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Screen time trajectories and psychosocial well-being among Chinese adolescents: a longitudinal study

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Abstract

Background While the association between screen time (ST) and psychosocial well-being has been extensively examined, limited studies have investigated the dynamic patterns of ST, and their impact on subsequent psychosocial well-being among adolescents. Therefore, this longitudinal study aimed to examine the association between ST trajectories and the subsequent psychosocial well-being among Chinese adolescents.

Methods Data were drawn from the Longitudinal Study of Adolescents' Mental and Behavioral Well-being Research (Registration No. ChiCTR1900022032). The final analysis included 1480 participants who completed baseline and two follow-up surveys. Standardized measures were employed to assess ST and multiple psychosocial well-being, including depressive symptoms, anxiety, externalizing problems, and coping style. Group-based trajectory modeling and generalized linear mixed models were performed.

Results Over the two-year follow-up period, two distinct ST trajectories emerged: continued high (298 [20.1%]) and continued low (1182 [79.9%]). Compared with those in the continued low ST group, adolescents in the continued high group exhibited a higher likelihood of presenting depressive symptoms ($\beta = 0.97$, 95% CI = 0.43 ~ 1.50), anxiety symptoms ($\beta = 0.29$, 95% CI = 0.05 ~ 0.53), and emotional problems ($\beta = 0.35$, 95% CI = 0.22 ~ 0.48), and were less likely to demonstrate prosocial behavior or employ positive coping style. The stratified analysis demonstrated that the aforementioned associations only existed among female adolescents.

Conclusions Persistent high exposure to ST was associated with an increased odds of emotional problems and a decreased probability of engaging in prosocial behavior and positive coping style, with particularly noteworthy effects observed among female adolescents. These findings underscore the importance of reducing ST exposure to improve the psychological well-being of adolescents.

Keywords Screen time, Adolescents, Psychosocial well-being, Longitudinal study

Background

Screen time (ST) refers to the duration individuals spend watching television, playing video games, and using mobile phones, tablets, and other electronic devices. The ST of children and adolescents has witnessed a surge in recent years, propelled by the rapid proliferation of digital devices, an increasing amount of extracurricular online courses, and the impact of the COVID-19 pandemic [1–3]. Experts have recommended that recreational screen time not exceed 2 h

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per day for children and adolescents [4–6]. However, large-scale researches indicate that nearly half of Chinese school-aged youth reported daily ST over 2 h [7, 8].

The deleterious effects of excessive screen activities on cognitive development and psychosocial well-being are concerning [9]. Among younger children, longer ST exposure significantly delayed their development during early childhood [1, 10–12]. As for adolescents, existing evidence showed that longer ST is largely associated with psychosocial problems including depressive symptoms [13, 14], anxiety [15], and externalizing problems [8]. Adolescence is a crucial transitional period of rapid biological and psychosocial growth, during which electronic technology is the most common way for adolescents to express themselves and connect with others [16]. Compared with younger children, adolescents are more likely to have their own smartphones or other hand-held devices [17], hence leading to a further amplification of ST. Longitudinal research also demonstrated that as age increased, more youth tend to engage in longer screen-based activities [18].

In terms of the dynamic nature of adolescents' screen use [19, 20], it is crucial to examine ST trajectories longitudinally. This approach offers a more robust understanding of longitudinal screen use habits. However, very limited research has delved into how ST trajectories affect adolescents' psychosocial well-being. A recent longitudinal study of Canadian adolescents found that increasing ST was significantly associated to anxiety within the same year, yet they failed to observe the lasting effects of ST on anxiety if increases in ST were not sustained [15]. A study among Swiss adolescents showed higher or increasing ST trajectories during adolescence were associated with depressive symptoms, anxiety, aggression, suicidal and self-injury behaviors in early adulthood, indicating that screen use patterns may have a long-term effect on people's psychosocial well-being [21]. However, there are other studies that showed an inconsistent association between ST and psychosocial well-being among adolescents. Plackett and colleagues found non-significant association between time spent on social media and subsequent psychosocial difficulties (i.e., internalizing and externalizing problems) [22]. Tang's review of longitudinal studies between 2005 and 2020 found some evidence supporting the deleterious effects of ST on psychosocial well-being, including depressive symptoms, anxiety, self-esteem, and other internalizing problems. However, the review also pointed out that the associations were inconsistent, with findings ranging from positive to nonsignificant and some effects varying substantially by sex or other factors [23].

Additionally, as an integral component of interpersonal functioning within psychosocial well-being, maladaptive coping style and social maladjustments stemming from excessive ST received limited attention [24]. Engagement in screen activities often signifies an inclination towards a negative avoidant coping style, which plays a vital role in psychosocial well-being [24]. According to existing evidence, positive/negative coping style is a significant mediator between screen-based activities and mental health [24, 25]. Therefore, research focusing on the association between ST and comprehensive psychosocial well-being among Chinese adolescents warrants further investigation.

To address these research gaps, this longitudinal study among Chinese adolescents aims to investigate the associations of ST trajectories with subsequent psychosocial well-being, including depressive symptoms, anxiety, externalizing problems, sleep quality, and coping style.

Methods

Study design and participants

Data were derived from the Longitudinal Study of Adolescents' Mental and Behavioral Well-being Research in Guangzhou, China (Registration No. ChiCTR1900022032, Registration Date: 2019/03/21). A multi-stage, stratified cluster, random sampling method was used to recruit participants from six junior high schools and four senior high schools in four districts of Guangzhou. The junior high school in China is 7th grade to 9th grade, and the senior high school is 10th to 12th grade. After finishing junior high school, adolescents will enter different senior high school, and adolescents who finish senior high school will enter different colleges, which makes it hard to follow up. As a result, to extend follow-up period and avoid the loss of follow-up, only the first graders of the junior high schools (7th grade, junior grade one) and the senior high schools (10th grade, senior grade one) were included. The data collection procedure has been described elsewhere [26]. At baseline (January to April 2019), 1,957 participants (wave 1; response rate: 99.03%) were eligible, 1831 students were followed up at wave 2 (October to December 2019; retention rate: 93.56%), and 1738 completed the follow-up at wave 3 (October to December 2020; retention rate: 88.81%). A total of 1480 participants were included in the final analysis with the complete dataset for ST exposure in all three waves (Fig. 1). The mean (SD) age of the final sample was 13.6 (1.5) years at baseline, with 741 (50.1%) of them being male adolescents and 739 (49.9%) being females. Self-reported questionnaires were completed without teachers present during all three surveys to reduce information bias and protect privacy. Participants completed the questionnaires in classrooms with

