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Association between screen time, homework and reading duration, sleep duration, social jetlag and mental health among Chinese children and adolescents

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Abstract

Objectives To examine the associations of screen time, homework and reading duration, sleep duration, social jetlag with mental health in children and adolescents, as well as its gender differences.

Methods From December 2023 to April 2024, a total of 62 395 children and adolescents were selected from 51 schools in 17 cities of China by stratified cluster sampling. Screen time, homework and reading duration, sleep duration, and social jetlag were calculated by answering the questions about watching TV time, playing smartphones time, doing homework time, reading extracurricular books time, bedtime, wake-up time, and nap time during weekdays and weekends. Mental health was assessed by the Revised Mental Health Inventory-5 (MHI-5). The generalized linear model was used to determine the association between screen time, homework and reading duration, sleep duration, social jetlag, and mental health in children and adolescents.

Results The generalized linear model results showed that longer watching TV time, longer playing smartphones time, longer homework time, and greater social jetlag were correlated with poorer mental health in children and adolescents, while longer nighttime sleep duration, and longer daytime nap duration were correlated with better mental health. Moreover, in primary school and junior high school, we found that this association was stronger during the weekdays. However, in senior high school, this association was stronger during the weekends. After according to gender stratified, we found that the strength of this association was different in boys and girls at different study phases. Furthermore, our findings also revealed a significant quadratic relationship, indicating the association of better mental health with an optimal amount of sleep duration.

Conclusions There was a significant association between screen time, homework and reading duration, sleep duration, social jetlag, and mental health in children and adolescents. This study has the potential to offer useful insights for the prevention and control of mental health issues in children and adolescents.

Keywords Screen time, Homework and reading duration, Sleep duration, Social jetlag, Mental health

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Introduction

Mental health includes a series of social, mental, emotional, and behavioral functions, which is a continuous process from good to poor [1]. Children and adolescents are particularly vulnerable to developing mental health problems because their brains are still developing [2]. According to 2021 data from the World Health Organization, an estimated 14% of children and adolescents aged 10~19 suffer from mental health issues globally, accounting for 13% of all diseases affecting this population [3]. Furthermore, before the COVID-19 pandemic, projections indicated that up to 20% of children and adolescents suffered from mental health disorders, and 16% of the global burden of disease and injury among individuals aged 10~19 could be attributed to mental health conditions [4]. Mental health disorders are the result of the interaction of biological, psychological and social factors [5]. In terms of psychological and social factors, longer screen time [6], longer homework and reading duration [7], shorter sleep duration [8], and greater social jetlag [9] may have a significant impact on the mental health of children and adolescents.

With the rapid development of technology and electronic devices are everywhere in our lives, there is growing concern about the psychological impact of prolonged screen time, especially for children and adolescents [10]. Research has shown a complex bidirectional relationship of screen time with mental health among children and adolescents [11], while some studies have found no association [12]. Moreover, several studies have shown that screen time is also correlated with increased psychological distress [13], anxiety [14], depression [15], and low self-esteem [16] among children and adolescents. Similarly, this assertion is reinforced by a recent study in Finland, which revealed that excessive screen time among 5-year-old children is correlated with a range of psychosocial symptoms [17].

In addition, school-aged children and adolescents often endure substantial academic pressures because they need to complete academic assignments or engage in related activities [18]. Previous research has indicated that heavy academic burdens can adversely impact the mental health of children and adolescents [19]. For example, a recent study of 1 225 children and adolescents aged 13~19 years in Singapore found that spending more time studying and doing homework was positively associated with higher depressive symptoms [7]. Similarly, a study of 3 967 children and adolescents aged 11~19 in China found that time spent on homework more than 3 h per day was positively correlated with depressive symptoms in both boys and girls [20]. Compared with other countries and regions, Chinese children and adolescents face fierce academic competition and pressure, and their academic burdens are heavier. They often feel stressed and

anxious because of homework and after-school studies [21].

Sleep duration, a crucial sleep metric, is often investigated in relation to health consequences. In children and adolescents, adequate sleep duration has been linked to better attention, emotional regulation, cognitive functioning, behavior, and physical health [22]. Conversely, inadequate sleep has been linked to negative health effects, such as hypertension, diabetes, and obesity [23]. Furthermore, some research suggests that sleep duration may be related to mental health among children and adolescents [24, 25]. In these studies, it has been observed that children and adolescents who sleep for less than the recommended hours are at a higher risk of developing mental health disorders [26, 27]. For instance, a study of 18 250 children and adolescents aged 12~18 in Japan found that sleep duration less than 8.5 h per day in boys and less than 7.5 h per day in girls had a higher risk of depression/anxiety symptoms [28].

In addition to short sleep duration, social jetlag is also reported to be prevalent among children and adolescents [29]. Social jetlag refers to the mismatch between an individual's intrinsic circadian rhythm and social timing, quantifying the discrepancy between biological and social time [30]. Recent studies have reinforced the focus on the relationship between social jetlag and mental health among children and adolescents, particularly with regard to anxiety [31] and depression [32, 33]. For example, a study of 3 097 children and adolescents in America found that social jetlag is positively and independently associated with anxiety symptoms [34]. Similarly, a study conducted on 37 871 children and adolescents in China found that social jetlag of more than 2 h is correlated with a higher risk of depression [35]. However, there is some inconsistent evidence. For instance, a study of 4 787 children and adolescents in Hong Kong, China found that while social jetlag was correlated with poor mental health, the association disappeared when sleep problems were considered [36].

