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A prospective study of screen time in adolescence and depression symptoms in young adulthood

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ABSTRACT

Objectives. The purpose of this study was to examine the association between screen time in adolescence and depressive symptoms in young adulthood in a population-based cohort study of Danish adolescents.

Methods. Data were from a cohort of adolescents who were followed-up in young adulthood for a period of up to 12 years (1997–2010, mean 8.8 years, $n = 435$). Information on television viewing, computer use, total screen time and other determinants of depression were obtained in adolescence. Depressive symptoms were obtained in young adulthood using the Major Depression Inventory (MDI) and classified as mild, moderate or severe depression. Mixed regression models were used to examine the associations, with adjustment for major confounders.

Results. In multivariable adjusted analyses, each additional hour/day spent watching television or screen viewing in adolescence was associated with 1.36 (95% CI 0.73–1.98) and 1.05 (95% CI 0.50–1.60), respectively, greater MDI depression summary score in young adulthood ($p < 0.001$). In logistic regression models, each additional hour/day spent watching television or screen viewing was associated with 1.64 (95% CI 1.18–2.27) and 1.58 (95% CI 1.18–2.12), respectively, greater odds of prevalent depression in young adulthood, and dose–response relationships were indicated. Additional adjustment for either cardiorespiratory fitness or BMI did not materially change the results. No significant associations were observed between adolescent computer use and depressive symptoms in young adulthood.

Conclusions. Limiting screen time, particularly television viewing, during adolescence may be important for preventing depression in young adulthood.

Introduction

Screen use such as television (TV) viewing is highly popular and pervasive among young people. According to the most recent 2014 US Nielsen Company rating, adolescents 12–17 years old spend an average of 3 h and 53 min per day engaging in screen viewing behaviors, with traditional TV viewing at home as the predominant source (Nielsen Co., 2014). While several studies have reported that prolonged screen time in adolescence impairs cardiovascular health outcomes in later life (Grøntved et al., 2014; Hancox et al., 2004; van de Laar et al., 2014), evidence regarding its influence on other health outcomes such as mental health characteristics remains limited. Depression is a common mental health disorder among adolescents and young adults, with a population median age of onset at early to mid twenties (Kessler and Bromet, 2013), and it is a principal cause of disability adjusted life years lost among adolescents and young adults worldwide (World Health Organization, 2014; Gore et al., 2011).

The underlying processes through which screen time could be involved in the development of depression are likely to be complex and multidimensional. Excessive screen time may lead to withdrawal from interpersonal relationships, and media content could shape people's behavior and mood and lead to negative comparison of oneself with others, that in turn could cause depressive symptoms (Kraut et al., 1998; Lewinsohn et al., 1998). Furthermore, obesity, lack of engagement in physical activity, and poor sleep quality and quantity are other plausible mechanisms that could link screen time with depression (Baglioni et al., 2011; Luppino et al., 2010; Aberg et al., 2012).A number of cross-sectional studies have reported the association of screen time with

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symptoms of depression in young people (Kim et al., 2010; Hong et al., 2009; Casiano et al., 2012). However, the relationship between depression and excessive screen time is likely to be bidirectional (Hume et al., 2011), indicating that it is critical to use prospective data to limit the possibility of reverse causation bias. We are aware of two previous prospective studies that have examined the relationship of screen use with later depression in young people (Hume et al., 2011; Primack et al., 2009), but the results have been mixed. Additional prospective studies on the topic are warranted to clarify the relationship. In this study our aim was to examine the association of screen time in adolescence with symptoms of depression in young adulthood in a population-based sample of Danish adolescents followed for up to 12 years.

Methods

Study design and sampling of participants

The data used for this study are based on the Danish cohorts of the European Youth Heart Study (EYHS). EYHS is an ongoing, international, population-based prospective observational multicenter study. A description of the sampling procedure and the general description of the EYHS can be found elsewhere (Riddoch et al., 2005). Random samples of 658 and 771 15-year-old adolescents were invited to participate in 1997–1998 and 2003–2004, respectively, of whom 429 (65%) and 444 (58%) agreed to take part (the source population was all adolescents attending school in the Municipality of Odense, the third largest municipality in Denmark). Follow-up visits were conducted in 2009–2010 where all originally invited participants were re-invited, and 650 (45%) participated in the follow-up visits. The eligible cohort for the current analyses consisted of 435 individuals who had complete data for all exposure and outcome variables (242 individuals with 6-year follow-up and 193 individuals with 12-year follow-up). Ninety-six percent of the population at baseline was white (Caucasian). The local scientific ethics committee approved the study, and all participants (and their parents when participants were 15 years of age) gave informed consent to participate.