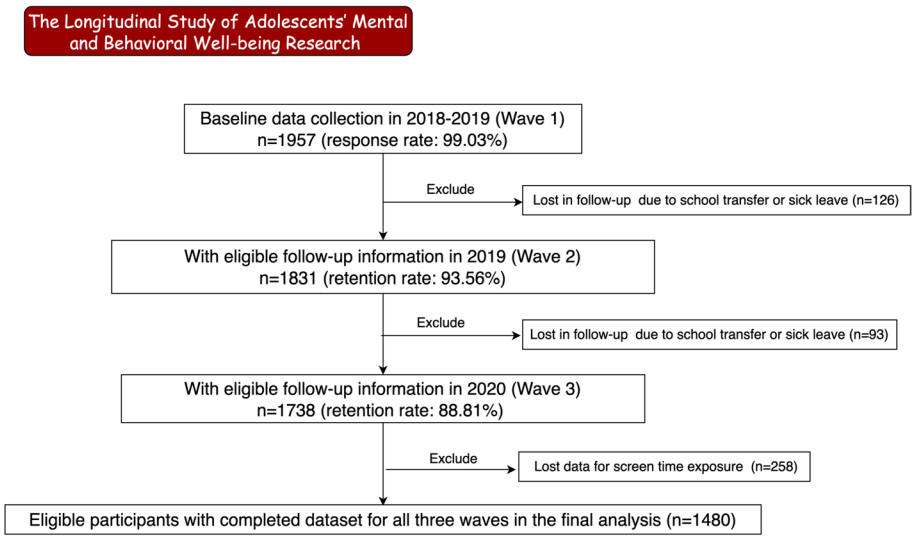

Fig. 1 The flowchart of the study participants

Legend: Inclusion and exclusion procedure of the study participants

the presence of trained investigators, who ensured the completeness and logical consistency of each questionnaire. Written informed consent was distributed to the participants and legal guardians, and those who agreed to participate were included. The study was performed in accordance with the Declaration of Helsinki, and obtained ethical approval from Sun Yat-sen University School of Public Health Institutional Review Board (Ethics Number: L2017060).

Measures

Screen time

Screen time was designed and calculated based on previous studies [8, 27] using six questions as follows: "How long do you spend on electronic devices (e,g., for entertainment, including computer, smartphone, tablet, video game)/television/Internet (for entertainment and academic use) in a typical day of weekdays/weekends during the last month?" Participants reported the mean hours and minutes per day. The daily mean ST for each item (i.e., electronic devices/television/Internet) was calculated as follows: (weekday ST*5 + weekend ST*2)/7. The total daily mean ST was calculated by summing STs for all three items.

Psychosocial well-being

Depressive symptoms were measured by the Center for Epidemiology Scale for Depression (CES-D) in Chinese, which has shown good reliability and validity in Chinese adolescents [28, 29], and the Cronbach's alpha was 0.89 in this study. The respondents were asked to rate the frequency of 20 depressive symptoms by selecting one of four response options ranging from "0 = rarely or none of the time" to "3 = most or all of the time" over the past week. The total scores range from 0 to 60. Higher scores reflect more severe depressive symptoms.

Anxiety symptoms were assessed by the Generalized Anxiety Disorder Scale-7 (GAD-7) in Chinese, which has been validated and extensively utilized in Chinese studies [30, 31], and the Cronbach's alpha was 0.89 in this study. The respondents were asked to rate the frequency of seven anxiety symptoms during the last two weeks, with the response options given on a 4-point scale from 0 to 4. The seven items' total scores range from 0 to 21, with higher scores indicating more severe anxious symptoms [32].

The Pittsburgh Sleep Quality Index (PSQI) was used to evaluate sleep quality and disturbances in the last month. The Chinese version of the PSQI has been validated in a Chinese adolescents-based study [33], and the Cronbach's alpha was 0.77 in the present study. The PSQI includes 19 items constituting seven components of sleep: sleep duration, sleep latency, sleep efficiency, sleep disturbances, subjective self-assessed sleep quality, daytime dysfunction, and use of sleeping medication. The sum of the scores for these seven components yields one global score with a range of 0–21 points, in which higher scores indicate worse sleep quality [34].

The self-reported version of the Strengths and Difficulties Questionnaire (SDQ) was also adopted in this study, and the Chinese version of SDQ has been validated and utilized in the Chinese population [35]. The SDQ

comprises five subscales with five items each, generating scores for emotional problems, conduct problems, hyperactivity, peer problems, and prosocial behavior. A total difficulties score ranging from 0 to 40 was summed by the scores within all subscales except prosocial behavior [36]. Higher scores suggest greater emotional and behavioral problems, while a lower score of the prosocial subscale indicates more significant prosocial problems. The Cronbach's alphas of the total difficulties scale and prosocial scale were 0.74 and 0.75 in this study.

Coping style was evaluated by the Simplified Coping Style Questionnaire (SCSQ) [37], which was developed based on the Ways of Coping Questionnaire by Folkman and Lazarus [38] according to Chinese culture. The SCSQ has been validated and widely used in Chinese adolescents [39], and the Cronbach's alpha was 0.83 in this study. The SCSQ includes two dimensions that assess the positive and negative coping styles. The respondents were asked to rate each item on a 4-point scale based on the frequency they adopted the positive or negative coping style in their daily life, with higher scores indicating greater positive/negative coping.

Covariates

Demographic factors included age, sex, living arrangement, household socioeconomic status (HSS), one child or not, relationships with classmates and teachers, perceived academic pressure, parents' education level, and ever smoking a cigarette at least once. In addition, based on previous researches [40, 41], physical activity is a significant influence factor on psychosocial well-being, and the association of screen-based activity and people's health condition is independent of physical activity. As a result, self-reported physical activity (PA, hours per week) was included as a covariate in this study.

Statistical analysis

The analysis was restricted to participants with the complete dataset for ST exposure in all three waves. As for other variables, a total of 2.9% (43 of 1480) of total items were missing and were assumed to be missing at random, and thus were imputed with the multiple imputations of chained equations (MICEs) method using the baseline characteristics [42]. We created 5 imputed data sets and pooled the results using the command "mi estimate" in the Stata.

Considering ST may change over time and differ among individuals, the group-based trajectory modeling was used to classify participants into subgroups with similar ST exposure patterns during follow-up, based on identifying heterogeneous longitudinal polynomial trajectories [20, 43]. We implemented this technique using TRAJ in Stata [43]. Goodness-of-fit and model adequacy indexes, such as the Bayesian information criterion (BIC), were used to select the best model.

Baseline participant characteristics were summarized in total participants and by ST trajectories using mean (standardized deviation, SD) or median (interquartile range, IQR) for continuous variables and frequency and percentages for categorical variables. Generalized linear mixed models were conducted to test the association of ST trajectory groups with the psychosocial well-being score among adolescents, with the mean effect size evaluated using inverse probability weighting. To test the robustness and potential variations in different subgroups, we repeated all analyses stratified by sex (male and female adolescents). Furthermore, we conducted weighted generalized linear mixed models with logit links to explore factors associated with ST trajectory group and the probability of group membership weighted these regressions to account for measurement error introduced by the probabilistic nature of group assignment [44]. In addition, we conducted sensitivity analyses by repeating all analyses using the complete data set (1437 participants) without multiple imputations. All statistical analyses were performed with Stata (version 17.0, StataCorp LLC, Texas, USA). Statistical significance was set at $P \leq 0.05$, and 2-sided tests were used.

