were coded as 0. Adolescents who described themselves as "slightly overweight" or "very overweight" were considered as overweight and coded as 1; otherwise, they were coded as 0. Physical activity was measured based on the question "During the past 7 days, on how many days were you physically active for a total of at least 60 min per day? (Add up all the time you spent in any kind of physical activity that increased your heart rate and made you breathe hard some of the time)" with response options of 0 to 7 days. Adolescents who engaged in physical activity that met the CDC recommended physical activity guidelines of 60 min per day (McGuire, 2011; US Department of Health and Human Services, 2012) were recoded as 1; otherwise, they were recoded as 0. The YRBS items assessing health-risk and mental health-related behaviors have been found to have adequate psychometric properties (Brener et al., 2013; Kann et al., 2018).

2.2.4. Demographic variables

The study controlled for the following demographic variables. Age was measured in years whereas sex was coded as "male = 0″ and "female = 1″. Adolescents who self-identified as lesbian, gay, or bisexual were coded as 1; otherwise, they were coded as 0. Grade level was coded into "9th grade", "10th grade", "11th grade", and "12th grade". Race/ethnicity was coded as a nominal variable into the following categories "0 = non-Hispanic White", "1 = Black/African American", "2 = Hispanic/Multiple Hispanic", "3 = Other".

2.2.4.1. Data analyses. Data were analyzed using descriptive and multivariate analytic techniques. The general distribution of all the variables included in the analysis was first examined using percentages. Next, we examined the bivariate association between excessive screen-time behaviors and the sample characteristics using Pearson chi-square test of association. The main analysis involves the use of binary logistic regression to examine the association between excessive screen-time behaviors and insufficient sleep while controlling for the effects of demographic factors, health-risk behaviors, and mental health factors. Three logistic regression models were fitted with demographic variables entered in Model 1. Model 2 consists of demographic variables plus health and mental health factors. The final model consists of variables in Model 2, plus excessive screen-time behaviors. Adjusted odds ratios (AOR) are reported together with their 95% Confidence Intervals (C.I.). Variables were considered significant if the *p*-value was less than 0.05. Stata's "svy" command was used to account for the weighting and complexity of the sampling design employed by the YRBS. All analyses were performed using Stata version 14 (Stata Corp., College Station, Texas, USA).

3. Results

3.1. Sample characteristics

Table 1 shows the general distribution of the study variables. Of the

Table 1
Sample characteristics (N = 14,603).

Variables	N (%)
Outcome variable	
Insufficient sleep	
No	3678 (25.2)
Yes	10,925 (74.8)
Explanatory variables	
Engaged in excessive screen-time behaviors	
No	8269 (56.6)
Yes	6334 (43.4)
Age	
14 years	1922 (13.1)
15 years	3586 (24.6)
16 years	3688 (25.3)
17 years	3611 (24.7)
18 years or older	1796 (12.3)
Sex	
Male	7076 (48.5)
Female	7527 (51.5)
Lesbian, gay, or bisexual	
No	12,465 (85.4)
Yes	2138 (14.6)
Grade level	
9th grade	3890 (26.6)
10th grade	3754 (25.7)
11th grade	3590 (24.6)
12th grade	3369 (23.1)
Race/ethnicity	
Non-Hispanic White	6348 (43.5)
Black/African-American	2939 (20.1)
Hispanic/Multiple Hispanic	3604 (24.7)
Other	1712 (11.7)
Felt sad or hopeless	
No	9957 (68.2)
Yes	4646 (31.8)
Suicidal ideation	
No	12,036 (82.4)
Yes	2567 (17.6)
Overweight	
No	9999 (68.5)
Yes	4604 (31.5)
Physically active	
No	8178 (56.0)
Yes	6425 (44.0)

Table 2
Bivariate association between excessive screen-time behaviors and sample characteristics (N = 14,603).

Variables	Engaged in excessive screen-time behaviors		Chi-square (Sig)
	% No	% Yes	
Age			38.61 (p = .008)
14 years	54.1	45.9	
15 years	55.0	45.0	
16 years	55.2	44.8	
17 years	60.2	39.9	
18 years or older	60.6	39.4	
Sex			0.03 (p = .9354)
Male	57.1	42.9	
Female	56.9	43.1	
Lesbian, gay, or bisexual			51.68 (p < .0001)
No	57.3	42.7	
Yes	48.5	51.5	
Grade level			33.03 (p < .0001)
9th grade	55.0	45.0	
10th grade	54.9	45.1	
11th grade	57.7	42.3	
12th grade	61.0	39.0	
Race/Ethnicity			40.76 (p = .0099)
Non-Hispanic White	59.3	40.7	
Black/African-American	52.7	47.3	
Hispanic/Multiple Hispanic	54.7	45.3	
Other	53.8	46.2	
Felt sad or hopeless			96.89 (p < .0001)
No	59.7	40.3	
Yes	50.7	49.3	
Suicidal ideation			124.45 (p < .0001)
No	59.0	41.0	
Yes	46.4	53.6	
Overweight			75.54 (p < .0001)
No	59.4	40.6	
Yes	51.5	48.5	
Physically active			143.90 (p < .0001)
No	52.2	47.8	
Yes	62.4	37.6	

14,603 adolescents, almost three out of four (74.8%) had less than eight hours of sleep on an average school night. About 43% engaged in excessive screen-time behaviors on an average school day. About 52% of the adolescents were females, and one in seven (14.6%) self-identified as lesbian, gay, or bisexual. Almost a third (31.8%) of the adolescents felt depressed almost every day for two weeks or more in a row, and about 18% experienced suicidal ideation during the past 12 months. Close to a third of the adolescents (31.5%) perceived themselves as slightly or very overweight. Less than half of the adolescents (44%) met the recommended physical activity guidelines for health.