Assessment of symptoms of depression

During the follow-up visits in 2009–2010, symptoms of depression were assessed using the Major Depression Inventory (MDI) scale (Bech et al., 2001). The MDI scale consists of 10 ICD-10 symptoms of depression which are nearly identical to the Diagnostic and Statistical Manual of Mental Disorders—Fourth Edition (DSM-IV) major depression symptoms (the low self-esteem symptom is incorporated in the symptom of guilt in the DSM-IV). The 10 symptoms are based on 12 items on a six-point Likert scale (0 to 5), and each individual item measures how much time the symptoms have been present during the past 14 days. Zero on the scale indicates that the symptom has not been present at all and five that the symptom has been present all of the time. Examples of items on the scale include: “Have you felt lacking in energy and strength” (item 2), "Have you felt that life wasn't worth living" (item 6), "Have you had trouble sleeping at night" (item 9). We scored and classified individuals with any significant depressive symptoms including mild, moderate or severe depression defined as MDI ≥20. The MDI scale has been reported to have a high degree of agreement with the Schedules for Clinical Assessment in Neuropsychiatry tool (sensitivity 0.86 and specificity 0.86 for classification of moderate to severe depression) and the Hamilton Depression Scale ($r = 0.86$) (Bech et al., 2001; Olsen et al., 2003). Because of the sample size we were unable to further sub-divide participants into mild, moderate, and severe depression for analyses. However, for descriptive purpose we also reported prevalence according to DSM-IV major depression and ICD-10 mild, moderate or severe depression (Table 2). We also used the MDI scale as a summary score indicating the severity of depression, which includes values from 0 to 50 with 50 representing extreme depression. We did not administer the MDI tool nor did we specifically ask the participants or their parents about history of depression at baseline when they were 15 years old. However, we asked the parents to provide information on the participants' history of long-term illnesses. Of the participants eligible for the current analyses, the parents of one female participant reported a history of depression in adolescence, and we excluded this individual from the analysis.

Assessment of screen time in adolescence and young adulthood

TV and computer use during leisure time was obtained by self-report using a computer-based questionnaire as previously described (Grøntved et al., 2014). Participants answered each question individually, and the computers were placed in a quiet area in the clinical testing facility. A researcher was present in the case of any questions. At baseline the participants answered two questions about the amount of time viewing TV (the number of hours per day spent viewing TV before and after school with response categories: none, <1, 1–2, 2–3, >3). For these categories we assigned the mid-point of each viewing interval and assumed that the categories ‘<1’ and ‘>3’ had the same amplitude (>0–1 and 3–4 h per day respectively). A summary variable of daily TV viewing time was then constructed based on the two derived times (hours/day). Daily leisure time spent using a computer was asked in one question (number of hours per day spent playing computer games with response categories none, <1, 1–2, >2) and was derived similar to the TV viewing variable. At the follow-up visits, participants were also asked about their daily time spent viewing TV and using a computer. At both time-points, a total screen time variable (hours/day) was created by summarizing TV viewing time and computer use. These screen time questions are fairly comparable with the HELENA sedentary behavior questionnaire, which has moderate to high reliability in European adolescents (test–retest reliability coefficient 0.68–0.82) (Rey-López et al., 2012).