Results

Among the 1480 adolescents included in the analyses, the mean (SD) age at baseline was 13.6 (1.5) years, 50.1% of them were male adolescents, 44.5% and 47.4% of their mothers and fathers had a college or above education level, respectively, and 1.0% of them reported ever smoking (Table 1). No significant differences in the distributions of covariates were observed between those included in this analysis and all participants in the original longitudinal study (eTable 1 in the supplement).

Adolescents were classified into 2 trajectory groups (continued high and low trajectory groups) based on their total ST at three waves (Fig. 2), and the optimal group-based trajectory model was selected according to the model fit indexes (eTable 2 in the supplement). The continued high trajectory group ($n = 298$ [20.1%]) demonstrated a higher average baseline ST (mean: 6.01 h/d, SE: 0.10) and exhibited a stably high exposure level, and the continued low trajectory group ($n = 1182$ [79.9%]) was characterized by a relatively stable amount of ST (eFigure 1 and eTable 3 in the supplement).

Table 2 demonstrates that ST trajectories were associated with all psychological well-being outcomes in wave 3 in the unadjusted model (Model 1). In Model 2, after adjusting for covariates and depressive symptoms scores at baseline, compared to the continued low group, adolescents in the continued high group

Table 1 Descriptive characteristics by ST trajectory groups

	Total, N (%) ($n=1480$)	Screen time trajectory groups, N (%)		*P*-value[a]
		Continued low ($n=1182$)	Continued high ($n=298$)	
Age at baseline, mean (SD), year	13.6 (1.5)	13.4 (1.4)	14.1 (1.6)	< 0.001
Sex				
Male	741 (50.1)	593 (50.2)	148 (49.7)	0.876
Female	739 (49.9)	589 (49.8)	150 (50.3)	
Living arrangement[b]				
Living with both parents	1230 (83.3)	991 (84.1)	239 (80.2)	0.184
Living with a single parent	126 (8.5)	93 (7.9)	33 (11.1)	
Living with others	121 (8.2)	95 (8.1)	26 (8.7)	
Household socioeconomic status				
Excellent	764 (51.8)	635 (53.9)	129 (43.3)	0.002
Good	657 (44.5)	505 (42.9)	152 (51.0)	
Fair	55 (3.7)	38 (3.2)	17 (5.7)	
One child or not				
Yes	888 (60.2)	705 (59.8)	183 (61.4)	0.623
No	588 (39.8)	473 (40.2)	115 (38.6)	
Classmate relations				
Good	1276 (86.4)	1038 (87.9)	238 (80.4)	0.003
Average	181 (12.3)	128 (10.8)	53 (17.9)	
Poor	20 (1.4)	15 (1.3)	5 (1.7)	
Relationship with teachers				
Good	1251 (85.3)	1028 (87.8)	223 (75.6)	< 0.001
Average	205 (14.0)	136 (11.6)	69 (23.4)	
Poor	10 (0.7)	7 (0.6)	3 (1.0)	
Perceived academic pressure[b]				
Below average	396 (26.8)	320 (27.1)	76 (25.5)	0.690
Average	691 (46.8)	545 (46.2)	146 (49.0)	
Above average	390 (26.4)	314 (26.6)	76 (25.5)	
Mother's education level				
Primary school or below	100 (6.8)	63 (5.3)	37 (12.4)	< 0.001
Middle and high school	721 (48.7)	550 (46.5)	171 (57.4)	
College or above	659 (44.5)	569 (48.1)	90 (30.2)	
Father's education level				
Primary school or below	57 (3.9)	38 (3.2)	19 (6.4)	< 0.001
Middle and high school	722 (48.8)	544 (46.0)	178 (59.7)	
College or above	701 (47.4)	600 (50.8)	101 (33.9)	
Ever smoking[b]				
Yes	15 (1.0)	6 (0.5)	9 (3.0)	< 0.001
No	1458 (99.0)	1170 (99.5)	288 (97.0)	
CES-D scores[b] **(median, IQR)**	11.0 (6.0 ~ 17.0)	10.0 (6.0 ~ 16.0)	13.0 (7.0 ~ 21.0)	< 0.001
GAD-7 scores[b] **(median, IQR)**	3.0 (0 ~ 5.0)	2.0 (0 ~ 5.0)	4.0 (1.0 ~ 6.0)	< 0.001
PSQI scores[b] **(median, IQR)**	5.0 (3.0 ~ 7.0)	5.0 (3.0 ~ 7.0)	6.0 (4.0 ~ 8.0)	< 0.001
Physical activity[b] **(median, IQR), h/week**	7.2 (3.0 ~ 13.9)	7.0 (2.8 ~ 13.6)	8.3 (3.3 ~ 15.1)	< 0.001
SDQ scores (median, IQR)				
Prosocial behavior[b]	8.0 (6.0 ~ 9.0)	8.0 (6.0 ~ 9.0)	7.0 (5.0 ~ 9.0)	0.008
Hyperactivity[b]	3.0 (2.0 ~ 4.0)	3.0 (2.0 ~ 4.0)	4.0 (2.0 ~ 5.0)	< 0.001
Peer problems[b]	3.0 (2.0 ~ 5.0)	3.0 (2.0 ~ 4.0)	3.0 (2.0 ~ 4.0)	0.004
Emotional problems[b]	2.0 (0 ~ 3.0)	1.0 (0 ~ 3.0)	2.0 (1.0 ~ 4.0)	0.010
Conduct problems[b]	2.0 (1 ~ 3.0)	2.0 (1.0 ~ 3.0)	2.0 (1.0 ~ 3.0)	< 0.001

Table 1 (continued)

	Total, N (%) (*n* = 1480)	Screen time trajectory groups, N (%)		*P*-value[a]
		Continued low (*n* = 1182)	Continued high (*n* = 298)	
Coping style				
Positive coping[b]	19.0 (14.0 ~ 24.0)	20.0 (15.0 ~ 24.0)	18.0 (12.0 ~ 23.0)	< 0.001
Negative coping[b]	7.0 (4.0 ~ 10.0)	7.0 (4.0 ~ 10.0)	7.0 (4.0 ~ 11.0)	0.015

[a] The chi-square test was used for categorical variables, the *t*-test was used for normally distributed continuous variables, and the Wilcoxon rank sum test was used for nonnormally distributed continuous variables

[b] Missing data: 3 for living arrangement, 4 for household socioeconomic status, 4 for one child or not, 3 for classmate relations, 14 for relationship with teachers, 3 for perceived academic pressure, 7 for ever smoking, 4 for CES-D score, 8 for GAD-7 score, 1 for hyperactivity score, 1 for peer problems score, 1 for emotional problems score, 1 for conduct problems score