3.2. Bivariate association between excessive screen-time behaviors and sample characteristics

Table 2 shows the bivariate association between excessive screen-time behaviors and the sample characteristics. We found an inverse association between age and grade level and excessive screen-time behaviors such that older adolescents and adolescents in upper grades were less likely to engage in excessive screen-time behaviors. Adolescent females were not significantly different from their male counterparts in terms of engaging in excessive screen-time behaviors. Majority of adolescents who self-identified as lesbian, gay, or bisexual (51.5%) engaged in excessive screen-time behaviors compared to 42.7% of their heterosexual counterparts who engaged in excessive screen-time behaviors ($\chi^2(1) = 51.68$, $p < .0001$). Adolescents were more likely to engage in excessive screen-time behaviors if they felt depressed (40.3% vs. 49.3%; $\chi^2(1) = 96.89$, $p < .0001$), experienced suicidal ideation (41.0% vs. 53.6%; $\chi^2(1) = 124.45$, $p < .0001$), or perceived themselves to be slightly or very overweight (40.6% vs. 48.5%; $\chi^2(1) = 75.54$, $p < .0001$). The proportion of adolescents that were physically active and engaged in excessive screen-time behaviors (37.6%) was significantly lower than the proportion of adolescents that were physically inactive and engaged in excessive screen-time behaviors (47.8%; $\chi^2(1) = 143.90$, $p < .0001$). We also found that the proportion of adolescents who self-identified as lesbian, gay, or bisexual and experienced suicidal ideation (41.7%) was significantly greater than the proportion of their heterosexual counterparts who experienced suicidal ideation (13.6%; $\chi^2(1) = 928.16$, $p < .0001$). Similarly, the proportion of adolescents who self-identified as lesbian, gay, or bisexual and felt depressed (58.1%) was significantly greater than the proportion of their heterosexual counterparts who felt depressed (27.5%; $\chi^2(1) = 736.11$, $p < .0001$).

Table 3
Multivariate logistic regression results predicting insufficient sleep (N = 14,603).

Variables	AOR (95% C.I.)	p-value	AOR (95% C.I.)	p-value	AOR (95% C.I.)	p-value
Age in years	0.99 (0.92–1.07)	.780	0.98 (0.91–1.06)	.654	0.99 (0.91–1.07)	.747
Sex (Male)						
Female	1.05 (0.96–1.15)	.259	0.90 (0.82–0.99)	.030	0.92 (0.84–1.00)	.050
Lesbian, gay, or bisexual (No)						
Yes	1.50 (1.31–1.73)	.001	1.17 (1.01–1.36)	.031	1.16 (1.01–1.34)	.047
Grade level (9th grade)						
10th grade	1.44 (1.27–1.64)	.001	1.44 (1.26–1.64)	.001	1.44 (1.26–1.64)	.001
11th grade	1.91 (1.57–2.31)	.001	1.88 (1.55–2.29)	.001	1.90 (1.57–2.31)	.001
12th grade	2.54 (1.99–3.25)	.001	2.53 (1.98–3.24)	.001	2.55 (1.99–3.28)	.001
Race/ethnicity (non-Hispanic White)						
Black/African-American	1.13 (1.01–1.27)	.032	1.14 (1.01–1.28)	.031	1.11 (0.99–1.25)	.075
Hispanic/Multiple Hispanic	1.14 (1.03–1.26)	.010	1.09 (0.98–1.21)	.094	1.08 (0.97–1.20)	.146
Other	1.58 (1.35–1.83)	.001	1.54 (1.32–1.79)	.001	1.52 (1.30–1.77)	.001
Felt sad or hopeless (No)						
Yes			1.60 (1.44–1.79)	.001	1.58 (1.41–1.76)	.001
Suicidal ideation (No)						
Yes			1.39 (1.20–1.60)	.001	1.36 (1.18–1.57)	.001
Overweight (No)						
Yes			1.23 (1.10–1.37)	.001	1.21 (1.09–1.34)	.001
Physically active (No)						
Yes			0.81 (0.74–0.90)	.001	0.83 (0.76–0.92)	.001
Excessive Use of Electronic Device (No)						
Yes					1.34 (1.22–1.48)	.001

Notes: Reference category is identified in bracket; AOR = Adjusted Odds Ratios; CI = Confidence Intervals.

3.3. Logistic regression examining the association between excessive screen-time behaviors and insufficient sleep

Table 3 shows the multivariate logistic regression results examining the association between excessive screen-time behaviors and insufficient sleep. In Models 1 and 2, adolescent females were not significantly different from their male counterparts in terms of having insufficient sleep. However, controlling for excessive screen-time behaviors in Model 3, adolescents females had 8% lower odds of having insufficient sleep when compared to their male counterparts (*AOR* = 0.92, $p = .05$, 95% CI = 0.84–1.00). In Model 1, adolescents who self-identified as lesbian, gay, or bisexual had 50% higher odds of having insufficient sleep when compared to their heterosexual peers (*AOR* = 1.50, $p < .001$, 95% CI = 1.31–1.73). This significant effect was partially attenuated in Models 2 and 3. In the final model, adolescents who self-identified as lesbian, gay, or bisexual were 1.16 times more likely to have insufficient sleep when compared to their heterosexual peers (*AOR* = 1.16, $p < .05$, 95% CI = 1.01–1.34). In Models 1, 2, and 3, adolescents in upper grades were more likely to have insufficient sleep when compared to adolescents in grade 9.

In Model 3, odds were 1.58 times higher for adolescents who felt depressed to have insufficient sleep when compared to their counterparts who do not feel depressed (*AOR* = 1.58, $p < .001$, 95% CI = 1.41–1.76). Adolescents who experienced suicidal ideation were 1.36 times more likely to have insufficient sleep when compared to their counterparts who do not experience suicidal ideation (*AOR* = 1.36, $p < .001$, 95% CI = 1.18–1.57). Adolescents who perceived themselves as slightly or very overweight were 1.21 times more likely to have insufficient sleep when compared to their counterparts who perceived themselves to be normal or underweight (*AOR* = 1.21, $p < .001$, 95% CI = 1.09–1.34). Physical activity had a protective effect of insufficient sleep such that adolescents who reported meeting the recommended physical activity level had a 17% lower odds of having insufficient sleep when compared to their counterparts not meeting the recommended physical activity level (*AOR* = 0.83, $p < .001$, 95% CI = 0.76–0.92). Controlling for all other factors, adolescents who engaged in excessive screen-time behaviors were 1.34 times more likely to have insufficient sleep when compared to their counterparts who do not engage in excessive screen-time behaviors (*AOR* = 1.34, $p < .001$, 95% CI = 1.22–1.48).

