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Specific Types of Screen-Based Sedentary Time and Depressive Symptoms in Adolescents

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ABSTRACT

Purpose: Screen-based sedentary behavior (SSB) has been identified as risk factor for mental disorders in most of adolescents. However, there is little literature pertaining to the specific kinds of SSB and its connections with depressive symptoms in most of adolescents. In the present study, we are going to find out the connections between specific types of SSB and depressive symptoms in Chinese adolescents. **Methods:** A cross-sectional data based on 996 study participants of middle school students in Guangdong Province. SSB was evaluated by distributing the questionnaire of Health Behavior in School-aged Children, while depressive symptoms were evaluated using Chinese version of Children's Depressive symptoms Inventory (CDI). SSB was categorized into TV/movie time, video games time and other electronic devices-based time (e.g., mobile phone, computer use). Generalized linear models was used to explore the connections between specific kinds of SSB and depressive symptoms. **Results:** After controlling for variables of sex, ethnicity, grade, residence, siblings, perceived family affluence, father educational level, mother educational background, body mass index (BMI), physical exercise, duration of sleep, other electronic devices-based time was positively correlated with depressive symptoms in Chinese adolescents ($B = 0.557\%$, $95\%CI: 0.187-0.926$, $p = 0.003$). This significant connection was also found in girls ($B = 0.728\%$, $95\%CI: 0.230-1.225$, $p = 0.004$) instead of boys ($p > 0.05$). The other types of SSB were not significantly in relation to depressive symptoms in adolescents regardless of sex. **Conclusion:** This study suggested that it might be effective in reducing or preventing depressive symptoms through limiting electronic devices-based time, like computer use or mobile phone use time. This strategy would be particularly useful in girls. Future studies should negate or replicate the research results by introducing more improved study design, which is beneficial to better understand the connections between SSB and depressive symptoms as well as then design more efficient interventions in adolescents.

KEYWORDS

Screen time; types; middle school students; depression

1 Introduction

Depressive symptoms are a common psychiatric disorder, which has gained widespread concerns across the world. Recently, depressive symptoms are considered as a public health priority in adolescents [1,2], because about 20% of adolescents were affected by this psychiatric disorder worldwide [3]. Compared with other psychiatric disorders, depressive symptoms cause higher mortality and morbidity [4].



According to the World Health Organization (WHO), depressive symptoms will have become the second major cause of disease burden in the world by 2030 [5]. Notably, previous data demonstrated that more than 340 million people suffered from depressive symptoms, so this has become a mental health issue worth attention [6]. Specifically, pieces of evidence have revealed that depressive symptoms are associated with several health risks in adolescents, including cognitive impairment, functional impairment, academic performance, suicide, psychosocial [7,8]. Adolescent depressive symptoms can strongly predict the risk of mental health disorders in adulthood [9]. Due to negative consequences caused by depressive symptoms for mental and physical health results in Chinese adolescents, it is a critical to prevent and control depressive symptoms development in adolescents.

Recently, epidemiological surveys have been performed in general populations, and the results show that the prevalence of depressive symptoms is in the range of 10% to 15%. Furthermore, approximately 50% of serious cases of depressive symptoms were found in developed countries, and this proportion in undeveloped countries varied from 76.3% to 85.4%. Notably, the severe depressive symptoms and increasing trend were also found in adolescents [10,11]. Recent epidemiological surveys in Chinese adolescents indicated that the general prevalence of depressive symptoms reached 22.2% [12], and ranged from 6.4% to 54.4% [13,14] across different young subpopulations. Currently, the depressive symptoms are quite prevalent, which has attracted attention from society, and alleviating the burden of depressive symptoms has been proposed in the Healthy China Blueprint 2019–2030 [15]. Based on the current status of depressive symptoms in Chinese adolescents and the growing concern of the Chinese government, it is urgent to identify factors on depressive symptoms in Chinese adolescents.

