Risk Management and Healthcare Policy

Dovepress
open access to scientific and medical research

Open Access Full Text Article

ORIGINAL RESEARCH

The Association Between Screen Time and Outdoor Time on Adolescent Mental Health and Academic Performance: Evidence from Rural China

Huan Wang[1], Cody Abbey[1], Thomas Kennedy[1], Erik Feng[1], Robin Li[1], Finley Liu[1], Annli Zhu[1], Sharon Shen[1], Prateek Wadhavkar[1], Scott Rozelle[1], Manpreet K Singh[2]

[1]Stanford Center on China's Economy and Institutions, Stanford University, Stanford, CA, USA; [2]Stanford School of Medicine, Stanford University, Stanford, CA, USA

Correspondence: Cody Abbey, Stanford Center on China's Economy and Institutions, Stanford University, Stanford, CA, USA, Tel +1 650-723-4581, Email cjabbey@stanford.edu

Purpose: We examine how adolescent free time allocation—namely, screen time and outdoor time—is associated with mental health and academic performance in rural China.

Methods: This paper used a large random sample of rural junior high school students in Ningxia (n = 20,375; $\bar{X}_{age}$=13.22), with data collected from self-reported demographic questionnaires (to assess free time allocation), the Strengths and Difficulties Questionnaire (to assess mental health), and a standardized math test (to measure academic performance). We utilized a multivariate OLS regression model to examine associations between free time allocation and adolescent outcomes, controlling for individual and family characteristics.

Results: Our sample's screen time and outdoor time both averaged around 1 hour. About 10% of the sample adolescents reported behavioral difficulties, while a similar percentage (11%) reported abnormal prosocial behaviors. Adolescents with higher levels of screen time (>2 hours) were 3 percentage points more likely to have higher levels of behavioral difficulties ($p<0.001$), indicating that excessive screen time was associated with worse mental health. Meanwhile, outdoor time was associated with better mental health, and positive correlations were observed at all levels of outdoor time (compared to no outdoor time, decreasing the likelihood of higher levels of behavioral difficulties by between 3 and 4 percentage points and of lower prosocial scores by between 6 and 8 percentage points; all p's<0.001). For academic performance, average daily screen times of up to 1 hour and 1–2 hours were both positively associated with standardized math scores (0.08 SD, $p<0.001$; 0.07 SD, $p<0.01$, respectively), whereas there were no significant associations between outdoor time and academic performance.

Conclusion: Using a large sample size, this study was the first to examine the association between adolescent free time allocation with mental health and academic performance, providing initial insights into how rural Chinese adolescents can optimize their free time.

Keywords: adolescent outcome, free time allocation, correlational analysis, developing countries

Introduction

How adolescents spend their free time can be an important determinant of their mental health and academic outcomes.[1] Screen time (eg, watching TV, using gaming consoles, browsing the internet) and outdoor time (eg, participating in sports outdoors, running/walking, and playground activities) constitute two common types of free time activities for adolescents. In developed countries, such as the US, recent evidence suggests that contemporary youth – including those who live in rural areas – are spending less time outdoors and more time using electronic media than previous generations.[2] Due to these shifts in adolescent free time allocation,[3] it is crucial to determine how their engagement in these activities is associated with their development.

Received: 4 August 2022
Accepted: 31 January 2023
Published: 9 March 2023

Studies on the link between free time allocation and adolescent outcomes generally fall within one of two different categories. The first line of research examines how free time activities like screen time and outdoor time might be linked to adolescent mental health. For example, a study of adolescents in the UK found that low to moderate levels of screen time were associated with optimal mental health outcomes, suggesting that conservative amounts of video game time and social media usage can stimulate creativity, relaxation, and connectedness.[4] However, another study among Canadian adolescents found that longer screen time can be associated with lower optimism as well as worse symptoms of anxiety and depression.[3] In terms of outdoor time, the existing literature has suggested that outdoor play and nature-based experiences are linked with better adolescent mental health,[5] as these experiences could decrease one's anxiety and rumination.[6] On the other hand, other studies did not find any significant association between access to "green space" (ie, natural outdoor areas) and mental wellbeing.[7–9]

A second line of research focuses on academic performance as an outcome of interest. Past studies have found screen time to be positively linked with academic performance, including one that found that college students who more frequently used the internet to communicate demonstrated a higher cognitive capacity than their peers.[10] However, recreational screen time has also been linked with poorer academic performance,[11] as excessive usage of social media can occupy an adolescent's learning time. Meanwhile, outdoor time, or time spent engaging in physical activities outdoors, has generally been associated with better academic performance,[6,12] as outdoor play has been suggested to bring a range of cognitive benefits including heightened creativity and improved attention span.[13] Yet, it is possible that outdoor time may not always be positively linked with academic performance,[14] which may especially be the case if time spent engaging in outdoor activities displaces the amount of time students spend studying or completing homework.

Although associations between screen time and outdoor time with adolescent mental health and academic performance have been examined separately, research that jointly examines these two outcomes is limited. Such a study is essential for several reasons. First, both mental health and academic achievement are common outcomes in studies on adolescent development. When studies independently explore the impact of internet usage on student learning outcomes and adolescent mental health,[15,16] there is no opportunity to compare its effects on both of these two interrelated outcomes. Further, an analysis of free time activities and their association with both mental health and academic performance offers a more comprehensive understanding of the link between free time allocation and adolescent development. Indeed, these two outcomes might not be associated with free time activities in the same way (ie, the associations may have different directions or magnitudes). Studying mental health and academic performance together in the same study may generate more specific insights on the impact of free time activities on adolescent development.