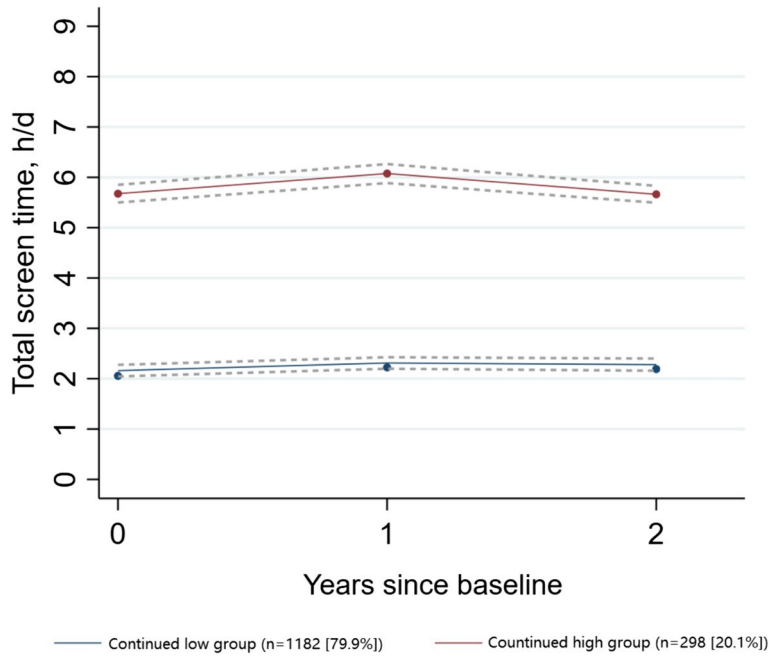

Fig. 2 Screen time trajectories of the two groups. Legend: Screen time trajectories was conducted with group-based trajectory model using total screen time in three waves during follow-up

were significantly related to a higher level of depressive symptoms ($\beta = 0.97$, 95%CI = 0.43 ~ 1.50). Similar results were observed for anxiety symptoms and emotional problems at wave 3, after adjusting for covariates and corresponding outcomes at baseline (e.g., $\beta = 0.29$, 95%CI = 0.05 ~ 0.53 for anxiety symptoms, Model 2 in Table 2). As for coping style, those in the continued high group were less likely to have a positive coping style or prosocial behaviors ($\beta < 0$, $P < 0.05$). Similar results were observed in Model 3, where all covariates in Model 2 and all psychosocial well-being variables at baseline were adjusted.

Tables 3 and 4 show the results stratified by sex. Among male adolescents, when adjusting for covariates and corresponding outcomes (Model 2), compared to the continued low group, the continued high group was positively associated with only peer problems ($\beta = 0.13$, 95% CI = 0.03 ~ 0.24, Model 2 in Table 3). Among female dolescents, the continued high group was more likely to have depressive symptoms, anxiety symptoms, poor sleep quality, and emotional problems (e.g., $\beta = 1.78$, 95%CI = 0.95 ~ 2.62 for depressive symptoms, Model 2 in Table 4) and was less likely to have peer problems, prosocial behavior and positive coping style (e.g., $\beta = -1.98$, 95%CI = −2.63 ~ −1.32 for positive coping style, Model 2 in Table 4). Robust results were observed when all psychosocial well-being variables at baseline were adjusted (Model 3 in Tables 3 and 4).

Table 2 Screen time trajectory and psychosocial well-being by using inverse probability-weighted analysis

Psychosocial well-being[b]	Continued high group vs. Continued low group[a]					
	Model 1		Model 2		Model 3	
	β coefficient (95% CI)	*P*-value	*β* coefficient (95% CI)	*P*-value	*β* coefficient (95% CI)	*P*-value
Depressive symptoms (CES-D scores)	2.78 (2.19 ~ 3.37)	< 0.001	0.97 (0.43 ~ 1.50)	< 0.001	0.96 (0.39 ~ 1.53)	0.001
Anxiety symptoms (GAD-7 scores)	0.70 (0.46 ~ 0.95)	< 0.001	0.29 (0.05 ~ 0.53)	0.017	0.20 (−0.05 ~ 0.45)	0.116
Sleep quality (PSQI scores)	0.46 (0.27 ~ 0.65)	< 0.001	−0.03 (−0.23 ~ 0.17)	0.762		
SDQ						
Total difficulties	0.28 (0.01 ~ 0.55)	0.044	0.12 (−0.17 ~ 0.42)	0.415		
Hyperactivity	−0.09 (−0.17 ~ −0.001)	0.047	−0.19 (−0.29 ~ −0.08)	< 0.001	−0.21 (−0.31 ~ −0.11)	< 0.001
Emotional problems	0.38 (0.25 ~ 0.50)	< 0.001	0.35 (0.22 ~ 0.48)	< 0.001	0.20 (0.07 ~ 0.32)	0.002
Conduct problems	0.09 (0.02 ~ 0.17)	0.016	0.06 (−0.03 ~ 0.15)	0.215		
Peer problems	−0.14 (−0.21 ~ −0.06)	0.001	−0.01 (−0.09 ~ 0.08)	0.885		
Prosocial behavior	−0.68 (−0.80 ~ −0.55)	< 0.001	−0.59 (−0.74 ~ −0.44)	< 0.001	−0.59 (−0.76 ~ −0.42)	< 0.001
Coping style						
Positive coping style	−2.28 (−2.70 ~ −1.86)	< 0.001	−1.22 (−1.69 ~ −0.75)	< 0.001	−1.43 (−1.95 ~ −0.92)	< 0.001
Negative coping style	0.55 (0.30 ~ 0.80)	< 0.001	0.15 (−0.13 ~ 0.42)	0.288		

Abbreviations: *CES-D* Center for Epidemiology Scale for Depression, *GAD-7* Generalized Anxiety Disorder Scale-7, *PSQI* Pittsburgh Sleep Quality Index, *SDQ* Strengths and Difficulties Questionnaire

[a] Continued low group used as reference. The multiple imputations of chained equations method were applied for missing data with creating 5 imputed data sets. Mean effect size was evaluated by using inverse-probability weighting analysis

[b] All the psychosocial well-being outcomes in this analysis were measured in wave 3

Model 1: Unadjusted model

Model 2: Adjusting for age, sex, living arrangement, household socioeconomic status, one child or not, classmate relations, relationship with teachers, academic pressure, both parents' education level, smoking, physical activity, and the corresponding outcome variable at baseline (e.g., adjusting for baseline CES-D scores when analysing ST trajectory with depressive symptoms)

Model 3: Adjusting for covariates in Model 2, and all the outcome variable CES-D scores, GAD-7 scores, PSQI scores, SDQ subscales scores, and coping style scores at baseline were included

As shown in eTable 4 and eTable 5 in the supplement, age, living with single parent, average relationship with teachers, ever smoking, depressive symptoms, poor sleep quality, PA, hyperactivity, peer problem, conduct problem, and negative coping style at baseline were related to higher odds of being in the continued high ST group (all adjusted odds ratios [AORs] > 1, $P < 0.05$). Students with above-average academic pressure, parents with higher education, and positive coping styles were at a decreased risk of being in the continued high ST group (all $AORs < 1$, $Ps < 0.05$). With the effect size (AOR in eTable 5 and parameter value in eTable 6) and the values for each participant's baseline characteristics, the probability of belonging to the identified trajectory group for every participant can be calculated using the equation stated in eTable 6 in the supplement.