Previous evidence showed that screen-based sedentary time (SSB) is an important factor of depressive symptoms [16], and positively associated with depressive symptoms [17]. The data from countries featuring low and middle incomes suggested that the prevalence of adolescents who engage in 1–2 h SSB was extremely lower [18]. Besides, one study revealed that SSB may independently and positively affect depressive symptoms [19]. In addition to exploring the connections between SSB and depressive symptoms in Chinese adolescents, recently, more and more studies have sought to explore the connections between specific types of SSB (e.g., time spent on television, internet and video game) and depressive symptoms in Chinese adolescents. Compared with playing computer and video games, television viewing time seems unlikely to be related with depressive symptoms [20]. A study based on a large samples of UK birth cohort found that the use of computer was particularly and significantly correlated with depressive symptoms, while the connections between other types of SSB and depressive symptoms was considered as non-significant [21]. Indeed, studies on the links between specific kinds of SSB and depressive symptoms generated mix results [22,23]. On this regard, it is urgently required to better understand the connections between specific kinds of SSB and depressive symptoms in adolescents.

Across the literature, although some studies have started assessing the connection between specific types of SSB and depressive symptoms. Some other study limitations existed, which should seek to address in the current study or future studies. Specifically, previous evidence showed that regular physical exercise was correlated with depressive symptoms [24,25]. though there is no conclusive claim. However, some of prior research failed to control physical activity when assessing the connections between specific types of SSB and depressive symptoms [21,26]. Furthermore, studies have confirmed that sleep duration is a risk factor of depressive symptoms [27–30], but the variable of sleep in the previous studies. The omission of variables of physical activity and sleep could result in bias when assessing the connections between SSB and depressive symptoms. last but not least, previous studies on the connections between specific types of SSB and depressive symptoms were mainly based on Western countries' young children and adolescents, there is little evidence on the connections based on Chinese children and adolescents. In fact, Chinese young people are exposed to excessive SSB [31–33], which may increase the risks of depressive symptoms.

Therefore, explore the relationships between different types of SSB and depressive symptoms in adolescents (a sample of Chinese middle school students).

2 Methods

2.1 Study Participants and Design

The purpose of the research is to discover the influence of summertime on the mental and physical health of adolescents. A cross-sectional study is performed to meet the purpose of study, and we have recruited some adolescents (students from grade 7 to 9 at the middle schools). There is one middle school (three grades are set up) at every city of Guangdong Province included in the current study (11 cities are included). Students were recruited from each grade randomly. Generally, 3,456 students have been included in the current study. Because in summer, the respondents will not actively respond to the survey, 1,998 respondents and their parents have filled out the form. The response rate of current survey wasn't ideal, with the response rate of 57.7%. Among these 1998 respondents, 966 of them gave valid data relevant to the study variables. Before the data was collected, principals of all the schools, the respondents and their parents have been informed of the research purpose, and they were given with relevant instructions. We obtained written consent from every respondent and their parents. To protect the privacy of respondents, the data were obtained and recorded anonymously.

2.2 Measures of Studied Variables

2.2.1 Sociodemographic

All the respondents were required to provide the following information: gender, BOD (year/month), their grades, ethnicity (minority or Han), residence (rural or urban), weight (Kg) or height (cm), perceived family affluence (based on Family Affluence Scale), educational background of their parents (primary school or below, middle school, occupation school or senior middle school, undergraduate, postgraduate or above), their siblings (give details).

2.2.2 Study Results (Depressive Symptoms)

The results of study were depressive symptoms. The depressive symptoms showed by the respondents had been evaluated using self-reported tool, that is, Children's Depressive Symptoms Inventory (CDI). The tool is developed by Kovacs [34] and the tool has been further validated among adolescents and children aged between 7 and 17 years at Chinese schools [35]. The tool comprises 27 items and the responses are scored 0 to 2, and the general score is ranged within 0–54. The higher the score, the greater the severity of depression.