4. Discussion

This study contributes to the extant literature by examining the association between excessive screen-time behaviors and insufficient sleep among adolescents. We found that only one in four adolescents had the recommended eight hours of sleep on an average school night and 43% engaged in excessive screen-time behaviors. The proportion of adolescents not getting the recommended hours of sleep raises public health concerns given the number of cross-sectional studies (Blake et al., 2018; Ogawa et al., 2019; Pesonen et al., 2019; Shimura et al., 2018), longitudinal studies (Kaneita et al., 2009; Ritter et al., 2015), and systematic reviews and meta-analyses (Belmon et al., 2019; Cain and Gradisar, 2010; Carter et al., 2016; Hale and Guan, 2015; Lovato and Gradisar, 2014) demonstrating the adverse effects of lack of adequate sleep on physical and mental health. In the present study, the proportion of adolescents who engaged in excessive screen-time behaviors could be underestimated given the phrasing of excessive screen-time behaviors in the YRBS to include video and computer games and using the computer for something other than schoolwork.

As hypothesized, the finding of the present study provides evidence for an association between excessive screen-time behaviors and insufficient sleep among adolescents. Population-based studies continue to show that excessive screen-time is associated with depression (Cheung and Wong, 2011), substance use behaviors (Kirisci et al., 2013; Sampasa-Kanyinga and Chaput, 2016), suicidal behaviors (Messias et al., 2011; Twenge and Campbell, 2019), and risky sexual behaviors (e Silva et al., 2016). Given the association between television viewing and insufficient sleep (e.g., Brockmann et al., 2016; Hart et al., 2017; Thompson and Christakis, 2005), the finding of the present study adds to the broad range of health behaviors negatively impacted by excessive screen-time behaviors. It has been shown that blue light screen emission has the potential to disrupt the circadian rhythm through the suppression of melatonin release (Cabre-Riera et al., 2019; Cain and Gradisar, 2010; Hale and Guan, 2015; Heo et al., 2017; Tosini et al., 2016). It is also possible that excessive screen-time behaviors could lead to mental health problems (Sahin et al., 2013) and consequently sleep problems (Freeman et al., 2017). In the present study, we were unable to distinguish the use of video and computer games from the use of smartphones and tablets given the phrasing of excessive screen-time behaviors in the YRBS to include video and computer games and using the computer for something other than schoolwork even though it lists smartphones and tablets as potential devices and social media as potential options. We would expect to observe a much stronger effect between the use of smartphones and tablets on insufficient sleep given that unlike computers and gaming consoles, smartphones and tablets are more portable and offer social networking capabilities that provide real-time interaction (Carter et al., 2016). This would be of great interest for future studies.

In addition to excessive screen-time behaviors, the following were found to be associated with insufficient sleep: being a lesbian, gay, or bisexual, grade level, feeling depressed, experiencing suicidal ideation, and being overweight. Physical activity had a protective effect on insufficient sleep. Given that age and grade level to a large extent are collinear, it is somewhat surprising to find a positive association between grade level and insufficient sleep and no association between age and insufficient sleep. However, the finding that adolescents in upper grades are more likely to have insufficient sleep corroborates that of Mazzer et al. (2019) who also found a steady decline in sleep duration from Grade 7 through to Grade 10. Our findings add to developmental theories that suggest that sleep duration follows a “bathtub” distribution whereby it increases during childhood, decreases during adolescence and adulthood, and increases during late adulthood (Baiden et al., 2015). Adolescence is a vulnerable period characterized by mental health problems including poor sleep (Chassiakos et al., 2016; Ohayon et al., 2017; Owens and Adolescent Sleep Working Group, 2014; Pesonen et al., 2019).

The findings that adolescents who felt depressed or experienced suicidal ideation are more likely to have insufficient sleep corroborates past studies that have found that adolescents with sleep difficulties often present with symptoms of depression (Alvaro et al., 2014; Pesonen et al., 2019) and suicidal tendencies (Stanley et al., 2017; Winsler et al., 2015). Increased hyperarousal and hypervigilance, which often results from the experience of traumatic events, has been noted as one of the reasons underlying the link between depression and sleep (Baiden et al., 2015). This increased hyperarousal in individuals who are depressed is thought to account for difficulties sleeping due to increased activity within the brain, making it hard to fall asleep and stay asleep (Bader et al., 2007).

The finding that adolescents who perceived themselves to be slightly or very overweight are more likely to have insufficient sleep adds to the extant literature that has found an association between obesity and sleep-disordered breathing (SDB) and sleep onset latency (Biggs et al., 2017; Walter et al., 2018). Overweight or obesity may add to daytime dysfunction and thereby affecting sleep quality at night. It is also possible that lifestyle-related determinants, such as consumption of sugar-sweetened beverages, caffeine beverages (e.g., coffee, energy drinks), binge eating before bedtime, substance use, or lack of physical activity during the day may explain the association between body weight and insufficient sleep.