Moreover, sensitivity analysis was conducted using the complete original data (1437 participants) without multiple imputations, and the results consistently supported our main findings (eTables 7–10 in the supplement).

Discussion

In this longitudinal study, two patterns of ST trajectory (i.e., the continued high trajectory group and the continued low group) were identified based on participants' total daily ST exposure during the two-year follow-up. In terms of psychosocial well-being, we observed robust unfavorable associations of continued high ST exposure over two years with subsequent emotional and prosocial well-being. In addition, stratified results showed that the aforementioned associations were only significant in female adolescents but not in males.

Our results supported that adolescents with high levels of ST were at higher risk of presenting with depressive and anxiety symptoms. In line with previous study, higher-level ST users (over 7 h/day, compared to 1 h/day users) were at higher risk of having emotional problems or being diagnosed with depression or anxiety disorders [17]. Li et al. also found that adolescents with persistent Internet addiction were at a higher risk of presenting with depressive symptoms subsequently [45]. Another research indicated that adolescents with increasing or high levels of ST trajectories demonstrated higher levels of psychosocial difficulties (e.g., depression, anxiety, and suicidal ideation) in early adulthood [21]. These changes may be attributable to the adverse influence of the Internet and social media overuse on social behaviors. Persistently high levels of screen-based activity may lead to inadequate time and

Table 3 Screen time trajectory and psychosocial well-being by using inverse probability-weighted analysis in male adolescents

Psychosocial well-being[b]	Male adolescents (Continued high group vs. Continued low group[a])					
	Model 1		Model 2		Model 3	
	β coefficient (95% CI)	*P*-value	*β* coefficient (95% CI)	*P*-value	*β* coefficient (95% CI)	*P*-value
Depressive symptoms (CES-D scores)	1.84 (1.06 ~ 2.63)	< 0.001	0.37 (−0.36 ~ 1.10)	0.321		
Anxiety symptoms (GAD-7 scores)	0.41 (0.07 ~ 0.75)	0.019	0.22 (−0.12 ~ 0.56)	0.211		
Sleep quality (PSQI scores)	0.14 (−0.11 ~ 0.39)	0.270				
SDQ						
Total difficulties	−0.21 (−0.57 ~ −0.16)	0.270				
Hyperactivity	−0.18 (−0.30 ~ −0.06)	0.003	−0.12 (−0.27 ~ 0.03)	0.116		
Emotional problems	0.03 (−0.11 ~ 0.18)	0.646				
Conduct problems	0.04 (−0.07 ~ 0.15)	0.460				
Peer problems	−0.14 (−0.25 ~ −0.02)	0.022	0.13 (0.03 ~ 0.24)	0.014	0.14 (0.03 ~ 0.24)	0.010
Prosocial behavior	−0.49 (−0.68 ~ −0.30)	< 0.001	−0.03 (−0.24 ~ 0.18)	0.780		
Coping style						
Positive coping style	−2.15 (−2.78 ~ −1.51)	< 0.001	−0.58 (−1.30 ~ 0.14)	0.112		
Negative coping style	0.68 (0.33 ~ 1.03)	< 0.001	0.18 (−0.18 ~ 0.53)	0.338		

Abbreviations: *CES-D* Center for Epidemiology Scale for Depression, *GAD-7* Generalized Anxiety Disorder Scale-7, *PSQI* Pittsburgh Sleep Quality Index, *SDQ* Strengths and Difficulties Questionnaire

[a] Continued low group used as reference. The multiple imputations of chained equations method were applied for missing data with creating 5 imputed data sets. Mean effect size was evaluated by using inverse-probability weighting analysis

[b] All the psychosocial well-being outcomes in this analysis were measured in wave 3

Model 1: Unadjusted model

Model 2: Adjusting for age, living arrangement, household socioeconomic status, one child or not, classmate relations, relationship with teachers, academic pressure, both parents' education level, smoking, physical activity, and the corresponding outcome variable at baseline (e.g., adjusting for baseline CES-D scores when analysing ST trajectory with depressive symptoms)

Model 3: Adjusting for covariates in Model 2, and all the outcome variable CES-D scores, GAD-7 scores, PSQI scores, SDQ subscales scores, and coping style scores at baseline were included

opportunities for offline social communications, further leading to social isolation and withdrawal, and increasing the odds of emotional and prosocial problems [24, 46]. Another theory of excessive ST causing psychosocial difficulties is upward social comparison. Indulging in excessive screen-based activity, especially social media use, lower adolescents' self-esteem and self-satisfaction, therefore triggering the upward social comparison effect and resulting in negative affections like depression and anxiety [13].

Notably, we found that persistently high levels of ST exposure over two years was significantly associated with compromised prosocial behavior and positive coping style, which were supported by previous studies [24, 47]. Fitzpatrick et al. found a significant negative effect of more Internet and media exposure on prosocial behavior (e.g., helping others) in two years [47]. One explanation is that screen-based activities may reduce adolescents' time engaging in real-person interaction (e.g., peer friendship and parent–child connection), during which empathy and prosocial skills develop [48]. In regards to coping style, previous evidence also proposed that maladaptive coping, including avoidant coping (e.g., denial, substance use, or self-blame) and inflexible coping, represents a maladjustment consequence of problematic screen-based activity [24]. The excessive screen-based activity itself reflects a negative avoidant behavior to avoid facing stress [24]. Adolescents who spend too much time on screen-based activities or are addicted to the Internet have a greater propensity to use avoidant and inflexible coping methods [24]. However, our result did not observe a significant association between ST and negative coping style. It suggested that other factors, rather than excessive ST might influence negative coping style. Our result herein preliminarily demonstrated the harmful influence of persistent screen overuse on positive coping style. Our main findings indicated that persistent and excessive use of screen-based devices might negatively impact adolescents' psychosocial well-being. It is recommended that parents take proactive steps, such as supervising their children's recreational ST, in line with the suggested limit of 2 h per day. Schools and educational institutions are also encouraged to minimize the amount of time required for online assignments, ensuring that students can complete their work within an appropriate ST limit (e.g., less than 2 h/day).