2.2.3 Exposure of Study (Screen-Based Sedentary Behaviour, SSB)

SSB has been evaluated based on the health behaviour reported by the children at the questionnaire [36], the questions are: (1) How long did you spend on TV or film during your spare time on the last holidays or weekends? (2) How long did you spend on video games during your spare time on the last holidays or weekends? (3) How long did you spend on activity involving the use of devices based on electronic screen during your spare time on the last holidays or weekends? The answers included 0.5 or 7 h or more. The mean SSB hours every day was worked out using the formula: mean specific type of SB hours every day = (one SSB hours) Under the research background, SSB has been classified into three types, that is, time of playing video game, time of watching TV or movie, and other time of using devices based on electronic screen. For the purpose of statistical analysis, the variables and specific SSB types were considered continuous.

2.2.4 Other Behavioural Controlling Variables

SLP was evaluated using the measures developed based on HBSC questionnaire [36]: (1) When do you generally go to sleep when you need to attend a morning class on the next day? (2) When do you generally go

to sleep during holidays or at weekends? (3) When do you generally get up if you need to attend a morning class on the next day? (4) When do you generally get up on Saturday or Sunday? Answers to the questions 1 to 4 are shown below: (1) No later than 21:00; 21:30; 22:00; 22:30; 23:00; 23:30; 24:00; 00:30; 01:00; 01:30; 02:00 or later; (2) No later than 21:00; 21:30; 22:00; 22:30; 23:00; 23:30; 24:00; 00:30; 01:00; 01:30; 02:00; 02:30; 03:00; 03:30; 04:00 or later; (3) No later than 05:00; 05:30; 06:00; 06:30; 07:00; 07:30; 08:00 or later; and (4) no later than 07:00; 07:30; 08:00; 08:30; 09:00; 09:30; 10:00; 10:30; 11:00; 11:30; 12:00; 12:30; 13:00; 13:30; 14:00 or later. Based on the answers, SLP duration at night on weekend or weekdays was worked out. Then, the mean SLP duration every night (hours) was worked out using the following formula: mean duration of SLP = (SLP duration every night on weekdays \times 5 + SLP duration every night at weekends \times 2)/7. In the statistical analysis, SLP variable was considered continuous.

Based on the questionnaire of Health Behaviour in School-aged Children (HBSC), MVPA was evaluated, and the questionnaire has been frequently adopted in the epidemiological studies in China. One of the questions is: how long did you spend on physical activity that increases heart rates (including PE lesson, sports training, exercise, and regular activities such as excursion, hiking and brisk walking) (for example, sport participations, exercise, physical education). The answers included 0 to 7 days. For the purpose of statistical analysis, the MVPA variables were considered continuous.

2.3 Statistical Analysis

The statistical analysis was performed with the use of SPSS (25.0). Descriptive statistics was performed to review the percentage and frequency (%) categorical variables such as gender and residence, and the standard deviation of and mean continuous (BMI). Partial test was performed to check the gender difference across the categorical variables, and the student t test was performed to check the gender difference cross the continuous variables. Partial correlation analysis was performed to obtain the coefficient of correlation between the depressive symptoms and ST of different types, while controlling for grade, ethnicity, gender, affluence, siblings, residence, the educational background of parents, BMI, and physical activity and time of sleep. We have introduced Generalized Linear Models (GLMs) to check the relationship between ST, MVPA and SLP with depressive symptoms. We have adopted Robust Estimator, Maximum Likelihood Estimation (MLE) and GLMs to check the relationship between different ST types and depressive symptoms. Beta estimates adjusted (corresponding 95% confidence intervals (CI) were shown. Statistical significance was found to be $p < 0.05$ (which is two sided).

3 Results

Table 1 presents the study sample characteristics. 996 students from junior middle schools (grades 7–9) participated in the study. In total, 48.5% were boys ($n = 483$), and 51.4% were girls ($n = 514$). The majority were of Chinese Han ethnicity (97.1%) and from urban area (73.9%). The mean of BMI was 18.93 kg/m^2 ($SD = 4.02$). Overall, participants accumulated time spent in MVPA is 5.05 ± 2.08 . The MVPA time of boys was 5.37 days (± 2.11), significantly higher than that of girls (4.71 ± 1.89 , $p < 0.001$). In addition, the overall time (hours/day) participants spent on TV/movie is 2.76 ± 1.31 , video game time 2.28 ± 1.37 , other electronic devices-based time 2.62 ± 0.90 , and sleep 8.43 ± 1.27 . Moreover, the mean scores of depressive symptoms in girls were greater than that in boys with statistical significance (37.04 ± 5.32 vs. 36.44 ± 5.32). More details can be found in **Table 1**.