The finding that adolescents who met the recommended physical activity guideline are less likely to have insufficient sleep underscores the important role of physical activity in improving sleep duration. Physical activity has been shown to be an inexpensive intervention for improving mental health-well-being (Biddle et al., 2019; Eddols et al., 2018; Herman et al., 2015; Rodriguez-Ayllon et al., 2019). However, there is a debate as to whether engaging in physical activity has a positive or a negative effect on sleep (Flausino et al., 2012; Youngstedt, 2005). Some scholars have indicated that whereas engaging in physical activity in the morning can improve sleep, late-night physical activity can result in sleep difficulties (Driver and Taylor, 2000). For instance, Oda and Shirakawa (2014) found that engaging in physical activity in the evening was associated with a delay in sleep onset. However, Buman et al. (2014) analyzed data from the 2013 National Sleep Foundation Sleep in America Poll and found that those who engaged in physical activity either in the morning or evening believed that their sleep was of better quality than their counterparts who did not engage in physical activity. A recent meta-analysis that investigated the extent to which evening exercise can affect sleep also failed to find support for the hypothesis that evening exercise negatively affects sleep quality; rather, evening exercise leads to sleep efficiency and less wake after sleep onset (Stutz et al., 2019). Stutz et al. (2019) further cautioned that engaging in vigorous physical activity too close to bedtime might impair sleep efficiency, sleep-onset latency, and total sleep time.

School-based behavior change interventions that focus on reduction in excessive screen-time and sedentary behaviors (such as sitting, watching television, playing video games that are characterized by little or no physical activity) have been shown to be successful (Biddle et al., 2011). For instance, the Canadian guidelines for sedentary behavior (Tremblay et al., 2011) states that "for health benefits, children (aged 5–11 years) and youth (aged 12–17 years) should minimize the time they spend being sedentary each day" (p. 62). They recommended limiting recreational screen time to no more than 2 h per day and limiting motorized transport, extended sitting time, and time spent indoors throughout the day. It would be important for parents to pay attention to the amount of time adolescents are spending on their electronic devices for non-school related work.

Behavioral counseling which aims to increase homeostatic sleep drive and normal circadian rhythms is also known to be effective in treating children and adolescents with sleep problems (Maski and Owens, 2016). Effective behavioral counseling does require knowledge of the suggested optimal sleep duration for different age groups such as those suggested by the American Academy of Sleep Medicine (Paruthi et al., 2016), or the National Sleep Foundation (National Sleep Foundation, 2015). According to the American Academy of Sleep Medicine, adolescents between the ages of 13–18 years require 8–10 h of sleep in a 24-h period to promote optimal health (Paruthi et al., 2016). A systematic review and meta-analysis of published studies to identify behavioral interventions for sleep problems among children and adolescents found that behavioral treatments for children and adolescents results in significant improvements for sleep-onset latency, frequency of and duration of night waking, and sleep efficiency measured by number of minutes of sleep divided by number of minutes in bed (Meltzer and Mindell, 2014).

This study has some limitations that are worth mentioning. First, the use of secondary data limits our ability to examine other theoretically relevant predictors that are known to influence sleep, such as childhood trauma and chronic pain. We were unable to distinguish the use of video and computer games from the use of smartphones and tablets given the phrasing of excessive screen-time behaviors in the YRBS to include video and computer games and using the computer for something other than schoolwork even though it lists smartphones and tablets as potential devices and social media as potential options. In addition to excessive screen-time behaviors, future studies should consider the examination of childhood sexual and physical abuse and chronic pain as found to be associated with insufficient sleep. Second, the cross-sectional nature of the data also limits our ability to make any causal claims between excessive screen-time behaviors and insufficient sleep. Thus, only association can be inferred. Additional studies that follow adolescents over time are needed to establish the temporal order between excessive screen-time behaviors and insufficient sleep. Also, longitudinal studies might help to empirically test whether there is a bi-direction between insufficient sleep and some of the factors examined in this study. Such studies over time can also help us understand other plausible factors related to insufficient sleep. Lastly, although nationally representative, data for this study is based on self-reports and may be subject to recall bias. However, the possibility of recall bias or false reporting was addressed in the YRBS by screening the data for responses that conflict in logical terms (Brener et al., 2013). For instance, if a student responds to one question that he or she has never smoked but then responds to a subsequent question that he or she has smoked two cigarettes during the previous 30 days, the processing system sets both responses to missing, and data are not imputed. For instance, in the 2011 YRBS, 179 logical edits were performed on each standard questionnaire, and a total of 78 representing less than 1% of questionnaires in the national survey failed quality-control checks and therefore were excluded from the dataset (Brener et al., 2013).

In conclusion, the findings of this study demonstrate that adolescents who engaged in excessive screen-time behaviors are more likely to have insufficient sleep on an average school night, after adjusting for the effects of demographic factors, depression, suicidal ideation, overweight, and physical activity. School counselors, clinicians, and social work practitioners should consider ways of educating adolescents on how to cut down on excessive screen-time to increase sleep duration. School-based behavior change interventions that focus on reduction in excessive screen-time and sedentary behaviors might be beneficial in reducing excessive screen-time behaviors and consequently improve sleep quality among adolescents.

Declaration of Competing Interest

The authors declare that they have no conflicts of interests with respect to the authorship and/or the publication of this paper.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2019.112586.

References

Alvaro, P.K., Roberts, R.M., Harris, J.K., 2014. The independent relationships between insomnia, depression, subtypes of anxiety, and chronotype during adolescence. Sleep Med 15 (8), 934–941.
Bader, K., Schafer, V., Schenkel, M., Nissen, L., Schwander, J., 2007. Adverse childhood experiences associated with sleep in primary insomnia. J. Sleep Res. 16 (3), 285–296.
Baer, S., Saran, K., Green, D.A., 2012. Computer/gaming station use in youth: correlations among use, addiction and functional impairment. Paediatr. Child Healt. 17 (8), 427–431.
Baiden, P., Fallon, B., den Dunnen, W., Boateng, G.O., 2015. The enduring effects of early-childhood adversities and troubled sleep among canadian adults: a population-based study. Sleep Med 16 (6), 760–767.
Baiden, P., Graaf, G., Zaami, M., Acolatse, K.C., Adeku, Y., 2019. Examining the association between prescription opioid misuse and suicidal behaviors among adolescent high school students in the United States. J. Psychiat Res. 112C, 44–51.
Baiden, P., Mengo, C., Boateng, G.O., Small, E., 2019. Investigating the association between age at first alcohol use and suicidal ideation among high school students: evidence from the youth risk behavior surveillance system. J. Affect. Disorders 242, 60–67.
Baiden, P., Tadeo, K.S., Tonui, C.B., Seastrunk, D.J., Boateng, O.G., 2019. Effects of insufficient sleep on suicidal ideation among adolescents. Psychiat. Res. https://doi.org/10.1016/j.psychres.2019.112579. (Epub ahead of print: September 23, 2019).
Baiden, P., Tadeo, K.S., 2019. Examining the association between bullying victimization and prescription drug misuse among adolescents in the United States. J. Affect. Disorders 259, 317–324.
Belmon, L.S., van Stralen, M.M., Busch, V., Harmsen, I.A., Chinapaw, M.J.M., 2019. What