Table 4 Screen time trajectory and psychosocial well-being by using inverse probability-weighted analysis in female adolescents

Psychosocial well-being[b]	Female adolesents (Continued high group vs. Continued low group[a])					
	Model 1		Model 2		Model 3	
	β coefficient (95% CI)	*P*-value	*β* coefficient (95% CI)	*P*-value	*β* coefficient (95% CI)	*P*-value
Depressive symptoms (CES-D scores)	3.56 (2.71 ~ 4.41)	< 0.001	1.78 (0.95 ~ 2.62)	< 0.001	2.18 (1.22 ~ 3.14)	< 0.001
Anxiety symptoms (GAD-7 scores)	0.96 (0.62 ~ 1.30)	< 0.001	0.46 (0.09 ~ 0.82)	0.013	0.42 (0.07 ~ 0.77)	0.018
Sleep quality (PSQI scores)	0.75 (0.48 ~ 1.02)	< 0.001	0.35 (0.07 ~ 0.64)	0.016	0.14 (−0.18 ~ 0.46)	0.393
SDQ						
Total difficulties	0.70 (0.32 ~ 1.09)	< 0.001	0.37 (−0.13 ~ 0.87)	0.142		
Hyperactivity	−0.003 (−0.12 ~ 0.12)	0.959				
Emotional problems	0.68 (0.50 ~ 0.87)	< 0.001	0.69 (0.47 ~ 0.90)	< 0.001	0.39 (0.19 ~ 0.59)	< 0.001
Conduct problems	0.14 (0.04 ~ 0.25)	0.009	0.06 (−0.07 ~ 0.18)	0.370		
Peer problems	−0.14 (−0.24 ~ −0.04)	0.007	−0.15 (−0.27 ~ −0.03)	0.016	−0.20 (−0.33 ~ −0.06)	0.004
Prosocial behavior	−0.87 (−1.03 ~ −0.72)	< 0.001	−1.09 (−1.29 ~ −0.88)	< 0.001	−1.01 (−1.22 ~ −0.80)	< 0.001
Coping style						
Positive coping style	−2.43 (−2.98 ~ −1.88)	< 0.001	−1.98 (−2.63 ~ −1.32)	< 0.001	−2.58 (−3.31 ~ −1.85)	< 0.001
Negative coping style	0.41 (0.06 ~ 0.76)	0.020	0.22 (−0.15 ~ 0.59)	0.244		

Abbreviations: *CES-D* Center for Epidemiology Scale for Depression, *GAD-7* Generalized Anxiety Disorder Scale-7, *PSQI* Pittsburgh Sleep Quality Index, *SDQ* Strengths and Difficulties Questionnaire

[a] Continued low group used as reference. The multiple imputations of chained equations method were applied for missing data with creating 5 imputed data sets. Mean effect size was evaluated by using inverse-probability weighting analysis

[b] All the psychosocial well-being outcomes in this analysis were measured in wave 3

Model 1: Unadjusted model

Model 2: Adjusting for age, living arrangement, household socioeconomic status, one child or not, classmate relations, relationship with teachers, academic pressure, both parents' education level, smoking, physical activity, and the corresponding outcome variable at baseline (e.g., adjusting for baseline CES-D scores when analysing ST trajectory with depressive symptoms)

Model 3: Adjusting for covariates in Model 2, and all the outcome variable CES-D scores, GAD-7 scores, PSQI scores, SDQ subscales scores, and coping style scores at baseline were included

It is of particular note that in our stratification analyses, we observed that except for peer problems, the aforementioned associations remained significant in female adolescents but not in males, which extended the evidence that female adolescents were more likely to have compromised psychosocial well-being if characterized as heavy users of screen-based devices compared to males [49, 50]. Except for the biological and hormonal differences that contributed to females' vulnerability to psychosocial difficulties [51], the divergent association of males' and females' screen-based activity with psychosocial well-being might be attributed to the content of screen-based activity they engaged in. Female adolescents spend more time on social media, which, according to the upward social comparison hypothesis, could bring anxiety about body image or popularity, lower individuals' self-esteem, and trigger emotional problems [13, 50]. On the other hand, Chodorow's theory indicated that females were prone to adopt an internalizing and maladaptive coping method, including suppressing their emotions, self-blame, hiding feelings, and escaping, which deteriorate psychosocial well-being [49, 52]. Therefore, sex differences should be cautiously noticed when discussing the association between screen-based activities and psychosocial well-being. Further, targeted preventive strategies and intervention for psychosocial difficulties among male and female adolescents separatly are recommended.

Additionally, the current study explored the influence factors associated with ST trajectories. Parental attainment of higher education level (i.e., above middle school) protected adolescents from being classified in the continued high ST group, which aligns with Trinh's study, where the inverse association between parental education level and ST trajectory was found among children [19]. Furthermore, we observed that compared to adolescents with good relationships with their teachers, those who have average or poor relationships had higher odds of being in the continued high ST group. Relationship with teachers is a part of school-related social support, and is beneficial for adolescents' mental and behavioral health [53]. Additionally, our results supported previous evidence that psychosocial well-being at baseline was associated with ST exposure level [54], and extended the evidence that a positive coping style protected against longer ST exposure, while a negative coping style predicted it [55]. These associations potentially reflected a

bidirectional association of ST trajectories and psychosocial well-being, and reinforce the relationship between ST trajectories and future psychosocial well-being. On the other hand, our study illustrated a positive association between longer PA and continued high level of ST exposure, which is opposite to the traditional assumption of an inverse relationship [56, 57]. Nonetheless, PA and screen-based activity can coexist [58]. Adolescents with high levels of PA can also engage in a high level of ST [59]. These results indicated that adolescents who have the above characteristics may be more vulnerable to presenting excessive ST habit than others. They may require more attention from parents and teachers, especially adolescents who have already demonstrated poor psychosocial well-being.

One of the strengths of this study is that we took into account the trajectory of screen-based activities by measuring them within multiple time points during follow-up, which may better assess the long-term influence of screen-based activities on psychosocial well-being among adolescents. Besides, our study has a reasonable response rate and retention rate, which could reduce selection bias. However, several limitations should be noticed when interpreting the current results: 1) Due to school transfer and graduation, times of follow-up were limited to 3 waves, where only two trajectories were fitted using group-based trajectory modeling. In future research, multiple follow-ups are recommended to improve ST trajectories. 2) This study only investigated students who were present at school on the research day and did not include students absent from school. However, excessive and addictive screen-based activities and psychosocial difficulties may be more common among those students. 3) The ST we assessed in the current study was based on self-report. It could cause information bias since adolescents may misremember or underestimate the precise ST. Nonetheless, self-report ST has been widely used in previous studies [60], and studies using objective measures like accelerometer and parents-report ST have observed similar results as our study, indicating that self-report is a validated method to assess ST [60, 61]. In our future study, we are planning to include parent-report ST in our questionnaire or use wearable electronic devices to capture a more precise value of ST. 4) Although the missing rate of data on psychosocial well-being and covariates was low (2.9% of the total analytic participants 1480), it is possible that the missing not at random might exist, which could cause underestimated associations.

Conclusions

This longitudinal study demonstrated that continued high ST exposure is associated with more emotional problems, and compromised prosocial behaviors and positive coping style, whereas female adolescents have much closer associations between ST trajectories and poor psychosocial well-being than male. These findings suggest that proper guidance and supervision are necessary to help adolescents manage ST in their daily routines. Moreover, intervention strategies aimed at reducing persistent excessive ST exposure may be beneficial for improving adolescents' psychosocial well-being.