Another notable gap is that most extant studies in the literature only examine the association between free time activities and adolescent development in urban areas of developed countries and tend to overlook low- and middle-income country settings. Free time allocation in developing contexts, such as that of rural China, may provide unique insights about regional variations in adolescent outcomes. Critically, rural Chinese adolescents have a higher risk of mental illnesses than adolescents in most developed countries, with about 20% of the children and adolescents suffering from depression and 6% at risk for general anxiety.[17] There is also a stark urban-rural gap in educational outcomes among students in China,[18] with data from a nationally representative survey showing that rural youth are 2 years behind urban children in both math and Chinese.[19] Considering that 70% of the Chinese adolescents are rural (ie, have a rural household registration status) and that China's youth constitute 15% of the world's population under 18 years old,[17,20] the scale of these disparities is large. Thus, understanding how certain free time activities relate to the adolescent outcomes in the context of rural China can be an initial step toward exploring how to mitigate associated risk factors while strengthening protective factors for tens of millions of adolescents.

Rural China is an ideal setting to conduct this research because it has witnessed a significant rise in technology use among rural adolescents over the last decade, which may indicate a shift towards longer screen time and less outdoor time. The gap between rural and urban internet usage has steadily decreased, with 90.3% of the Chinese rural adolescents having access to internet services in 2019 (compared to 93.9% of the urban adolescents).[21] Moreover, technology access is much higher in rural China than in other developing countries. For example, the smartphone ownership rate of families is over 63% in rural China, compared to just 13% in rural India.[22] In recent years, the Chinese government has taken steps to address adolescent technology addiction.[23] However, little is known about how much screen time is optimal

versus problematic for adolescent mental health and academic performance in rural areas, and there is even less understanding of the role of other free time activities such as outdoor time on these outcomes. Thus, there is a need for large-scale, empirical data to inform both the design of policy and clinical practice in rural China.

This study aims to address these shortcomings with three specific objectives. First, this paper describes the free time allocation of adolescents in rural China, focusing on their screen time and outdoor time. Second, it examines the association of screen time and outdoor time with mental health outcomes. Finally, it investigates the association of screen time and outdoor time with academic achievement.

Methods

Ethical Approval

Ethical approval for this study was granted by the Institutional Review Boards of Stanford University in Palo Alto, USA; Queen's University Belfast in Belfast, Northern Ireland; and Sun Yat-sen University in Guangzhou, China. In addition, the local education bureaus and the principals of each sample school granted permission to conduct the in-school survey. Written informed consent was provided from at least one parent for each child participant. Student participants gave oral consent at the time of the survey and were allowed to withdraw from the study at any time. The Declaration of Helsinki was closely adhered to throughout the study.

Setting

The data for this study were collected in October 2019 in rural schools in Ningxia province, which is a relatively poor province located in northwestern China. Ningxia has a total population of 6.95 million people within a total area of 66,400 square kilometers. The GDP per capita in Ningxia was approximately $9623, which was significantly lower than the national average of approximately $12,458.[24] In addition, as of 2021, 33.9% of Ningxia's permanent residents had a rural hukou (residence registration) status, which was close to the national average of 35.3%.

Sampling

A two-step protocol was used to select the sample students. First, a list of all 273 junior high schools in Ningxia was obtained from the provincial educational bureau. As this study focused on rural students, we excluded 122 of these schools because of their locations in the provincial capital city, prefectural/city seats, or other urban centers. Due to logistical constraints, schools with fewer than 40 students in the 7th grade were also excluded. After applying the exclusion criteria, we invited all 128 schools in our sample pool to participate in the study. Four schools refused to participate. This resulted in 124 rural junior high schools being included into the sample. Next, this study randomly chose a maximum of two classes in both grades 7 and 8 in every school. All students in the selected classes participated in the study. Altogether, our final analytical sample consisted of 20,375 students from 474 classes across 124 schools, averaging 43 students per sample class.

Questionnaires

Students were each given an 84-item questionnaire collecting information on basic demographic information such as age, sex, parental education level, as well as information related to how they allocate their time outside of school. Separate questions were asked for time spent on these activities on weekdays and during the weekend. To assess mental health and wellbeing outcomes, each adolescent filled out the Strengths and Difficulties Questionnaire (SDQ). They also received a 35-minute standardized mathematics test to measure their academic performance.

Sociodemographic Characteristics

The demographic questionnaire included questions about a range of individual and family characteristics. These included adolescent age (years), sex (1=female), whether the adolescent was an only child (1=Yes), whether or not they boarded at school (1=Yes), whether or not their parents had divorced (1=Yes), and whether or not they received extracurricular tutoring (1=Yes). To collect data on family income, we asked sample adolescents whether their household owned 12

assets included in the National Household Income and Expenditure Survey (1 = Yes, 0 = No) and then used the data to generate an index of family assets. The questionnaire also asked students whether they have a computer at home (1=Yes) and whether they own a phone at home (1=Yes).

Free Time Activities Measures

To collect data on student time allocation, we used a self-reported multi-item questionnaire. This questionnaire was developed by a group of health professionals and was used in a previous trial accessing the time allocation of children in China.[25] This questionnaire is structured chronologically and with discrete periods, which has shown a good reliability.[26] The first part is on screen time, in which the questionnaire asked respondents to report how much time they spent watching TV and using phones, computers, and gaming consoles on a typical day both during the school week and on the weekend. It is worth noting that, however, our questionnaire did not distinguish between free-time and school-related online activities. As we did not explore these, we included them as a limitation of this study. To obtain each student's average daily time using each device, we took the weighted average of their typical duration of daily use on weekdays and on weekends [(typical time using the device on a weekday*5 + typical time using the device on a weekend*2) divided by 7]. Next, to obtain an estimate of their total average daily screen time, we added together the average daily time spent using each device. We then created categorical variables based on the patterns of average daily screen time reported by each respondent. The four categories are 1) respondents who did not spend any time on screen; 2) respondents with a daily average screen time of less than 1 hour; 3) respondents with a daily average screen time between 1 and 2 hours; and 4) respondents with a daily average screen time over 2 hours. The cut-off of 2 hr/day was based on recommended screen time limits by previous studies.[3] The same categorical variables were created for daily outdoor time as well.