are the determinants of children's sleep behavior? A systematic review of longitudinal studies. Sleep Med. Rev 43, 60–70.
Bennett, D.S., Ambrosini, P.J., Kudes, D., Metz, C., Rabinovich, H., 2005. Gender differences in adolescent depression: do symptoms differ for boys and girls? J. Affect. Disorders 89 (1–3), 35–44.
Berchtold, A., Akre, C., Barrense-Dias, Y., Zimmermann, G., Surís, J., 2018. Daily internet time: towards an evidence-based recommendation? Eur. J. Public Health 28 (4), 647–651.
Biddle, S.J., Ciaccioni, S., Thomas, G., Vergeer, I., 2019. Physical activity and mental health in children and adolescents: an updated review of reviews and an analysis of causality. Psychol. Sport Exerc. 42, 146–155.
Biggs, S.N., Tamanyan, K., Walter, L.M., Weichard, A.J., Davey, M.J., Nixon, G.M., et al., 2017. Overweight and obesity add to behavioral problems in children with sleep-disordered breathing. Sleep Med 39, 62–69.
Blake, M.J., Trinder, J.A., Allen, N.B., 2018. Mechanisms underlying the association between insomnia, anxiety, and depression in adolescence: implications for behavioral sleep interventions. Clin. Psychol. Rev. 63, 25–40.
Brener, N.D., Kann, L., Shanklin, S., Kinchen, S., Eaton, D.K., Hawkins, J., et al., 2013. Methodology of the youth risk behavior surveillance system—2013. MMWR Recomm. Rep. 62 (1), 1–20.
Brockmann, P.E., Diaz, B., Damiani, F., Villarroel, L., Núñez, F., Bruni, O., 2016. Impact of television on the quality of sleep in preschool children. Sleep Med 20, 140–144.
Buman, M.P., Phillips, B.A., Youngstedt, S.D., Kline, C.E., Hirshkowitz, M., 2014. Does nighttime exercise really disturb sleep? Results from the 2013 National Sleep Foundation Sleep in America Poll. Sleep Med 15 (7), 755–761.
Cabré-Riera, A., Torrent, M., Donaire-Gonzalez, D., Vrijheid, M., Cardis, E., Guxens, M., 2019. Telecommunication devices use, screen time and sleep in adolescents. Environ. Res. 171, 341–347.
Cain, N., Gradisar, M., 2010. Electronic media use and sleep in school-aged children and adolescents: a review. Sleep Med 11 (8), 735–742.
Cameron, J.D., Maras, D., Sigal, R.J., Kenny, G.P., Borghese, M.M., Chaput, J., et al., 2016. The mediating role of energy intake on the relationship between screen time behaviour and body mass index in adolescents with obesity: the HEARTY study. Appetite 107, 437–444.
Carter, B., Rees, P., Hale, L., Bhattacharjee, D., Paradkar, M.S., 2016. Association between portable screen-based media device access or use and sleep outcomes: a systematic review and meta-analysis. JAMA Pediatr 170 (12), 1202–1208.
Centers for Disease Control and Prevention (CDC). 2017. How much sleep do I need?Retrieved fromhttps://www.cdc.gov/sleep/about_sleep/how_much_sleep.html.
Champion, K.E., Newton, N.C., Spring, B., Wafford, Q.E., Parmenter, B.J., Teesson, M., 2017. A systematic review of school-based eHealth interventions targeting alcohol use, smoking, physical inactivity, diet, sedentary behaviour and sleep among adolescents: a review protocol. Syst Rev 6 (1), 246. https://doi.org/10.1186/s13643-017-0645-x.
Chaput, J., Dutil, C., 2016. Lack of sleep as a contributor to obesity in adolescents: impacts on eating and activity behaviors. Int. J. Behav. Nutr. Phy. 13 (1), 103. https://doi.org/10.1186/s12966-016-0428-0.
Chassiakos, Y.L.R., Radesky, J., Christakis, D., Moreno, M.A., Cross, C., COUNCIL ON COMMUNICATIONS AND MEDIA, 2016. Children and adolescents and digital media. Pediatrics 138 (5), e20162593.
Cheung, L.M., Wong, W.S., 2011. The effects of insomnia and internet addiction on depression in Hong Kong Chinese adolescents: an exploratory cross-sectional analysis. J. Sleep Res. 20 (2), 311–317.
Chorney, D.B., Detweiler, M.F., Morris, T.L., Kuhn, B.R., 2007. The interplay of sleep disturbance, anxiety, and depression in children. J. Pediatr. Psychol. 33 (4), 339–348.
Crawford, T.N., Ridner, S.L., 2018. Differences in well-being between sexual minority and heterosexual college students. J. LGBT Youth 15 (3), 243–255.
Dewald, J.F., Meijer, A.M., Oort, F.J., Kerkhof, G.A., Bögels, S.M., 2010. The influence of sleep quality, sleep duration and sleepiness on school performance in children and adolescents: a meta-analytic review. Sleep Med. Rev. 14 (3), 179–189.