Assessment of other covariates in adolescence

Body height and weight were assessed using standard anthropometric procedures by trained research staff, and body mass index (BMI) was calculated. Parental educational level was obtained by parental self-report and defined according to the International Standard Classification of Education (ISCED) (UNESCO 1997) and was divided into basic education (basic), secondary or post-secondary education (secondary), and tertiary education (higher). The ethnicity of the adolescent and the parental marital status were obtained by parental self-report. Alcohol intake and smoking status were obtained by self-report using a computer-based questionnaire. Alcohol intake (beer, wine, spirits, alcoholic lemonade) was asked in a sequence of questions that were subsequently re-coded to form a nominal scale variable: never tasted alcohol or only tasted alcohol at celebrations, occasionally (≤1 serving per month), weekly or daily. Smoking status was asked in a single question with the following response options (I don't smoke, I sometimes smoke, I smoke every day). Cardiorespiratory fitness was assessed during a progressive maximal ergometer bicycle test as previously described (Riddoch et al., 2005). Heart rate (HR) was recorded every 5 s throughout the test using an HR monitor (Polar Vantage, Finland). Criteria for a maximal effort were HR of 185 beats per minute or greater and a subjective judgment by the observer that the participant could no longer continue, even after encouragement. Maximal power output normalized to body weight (max watts/kg) was used as a measure of cardiorespiratory fitness, and this measure was highly correlated with VO_2-max assessed directly ($r > 0.90$, $p < 0.001$) (Anderssen et al., 2007).

Statistical analysis

The associations of screen time in adolescence with symptoms of depression (MDI summary score) in young adulthood were examined using a mixed linear regression model with screen time as a continuous variable. Initially, we adjusted the models for age at baseline, follow-up time, and sex (as fixed effects), and the school was treated as a random effect. Subsequently we conducted multivariable adjusted analyses including the original variables plus parental educational level, marital status, smoking status, and alcohol intake in adolescence as these were identified as possible confounding factors. Furthermore, we additionally and separately adjusted for cardiorespiratory fitness and BMI in adolescence, since these may be putative intermediates of the association or alternatively confounding factors of the relationship. Although we *a priori* identified ethnicity as a confounding variable, it was not considered in the analyses because 96% of the study population was white. We also examined the possibility that the associations of screen time with depression were different between boys and girls as previously suggested (Primack et al., 2009) by including an interaction term and main effects of sex and screen time. Standard linear regression diagnostics were examined, including examining the linearity and normality of residuals, and these evaluations revealed no indication of violation of assumptions.

We then analyzed the association of screen time in adolescence with the odds of any significant depression (MDI score ≥ 20) in young adulthood using

mixed logistic regression models adjusting for the same covariates as in the linear regression models and treating school as a random effect. In these models we treated screen time in different ways: continuous, categorized in 0 to 1, >1 to 3, and >3 h/day, and defined as meeting the recommendations from the American Academy of Pediatrics (0–2 h/day vs. >2 h/day) (Committee on Public Education, 2001).

Finally, we carried out a sensitivity analysis to assess the possibility of selection bias due to missing data and loss to follow-up by comparing estimates of associations in the sample with complete data on covariates and outcome ($n = 435$) with the full sample ($n = 873$) with the missing values being imputed. Missing values were imputed using a multivariate chained equation imputation approach ("mi impute chained" in STATA) including all covariates and respective outcomes (Royston, 2004). Beta coefficients and SE's were obtained based on 30 imputed datasets. All statistical analyses were performed in STATA 12.1 with alpha = 0.05 (two-sided).

Results

Table 1 shows the baseline characteristics of the study population by TV viewing in adolescence. No significant differences were observed across the categories of TV viewing time with respect to age, ethnicity, BMI, sex, parental marital status, and parental educational level ($p > 0.05$), whereas computer use was related to television viewing ($p = 0.01$). Individuals with missing data or that were lost to follow-up in 2009–2010 were not different according to age, BMI, computer use, or distribution of sex and parental marital status compared with participants with full data (Table S1). However, participants with missing data or lost to follow-up had lower fitness, higher TV viewing time, were more likely to smoke and drink alcohol, and a larger proportion was non-white and from parents with only a basic education.

Table 2 shows a mean MDI score and prevalence of depression in young adulthood according to MDI ≥ 20 and ICD-10 defined mild, moderate, or severe depression and DSM-IV major depression in the total population and by sex and age-group. Women reported a higher MDI score and had a marginally greater prevalence of depression compared with men. No differences were observed in depression score or proportions by age-group.

Table 1
Baseline characteristics by television viewing time in adolescence ($n = 435$).