Based on the aforementioned evidence, it is reasonable to hypothesize that longer screen time, longer homework and reading duration, shorter sleep duration, and greater social jetlag may be a potential risk factor for mental health in children and adolescents. Therefore, we conducted a cross-sectional investigation of the association between screen time, homework and reading duration, sleep duration, social jetlag, and mental health in Chinese children and adolescent to test this hypothesis. The primary aim of this study was to investigate the associations of screen time, homework and reading duration, sleep duration, and social jetlag with mental health among Chinese children and adolescents, as well as its gender differences.

Methods

Participants

This research was conducted between December 2023 and April 2024. Participants were recruited from 17 cities in China including Anqing, Bengbu, Shenyang, Chizhou, Chuzhou, Ganzhou, Hefei, Huangshan, Jian, Jiujiang, Luan, Maanshan, Nanchang, Shaoyang, Xuancheng, Yangzhou, and Zhongshan, using stratified cluster sampling. First, 17 cities were selected by convenience sampling. Then, 1 primary school (4~6 grade), 1 junior high school, and 1 senior high school were randomly selected for each city using stratified cluster sampling. Finally, all students from 51 schools were required to complete a questionnaire survey. Students completed the electronic questionnaire by using smartphones to scan the quick response code. A total of 62 395 questionnaires were sent out, 37 989 were returned and 37 894 were valid. The effective questionnaire rate was 99.7%.

The Ethics Committee of Anhui Medical University approved this study (NO: 20210735). Both the adult participants and the parents / guardians of all under-18s provided written informed consent.

Sociodemographic data

The following sociodemographic characteristics were obtained: age, gender (boys, girls), ethnicity (Han-ethnicity, others), study phase (primary school, junior high school, senior high school), and self-reported learning burden (a little, some, much).

Screen time assessment

Watching TV time was assessed with the following 2 questions with 2 parts each: (1) "How many hours per day do you spend on watching TV on weekdays?" (2) "How many hours per day do you spend on watching TV on weekend days?" These questions were used to create the watching TV time on weekdays and weekends, separately. Average daily watching TV time was calculated: $(5/7 \times [\text{watching TV time on weekdays}] + 2/7 \times [\text{watching TV time on weekend days}])$. Playing smartphones time was assessed with the following 2 questions with 2 parts each: (1) "How many hours per day do you spend on playing smartphones on weekdays?" (2) "How many hours per day do you spend on playing smartphones on weekend days?" These questions were used to create the playing smartphone time on weekdays and weekends, separately. Average daily playing smartphones time was calculated: $(5/7 \times [\text{playing smartphones time on weekdays}] + 2/7 \times [\text{playing smartphones time on weekend days}])$.

Homework and reading duration assessment

Doing homework time was assessed with the following 2 questions with 2 parts each: (1) "How many hours per

day do you spend on doing homework on weekdays?" (2) "How many hours per day do you spend on doing homework on weekend days?" These questions were used to create the homework time on weekdays and weekends, separately. Average daily homework time was calculated: $(5/7 \times [\text{doing homework time on weekdays}] + 2/7 \times [\text{doing homework time on weekend days}])$. Reading extracurricular books time was assessed with the following 2 questions with 2 parts each: (1) "How many hours per day do you spend on reading extracurricular books on weekdays?" (2) "How many hours per day do you spend on reading extracurricular books on weekend days?" These questions were used to create the reading extracurricular books time on weekdays and weekends, separately. Average daily reading extracurricular books time was calculated: $(5/7 \times [\text{reading extracurricular books on weekdays}] + 2/7 \times [\text{reading extracurricular books time on weekend days}])$.

Sleep duration assessment

Nighttime sleep duration was assessed with the following 2 questions with 2 parts each: (1) "What time do you usually go to bed on a weeknight?" "What time do you usually get up on a weekday?" (2) "What time do you usually go to bed on a weekend night?" "What time do you usually get up on a weekend day?" These questions were used to create the nighttime sleep duration on weekdays and weekends, separately. Average daily nighttime sleep duration was calculated: $(5/7 \times [\text{nighttime sleep duration on weekdays}] + 2/7 \times [\text{nighttime sleep duration on weekend days}])$. Daytime nap duration was assessed with the following 2 questions with 2 parts each: (1) "How many hours per day do you spend on nap duration on weekdays?" (2) "How many hours per day do you spend on nap duration on weekend days?" These questions were used to create the nap duration on weekdays and weekends, separately. Average daily nap duration was calculated: $(5/7 \times [\text{nap duration on weekdays}] + 2/7 \times [\text{nap duration on weekend days}])$.

Social jetlag assessment

Social jetlag was assessed by to investigate the bedtime and wake-up time of children and adolescents on weekdays and weekends, and to calculate the midsleep on weekdays and weekends respectively [37]. The social jetlag value is the absolute value of the difference between the midsleep of weekends and the midsleep of weekdays.