Driver, H.S., Taylor, S.R., 2000. Exercise and sleep. Sleep Med. Rev. 4 (4), 387–402.
e Silva, R.N.A., Wijtzes, A., Van De Bongardt, D., van de Looij-Jansen, P., Bannink, R., Raat, H., 2016. Early sexual intercourse: prospective associations with adolescents physical activity and screen time. PLoS ONE 11 (8), e0158648.
Eddolls, W.T., McNarry, M.A., Lester, L., Winn, C.O., Stratton, G., Mackintosh, K.A., 2018. The association between physical activity, fitness and body mass index on mental well-being and quality of life in adolescents. Qual. Life Res. 27 (9), 2313–2320.
Exelmans, L., Van den Bulck, J., 2016. Bedtime mobile phone use and sleep in adults. Soc. Sci. Med. 148, 93–101.
Flausino, N.H., Da Silva Prado, J.M., de Queiroz, S.S., Tufik, S., de Mello, M.T., 2012. Physical exercise performed before bedtime improves the sleep pattern of healthy young good sleepers. Psychophysiology 49 (2), 186–192.
Freeman, D., Sheaves, B., Goodwin, G.M., Yu, L.M., Nickless, A., Harrison, P.J., Hinds, C., 2017. The effects of improving sleep on mental health (OASIS): a randomised controlled trial with mediation analysis. Lancet Psychiat 4 (10), 749–758.
Garcia, J.M., Sirard, J.R., Whaley, D.E., Rice, D.J., Baker, K., Weltman, A., 2019. The influence of friends and psychosocial factors on physical activity and screen time in normal and overweight adolescents: a mixed-methods analysis. Am. J. Health Promot. 33 (1), 97–106.
Gerber, L., 2014. Sleep deprivation in children: a growing public health concern. Nurs. Manage. 45 (8), 22–28.
Gruber, R., Carrey, N., Weiss, S.K., Frappier, J.Y., Rourke, L., Brouillette, R.T., et al., 2014. Position statement on pediatric sleep for psychiatrists. J. Can. Acad. Child Adolesc. Psychiatry 23 (3), 174–195.
Hale, L., Guan, S., 2015. Screen time and sleep among school-aged children and adolescents: a systematic literature review. Sleep Med. Rev. 21, 50–58.
Hart, C.N., Hawley, N., Davey, A., Carskadon, M., Raynor, H., Jelalian, E., et al., 2017. . effect of experimental change in children's sleep duration on television viewing and physical activity. Pediatr. Obes. 12 (6), 462–467.
Heath, M., Sutherland, C., Bartel, K., Gradisar, M., Williamson, P., Lovato, N., Micic, G., 2014. Does one hour of bright or short-wavelength filtered tablet screenlight have a meaningful effect on adolescents' pre-bedtime alertness, sleep, and daytime functioning? Chronobiol. Int. 31 (4), 496–505.
Heo, J.Y., Kim, K., Fava, M., Mischoulon, D., Papakostas, G.I., Kim, M.J., Jeon, H.J., 2017. Effects of smartphone use with and without blue light at night in healthy adults: a randomized, double-blind, cross-over, placebo-controlled comparison. J. Psychiat. Res. 87, 61–70.
Herman, K.M., Hopman, W.M., Sabiston, C.M., 2015. Physical activity, screen time and self-rated health and mental health in Canadian adolescents. Prev. Med. 73, 112–116.
Johansson, A.E., Petrisko, M.A., Chasens, E.R., 2016. Adolescent sleep and the impact of technology use before sleep on daytime function. J. Pediatr. Nurs. 31 (5), 498–504.
Kaneita, Y., Yokoyama, E., Harano, S., Tamaki, T., Suzuki, H., Munezawa, T., et al., 2009. . associations between sleep disturbance and mental health status: a longitudinal study of Japanese junior high school students. Sleep Med. 10 (7), 780–786.
Kann, L., Kinchen, S., Shanklin, S.L., Flint, K.H., Hawkins, J., Harris, W.A., et al., 2014. Youth risk behavior surveillance—United States, 2013. MMWR Surveill. Summ. 63 (4), 1–168.
Kann, L., McManus, T., Harris, W.A., Shanklin, S.L., Flint, K.H., Queen, B., et al., 2018. Youth risk behavior surveillance - United States, 2017. MMWR Surveill. Summ. 67 (8), 1–114.
Kenney, E.L., Gortmaker, S.L., 2017. United States adolescents' television, computer, videogame, smartphone, and tablet use: associations with sugary drinks, sleep, physical activity, and obesity. J. Pediatr. 182, 144–149.
Kirisci, L., Reynolds, M., Carver, D., Tarter, R., 2013. Quick screen to detect current substance use disorder in adolescents and the likelihood of future disorder. Drug Alcohol Depend. 128 (1–2), 116–122.