	Television viewing time in adolescence			
	0–1 h/day ($n = 164$)	>1–3 h/day ($n = 226$)	>3 h/day ($n = 45$)	P*
Age (years)	15.6 (0.4)	15.6 (0.4)	15.6 (0.4)	0.73
Sex (% boys)	45.1	44.7	62.2	0.09
Ethnicity (% white)	95.7	96.0	97.8	0.82
BMI (kg/m^2)	21.0 (2.4)	20.8 (2.4)	21.4 (3.4)	0.51
Cardiorespiratory fitness (watts/kg)	3.44 (0.57)	3.38 (0.60)	3.36 (0.64)	0.08
Computer use (hours/day)	0.7 (0.8)	0.6 (0.7)	0.8 (0.8)	0.01
Parental education level[a] *(%)*				
Basic	7.9	10.6	8.9	0.23
Secondary	22.6	31.4	31.1	
Higher	69.5	58.0	60.0	
Parental marital status (% married)	78.7	67.7	71.1	0.06
Smoking status (%)				
Not smoking	80.5	83.2	86.7	0.89
Sometimes but not every day	12.8	10.6	8.9	
Every day	6.7	6.2	4.4	
Alcohol intake (%)				
Never	42.7	42.9	55.6	0.40
Once a month or less	52.4	49.6	37.8	
Every week or every day	4.9	7.5	6.7	

Data are means (SD) or percent.
P is the *p* value for global difference based on chi-squared or Wald test.
[a] Based on educational level (International Standard Classification of Education (ISCED) (UNESCO 1997). The ISCED level 1 and 2 were grouped (basic), 3 and 4 were grouped (secondary), and 5, 6 and 7 were grouped (higher).

Table 3 shows univariate relationships of screen time variables and covariates in adolescence with MDI depression scale in young adulthood. Smoking status, alcohol intake, BMI, fitness, sex, TV, and total screen time in adolescence were all crudely related to MDI depression score in young adulthood. TV and total screen time in adolescence were significantly and positively associated with depression score in young adulthood in multivariable adjusted models (Table 4). Additional adjustment for cardiorespiratory fitness or BMI had only minor influence on the magnitude and precision of these estimates. We observed no associations of computer use in adolescence with MDI score in young adulthood in any analyses. Furthermore, we did not observe statistical evidence that the associations of screen time with depression score were modified by sex [$p = 0.89$ (TV), $p = 0.18$ (computer use), $p = 0.45$ (total screen time) for interaction; Fig. S1]. To examine the possibility that the relationship of screen time in adolescence with depression score in young adulthood was explained by more recent screen use in adulthood, we also additionally adjusted our model 2 in Table 4 for screen time in young adulthood. These adjustments only modestly attenuated the relationships [beta for TV 1.18 (95% CI 0.52–1.84, $p < 0.001$, beta for total screen time 0.85 (95% CI 0.29–1.42, $p = 0.003$)]. In the sensitivity analyses, where missing values due to loss to follow-up or missing data were imputed, we obtained fairly similar results compared with non-imputed analyses (data not shown; e.g., model 2 of Table 3 TV viewing: beta = 1.32 (95% CI 0.81–1.83) and total screen time model 2: beta = 1.13 (95% CI 0.59–1.67).

In the logistic regression analyses including putative confounding factors, each hour/day of TV or total screen time was associated greater odds of prevalent depression in young adulthood (Table 5). Furthermore, additional adjustment for TV and total screen time at follow-up only modestly affected these relationships [odds ratio for TV time 1.50 (95% CI 1.06–2.12, $p = 0.02$), odds ratio for total screen time 1.47 (95% CI 1.09–1.98, $p = 0.01$)]. We also divided screen time in categories to further examine possible dose–response relationships with prevalent depression. These analyses suggested dose–response relationships in multivariable adjusted analyses ($p = 0.01$ and $p = 0.04$ for trend respectively), although for total screen time additional adjustment for BMI or fitness provided non-significant *p* values for trend ($p = 0.05$ and $p = 0.06$ respectively). Lastly, participants not meeting total screen time recommendations in adolescence had 2.32 (95% CI 1.07–5.03) higher odds of prevalent mild, moderate, or severe depression and 1.84 (95% CI 0.35–3.32) greater MDI depression score in young adulthood, respectively, compared with participants meeting recommendations in the multivariable adjusted analysis. Adjusting for adolescent fitness or BMI made no difference in the size and precision of these estimates.