Outdoor time was measured in a similar fashion. Respondents were asked to report how much time they spent in outdoor activities. The types of outdoor activities we included in our questionnaire were meant to capture the average time an ordinary student spent outdoors in a normal week. These outdoor activities therefore included playing outside (eg, exercise, running, playing football or basketball, etc.) before and after school; being outside during recess or lunch break; having outdoor time during class, such as during a PE class; and having outdoor activity during a commute, such as walking to and back from school. Notably, we decided not to count farm work as an outdoor activity because, according to our data, only about 25% of our sample students reported that their parents were full-time farmers. Like our calculations for screen time, we first averaged each respondent's typical daily outdoor time during the weekday and weekend, and we then summed up times across all these activities to obtain each adolescent's average daily outdoor activity time.

Adolescent Outcomes Measures

Mental health outcomes were measured with the self-reported version of the Strengths and Difficulties Questionnaire (SDQ). The SDQ is a well-recognized behavioral screening questionnaire for 3- to 16-year-old children and adolescents.[27] This questionnaire has been adapted and validated for use in China, demonstrating high levels of internal consistency (Cronbach's alpha coefficient=0.927) and moderate test–retest reliability (Pearson's correlation coefficient=0.719).[28] The SDQ questionnaire consists of 25 items and is divided into five subscales with five items each: 1) emotional symptoms; 2) conduct problems; 3) hyperactivity/inattention; 4d.) peer relationship problems; and 5e.) prosocial behaviors. These subscales include both items that asked about positive behavioral attributes ("strengths") as well as those that asked negative behavioral attributes ("difficulties"). For example, item 7 ("generally obedient") is one of the positive attributes under the conduct problems subscale, whereas item 18 ("often lies or cheats") asks about a negative attribute. The prosocial subscale, however, only includes items that ask about positive behavioural attributes that involve voluntary behaviors to benefit others, as characterized by acts of kindness, empathy, compassion, and helping behaviors.

Each item is scored on a scale of 0 to 2 (0 = not true, 1 = somewhat true, and 2 = certainly true). The sum of the first four scales generates a total behavioral difficulties score ranging from 0 to 40, while the prosocial scale is not included in this score. The items on the difficulties subscales that ask about positive attributes are reverse scored. Each respondent's

total difficulties and prosocial scores can be classified as "abnormal" according to cutoff thresholds validated for Chinese children.[28] For the total difficulties score, a score of 19 or above is in the abnormal range. An abnormal prosocial score is 4 or below.

Academic performance was measured with a standardized math test. The math test was designed by the research team with assistance from local county education bureaus in several rural counties in China to ensure coherence with the national curriculum. The tests were timed carefully and closely proctored by enumerators. All test scores were normalized according to the distribution of scores in each grade.

Statistical Methods

The statistical methods for the paper used two basic approaches. First, we calculated the summary statistics of the sample, including individual and family characteristics, the screen time and outdoor time of adolescents, as well as adolescent mental health as measured by the SDQ. Second, we conducted a linear regression model (multivariate ordinary least square regression) to examine how screen and outdoor time were associated with adolescent mental health and academic performance while controlling for individual and family characteristics, including self-reported study time, sex, age, only child status, boarding status, participation in extracurricular tutoring, parental marriage status, parental migration, parental education level, and family asset index. All statistical analyses were performed using Stata 16.0 (Stata Corp, College Station, TX). Robust standard errors were calculated, adjusting for clustering by school.

Results

Descriptive Analysis

Table 1 displays the summary statistics of the sample. The mean age of the sample adolescents was around 13 years and slightly under half of them (48%) were female. About 7% of the sample adolescents were only children and 35% attended a boarding school. Adolescents with at least one parent migrating for work (partially or fully left-behind children) made up 35% of the sample, while adolescents with divorced parents accounted for 7% of the sample. A small share of the students (11%) participated in extracurricular tutoring. About 30% had a computer at home and 29% owned a phone.

In terms of daily time allocation, the average screen time was slightly above 1 hour per day. About 34% of the adolescents spent over 2 hours per day on their screens. The average outdoor time was also 1 hour per day, with 11% of adolescents spending over 2 hours per day. Finally, the average study time was 1.5 hours per day with 26% of the students studying for over 2 hours per day.

Table 1 also displays the mean SDQ total difficulties and prosocial scores among the sample, as well as the share of students with scores in the abnormal ranges of these subscales. The mean total difficulties score was 12.60, with 9.5% of the adolescents in the abnormal range (difficulties score $\geq$19). Additionally, the mean prosocial score of the sample was 7.21, with 10.6% in the abnormal range ($\leq$4).

The Association Between Free Time Activities and Adolescent Mental Health

Table 2 shows the association of screen time and outdoor time with the likelihood that adolescents have an abnormal total difficulties or prosocial score. Columns 1 and 2 display the unadjusted equations (not controlling for sociodemographic characteristics), while columns 3 and 4 display the adjusted equations (controlling for individual and family variables such as their gender, age, and household characteristics). All equations controlled for study time, as well as controlled for either screen time or outdoor time, depending on the independent variable. For example, if outdoor time was the key independent variable of interest, then the equations controlled for study time as well as screen time and vice versa.