Kohler, M.J., van den Heuvel, C.J., 2008. Is there a clear link between overweight/obesity and sleep disordered breathing in children? Sleep Med. Rev. 12 (5), 347–361.
Kovess-Masfety, V., Keyes, K., Hamilton, A., Hanson, G., Bitfoi, A., Golitz, D., et al., 2016. Is time spent playing video games associated with mental health, cognitive and social skills in young children? Soc. Psych. Psych. Epid 51 (3), 349–357.
Lechner, M., Breeze, C.E., Ohayon, M.M., Kotecha, B., 2019. Snoring and breathing pauses during sleep: interview survey of a United Kingdom population sample reveals a significant increase in the rates of sleep apnoea and obesity over the last 20 years - data from the UK sleep survey. Sleep Med. 54, 250–256.
Li, L., Zhang, S., Huang, Y., Chen, K., 2017. Sleep duration and obesity in children: a systematic review and meta-analysis of prospective cohort studies. J. Paediatr. Child H. 53 (4), 378–385.
Lichstein, K.L., 2006. Secondary insomnia: a myth dismissed. Sleep Med. Rev. 10 (1), 3–5.
Lovato, N., Gradisar, M., 2014. A meta-analysis and model of the relationship between sleep and depression in adolescents: recommendations for future research and clinical practice. Sleep Med. Rev. 18 (6), 521–529.
Lufi, D., Tzischinsky, O., Hadar, S., 2011. Delaying school starting time by 1 h: some effects on attention levels in adolescents. J. Clin. Sleep Med. 7 (02), 137–143.
Maski, K., Owens, J.A., 2016. Insomnia, parasomnias, and narcolepsy in children: clinical features, diagnosis, and management. Lancet Neurol 15 (11), 1170–1181.
Mazzer, K., Boersma, K., Linton, S.J., 2019. A longitudinal view of rumination, poor sleep and psychological distress in adolescents. J. Affect. Disorders 245, 686–696.
McDowell, C.P., MacDonncha, C., Herring, M.P., 2017. Brief report: associations of physical activity with anxiety and depression symptoms and status among adolescents. J. Adolescence 55, 1–4.
McGuire, S., 2011. U.S. Department of Agriculture and U.S. Department of Health and Human services, Dietary Guidelines for Americans, 2010, 7th edition. U.S. Government Printing Office, Washington, DC January 2011. Adv. Nutr. 2, 293-294.
McMahon, E.M., Corcoran, P., O'Regan, G., Keeley, H., Cannon, M., Carli, V., et al., 2017. Physical activity in european adolescents and associations with anxiety, depression and well-being. Eur. Child Adoles. Psy. 26 (1), 111–122.
Meldrum, R.C., Jackson, D.B., Archer, R., Ammons-Blanfort, C., 2018. Perceived school safety, perceived neighborhood safety, and insufficient sleep among adolescents. Sleep Health 4 (5), 429–435.
Meltzer, L.J., Mindell, J.A., 2014. Systematic review and meta-analysis of behavioral interventions for pediatric insomnia. J. Pediatr. Psychol. 39 (8), 932–948.
Messias, E., Castro, J., Saini, A., Usman, M., Peeples, D., 2011. Sadness, suicide, and their association with video game and internet overuse among teens: results from the Youth Risk Behavior Survey 2007 and 2009. Suicide Life-Threat. 41 (3), 307–315.
Mireku, M.O., Barker, M.M., Mutz, J., Dumontheil, I., Thomas, M.S., Röösli, M., et al., 2019. Night-time screen-based media device use and adolescents' sleep and health-related quality of life. Environ. Int. 124, 66–78.
National Sleep Foundation., 2014. 2014 sleep in america poll: sleep in the modern family: summary of findings. Retrieved from https://www.sleepfoundation.org/sites/default/files/inline-files/2014-NSF-Sleep-in-America-poll-summary-of-findings—FINAL-Updated-3-26-14-.pdf.
National Sleep Foundation., 2015. National sleep foundation recommends new sleep times. Retrieved fromhttps://www.sleepfoundation.org/press-release/national-sleep-foundation-recommends-new-sleep-times.
Oda, S., Shirakawa, K., 2014. Sleep onset is disrupted following pre-sleep exercise that causes large physiological excitement at bedtime. Eur. J. Appl Physiol. 114 (9), 1789–1799.
Ogawa, S., Kitagawa, Y., Fukushima, M., Yonehara, H., Nishida, A., Togo, F., et al., 2019. Interactive effect of sleep duration and physical activity on anxiety/depression in adolescents. Psychiat. Res. 273, 456–460.
Ohayon, M., Wickwire, E.M., Hirshkowitz, M., Albert, S.M., Avidan, A., Daly, F.J., et al.,