Discussion

In this population-based, prospective study, we found that prolonged TV viewing and total screen time in adolescence were associated with more symptoms of depression and higher odds of mild, moderate or severe depression in young adulthood. These prospective relationships were independent of a number of putative confounders and were fairly similar for men and women. We observed no evidence that computer use in adolescence was associated with symptoms of depression in young adulthood.

The possible detrimental effect of screen time on depression in young people has received little attention in prospective studies. Primack et al. (2009) reported that TV viewing and total media exposure were related to increased odds of depression symptoms in young adulthood in a large group of US adolescents followed during 7 years into young adulthood. Furthermore, in line with our study, they did not observe associations of computer use with depression symptoms. However, in contrast to our study they reported some evidence of a sex-specific relationship for total media exposure, suggesting a greater influence of excessive media use in the development of depression

Table 2
Depression scores and prevalence proportions in the total population and by sex and age-group in young adulthood.

		Prevalence proportions (%) (95% CI)		
	Mean MDI score (SD)	Mild, moderate or severe depression (MDI ≥ 20)	DSM-IV major depression	ICD-10 mild, moderate or severe depression
Total population ($n = 435$)	8.4 (7.5)	8.5 (5.9–11.1)	4.4 (2.4–6.2)	4.8 (2.8–6.8)
Men ($n = 203$)	7.2 (6.6)	5.9 (2.6–9.2)	2.0 (0.5–3.9)	3.0 (0.6–5.3)
Women ($n = 232$)	9.6 (8.0)	10.8 (6.8–14.8)	6.4 (3.3–9.6)	6.5 (3.0–9.6)
21-year olds ($n = 242$)	8.7 (7.2)	7.9 (4.4–11.3)	5.0 (2.2–7.7)	3.7 (1.3–6.1)
27-year olds ($n = 193$)	8.1 (7.9)	9.3 (5.2–13.5)	3.6 (1.0–6.3)	6.2 (2.8–9.6)

MDI = Major Depression Inventory, DSM-IV = Diagnostic and Statistical Manual of Mental Disorders—Fourth Edition. ICD = International Classification of Diseases.

symptoms for men compared to women. Another small-scale prospective study among 155 adolescents followed over two years found no association of TV viewing time with depression symptoms, yet the authors reported that depression symptoms were related to TV viewing time at follow-up in girls but not in boys (Hume et al., 2011).Also, a few studies conducted among middle-aged or older adults suggested that screen time was prospectively associated with risk of depression (Teychenne et al., 2011; Lucas et al., 2011; Hamer and Stamatakis, 2014). We are unaware of other prospective, observational studies on this topic conducted among children, adolescents and young adults, and to the best of our knowledge there are no experimental studies examining the effect of limiting screen time on symptoms of depression.

There are a number of plausible explanations for a potential causal relationship between screen time and depression in young people. First, it is possible that excessive screen time may lead to less communication with family and friends, affecting face-to-face social interactions and possible social isolation (Kraut et al., 1998). Second, TV viewing may, via exposure to its content, lead to attention problems, antisocial behavior, and body dissatisfaction (Johnson et al., 2007; Robertson et al., 2013; Schooler and Trinh, 2011; Landhuis et al., 2007), which are known determinants of depression. Because we found no association of computer use with depression symptoms, it is possible that exposure to specific content or context relative to screen use may cause depression in the long term. Third, screen use may displace time spent on specific activities such as physical activity (e.g. moderate and vigorous physical activity) and academic study-related activities. Previous studies have suggested that TV viewing in adolescence is related to learning difficulties and academic achievement in young adulthood (Johnson et al., 2007; Hancox et al., 2005).While it is difficult for us to address many of these explanations using our data, we did find that adjustment for cardiorespiratory fitness or adiposity had little impact on the magnitude of the association of screen time with depression symptoms. The current evidence base to support a causal link between physical activity and development of depression symptoms in adolescents and young adults is inconclusive (Biddle and Asare, 2011; Toseeb et al., 2014), which together provides little support for this explanation. Additional prospective studies are needed to further provide explanations of the relationship between screen time and depression in adolescents and young adults.