According to the findings in Table 2 (Panel A), when compared to the reference group of adolescents with no screen time, individuals with screen times of up to 1 hour were 2.0 percentage points less likely to have an abnormal total difficulties score ($p<0.01$) and 2.8 percentage points ($p<0.001$) less likely to have abnormal prosocial scores (columns 1 and 2). Individuals with screen times greater than 2 hours were 2.7 percentage points ($p<0.001$) more likely to have abnormal total difficulties scores. We did not observe a statistically significant association between abnormal SDQ scores

Table 1 Summary Statistics of Student Individual and Family Characteristics

Variables	Value
Demographic characteristics and time allocation	
Student age (years), mean (SD)	13.22 (1.08)
Female, n (%)	9572 (48.37)
Only child, n (%)	1357 (6.86)
Boarding student, n (%)	7010 (35.42)
Parents divorced, n (%)	1932 (9.76)
At least one parent migrated for work, n (%)	6904 (34.88)
Father age (years), mean (SD)	41.34 (5.31)
Father years of schooling (years), mean (SD)	7.08 (3.21)
Mother age (years), mean (SD)	38.67 (5.03)
Mother years of schooling (years), mean (SD)	5.13 (4.01)
Participate in extracurricular tutoring, n (%)	2261 (11.42)
Family asset index (standardized), mean (SD)	0.01 (1.18)
Has computer at home, n (%)	5890 (29.76)
Student owns phone, n (%)	5820 (29.41)
Student walks to school, n (%)	7399 (37.39)
Screen time, hours/day, mean (SD)	1.08 (1.18)
Outdoor time, hours/day, mean (SD)	1.00 (0.08)
Study time, hours/day, mean (SD)	1.50 (1.30)
Screen time>2h/day, n (%)	3041 (15.37)
Outdoor time>2h/day, n (%)	2196 (11.10)
Study time>2h/day, n (%)	5199 (26.27)
Adolescent outcomes	
SDQ total difficulties score, mean (SD)	12.60 (4.92)
SDQ total difficulties abnormal, n (%)	1844 (9.32)
SDQ prosocial score, mean (SD)	7.21 (2.11)
SDQ prosocial, abnormal, n (%)	2081 (10.52)
Standardized values of math test scores, mean (SD)	0.00 (1.00)

and a daily screen time of 1–2 hours. We also did not observe statistically significant associations between having a screen time of 1–2 hours, having a screen time of more than 2 hours, and having an abnormal prosocial score. These results remained consistent after adjusting for confounding factors in columns 3 and 4, though there was a slightly stronger positive association between screen time of over 2 hours and the prevalence of abnormal total difficulties (2.9 percentage points, $p < 0.001$) than in the unadjusted equation. Appendix Table 1 (Panel A, Columns 5, 6, 7 and 8), which displays the results of regressions using continuous SDQ subscale measures (standardized and raw scores) as the outcome variable, also demonstrates that higher levels of screen time (1 hour or more) are negatively associated with adolescent mental health.

Table 2 (Panel B) also shows that any amount of outdoor time was associated with a lower prevalence of abnormal mental health among adolescents compared to the reference group with no daily outdoor time. Adolescents with an average daily outdoor time of up to 1 hour, 1–2 hours, and more than 2 hours were 3.6 ($p<0.001$), 3.4 ($p<0.001$), and 2.9 ($p<0.01$) percentage points less likely to have an abnormal total difficulties score, respectively, indicating that the strength of the correlation diminished slightly as the amount of outdoor time increased. Outdoor time had a similar association with the prevalence of abnormal prosocial scores. Compared to the reference group of no outdoor time, an adolescent in our sample with an outdoor time of less than 1 hour, 1 to 2 hours, and more than 2 hours was 5.4 ($p<0.001$), 6.8 ($p<0.001$), and 6.0 ($p<0.001$) percentage points less likely to have an abnormal prosocial score, respectively. These associations slightly increased in magnitude after adjusting for confounding factors in column 4 (5.7 percentage points,

Table 2 Linear Regression Results on Association Between Adolescent Mental Health and Free Time Activities

	(1) Abnormal Total Difficulties Score	(2) Abnormal Prosocial Score	(3) Abnormal Total Difficulties Score	(4) Abnormal Prosocial Score
Panel A				
Screen time=0	Reference	Reference	Reference	Reference
Screen time <1hr	−0.020**	−0.028***	−0.018**	−0.026***
	(0.009)	(0.008)	(0.009)	(0.008)
Screen time 1–2hrs	−0.005	−0.009	−0.003	−0.011
	(0.009)	(0.009)	(0.009)	(0.009)
Screen time >2hrs	0.027**	0.012	0.029***	0.004
	(0.011)	(0.010)	(0.010)	(0.011)
Panel B				
Outdoor time=0	Reference	Reference	Reference	Reference
Outdoor time <1hr	−0.036***	−0.054***	−0.036***	−0.057***
	(0.012)	(0.013)	(0.012)	(0.013)
Outdoor time 1–2hrs	−0.034***	−0.068***	−0.035***	−0.078***
	(0.012)	(0.013)	(0.012)	(0.013)
Outdoor time >2hrs	−0.029**	−0.060***	−0.030**	−0.075***
	(0.013)	(0.015)	(0.012)	(0.015)
Control variables				
Study time=0	Reference	Reference	Reference	Reference
Study time <1hr	−0.064***	−0.112***	−0.067***	−0.105***
	(0.018)	(0.021)	(0.018)	(0.021)
Study time 1–2hrs	−0.101***	−0.157***	−0.102***	−0.147***
	(0.018)	(0.022)	(0.018)	(0.022)
Study time > 2hrs	−0.115***	−0.183***	−0.114***	−0.172***
	(0.018)	(0.021)	(0.018)	(0.021)
Constant	0.221***	0.318***	0.210***	0.387***
	(0.022)	(0.024)	(0.040)	(0.038)
Student individual and family controls	No	No	Yes	Yes
Observations	19,791	19,790	19,791	19,790
Mean of Dep. Var.	0.093	0.105	0.093	0.105

Notes: Beta estimated by OLS linear regressions. Standard errors clustered at school level are reported in parentheses. **p < 0.01, ***p < 0.001.

7.8 percentage points, and 7.5 percentage points, respectively; all p-values <0.001). In line with these results, Appendix Table 1 (Panel B, Columns 5, 6, 7 and 8) shows that there were significant associations between any amount of outdoor time and both lower total difficulties scores (except at the more than 2-hour threshold) as well as higher prosocial scores (both when using the raw and standardized score).