Mental health assessment

The Revised Mental Health Inventory-5 (MHI-5) was used to assess mental health in children and adolescents [38]. The MHI-5 is a questionnaire with 5 items, and each item is scored from 0 to 3 using the Likert scale (0=never, 1=sometimes, 2=several times, and 3=always). The 5

items pertain to mood during the past month, assessing the presence of psychological well-being and the absence of psychological distress. The total score ranges from 0 to 15, with higher scores indicating better mental health. In this study, the Cronbach's alpha coefficient of MHI-5 was 0.60.

Covariates

Confounding factors controlled for in this study included age, gender, ethnicity, self-reported learning burden, arrangement between classes at school, weekdays outdoor time, weekends outdoor time, and sleep latency. Arrangement between classes at school was assessed by asking "During the past month, what is your arrangement between classes at school?" The answers were recorded as "rest at the desk", "activities inside the classroom", "activities outside the classroom", and "no rest, keep learning". Weekdays and weekends outdoor time was recoded into 3 categories: "< 1 h/d", "1~2 h/d", and "> 2 h/d". Sleep latency was assessed by asking "During the past month, how long has it usually taken you to fall asleep?" The answers were recorded as "≤ 15 min", "16~30 min", "31~60 min", and "> 60 min".

Statistical analyses

Statistical analyses were performed using SPSS 23.0 software and R 4.1.1 software. Categorical variables were expressed as frequency (percentages) and continuous variables as mean±standard deviation. The measured non-normal distribution was represented by the median and interquartile range. Spearman correlations between screen time, homework and reading duration, sleep duration, social jetlag, and mental health were calculated. The generalized linear model was used to determine the relationship between screen time, homework and reading duration, sleep duration, social jetlag, and mental health. β value and 95% confidence intervals (95%CI) were calculated for the explanatory factors. Specifically, the generalized linear model was initially employed to evaluate the separate effect of 19 independent variables on mental health. Subsequently, the effects of potential interactions were assessed by incorporating the combined effects of these 19 independent variables and gender on mental health into the interaction model, respectively. Ultimately, the separate effect of 19 independent variables on mental health for each gender was established by stratifying the sample by gender. Furthermore, we also conducted an analysis to examine the quadratic effect of sleep duration on mental health. In the generalized linear model, we using a linear equation minimizing residual deviance. Under the condition of heteroscedasticity in the residual of the model, the robust estimator was employed. The overall significance of the model was determined using the Omnibus test χ^2 . Models that were

not statistically significant were rejected. Goodness-of-fit test was also employed to evaluate how well the statistical model fits the set of observations. The Akaike's Information Criterion and deviance statistic were used as standards to judge the quality of the model. Moreover, 19 independent variables were standardized (mean=0, SD=1) before being included into the models. Therefore, we report standardized β coefficients and 95%CI throughout the results. Meanwhile, prior to the analysis, multicollinearity was examined by calculating the variance inflation factor (VIF), with a cut-off of 5 indicating potential problematic multicollinearity. In this study, VIF spanning from 1.006~2.749, not exist multicollinearity. A two-tailed P value<0.05 was regarded as statistically significant.

Results

Characteristics of the study sample

In this study, the mean age of participants was 14.41 years (SD=2.88), and 53.1% (20 116/37 894) were boys. The majority of the 37 894 participants in this sample were of Han ethnicity (97.3%, $n=36 861$). Table 1 shows the characteristics of the study sample.

Spearman correlations between screen time, homework and reading duration, sleep duration, social jetlag and mental health in children and adolescents

Spearman coefficients of correlations between screen time, homework and reading duration, sleep duration, social jetlag, and mental health were presented in the heatmap (Fig. 1) and Table S1. In primary school, watching TV time, playing on smartphones time, doing homework time, and social jetlag showed a weak but significant negative correlations with mental health. The reading of extracurricular books time, nighttime sleep duration, and daytime nap duration showed a weak but significant positive correlations with mental health. In junior high school and senior high school, playing on smartphones time, doing homework time, and social jetlag showed a weak but significant negative correlations with mental health. The reading of extracurricular books time, nighttime sleep duration, and daytime nap duration showed a weak but significant positive correlations with mental health. Interestingly, we found that watching TV only negatively affected the mental health of primary school students but not junior high school and senior high school students.