In our population-based sample of young Danish adults we found a prevalence rate of 4.4 percent of major depression (DSM-IV). In a previous study among Danish adults from the general population collected in the year 2000, a prevalence rate of 3.5 percent for major depression (DSM-IV) was reported among 20–34 year olds using the same instrument to assess depression as the present study (Olsen et al., 2004). This is moderately lower than the current investigation and may point to an increase in the prevalence rates of depression among young adults

Table 3
Univariate relationship of characteristics in adolescence with MDI Depression Scale in young adulthood.

	MDI Depression Scale (0–50 points) in young adulthood	
	Crude beta (95% CI)	*P* value
Characteristic in adolescence		
Television viewing (hours/day)	1.14 (0.51–1.78)	<0.001
Computer use (hours/day)	−0.60 (−1.52–0.32)	0.20
Total screen time (hours/day)	0.55 (0.04–1.07)	0.04
Age (years)	1.22 (−0.69–3.14)	0.21
Sex (reference is girls)	−2.39 (−3.79–−0.99)	0.001
Parental education level		
Basic (reference)	–	
Secondary	−0.53 (−3.20–2.14)	0.70
Higher	−1.00 (−3.48–1.47)	0.43
Parental marital status (not married is reference)	−0.99 (−2.57–0.59)	0.22
Smoking status (%)		
Not smoking (reference)	–	
Sometimes but not every day	2.78 (0.65–5.09)	0.01
Every day	3.78 (0.87–6.70)	0.01
Alcohol intake (%)		
Never (reference)	–	
Once a month or less	0.19 (−1.27–1.65)	0.80
Every week or every day	3.14 (0.16–6.12)	0.04
BMI (kg/m^2)	0.44 (0.17–0.72)	0.002
Cardiorespiratory fitness (watts/kg)	−2.81 (−3.97–−1.64)	<0.001

Beta coefficient (95% CI) represents change in MDI depression score in young adulthood per unit difference in characteristic in adolescence.

Table 4
Associations of screen time in adolescence with symptoms of depression in young adulthood.

	MDI Depression Scale (0–50 points) in young adulthood	
	Beta (95% CI)	*p*-value
Screen time exposure in adolescence		
Television viewing (hours/day)		
Model 1	1.34 (0.72–1.96)	<0.001
Model 2	1.36 (0.73–1.98)	<0.001
Model 3	1.34 (0.73–1.96)	<0.001
Model 4	1.24 (0.62–1.87)	<0.001
Computer use (hours/day)		
Model 1	0.16 (−0.90–1.21)	0.77
Model 2	0.01 (−1.06–1.08)	0.98
Model 3	0.07 (−0.99–1.12)	0.90
Model 4	−0.06 (−1.12–1.00)	0.91
Total screen time (hours/day)		
Model 1	1.04 (0.51–1.59)	<0.001
Model 2	1.05 (0.50–1.60)	<0.001
Model 3	1.05 (0.50–1.59)	<0.001
Model 4	0.94 (0.39–1.49)	0.001

Beta coefficient (95% CI) represents change in MDI depression score in young adulthood per hours/day difference in screen time in adolescence.
Model 1 was adjusted for age at baseline, follow-up time, sex, and school id treated as a random effect.
Model 2 included variables in Model 1 but with additional adjustment for parental education level, parental marital status, smoking status, and alcohol intake in adolescence.
Model 3 included variables in Model 2 but with additional adjustment for body mass index in adolescence.
Model 4 included variables in Model 2 but with additional adjustment for cardiorespiratory fitness in adolescence.

Table 5
Associations of screen time in adolescence with any significant depression (MDI ≥ 20) in young adulthood.