Abbreviations

ST	Screen time
CES-D	Center for Epidemiology Scale for Depression
GAD-7	Generalized Anxiety Disorder Scale-7
PSQI	Pittsburgh Sleep Quality Index
SDQ	Strengths and Difficulties Questionnaire
SCSQ	Simplified Coping Style Questionnaire
HSS	Household socioeconomic status
PA	Physical activity
SD	Standardized deviation
IQR	Interquartile range
BIC	Bayesian information criterion
MICEs	Multiple imputations of chained equations

Supplementary Information

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Supplementary Material 1.

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Authors' contributions

LG and CYL contributed to the study conception and design. Material preparation, data collection and analysis were performed by WXW, WQJ, LG, LWZ, YZL, and WJL. The first draft of the manuscript was written by WXW, LG and WQJ. LWZ, CYL, YZL, and WJL revised it critically for important intellectual content. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability

The data necessary to reproduce the analyses presented here are available from the corresponding author upon reasonable request (Dr. Lan Guo, guolan3@mail.sysu.edu.cn).

Declarations

Ethics approval and consent to participate

Written informed consents was obtained from the participants and their legal guardians. The study was performed in accordance with the Declaration of Helsinki, and obtained ethical approval from Sun Yat-sen University School of Public Health Institutional Review Board (Ethics Number: L2017060).

Consent for publication

Written informed consents was obtained from the participants and their legal guardians with detailed information on this research and related publications. In addition, all data was deidentified at the first time before further analysis.

Competing interests
The authors declare no competing interests.

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References

1. Takahashi I, Obara T, Ishikuro M, Murakami K, Ueno F, Noda A, et al. Screen time at age 1 year and communication and problem-solving developmental delay at 2 and 4 years. JAMA Pediatr. 2023;177(10):1039.
2. Ozturk Eyimaya A, Yalçin IA. Relationship between parenting practices and children's screen time during the COVID-19 pandemic in Turkey. J Pediatr Nurs. 2021;56:24–9.
3. Wang G, Zhang Y, Zhao J, Zhang J, Jiang F. Mitigate the effects of home confinement on children during the COVID-19 outbreak. Lancet. 2020;395(10228):945–7.
4. Okely AD, Ghersi D, Loughran SP, Cliff DP, Shilton T, Jones RA, et al. A collaborative approach to adopting/adapting guidelines. The Australian 24-hour movement guidelines for children (5–12 years) and young people (13–17 years): an integration of physical activity, sedentary behaviour, and sleep. Int J Behav Nutr Phys Act. 2022;19:2.
5. Tremblay MS, Carson V, Chaput JP, Connor Gorber S, Dinh T, Duggan M, et al. Canadian 24-hour movement guidelines for children and youth: an integration of physical activity, sedentary behaviour, and sleep. Appl Physiol Nutr Metab. 2016;41(6 (Suppl. 3)):S311-27.
6. Council on communications and media, Strasburger VC, Hogan MJ, Mulligan DA, Ameenuddin N, Christakis DA, et al. Children, Adolescents, and the Media. Pediatrics. 2013;132(5):958–61.
7. Chen ST, Liu Y, Tremblay MS, Hong JT, Tang Y, Cao ZB, et al. Meeting 24-h movement guidelines: prevalence, correlates, and the relationships with overweight and obesity among Chinese children and adolescents. J Sport Health Sci. 2021;10(3):349–59.
8. Song Y, Li L, Xu Y, Pan G, Tao F, Ren L. Associations between screen time, negative life events, and emotional and behavioral problems among Chinese children and adolescents. J Affect Disord. 2020;264:506–12.
9. Weighing the risks and benefits of screen time for children. Nat Hum Behav. 2024;8:16–7. https://doi.org/10.1038/s41562-023-01713-7.
10. Yamamoto M, Mezawa H, Sakurai K, Mori C, Japan Environment and Children's Study Group, Kamijima M, et al. Screen time and developmental performance among children at 1–3 years of age in the Japan environment and children's study. JAMA Pediatr. 2023;177(11):1168.
11. Zhao J, Yu Z, Sun X, Wu S, Zhang J, Zhang D, et al. Association between screen time trajectory and early childhood development in children in China. JAMA Pediatr. 2022;176(8):768.
12. Madigan S, Browne D, Racine N, Mori C, Tough S. Association between screen time and children's performance on a developmental screening test. JAMA Pediatr. 2019Mar 1;173(3):244.
13. Boers E, Afzali MH, Newton N, Conrod P. Association of screen time and depression in adolescence. JAMA Pediatr. 2019;173(9):853.
14. Kandola A, Owen N, Dunstan DW, Hallgren M. Prospective relationships of adolescents' screen-based sedentary behaviour with depressive symptoms: the Millennium Cohort Study. Psychol Med. 2022;52(15):3531–9.
15. Boers E, Afzali MH, Conrod P. Temporal associations of screen time and anxiety symptoms among adolescents. Can J Psychiatry. 2020;65(3):206–8.
16. Sinclair-McBride K, Rich M. Social adolescents, social media, and social emotional development. Lancet Child Adolesc Health. 2023;7(10):673–5.
17. Twenge JM, Campbell WK. Associations between screen time and lower psychological well-being among children and adolescents: evidence from a population-based study. Prev Med Rep. 2018;18(12):271–83.
18. Song K, Zhang JL, Zhou N, Fu Y, Zou B, Xu LX, et al. Youth screen media activity patterns and associations with behavioral developmental measures and resting-state brain functional connectivity. J Am Acad Child Adolesc Psychiatry. 2023;62(9):1051–63.
19. Trinh MH, Sundaram R, Robinson SL, Lin TC, Bell EM, Ghassabian A, et al. Association of Trajectory and covariates of children's screen media time. JAMA Pediatr. 2020;174(1):71.
20. Zhao J, Yu Z, Sun X, Wu S, Zhang J, Zhang D, et al. Association between screen time trajectory and early childhood development in children in China. JAMA Pediatr. 2022;176(8):768.
21. Zhu X, Griffiths H, Xiao Z, Ribeaud D, Eisner M, Yang Y, et al. Trajectories of screen time across adolescence and their associations with adulthood mental health and behavioral outcomes. J Youth Adolesc. 2023;52(7):1433–47.
22. Plackett R, Sheringham J, Dykxhoorn J. The longitudinal impact of social media use on UK adolescents' mental health: longitudinal observational study. J Med Internet Res. 2023;24(25):e43213.
23. Tang S, Werner-Seidler A, Torok M, Mackinnon AJ, Christensen H. The relationship between screen time and mental health in young people: a systematic review of longitudinal studies. Clin Psychol Rev. 2021;86:102021.
24. Cheng C, Sun P, Mak KK. Internet addiction and psychosocial maladjustment: avoidant coping and coping inflexibility as psychological mechanisms. Cyberpsychol Behav Soc Netw. 2015;18(9):539–46.
25. McNicol ML, Thorsteinsson EB. Internet addiction, psychological distress, and coping responses among adolescents and adults. Cyberpsychol Behav Soc Netw. 2017;20(5):296–304.
26. Wang W, Du X, Guo Y, Li W, Zhang S, Zhang W, et al. Associations among screen time, sleep duration and depressive symptoms among Chinese adolescents. J Affect Disord. 2021;284:69–74.
27. Cao H, Qian Q, Weng T, Yuan C, Sun Y, Wang H, et al. Screen time, physical activity and mental health among urban adolescents in China. Prev Med. 2011;53(4–5):316–20.
28. Radloff LS. The use of the Center for Epidemiologic Studies Depression Scale in adolescents and young adults. J Youth Adolescence. 1991;20(2):149–66.
29. Lee SW, Stewart SM, Byrne BM, Wong JPS, Ho SY, Lee PWH, et al. Factor structure of the Center for Epidemiological Studies Depression Scale in Hong Kong adolescents. J Pers Assess. 2008;90(2):175–84.
30. Qi M, Zhou SJ, Guo ZC, Zhang LG, Min HJ, Li XM, et al. The effect of social support on Mental Health in Chinese adolescents during the outbreak of COVID-19. J Adolesc Health. 2020;67(4):514–8.
31. Tong X, An D, McGonigal A, Park SP, Zhou D. Validation of the Generalized Anxiety Disorder-7 (GAD-7) among Chinese people with epilepsy. Epilepsy Res. 2016;120:31–6.
32. Spitzer RL, Kroenke K, Williams JBW, Löwe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. Arch Intern Med. 2006;166(10):1092.
33. Tsai PS, Wang SY, Wang MY, Su CT, Yang TT, Huang CJ, et al. Psychometric evaluation of the Chinese Version of the Pittsburgh Sleep Quality Index (CPSQI) in primary insomnia and control subjects. Qual Life Res. 2005;14(8):1943–52.
34. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh sleep quality index: a new instrument for psychiatric practice and research. Psychiatry Res. 1989;28(2):193–213.
35. Du Y, Kou J, Coghill D. The validity, reliability and normative scores of the parent, teacher and self report versions of the strengths and difficulties questionnaire in China. Child Adolesc Psychiatry Ment Health. 2008;2(1):8.
36. Goodman R, Meltzer H, Bailey V. The strengths and difficulties questionnaire: a pilot study on the validity of the self-report version. Eur Child Adolesc Psychiatry. 1998;7(3):6.
37. Xie Y. Preliminary study to the reliability and validity of the simple coping style scale (In Chinese). Chin J Clin Psychol. 1998;6(2):114–5.
38. Folkman S, Lazarus RS. Coping as a mediator of emotion. J Pers Soc Psychol. 1988;54(3):466.
39. Fang J, Wang YT, Xiao SY, Zhao M, Jiang H, Hu M. Reliability and validity of simplified coping style questionnaire among adolescents (In Chinese). Chin J Clin Psychol. 2018;26(5):905–9.
40. Mansoubi M, Pearson N, Clemes SA, Biddle SJ, Bodicoat DH, Tolfrey K, et al. Energy expenditure during common sitting and standing tasks: examining the 1.5 MET definition of sedentary behaviour. BMC Public Health. 2015;15(1):516.
41. Pearce M, Garcia L, Abbas A, Strain T, Schuch FB, Golubic R, et al. Association between physical activity and risk of depression: a systematic review and meta-analysis. JAMA Psychiat. 2022;79(6):550.
42. van Buuren S, Boshuizen HC, Knook DL. Multiple imputation of missing blood pressure covariates in survival analysis. Statist Med. 1999Mar 30;18(6):681–94.