Association between screen time, homework and reading duration, sleep duration, social jetlag and mental health in children and adolescents by generalized linear model

The generalized linear model results showed that, in primary school and junior high school, longer watching TV time, longer playing smartphones time, longer homework time, and greater social jetlag were correlated with

Table 1 Characteristics of the study sample

Variables	Overall (n = 37 894)	Primary school (n = 10 429)	Junior high school (n = 12 195)	Senior high school (n = 15 270)
Age, y, mean ± SD	14.41 ± 2.88	10.81 ± 1.55	14.05 ± 1.28	17.15 ± 1.09
Gender, n(%)				
Boys	20,116 (53.1)	5516 (52.9)	6262 (51.3)	8338 (54.6)
Girls	17,778 (46.9)	4913 (47.1)	5933 (48.7)	6932 (45.4)
Ethnicity, n(%)				
Han-ethnicity	36,861 (97.3)	10,132 (97.2)	11,979 (98.2)	14,750 (96.6)
Others	1033 (2.7)	297 (2.8)	216 (1.8)	520 (3.4)
Self-reported learning burden, n(%)				
A little	3781 (10.0)	1652 (15.8)	827 (6.8)	1302 (8.5)
Some	24,875 (65.6)	7643 (73.3)	8375 (68.7)	8857 (58.0)
Much	9238 (24.4)	1134 (10.9)	2993 (24.5)	5111 (33.5)
Arrangement between classes at school, n(%)				
Rest at the desk	8362 (22.1)	1317 (12.6)	2325 (19.1)	4720 (30.9)
Activities inside the classroom	12,675 (33.4)	3607 (34.6)	4264 (35.0)	4804 (31.5)
Activities outside the classroom	15,552 (41.0)	5322 (51.0)	5181 (42.5)	5049 (33.1)
No rest, keep learning	1305 (3.4)	183 (1.8)	425 (3.5)	697 (4.6)
Weekdays outdoor time, n(%)				
< 1 h/d	17,803 (47.0)	4899 (47.0)	5268 (43.2)	7636 (50.0)
1 ~ 2 h/d	11,658 (30.8)	3391 (32.5)	3946 (32.4)	4321 (28.3)
> 2 h/d	8433 (22.3)	2139 (20.5)	2981 (24.4)	3313 (21.7)
Weekends outdoor time, n(%)				
< 1 h/d	16,081 (42.4)	3730 (35.8)	4904 (40.2)	7447 (48.8)
1 ~ 2 h/d	11,566 (30.5)	3371 (32.3)	3887 (31.9)	4308 (28.2)
> 2 h/d	10,247 (27.1)	3328 (31.9)	3404 (27.9)	3515 (23.0)
Sleep latency, n(%)				
≤ 15 min	20,162 (53.2)	5594 (53.6)	6796 (55.7)	7772 (50.9)
16 ~ 30 min	13,878 (36.6)	4083 (39.2)	4356 (35.7)	5439 (35.6)
31 ~ 60 min	2659 (7.0)	572 (5.5)	711 (5.8)	1376 (9.0)
> 60 min	1195 (3.2)	180 (1.7)	332 (2.7)	683 (4.5)
Screen time, h/d, Median (IQR)				
Watching TV	0.29 (0.00 ~ 0.86)	0.43 (0.03 ~ 1.14)	0.29 (0.00 ~ 0.86)	0.00 (0.00 ~ 0.57)
Weekdays watching TV	0.00 (0.00 ~ 0.03)	0.00 (0.00 ~ 0.50)	0.00 (0.00 ~ 0.02)	0.00 (0.00 ~ 0.00)
Weekends watching TV	0.83 (0.00 ~ 2.00)	1.00 (0.05 ~ 2.00)	1.00 (0.00 ~ 2.00)	0.00 (0.00 ~ 1.02)
Playing smartphones	0.30 (0.00 ~ 1.29)	0.29 (0.00 ~ 0.64)	0.29 (0.00 ~ 0.93)	0.71 (0.03 ~ 2.14)
Weekdays playing smartphones	0.00 (0.00 ~ 0.50)	0.00 (0.00 ~ 0.33)	0.00 (0.00 ~ 0.33)	0.00 (0.00 ~ 1.00)
Weekends playing smartphones	1.00 (0.02 ~ 3.00)	0.50 (0.00 ~ 2.00)	1.00 (0.00 ~ 2.00)	2.00 (0.07 ~ 5.00)
Homework and reading duration, h/d, Median (IQR)				
Doing homework	1.64 (0.86 ~ 2.86)	1.30 (0.86 ~ 2.31)	1.71 (1.00 ~ 2.76)	1.71 (0.57 ~ 3.07)
Weekdays doing homework	1.25 (0.60 ~ 2.50)	1.00 (0.68 ~ 2.00)	1.50 (1.00 ~ 2.03)	1.50 (0.33 ~ 3.00)
Weekends doing homework	2.00 (1.00 ~ 4.00)	2.00 (1.00 ~ 3.00)	2.00 (1.00 ~ 4.00)	2.00 (0.38 ~ 4.00)
Reading extracurricular books	0.64 (0.14 ~ 1.29)	0.64 (0.36 ~ 1.29)	0.64 (0.29 ~ 1.29)	0.57 (0.00 ~ 1.43)
Weekdays reading extracurricular books	0.50 (0.00 ~ 1.00)	0.50 (0.33 ~ 1.00)	0.50 (0.02 ~ 1.00)	0.42 (0.00 ~ 1.00)
Weekends reading extracurricular books	1.00 (0.03 ~ 2.00)	1.00 (0.50 ~ 2.00)	1.00 (0.48 ~ 2.00)	1.00 (0.00 ~ 2.00)
Sleep duration, h/d, Median (IQR)				
Nighttime sleep duration	8.93 (8.33 ~ 9.58)	9.64 (9.29 ~ 10.02)	8.86 (8.43 ~ 9.29)	8.50 (7.85 ~ 9.01)
Weekdays nighttime sleep duration	8.50 (8.00 ~ 9.42)	9.50 (9.00 ~ 10.00)	8.33 (8.00 ~ 9.00)	8.00 (7.50 ~ 8.83)
Weekends nighttime sleep duration	10.00 (9.00 ~ 10.50)	10.00 (9.92 ~ 11.00)	10.00 (9.25 ~ 10.77)	9.00 (8.00 ~ 10.00)
Daytime nap duration	0.50 (0.21 ~ 0.75)	0.29 (0.00 ~ 0.52)	0.50 (0.24 ~ 0.71)	0.64 (0.38 ~ 0.93)
Weekdays daytime nap duration	0.50 (0.17 ~ 0.67)	0.25 (0.00 ~ 0.50)	0.50 (0.25 ~ 0.67)	0.58 (0.50 ~ 1.00)
Weekends daytime nap duration	0.50 (0.00 ~ 1.00)	0.15 (0.00 ~ 0.50)	0.50 (0.00 ~ 1.00)	0.50 (0.03 ~ 1.00)