	Screen time as a continuous variable (hours/day)	0–1 h/day	>1–3 h/day	>3 h/day	
	OR (95% CI)	reference	OR (95% CI)	OR (95% CI)	*p*-trend
Television viewing					
Model 1	1.64 (1.18–2.27)	1	2.63 (1.06–6.57)	4.56 (1.30–16.01)	0.01
Model 2	1.62 (1.17–2.25)	1	2.67 (1.07–6.65)	4.28 (1.21–15.16)	0.01
Model 3	1.63 (1.17–2.26)	1	2.62 (1.05–6.54)	4.35 (1.22–15.57)	0.01
Computer use					
Model 1	1.28 (0.73–2.25)	1	1.46 (0.58–3.68)	–	–
Model 2	1.28 (0.73–2.25)	1	1.46 (0.58–3.68)	–	–
Model 3	1.26 (0.72–2.21)	1	1.42 (0.56–3.58)	–	–
Total screen time					
Model 1	1.58 (1.18–2.12)	1	2.29 (0.80–6.54)	3.62 (1.02–12.84)	0.04
Model 2	1.56 (1.16–2.10)	1	2.30 (0.81–6.59)	3.50 (0.99–12.41)	0.05
Model 3	1.57 (1.16–2.12)	1	2.26 (0.79–6.47)	3.46 (0.96–12.46)	0.06

Data are odds ratios (OR) with 95% CI for presence of mild, moderate, and severe depression in young adulthood per difference in screen time in adolescence.
Model 1 was adjusted for age at baseline, follow-up time, sex, parental education level, parental marital status, smoking status, and alcohol intake in adolescence, and with school id treated as a random effect.
Model 2 included variables in Model 1 but with additional adjustment for body mass index in adolescence.
Model 3 included variables in Model 1 but with additional adjustment for cardiorespiratory fitness in adolescence.
Because none of the participants reported computer use beyond 3 h/day in adolescence, there was no estimate to report for this category.

in Denmark. Evidence for a potential increase in prevalence of depression was also suggested in a report based on a Danish collection of major depression prevalence rates among 40- and 50-year olds from the general population in 2000 and 2006 (Andersen et al., 2011). This comparison should, however, be interpreted with caution due to a wide confidence interval and because our prevalence estimates cannot be directly generalized to the entire Danish young adult population. We found that women reported substantially more symptoms of depression and a prevalence rate of major depression that was three times higher than men, although confidence intervals were wide for these estimates. Despite the fact that a larger study would be needed to provide estimates of sex differences in major depression with more confidence, our data indicate a particular awareness among young female adults.

Study limitations

Our study should be interpreted in light of a number of limitations. First, we cannot rule out the possibility that these results were explained by reverse causation, despite the 6- or 12-year interval between the exposures and outcome. In other words, symptoms of depression in adolescence may have led to more screen use. Our analyses with additional adjustment for screen time in young adulthood suggested that the relationships were not entirely explained by recent use of screen time. Second, although we were able to adjust our analyses for important determinants or correlates of depression, residual confounding is still possible and screen time may just be a correlate of depression rather than a causal risk factor. Furthermore, screen time was obtained via self-report and measurement error is inevitable. Because the questions regarding TV asked about viewing time before and after school it may be possible that viewing time during the weekend was measured with more error. Also the question on computer use did not separate type of usage such as video gaming. However, we do not expect that the reporting error in screen time at 15-years of age is related to depression symptoms reporting in young adulthood. As a consequence, the direction of the bias in the association between screen time and depression (due to measurement error in self-reported screen time) will most likely be toward the null value. Third, our study is limited by the modest number of cases in the analyses with any significant depression as outcome. Finally, a substantial number of individuals were lost to follow-up or had missing data at follow-up, which could lower generalizability and cause selection bias if associations of screen time with depression symptoms among these individuals were different compared with those who provided full data. While several baseline characteristics were different among individuals who were lost to follow-up compared with those who remained in the study, our imputation analyses provided no evidence of selection bias due to attrition. Major strengths of the study include the population-based sample, the long follow-up time, and the availability of many correlates or determinants of depression that we could use analytically to limit the possibility of confounding.

Conclusion

In conclusion, our study among a Danish population-based sample provides evidence that prolonged TV viewing and total screen time in adolescence are associated with more depression symptoms in young adulthood. These results support that limiting screen time in adolescence, in particular TV viewing time, may be of significance for the prevention of future depression.

Conflicts of interest statement

The authors declare that there are no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ypmed.2015.08.009.

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