Table 1: Sample characteristics of this study

	Total		Male		Female		<i>p</i>
	N	%	n	%	n	%	
Total	996	100	483	48.5	513	51.5	
Sex							
Boy	483	48.5					
Girl	514	51.5					
Ethnicity							
Han	967	97.1	468	96.9	500	97.3	0.724
Minority	29	2.9	15	3.1	14	2.7	
Grade							
7	537	53.9	251	52.0	287	55.8	0.274
8	212	21.3	108	22.4	104	20.2	
9	247	24.8	124	25.7	123	23.9	
Residence							
Urban	736	73.9	345	71.4	391	76.1	0.086
Rural	260	26.1	138	28.6	123	23.9	
Perceived family affluence		3.39 ± 0.71		3.42 ± 0.73		3.37 ± 0.69	0.250
Father educational level							
1	11	1.1	7	1.4	4	0.8	0.739
2	92	9.2	37	7.7	55	10.7	
3	471	47.3	241	49.9	230	44.8	
4	320	32.1	150	31.1	170	33.1	
5	70	7.0	34	7.0	36	7.0	
6	32	3.2	14	2.9	18	3.5	
Mother educational level							
1	28	2.8	15	3.1	13	2.5	0.402
2	156	15.7	76	15.7	80	15.6	
3	486	48.8	240	49.7	246	48.0	
4	226	22.7	108	22.4	118	23.0	
5	73	7.3	31	6.4	42	8.2	
6	27	2.7	13	2.7	14	2.7	
BMI		18.93 ± 4.02		19.81 ± 4.39		18.10 ± 3.44	0.000
MVPA (days)		5.03 ± 2.03		5.37 ± 2.11		4.71 ± 1.89	0.000
SLP (h/day)		8.43 ± 1.27		8.48 ± 1.17		8.38 ± 1.35	0.215
TV/movie time (h/day)		2.76 ± 1.31		2.81 ± 1.37		2.71 ± 1.25	0.228
Video game time (h/day)		2.28 ± 1.37		2.60 ± 1.49		1.98 ± 1.18	0.000

(Continued)

Table 1 (continued)							
	Total		Male		Female		<i>p</i>
	N	%	n	%	n	%	
Other electronic devices time (h/day)	2.62 ± 0.90		2.44 ± 0.83		2.78 ± 0.94		0.000
Depressive symptoms	36.75 ± 5.33		36.44 ± 5.32		37.04 ± 5.32		0.077

Notes: BMI: body mass index MVPA: moderate to vigorous physical activity SLP: sleep duration.

Table 2 shows the bivariate correlation between different types of ST and depressive symptoms. Significant correlation was found between depressive symptoms and other electronic devices-based time ($r = 0.085$, $p < 0.01$), TV/movie time and video/game time ($r = 0.177$, $p < 0.01$), TV/movie time and other electronic devices-based time ($r = 0.165$, $p < 0.01$), and video/game time and other electronic devices-based time ($r = 0.097$, $p < 0.01$). The result for further disentangled the difference in variables correlation between two genders are presented in **Table 3**. Notably, the connection between depressive symptoms and other electronic devices-based time in boys was not significant. However, depressive symptoms were positively related to other electronic devices-based time in girls ($r = 0.119$, $p < 0.01$).

Table 2: Partial correlation between different types of ST and depressive symptoms in study samples

	1 Depressive symptoms	2 TV/movie time	3 Video/game time	4 Other electronic devices-based time
1	1.00			
2	0.041	1.00		
3	0.009	0.177**	1.00	
4	0.085**	0.165**	0.097**	1.00

Notes: ** $P < 0.01$.