2017. National sleep foundation's sleep quality recommendations: first report. Sleep Health 3 (1), 6–19.
Owens, J., Adolescent Sleep Working Group, 2014. Insufficient sleep in adolescents and young adults: an update on causes and consequences. Pediatrics 134 (3), e921–e932.
Paruthi, S., Brooks, L.J., D'Ambrosio, C., Hall, W.A., Kotagal, S., Lloyd, R.M., et al., 2016. Recommended amount of sleep for pediatric populations: a consensus statement of the American Academy of Sleep Medicine. J. Clin. Sleep Med. 12 (06), 785–786.
Patel, S.R., Hu, F.B., 2008. Short sleep duration and weight gain: a systematic review. Obesity 16 (3), 643–653.
Pesonen, A., Gradisar, M., Kuula, L., Short, M., Merikanto, I., Tark, R., et al., 2019. REM sleep fragmentation associated with depressive symptoms and genetic risk for depression in a community-based sample of adolescents. J. Affect. Disorders 245, 757–763.
Pieters, S., Burk, W.J., Van der Vorst, H., Dahl, R.E., Wiers, R.W., Engels, R.C., 2015. Prospective relationships between sleep problems and substance use, internalizing and externalizing problems. J. Youth Adolesc. 44 (2), 379–388.
Ritter, P.S., Höfler, M., Wittchen, H., Lieb, R., Bauer, M., Pfennig, A., et al., 2015. Disturbed sleep as risk factor for the subsequent onset of bipolar disorder–Data from a 10-year prospective-longitudinal study among adolescents and young adults. J. Psychiat. Res. 68, 76–82.
Rodriguez-Ayllon, M., Cadenas-Sanchez, C., Estévez-López, F., Muñoz, N.E., Mora-Gonzalez, J., Migueles, J.H., Catena, A., 2019. Role of physical activity and sedentary behavior in the mental health of preschoolers, children and adolescents: a systematic review and meta-analysis. Sports Med. 49 (9), 1383–1410.
Rubin, D.B., 1996. Multiple imputation after 18 years. J. Am. Stat. Assoc. 91 (434), 473–489.
Sahin, S., Ozdemir, K., Unsal, A., Temiz, N., 2013. Evaluation of mobile phone addiction level and sleep quality in university students. Pak. J. Med. Sci. 29, 913–918.
Sami, H., Danielle, L., Lihi, D., Elena, S., 2018. The effect of sleep disturbances and internet addiction on suicidal ideation among adolescents in the presence of depressive symptoms. Psychiat. Res. 267, 327–332.
Sampasa-Kanyinga, H., Chaput, J., 2016. Use of social networking sites and alcohol consumption among adolescents. Public Health 139, 88–95.
Shanahan, L., Copeland, W.E., Angold, A., Bondy, C.L., Costello, E.J., 2014. Sleep problems predict and are predicted by generalized anxiety/depression and oppositional defiant disorder. J. Am. Acad. Child Psy. 53 (5), 550–558.
Shimura, A., Hideo, S., Takaesu, Y., Nomura, R., Komada, Y., Inoue, T., 2018. Comprehensive assessment of the impact of life habits on sleep disturbance, chronotype, and daytime sleepiness among high-school students. Sleep Med 44, 12–18.
Singh, G.K., Kenney, M.K., 2013. Rising prevalence and neighborhood, social, and behavioral determinants of sleep problems in US children and adolescents, 2003–2012. Sleep Disord 2013, 394320. https://doi.org/10.1155/2013/394320.
Sisson, S.B., Broyles, S.T., Baker, B.L., Katzmarzyk, P.T., 2010. Screen time, physical activity, and overweight in U.S. youth: national survey of children's health 2003. J. Adolesc. Health 47 (3), 309–311.
Sivertsen, B., Skogen, J.C., Jakobsen, R., Hysing, M., 2015. Sleep and use of alcohol and drug in adolescence. A large population-based study of norwegian adolescents aged 16–19 years. Drug Alcohol Depend 149, 180–186.
Stanley, I.H., Hom, M.A., Luby, J.L., Joshi, P.T., Wagner, K.D., Emslie, G.J., et al., 2017. Comorbid sleep disorders and suicide risk among children and adolescents with bipolar disorder. J. Psychiat. Res. 95, 54–59.
Stutz, J., Eiholzer, R., Spengler, C.M., 2019. Effects of evening exercise on sleep in healthy participants: a systematic review and meta-analysis. Sports Med. 49 (2), 269–287.
Thompson, D.A., Christakis, D.A., 2005. The association between television viewing and irregular sleep schedules among children less than 3 years of age. Pediatrics 116 (4), 851–856.
Torstveit, M.K., Johansen, B.T., Haugland, S.H., Stea, T.H., 2018. Participation in organized sports is associated with decreased likelihood of unhealthy lifestyle habits in adolescents. Scand. J. Med. Sci. Sports 28 (11), 2384–2396.
Tosini, G., Ferguson, I., Tsubota, K., 2016. Effects of blue light on the circadian system and eye physiology. Mol. Vis. 22, 61–72.
Tremblay, M.S., LeBlanc, A.G., Janssen, I., Kho, M.E., Hicks, A., Murumets, K., Duggan, M., 2011. Canadian sedentary behaviour guidelines for children and youth. Appl. Physiol. Nutr. Metab. 36 (1), 59–64.
Turel, O., Romashkin, A., Morrison, K., 2017. A model linking video gaming, sleep quality, sweet drinks consumption and obesity among children and youth. Clin. Obes. 7 (4), 191–198.
Twenge, J.M., Campbell, W.K., 2019. Media use is linked to lower psychological well-being: evidence from three datasets. Psychiat. Quart. 90 (2), 311–331.
Twenge, J.M., Joiner, T.E., Rogers, M.L., Martin, G.N., 2018. Increases in depressive symptoms, suicide-related outcomes, and suicide rates among US adolescents after 2010 and links to increased new media screen time. Clin. Psychol. Sci. 6 (1), 3–17.
US Department of Health and Human Services, 2012. Physical activity guidelines for americans midcourse report subcommittee of the president's council on fitness, sports & nutrition. Physical Activity Guidelines for Americans Midcourse Report: Strategies to Increase Physical Activity in. Services USDoHaH, Washington, DC.
Van Buuren, S., Oudshoorn, C., 2000. Multivariate imputation by chained equations: MICE V1.0 user's manual.leiden: (No. TNO Report PG/VGZ/00.038).TNO Preventie en Gezondheid. Retrieved from. http://www.multiple-imputation.com.
Walter, L.M., Tamanyan, K., Limawan, A.P., Biggs, S.N., Weichard, A.J., Davey, M.J., et al., 2018. Overweight and obese children with sleep disordered breathing have elevated arterial stiffness. Sleep Med. 48, 187–193.
Wethington, H., Pan, L., Sherry, B., 2013. The association of screen time, television in the bedroom, and obesity among school-aged youth: 2007 national survey of children's health. J. Sch. Health 83 (8), 573–581.
Wheaton, A.G., Jones, S.E., Cooper, A.C., Croft, J.B., 2018. Short sleep duration among middle school and high school students - United States, 2015. MMWR-Morbid. Mortal. W. 67 (3), 85–90.
Winsler, A., Deutsch, A., Vorona, R.D., Payne, P.A., Szklo-Coxe, M., 2015. Sleepless in Fairfax: the difference one more hour of sleep can make for teen hopelessness, suicidal ideation, and substance use. J. Youth Adolesc. 44 (2), 362–378.
Wood, B., Rea, M.S., Plitnick, B., Figueiro, M.G., 2013. Light level and duration of exposure determine the impact of self-luminous tablets on melatonin suppression. Appl. Ergon. 44 (2), 237–240.
Woods, H.C., Scott, H., 2016. # Sleepyteens: social media use in adolescence is associated with poor sleep quality, anxiety, depression and low self-esteem. J. Adolesc. 51, 41–49.
Youngstedt, S.D., 2005. Effects of exercise on sleep. Clin. Sport. Med. 24 (2), 355–365.
Zink, J., Belcher, B.R., Kechter, A., Stone, M.D., Leventhal, A.M., 2019. Reciprocal associations between screen time and emotional disorder symptoms during adolescence. Prev. Med. Rep. 13, 281–288.