Table 1 (continued)

Variables	Overall (n = 37 894)	Primary school (n = 10 429)	Junior high school (n = 12 195)	Senior high school (n = 15 270)
Social jetlag, h, Median (IQR)	0.75 (0.42 ~ 1.17)	0.75 (0.46 ~ 1.00)	0.75 (0.42 ~ 1.08)	0.75 (0.40 ~ 1.45)
MHI-5 scores, Median (IQR)	10.00 (8.00 ~ 12.00)	11.00 (9.00 ~ 13.00)	10.00 (8.00 ~ 12.00)	9.00 (7.00 ~ 11.00)

Note: SD, standard deviation; y, year; h, hour; d, day; min, minute; IQR, interquartile range; MHI-5, Mental Health Inventory-5

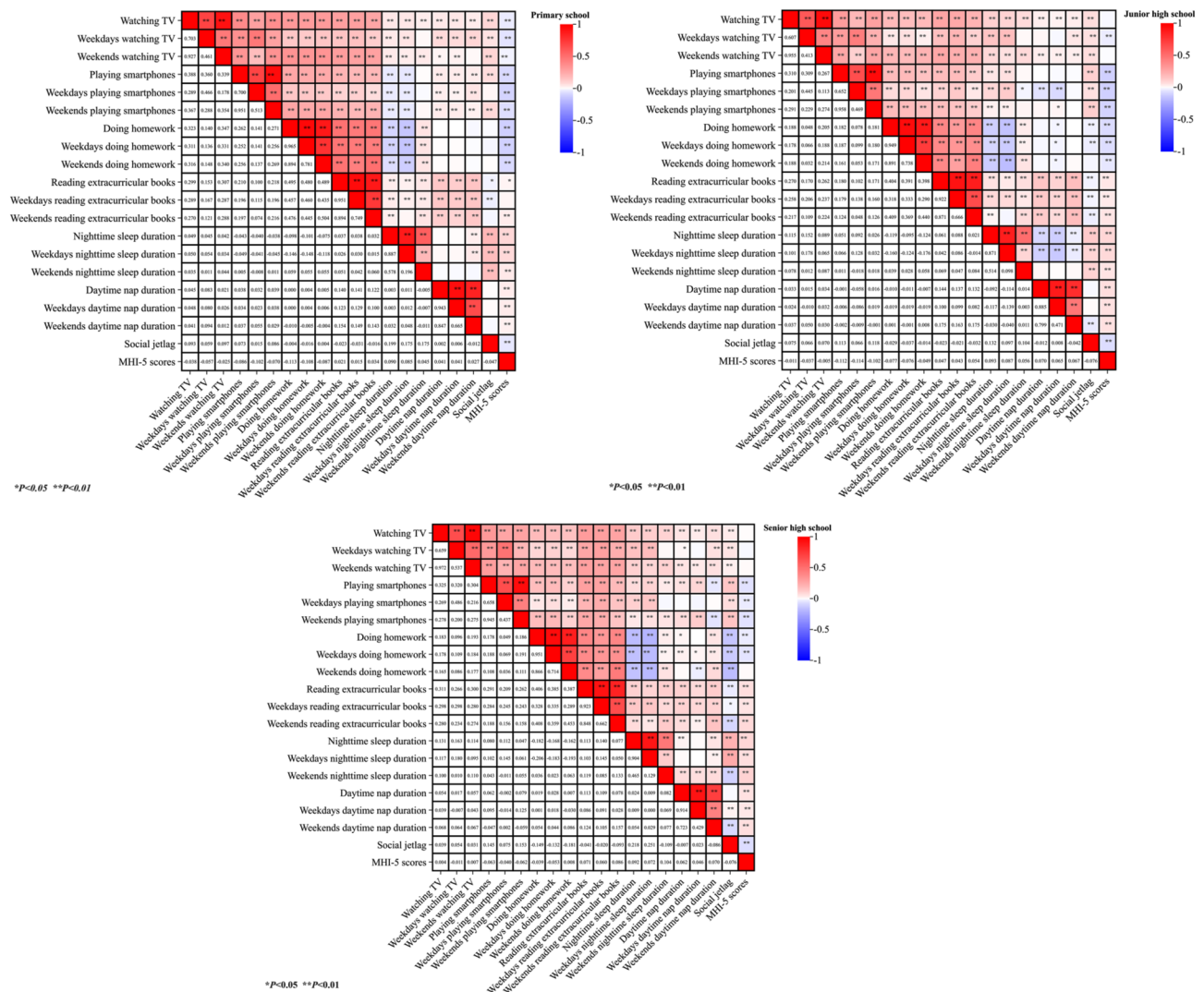


Fig. 1 Heatmap of the association between screen time, homework and reading duration, sleep duration, social jetlag and mental health in children and adolescents. Red indicate a positive association and blue indicate a negative association

poorer mental health in children and adolescents, while longer nighttime sleep duration, and longer daytime nap duration were correlated with better mental health. In senior high school, longer playing smartphones time, longer homework time, and greater social jetlag were correlated with poorer mental health in