Table 3: Partial correlation between different types of ST and depressive symptoms in study samples by sex

	1 Depressive symptoms	2 TV/movie	3 Video/game time	4 Other electronic devices-based time
Boy	1 1.00			
	2 0.057	1.00		
	3 0.01	0.123**	1.00	
	4 0.023	0.143**	0.148**	1.00
Girl	1 1.00			
	2 0.020	1.00		
	3 0.008	0.239**	1.00	
	4 0.119**	0.207**	0.149**	1.00

Notes: ** $P < 0.01$.

The results of the connection between screen time with different types of SSB and depressive symptoms are presented in **Table 4**. For the total sample, the results from GLMs indicated that only other electronic devices-based time positively associated with depressive symptoms ($B = 0.557\%$, 95%CI: 0.187–0.926, $p = 0.003$). However, TV/movie and video games time were not associated with depressive symptoms

(both $p > 0.05$). The similar results were also found in female samples. Specifically, other electronic-based time positively associated with depressive symptoms ($B = 0.728\%$, 95%CI: 0.230–1.225, $p = 0.004$). In the contrast, no specific type of SSB was associated with depressive symptoms in male samples (p for TV/movie time, p for video games time and p for other electronic devices-based time > 0.05).

Table 4: Connection between screen time with different types of SSB and depressive symptoms

Overall	B	Std. error	95%CI		<i>p</i> value
Intercept	35.982	0.614	34.779	37.186	0.000
TV/movie time	-0.224	0.132	-0.482	0.034	0.089
Video games time	-0.031	0.124	-0.275	0.212	0.801
Other electronic devices-based time	0.557	1.257	0.187	0.926	0.003
Boys					
Intercept	36.593	0.898	34.833	38.354	0.000
TV/movie time	-0.241	0.180	-0.594	0.111	0.180
Video games time	0.015	0.165	-0.308	0.339	0.926
Other electronic devices-based time	0.199	0.298	-0.385	0.784	0.504
Girls					
Intercept	35.557	0.842	33.908	37.207	0.000
TV/movie time	-0.199	0.194	-0.580	0.182	0.306
Video games time	-0.002	0.204	-0.401	0.398	0.993
Other electronic devices-based time	0.728	0.254	0.230	1.225	0.004

Notes: TV: television; B: beta; Std. error: standard error; Bold font denotes statistical significance; CI: confidence interval; all the models controlled for (except sex-stratified model) variables of sex, ethnicity, grade, residence, siblings, affluence, father educational level, mother educational level, body mass index, moderate to vigorous physical activity and sleep duration.

4 Discussion

The main of our study was to explore the connections between specific types of SSB and depressive symptoms in some typical Chinese adolescents in Guangdong Province. We mainly found that only other electronic devices-based time was positively associated with depressive symptoms in adolescents and this significant connection was observed in girls rather than boys. In addition, the connections of TV/movie time and video games time were not correlated with depressive symptoms in a significant way in adolescents regardless of sex. More discussions and analyses are presented in detail below.

The current study found that other electronic devices-based time was correlated with depressive symptoms in a significant way in adolescents. According to the measurement of other electronic devices-based time in our study can be defined as time spent for computer, mobile phone or tablet use. Some previous research suggested that time for computer [21,26], mobile phone [37,38] and tablet use were risk factors of depressive symptoms. Those prior research findings can support the current study consistently, which further stresses the adverse effects of this kind of SSB on depressive symptoms in adolescents. Standing on a practical perspective, reducing or curbing this kind of SSB may be an effective and preventive approach to reduce depressive symptoms in adolescents. Some plausible explanations can be used to better understand the underlying mechanism linking this specific kind of SSB and depressive symptoms. For example, prolonged time of phone use is positively associated with sleep problems, like insomnia and disturbance, which in turn may increase the risks for depressive symptoms [37,38]. For computer use, it is possible that adolescents who tend to spend more time in computer for

various purposes have a higher risk for sleep disturbance, and social isolation as well as other problems in social interactions that are independent factors of depressive symptoms [23,39]. However, the suggested mechanisms are yet conclusive. Future research is strongly recommended to determine the mechanism linking specific types of SSB and depressive symptoms in Chinese adolescents.