The Association Between Free Time Activities and Adolescent Academic Performance

Table 3 (Panel A) shows that moderate screen time (up to 2 hours per day) had a positive association with academic performance. Specifically, screen time of up to 1 hour per day was associated with a 9.2 percentage-point increase in math scores (p<0.001). Likewise, daily screen time of 1–2 hours per day was associated with a 9.7 percentage-point increase in the standardized math score (p < 0.01). However, no significant link was found between longer screen time (>2 hours per day) and academic performance. The results in the adjusted equations (column 2) were consistent with those in the unadjusted equations, though the magnitude of the coefficients were slightly smaller. Specifically, screen time

Table 3 Linear Regression Results on Association Between Adolescent Free Time Activities and Academic Performance

	(1) Standardized Math Score	(2) Standardized Math Score
Panel A		
Screen time=0	Reference	Reference
Screen time <1hr	0.092***	0.079***
	(0.027)	(0.028)
Screen time 1–2hrs	0.097***	0.070**
	(0.031)	(0.030)
Screen time >2hrs	0.020	−0.015
	(0.034)	(0.033)
Panel B		
Outdoor time=0	Reference	Reference
Outdoor time <1hr	0.033	0.038
	(0.037)	(0.036)
Outdoor time 1–2hrs	0.050	0.065
	(0.044)	(0.042)
Outdoor time >2hrs	0.030	0.043
	(0.048)	(0.046)
Control variables		
Study time=0	Reference	Reference
Study time <1hr	0.425***	0.432***
	(0.044)	(0.042)
Study time 1–2hrs	0.844***	0.823***
	(0.048)	(0.045)
Study time > 2hrs	1.153***	1.116***
	(0.051)	(0.047)
Constant	−0.843***	−0.778***
	(0.076)	(0.160)
Student individual and family controls	No	Yes
Observations	19,791	19,791
Mean of Dep. Var.	0.000	0.000

Notes: Beta estimated by OLS linear regressions. Standard errors clustered at school level are reported in parentheses. **p < 0.01, ***p < 0.001.

of up to 1 hour was associated with a 7.9 percentage-point increase in math score (p<0.001), while screen time of 1–2 hours was associated with a 7.0 percentage-point increase in math score (p<0.01).

In contrast, there was no evidence of associations between outdoor time and academic performance (Table 3 Panel B). Compared to the reference group with no outdoor time, any amount of outdoor time (up to 1 hour, 1–2 hours, and over 2 hours) had no statistically significant correlation with math scores. This was the case both with and without controlling for other variables.

Discussion

This paper examined the prevalence of screen time and outdoor time and their associations with the mental health and academic performance of a sample of 20,375 junior high school students (referred to in this study as "adolescents") in rural schools in Ningxia, China. Average daily screen time was slightly above 1 hour. Around 15% of the sample adolescents had screen times of 2 hours or more (the maximum screen time for adolescents recommended by US and Canadian guidelines that are often cited in the international literature).[29,30] The average screen time of the sample adolescents was significantly lower than found in a previous study using national survey data from 2016 which found that a high share (39.5%) of their rural Chinese middle school sample students had average daily screen times of 2 hours or

more.[31] The lower rates of screen time usage in our sample may be due their lower levels of access to technology (only 29% of sample adolescents owned a phone, compared to 78% of rural Chinese middle school students nationwide in 2021).[32] The mean outdoor time (also 1 hour, or 60 minutes per day) among sample adolescents was also low compared to other studies in China and abroad. A 2013 national survey of rural adolescents found the mean outdoor time to be 103 minutes,[33] which may be due to regional differences or differences in the dates the surveys were conducted. The outdoor time of sample adolescents was also lower than the mean outdoor time among similarly aged adolescents in Germany (203 minutes) and the US (100 minutes),[34,35] though these disparities may also be attributable to secular trends related to the year that the surveys took place.

Further, the share of sample adolescents at risk for mental health problems was relatively high compared to similarly aged adolescents in high-income settings, with about 9% of the sample with an abnormal total difficulties score (≥19) and 11% with an abnormal prosocial score (≤4), compared to 5% and 4% in the US, respectively.[36] The mean total difficulties score (12.60) was also higher than that found in a sample including both urban and rural adolescents in the northeastern Chinese province of Liaoning (10.96) and was on par with a rural sample in the southeastern province of Jiangxi (12.93).[37,38] One potential reason for the relatively high share of abnormal behaviors experienced by our sample might be that more than a third of the adolescents were left-behind children (with no parents at home due to migration to cities for work) or partially left-behind children (with one parent not at home). Past literature has demonstrated that left-behind children – with lower levels of social support at home – are significantly more likely to be at risk of mental health problems than their peers.[39]

Screen Time and Mental Health

Our results showed a small but statistically significant positive association between screen time of up to 1 hour per day and a lower prevalence of SDQ scores in the abnormal range (for both the total difficulties and prosocial scores), echoing previous literature that found that moderate screen time can actually benefit adolescent mental health. This may especially be the case when the time spent is in the form of "active screen time" in which adolescents mentally or physically engage with digital content or when these activities are used to connect with others.[40,41] For example, research shows that popular games such as Minecraft provide avenues for interpersonal connection and creativity, which may benefit mental health.[4] However, we also observed a higher prevalence of abnormal total difficulties scores among students with screen time of more than 2 hours per day, which also aligns with past research that found that screen time above this threshold may be linked with increased levels of anxiety and depression symptoms among adolescents.[3] This finding is notable in the context of the recent Chinese minor protection policies that limit children and adolescents to 1 hour of video games on weekends and official holidays in that it presents empirical evidence to support the moderate use of technology among rural Chinese adolescents.[23]