children and adolescents, while longer nighttime sleep duration, and longer daytime nap duration were correlated with better mental health. Moreover, in primary school and junior

high school, we found that this association was stronger during the weekdays. However, in senior high school, this association was stronger during the weekends. Meanwhile, we found that these effects persisted even after adjusting for covariates. As shown in Fig. 2 and Table S2. In addition, we also found that there was a significant interactions between screen time, homework and reading duration, sleep duration, social jetlag and gender in

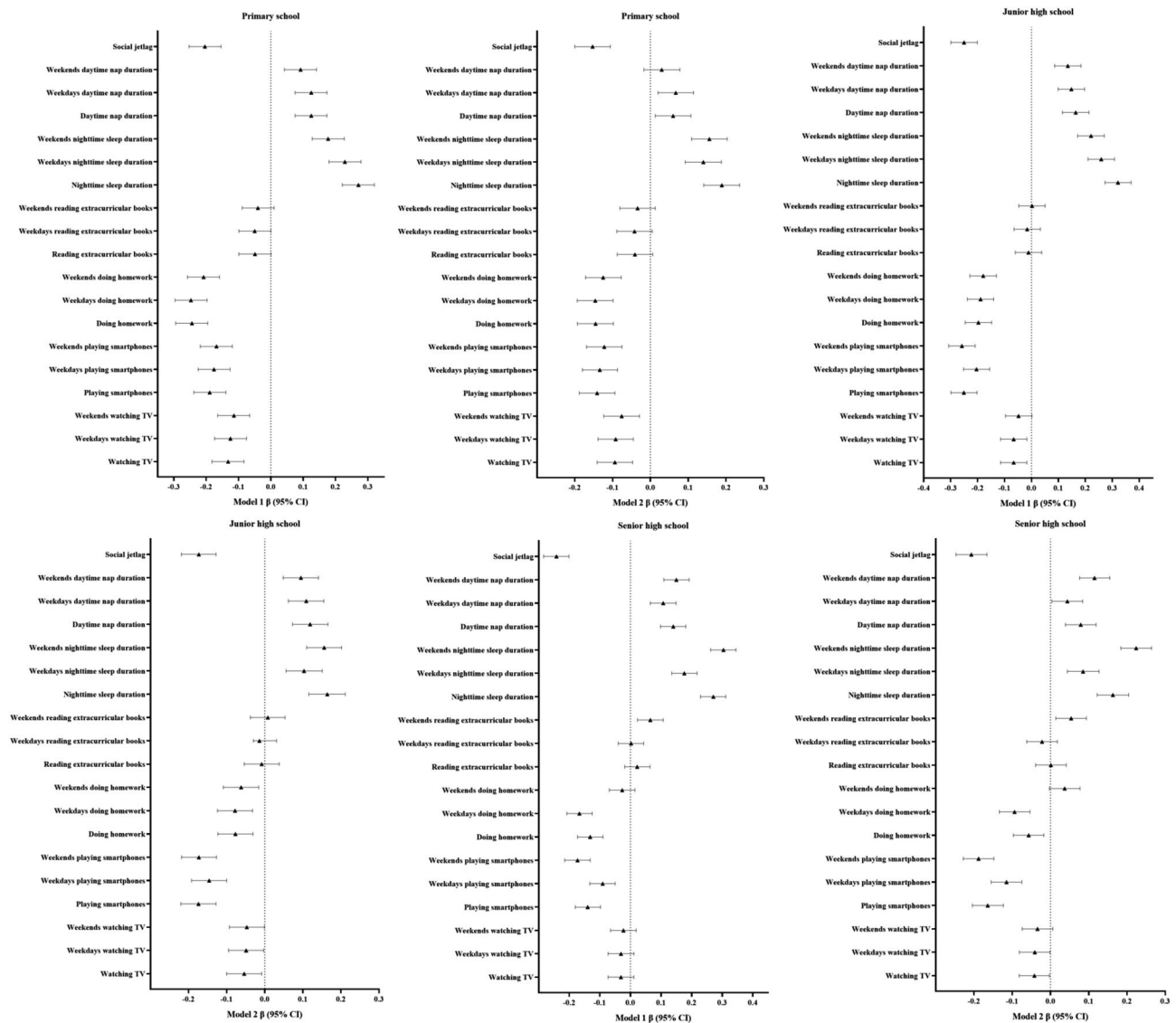


Fig. 2 Generalized linear model analysis of screen time, homework and reading duration, sleep duration, social jetlag and mental health in children and adolescents. Note: CI, confidence interval; Model 1 unadjusted for confounding factors; Model 2 adjusted for age, gender, ethnicity, self-reported learning burden, arrangement between classes at school, weekdays outdoor time, weekends outdoor time, and sleep latency