43. Jones BL, Nagin DS. Association between screen time trajectory and early childhood development in children in China. Sociological Methods & Research. 2013;42(4):608–13.
44. Ballinger GA. Using Generalized Estimating Equations for Longitudinal Data Analysis. Organ Res Methods. 2004;7(2):127–50.
45. Li JB, Mo PKH, Lau JTF, Su XF, Zhang X, Wu AMS, et al. Online social networking addiction and depression: The results from a large-scale prospective cohort study in Chinese adolescents. J Behav Addict. 2018;7(3):686–96.
46. Small GW, Lee J, Kaufman A, Jalil J, Siddarth P, Gaddipati H, et al. Brain health consequences of digital technology use. Dialogues Clin Neurosci. 2020;22(2):179–87.
47. Fitzpatrick C, Boers E. Developmental Associations Between Media Use and Adolescent Prosocial Behavior. Health Educ Behav. 2022;49(2):265–71.
48. Silke C, Brady B, Boylan C, Dolan P. Factors influencing the development of empathy and pro-social behaviour among adolescents: a systematic review. Child Youth Serv Rev. 2018;1(94):421–36.
49. Al-Bahrani M, Aldhafri S, Alkharusi H, Kazem A, Alzubiadi A. Age and gender differences in coping style across various problems: Omani adolescents' perspective. J Adolesc. 2013;36(2):303–9.
50. Twenge JM, Farley E. Not all screen time is created equal: associations with mental health vary by activity and gender. Soc Psychiatry Psychiatr Epidemiol. 2021;56(2):207–17.
51. Seney ML, Sibille E. Sex differences in mood disorders: perspectives from humans and rodent models. Biol Sex Differ. 2014;5(1):17.
52. Nancy C. Feminism and psychoanalytic theory. New Haven: Yale University Press; 1991:298.
53. Tian L, Zhao J, Huebner ES. School-related social support and subjective well-being in school among adolescents: the role of self-system factors. J Adolesc. 2015;45(1):138–48.
54. Frison E, Eggermont S. Browsing, posting, and liking on instagram: the reciprocal relationships between different types of instagram use and adolescents' depressed mood. Cyberpsychol Behav Soc Netw. 2017;20(10):603–9.
55. Lei H, Cheong CM, Li S, Lu M. The relationship between coping style and Internet addiction among mainland Chinese students: a meta-analysis. Psychiatry Res. 2018;270:831–41.
56. de Araújo LGM, Turi BC, Locci B, Mesquita CAA, Fonsati NB, Monteiro HL. Patterns of physical activity and screen time among Brazilian children. J Phys Act Health. 2018;15(6):457–61.
57. Xie H. Urban adolescents' physical activity experience, physical activity levels, and use of screen-based media during leisure time: a structural model. Front Psychol. 2018;8:9.
58. Ferrar K, Chang C, Li M, Olds TS. Adolescent time use clusters: a systematic review. J Adolesc Health. 2013;52(3):259–70.
59. Jago R, Fox KR, Page AS, Brockman R, Thompson JL. Physical activity and sedentary behaviour typologies of 10–11 year olds. Int J Behav Nutr Phys Act. 2010;7(1):59.
60. Zhang J, Yang SX, Wang L, Han LH, Wu XY. The influence of sedentary behaviour on mental health among children and adolescents: a systematic review and meta-analysis of longitudinal studies. J Affect Disord. 2022;306:90–114.
61. Kandola A, Lewis G, Osborn DPJ, Stubbs B, Hayes JF. Depressive symptoms and objectively measured physical activity and sedentary behaviour throughout adolescence: a prospective cohort study. Lancet Psychiatry. 2020;7(3):262–71.

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