Outdoor Time and Mental Health

While the association between screen time and mental health depended on the amount of time spent, the link between mental health and outdoor time was less variable. Specifically, our findings demonstrate that any amount of outdoor time was significantly associated with better mental health among adolescents, indicated by a lower prevalence of scores in the abnormal range of the SDQ total difficulties and prosocial subscales. These findings align with the previous literature in rural China and in other contexts like the US that highlight the benefits of outdoor time for adolescent mental health.[5,42] Our results also align with those of one past study of adults that showed that moderate amounts of outdoor time (ie, several hours per week) may be just as beneficial as longer amounts of outdoor time.[43] Considering the relatively low outdoor time of the sample adolescents and the high prevalence of mental health problems in rural China,[17] this preliminary evidence that integrating more time outdoors into the daily routines of adolescents could serve as a simple and low-cost intervention for improving the mental health outcomes for tens of millions of students. Future research is needed to investigate associations between specific types of outdoor activities (outdoor play activities, sports, nature-based activities, etc) and adolescent mental health in rural China.[33]

Screen Time and Academic Performance

Our finding that screen time of up to 2 hours per day was associated with higher standardized math scores and that screen time over this threshold had no significant association underscores the complex relationship between screen time and academic performance. A recent systematic review found no significant association between overall screen time and academic performance, although negative associations for certain kinds of screen time were identified.[44] This systematic review, however, did not compare the academic performance of adolescents at different thresholds of screen time (no screen time, up to 1 hour, 1–2 hours, etc). Other studies have generally found that screen time up to a certain limit is predictive of better academic performance, while higher amounts are not. One study in Canada, for example, found the highest-performing students were those whose screen time was 2–4 hours per day.[45]

However, just as in the case of the analysis of the association between screen time and mental health, the link between screen time and academic performance is likely dependent on a range of factors, such as the content accessed and context in which it is used. For instance, adolescents may use electronic devices to access learning resources (eg, computer assisted learning, digital textbooks, etc) or to engage in activities indirectly beneficial for learning (such as the potential of video games to improve children's visual and spatial reasoning).[46,47] In contrast, when time is spent on largely passive activities without educational value (such as watching certain television programs) or time is displaced from other activities more beneficial for a child's development, there is potential for screen time to negatively impact academic performance.[48] Future research will need to consider these factors when assessing the link between screen time and learning outcomes.

Outdoor Time and Academic Performance

The lack of a significant association between any amount of outdoor time (up to 1 hour, 1–2 hours, etc) and student academic performance in our study is in contrast with past research which has reported a positive link between outdoor activities – especially nature-based experiences – and cognitive adolescent outcomes like working memory and attentional control.[49,50] One potential reason for this difference is that there may be other domains of cognition that are linked with outdoor time that cannot be adequately measured by a standardized math test, such as creativity.[51] The generalized measurement of outdoor time in the current study may have also been a limitation, as – just like screen time activities – it is possible that certain outdoor activities (such as those that are unstructured and self-directed) may be more beneficial for a student's academic performance than others.[13] The setting of the outdoor time might also matter. Given Ningxia's relatively arid, desert-like terrain, sample rural students might not have had much access to "green spaces" (eg, settings with tree cover, vegetation, etc), which may provide unique benefits for student adolescent outcomes.[52]

Limitations and Implications

We acknowledge that there are several limitations to our study. First, due to the cross-sectional nature of our data, we cannot conduct a causal analysis of the impacts of screen time and outdoor time on mental health and academic performance. Future studies should implement experimental designs to examine such causal relationships. Second, as mentioned above, it is possible that screen time and outdoor time may be linked to academic or cognitive skills that cannot be adequately measured by a standardized math test, and further research should incorporate a greater diversity of academic performance and cognitive development measures. Finally, and importantly, our study did not distinguish between the various forms of screen time or outdoor time. Neither did we distinguish between free-time and school-related online activities. Exploring how specific activities within these broader categories relate to adolescent outcomes differently, as well as how they may displace other activities, will be important for informing the development of guidelines for adolescent free time allocation in the future. In the context of China, such a research agenda would be especially relevant in light of recent policy efforts to restrict child and adolescent time spent on video games to an hour a day on holidays and weekends.[23]

Conclusion

Building on past literature on the link between free time allocation and adolescent outcomes, this is the first study to use a large sample size from rural China to explore the prevalence of two common types of free time activities among adolescents (screen time and outdoor time) and their association with adolescent mental health and academic performance. On the one hand, moderate levels of daily screen time had positive associations with both student mental health (for up to 1 hour of screen time) and academic performance (for up to 2 hours of screen time) compared to no screen time, whereas an excessive amount of screen time (more than 2 hours per day) was found to be associated with worse mental health and had no statistically significant relationship with student academic outcomes. On the other hand, any amount of outdoor time had positive associations with adolescent mental health compared to no outdoor time (though there was no significant association with academic performance). This study's findings support the use of technologies in moderation and suggest that more efforts should be made to increase the time that adolescents spend outdoors. Future research should employ experimental designs to better understand the causal relationships between these variables, as well as explore how different forms of screen and outdoor activities are associated with adolescent outcomes.

Acknowledgments

We acknowledge collaborators from Queen's University, Belfast, and Sun Yat-sen University as well as the field research managers who made this study possible.

Disclosure

Dr Singh has received research support from Stanford's Maternal Child Health Research Institute and Stanford's Department of Psychiatry and Behavioral Sciences, National Institute of Mental Health, National Institute of Aging, Patient-Centered Outcomes Research Institute, Johnson & Johnson, and the Brain and Behavior Research Foundation. She is on the advisory board for Sunovion and Skyland Trail, is a consultant for Johnson & Johnson, Alkermes, and Neumora. She has previously consulted for X, Moonshot Factory, Alphabet Inc. and Limbix Health. She receives honoraria from the American Academy of Child and Adolescent Psychiatry, and royalties from American Psychiatric Association Publishing and Thrive Global. The authors report no other conflicts of interest.