relation to mental health. These interactions effects persisted even after adjusting for covariates. As shown in Table S3.

Generalized linear model analysis of screen time, homework and reading duration, sleep duration, social jetlag and mental health in children and adolescents according to gender stratified

According to gender and further stratified analysis, we found that, in primary school, watching TV time, playing on smartphones time, doing homework time, and social jetlag were negatively correlated with mental health both in boys and girls. The nighttime sleep duration and daytime nap duration were positively correlated with mental health both in boys and girls. In junior high school,

watching TV time was negatively correlated with mental health in boys. The playing smartphones time, doing homework time, and social jetlag were negatively correlated with mental health both in boys and girls. The nighttime sleep duration and daytime nap duration were positively correlated with mental health both in boys and girls. In senior high school, playing on smartphones time, doing homework time, and social jetlag were negatively correlated with mental health both in boys and girls. The nighttime sleep duration and daytime nap duration were positively correlated with mental health both in boys and girls. Furthermore, we found that the strength of this association was different in boys and girls at different study phases. Meanwhile, we found that these effects

persisted even after adjusting for covariates. As shown in Fig. 3 and Table S4.

Generalized linear model analysis of sleep duration (quadratic) and mental health in children and adolescents

Besides examining the linear effect of sleep duration on mental health (more sleep duration might help mental health), we also examined whether there were points of diminishing return (more sleep duration did not help mental health beyond a certain amount of sleep duration) or increasing return (more sleep duration helped mental health when it reached a certain threshold). To explore such possible curvilinear relations, a quadratic term of sleep duration was included. Our findings revealed a

significant quadratic relationship, indicating the association of better mental health with an optimal amount of sleep duration (Nighttime sleep duration: 10.2 h, 9.1 h, and 8.8 h in primary school, junior high school and senior high school, respectively; Weekdays nighttime sleep duration: 9.8 h, 8.7 h, and 8.2 h in primary school, junior high school and senior high school, respectively; Weekends nighttime sleep duration: 10.6 h, 9.8 h, and 9.9 h in primary school, junior high school and senior high school, respectively; Daytime nap duration: 0.8 h and 0.6 h in junior high school and senior high school, respectively; Weekdays daytime nap duration: 0.7 h and 0.5 h in junior high school and senior high school, respectively; Weekends daytime nap duration: 0.9 h and 0.8 h in