The current study suggested that TV/movie and video games time were not correlated with depressive symptoms in a significant way in adolescents. These two research findings are not in line with previous studies that indicated that TV/movie and video games time were independent correlates of depressive symptoms [26,40]. However, some previous studies can support that TV/movie time and video games was not correlated with depressive symptoms [21,22], which is consistent with our research findings. These discrepant findings between the present study and other previously published studies may be owing to methodological differences. Hence, research using standardized and similar study protocols are needed for more comparable evidence, which is beneficial to clearly determine the connections between specific types of SSB and depressive symptoms in adolescents. On this regard, more replicated research should be encouraged.

The non-significant connections between TV/movie time and video games time and depressive symptoms could be explained by the following reasons. However, there were some previous studies that have proposed plausible interpretations for mechanism linking TV/movie and video game time and depressive symptoms. One primary explanation is that adolescents are likely to choose their preferred or interested kinds of TV/movie and video games, which may reduce their negative moods. As a result, depressive symptoms might be reduced significantly. However, there are many studies suggesting extended TV/movie and video games time are risk factors of depressive symptoms as well as proposing potential mechanism. It is needed, thus, to further clarify the underlying mechanism linking TV/movie and video game time and depressive symptoms in adolescents.

Interestingly, the current study has shown that the connections between specific types of SSB and depressive symptoms in adolescents are with a sex difference, particularly in the connections between other electronic devices-based time and depressive symptoms. To our knowledge, little is known about this sex difference because of a limited number of studies that include sex-stratified analysis [41–43], especially in examining the connections between electronic devices-based time and anxiety symptoms. Based on the previous evidence in the literature, the sex difference in the connections between specific types of SSB and anxiety symptoms is null findings [23]. When explaining this sex difference, the preferences of specific types of SSB may be useful [23]. On this regard, the current study assumes that the sex difference in the connections between other electronic devices-based time and depressive symptoms matters sex-oriented preference on types of SSB. Specifically, girls are more likely to use computer, mobile phone for their social purposes as well as other purposes; in contrast, boys seem to have less interests in using electronic devices [44]. This difference could explain partially why other electronic devices-based time was correlated with depressive symptoms in a significant way in girls. However, its underlying mechanism by sex should be clarified clearly in the future. Practically, to better design and implement interventions aiming at reducing depressive symptoms, sex-specific interventional strategies should be utilized.

Although this study has some strengths, including a relatively large sample, using a standardized ST measure, controlling more potential confounders, some intrinsic limitations with the current study need to be mentioned, which is beneficial to better interpret the research findings of this study. First, our study used cross-sectional design study that cannot draw conclusions with causality. Hence, our study cannot determine the connection between different kinds of SSB and anxiety symptoms based on a perspective of casual reference. The second limitation concerns measurement in this study which was a self-reported questionnaire (although being used widely across the world). This could make our measurement of SSB

biased or inaccurate because of recall errors. Third, our study was based on samples recruited from Guangdong Province; so, our research findings may not be generalized into a wider spectrum of populations. As for the future studies, it is strongly recommended that these study limitations are addressed for more reliable and robust evidence, which can be applied for interventions aiming at reducing mental disorders.

5 Conclusion

In the present study, the connections between different kinds of SSB and depressive symptoms have been explored in adolescents (a sample of Chinese in Guangdong Province). To conclude, this study suggested that except TV/movie and video game screen time, only electronic devices time was a correlate of depressive symptoms in adolescents. This connection was also found in girls instead of boys. Our study could provide practical implication for designing more efficient interventions aiming at reducing depressive symptoms. However, owing to the study design and study characteristics (e.g., sample, measures, survey time), research findings of the current study should be negated or replicated by more research with improvements. On this regard, it is highly required to conduct more studies help researchers better understand specific types of SSB and depressive symptoms in adolescents.

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