References

1. Coyle KJ. Create high performing students. *Natl Wildl Fed*. 2010;41:163.
2. Larson LR, Szczytko R, Bowers EP, Stephens LE, Stevenson KT, Floyd MF. Outdoor time, screen time, and connection to nature: troubling trends among rural youth? *Environ Behav*. 2019;51(8):966–991. doi:10.1177/0013916518806686
3. Oberle E, Ji XR, Kerai S, Guhn M, Schonert-Reichl KA, Gadermann AM. Screen time and extracurricular activities as risk and protective factors for mental health in adolescence: a population-level study. *Prev Med*. 2020;141:106291. doi:10.1016/j.ypmed.2020.106291
4. Przybylski AK, Weinstein N. A large-scale test of the goldilocks hypothesis: quantifying the relations between digital-screen use and the mental well-being of adolescents. *Psychol Sci*. 2017;28(2):204–215. doi:10.1177/0956797616678438
5. Jackson SB, Stevenson KT, Larson LR, Peterson MN, Seekamp E. Outdoor activity participation improves adolescents' mental health and well-being during the COVID-19 pandemic. *Int J Environ Res Public Health*. 2021;18(5):2506. doi:10.3390/ijerph18052506
6. Bratman GN, Daily GC, Levy BJ, Gross JJ. The benefits of nature experience: improved affect and cognition. *Landsc Urban Plan*. 2015;138:41–50. doi:10.1016/j.landurbplan.2015.02.005
7. Dzhambov A, Hartig T, Markevych I, Tilov B, Dimitrova D. Urban residential greenspace and mental health in youth: different approaches to testing multiple pathways yield different conclusions. *Environ Res*. 2018;160:47–59. doi:10.1016/j.envres.2017.09.015
8. Huynh Q, Craig W, Janssen I, Pickett W. Exposure to public natural space as a protective factor for emotional well-being among young people in Canada. *BMC Public Health*. 2013;13(1):407. doi:10.1186/1471-2458-13-407
9. Vanaken GJ, Danckaerts M. Impact of green space exposure on children's and adolescents' mental health: a systematic review. *Int J Environ Res Public Health*. 2018;15(12):2668. doi:10.3390/ijerph15122668
10. Johnson G. Cognitive processing differences between frequent and infrequent Internet users. *Comput Hum Behav*. 2008;24:2094–2106. doi:10.1016/j.chb.2007.10.001
11. Yan H, Zhang R, Oniffrey TM, et al. Associations among screen time and unhealthy behaviors, academic performance, and well-being in Chinese adolescents. *Int J Environ Res Public Health*. 2017;14(6):596. doi:10.3390/ijerph14060596
12. Taras H. Physical activity and student performance at school. *J Sch Health*. 2005;75(6):214–218. doi:10.1111/j.1746-1561.2005.00026.x
13. Kemple KM, Oh J, Kenney E, Smith-Bonahue T. The power of outdoor play and play in natural environments. *Child Educ*. 2016;92(6):446–454. doi:10.1080/00094056.2016.1251793
14. Markevych I, Feng X, Astell-Burt T, et al. Residential and school greenspace and academic performance: evidence from the GINIplus and LISA longitudinal studies of German adolescents. *Environ Pollut*. 2019;245:71–76. doi:10.1016/j.envpol.2018.10.053

15. Li L, Zeng Y, Zhang Z, Fu C. The impact of internet use on health outcomes of rural adults: evidence from China. *Int J Environ Res Public Health*. 2020;17(18):6502. doi:10.3390/ijerph17186502
16. Kandola A, Del Pozo Cruz B, Hayes JF, Owen N, Dunstan DW, Hallgren M. Impact on adolescent mental health of replacing screen-use with exercise: a prospective cohort study. *J Affect Disord*. 2022;301:240–247. doi:10.1016/j.jad.2021.12.064
17. Jiang Q, She X, Dill SE, et al. Depressive and anxiety symptoms among children and adolescents in Rural China: a large-scale epidemiological study. *Int J Environ Res Public Health*. 2022;19(9):5026. doi:10.3390/ijerph19095026
18. Yang J; Huang X, Liu X. An analysis of education inequality in China. *Int J Educ Dev*. 2014;37:2–10. doi:10.1016/j.ijedudev.2014.03.002
19. Wang L, Min W, Zhang S, Shi Y, Rozelle S. Math and Chinese-Language learning: where are China's vulnerable subpopulations? *Asian Surv*. 2018;58(5):797–821. doi:10.1525/as.2018.58.5.797
20. Rozelle S, Hell N Invisible China: how the Urban-Rural divide threatens China's rise. University of Chicago Press; 2022. Available from: https://press.uchicago.edu/ucp/books/book/chicago/I/bo61544815.html. Accessed July 12, 2022.
21. CNNIC. National report on internet usage of minors; 2020. Available from: https://pic.cyol.com/img/20210720/img_960114c132531c521023e29b6c223e438461.pdf. Accessed February 13, 2023.
22. Poushter J. China outpaces India in internet access, smartphone ownership. Pew Research Center. Available from: https://www.pewresearch.org/fact-tank/2017/03/16/china-outpaces-india-in-internet-access-smartphone-ownership/. Accessed July 12, 2022.
23. National Press and Publication Administration. Notice about further increasing strict enforcement to prevent the internet addiction among minors; 2021. Available from: http://www.gov.cn/zhengce/zhengceku/2021-09/01/content_5634661.htm. Accessed July 6, 2022.
24. National Bureau of Statistics GDP per capita; 2021. Available from: https://data.stats.gov.cn/easyquery.htm?cn=E0103&zb=A0201&reg=640000&sj=2021. Accessed July 13, 2022.
25. He M, Xiang F, Zeng Y, et al. Effect of time spent outdoors at school on the development of myopia among children in china: a randomized clinical trial. *JAMA*. 2015;314(11):1142–1148. doi:10.1001/jama.2015.10803
26. van der Ploeg HP, Merom D, Chau JY, Bittman M, Trost SG, Bauman AE. Advances in population surveillance for physical activity and sedentary behavior: reliability and validity of time use surveys. *Am J Epidemiol*. 2010;172(10):1199–1206. doi:10.1093/aje/kwq265
27. Goodman R. The strengths and difficulties questionnaire: a research note. *J Child Psychol Psychiatry*. 1997;38(5):581–586. doi:10.1111/j.1469-7610.1997.tb01545.x
28. Liang L, Yang J, Yao S. Measurement equivalence of the SDQ in Chinese Adolescents: a horizontal and longitudinal perspective. *J Affect Disord*. 2019;257:439–444. doi:10.1016/j.jad.2019.06.049
29. Hill D, Ameenuddin N; Council on Communications and Media. Media use in school-aged children and adolescents. *Pediatrics*. 2016;138(5):e20162592. doi:10.1542/peds.2016-2592
30. Tremblay MS, Carson V, Chaput JP, 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(Suppl. 3):S311–S327. doi:10.1139/apnm-2016-0151
31. Cai Y, Zhu X, Wu X. Overweight, obesity, and screen-time viewing among Chinese school-aged children: national prevalence estimates from the 2016 Physical Activity and Fitness in China—The Youth Study. *J Sport Health Sci*. 2017;6(4):404–409. doi:10.1016/j.jshs.2017.09.002
32. Liu J, Liu H. *Regional Education Quality Health Checkups*. Beijing Normal University; 2020.
33. Gao F, Guo Q, Wang B, et al. Distributions and determinants of time spent outdoors among school-age children in China. *J Expo Sci Environ Epidemiol*. 2022;32(2):223–231. doi:10.1038/s41370-021-00401-w
34. Conrad A, Seiwert M, Hünken A, Quarcoo D, Schlaud M, Groneberg D. The German Environmental Survey for Children (GerES IV): reference values and distributions for time-location patterns of German children. *Int J Hyg Environ Health*. 2013;216(1):25–34. doi:10.1016/j.ijheh.2012.02.004
35. EPA. Exposure Factors Handbook; 2011. Available from: https://ordspub.epa.gov/ords/eims/eimscomm.getfile?p_download_id=526179. Accessed February 13, 2023.
36. NHIS. Normative SDQ Data from the USA; 2001. Available from: https://www.sdqinfo.org/norms/USNorm.html. Accessed February 13, 2023.
37. Liu L, Li S, Pan W, et al. Prevalence of mental health problems in Chinese schoolchildren: the influence of measuring impact score and combining information from multiple informants. *Child Adolesc Psychiatry Ment Health*. 2020;14:44. doi:10.1186/s13034-020-00346-2
38. Wang H, Abbey C, She X, Rozelle S, Ma X. Association of child mental health with child and family characteristics in Rural China: a cross-sectional analysis. *Int J Environ Res Public Health*. 2021;18(10):5107. doi:10.3390/ijerph18105107
39. Wu W, Qu G, Wang L, Tang X, Sun YH. Meta-analysis of the mental health status of left-behind children in China. *J Paediatr Child Health*. 2019;55(3):260–270. doi:10.1111/jpc.14349
40. Sweetser P, Johnson D, Ozdowska A, Wyeth P. Active versus passive screen time for young children. *Australas J Early Child*. 2012;37(4):94–98. doi:10.1177/183693911203700413
41. Fry C. Sleep deprived but socially connected: balancing the risks and benefits of adolescent screen time during COVID-19. *J Child Media*. 2021;15(1):37–40. doi:10.1080/17482798.2020.1858907
42. Hou T, Mao X, Dong W, Cai W, Deng G. Prevalence of and factors associated with mental health problems and suicidality among senior high school students in rural China during the COVID-19 outbreak. *Asian J Psychiatry*. 2020;54:102305. doi:10.1016/j.ajp.2020.102305
43. White MP, Alcock I, Grellier J, et al. Spending at least 120 minutes a week in nature is associated with good health and wellbeing. *Sci Rep*. 2019;9(1):7730. doi:10.1038/s41598-019-44097-3
44. Adelantado-Renau M, Moliner-Urdiales D, Cavero-Redondo I, Beltran-Valls MR, Martínez-Vizcaíno V, Álvarez-Bueno C. Association between screen media use and academic performance among children and adolescents: a systematic review and meta-analysis. *JAMA Pediatr*. 2019;173(11):1058–1067. doi:10.1001/jamapediatrics.2019.3176
45. Faught EL, Gleddie D, Storey KE, Davison CM, Veugelers PJ. Healthy lifestyle behaviours are positively and independently associated with academic achievement: an analysis of self-reported data from a nationally representative sample of Canadian early adolescents. *PLoS One*. 2017;12(7):e0181938. doi:10.1371/journal.pone.0181938
46. Anobile G, Stievano P, Burr D. Visual sustained attention and numerosity sensitivity correlate with math achievement in children. *J Exp Child Psychol*. 2013;116:380–391. doi:10.1016/j.jecp.2013.06.006
47. Green CS, Bavelier D. Action-video-game experience alters the spatial resolution of vision. *Psychol Sci*. 2007;18(1):88–94. doi:10.1111/j.1467-9280.2007.01853.x

48. Kostyrka-Allchorne K, Cooper NR, Simpson A. The relationship between television exposure and children's cognition and behaviour: a systematic review. *Dev Rev*. 2017;44:19–58. doi:10.1016/j.dr.2016.12.002
49. Briki W, Majed L. Adaptive effects of seeing green environment on psychophysiological parameters when walking or running. *Front Psychol*. 2019;10. doi:10.3389/fpsyg.2019.00252
50. Schertz KE, Berman MG. Understanding nature and its cognitive benefits. *Curr Dir Psychol Sci*. 2019;28(5):496–502. doi:10.1177/0963721419854100
51. Kiewra C, Veselack E. Playing with nature: supporting preschoolers' creativity in natural outdoor classrooms. *Int J Early Child Environ Educ*. 2016;4(1):70–95.
52. Hodson CB, Sander HA. Green urban landscapes and school-level academic performance. *Landsc Urban Plan*. 2017;160:16–27. doi:10.1016/j.landurbplan.2016.11.011