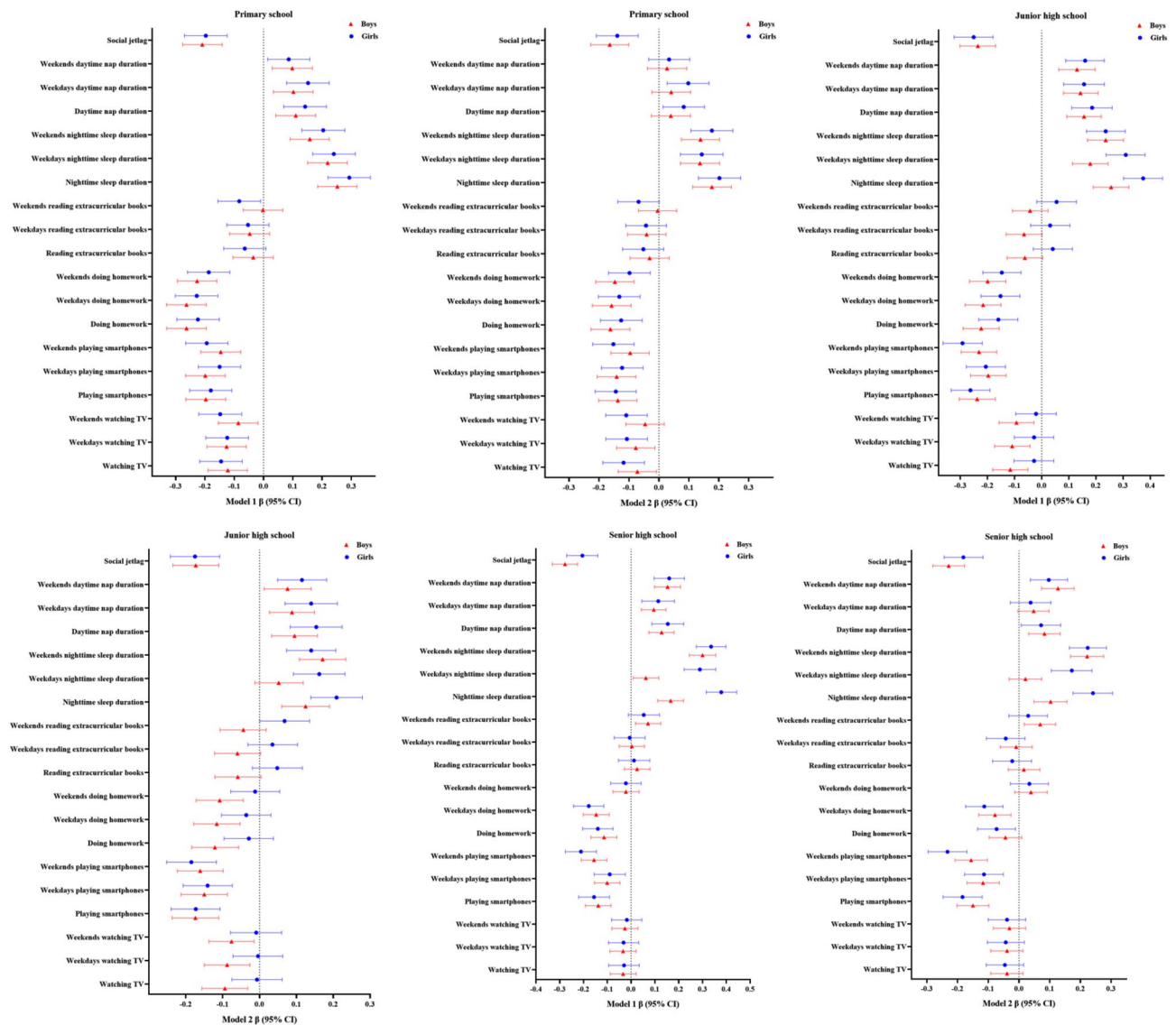


Fig. 3 Generalized linear model analysis of screen time, homework and reading duration, sleep duration, social jetlag and mental health in children and adolescents according to gender stratified. Note: CI, confidence interval; Model 1 unadjusted for confounding factors; Model 2 adjusted for age, gender, ethnicity, self-reported learning burden, arrangement between classes at school, weekdays outdoor time, weekends outdoor time, and sleep latency

junior high school and senior high school, respectively). These results were obtained after adjusting for relevant covariates. As shown in Fig. 4 and Table S5.

Discussion

The main findings of the present study were as follows: (a) screen time, homework and reading duration, sleep duration, and social jetlag were independently associated with mental health in children and adolescents; (b) in primary school and junior high school, this association was stronger during the weekdays, while, in senior high school, this association was stronger during the weekends; (c) according to gender and further stratified analysis, we found that the strength of this association was different in boys and girls at different study phase; and (d) our findings not only reveal the linear effect of sleep duration on mental health but also demonstrate a significant quadratic relationship, indicating the association of better mental health with an optimal amount of sleep duration. This study has the potential to offer useful insights for the prevention and control of mental health issues among children and adolescents.

It has been well established that excessive screen time is correlated with mental health issues in children and adolescents [39, 40]. For instance, a survey conducted among nearly 2 500 adolescents aged 12~18 years in Canada found that the duration of screen time was associated with the severity of depression and anxiety [41]. Likewise, in this study, we found that longer watching TV time and longer playing smartphones time were correlated with poorer mental health in children and adolescents. At the same time, we found that, in primary school, this association between screen time and mental health is stronger on weekdays, whereas, in junior high school and senior high school, this association is stronger on weekends. Our findings was consistent with previous research, which indicates that the use of cell phone/tablet was associated with increased depression, and the strength of this association was different on weekdays and weekends [42]. Furthermore, according to gender stratified, in primary school and senior high school, we found that this association was stronger in girls, while, in junior high school, this association was stronger in boys. Our study suggests that girls' mental health is more susceptible to the impact of screen time than boys' in primary school and senior high school, whereas the opposite is true in junior high school. Besides, studies have shown that excessive screen time has a significant negative impact not only on mental health but also on physical health and overall well-being [43]. Therefore, to mitigate these harms, limiting screen time for children and adolescents is recommended.

In China, the educational system is highly competitive, and children and adolescents are under great pressure

from an early age [44]. Currently, in the academic-oriented culture, Chinese children and adolescents are likely to spend more time on homework each day than Western children and adolescents [19]. However, studies have shown that doing homework for long periods can lead to anxiety symptoms, depressive symptoms, and somatic symptoms [45]. Similarly, in this study, we found that longer homework time was correlated with poorer mental health in children and adolescents, and this association was stronger on weekdays. Furthermore, study revealed that girls tend to experience higher levels of academic stress compared to boys [46]. However, another study indicated that there were no significant gender differences in terms of academic stress, as well as increased levels of academic stress were associated with poorer mental health outcomes [47]. In this study, we found that this association was stronger in boys in primary school and junior high school, while, in senior high school, this association was stronger in girls. This gender difference may be caused by different perceived school demands and stress at different study phases [46]. Thus, educators and psychotherapists should develop more tailored and effective educational and training strategies to help children and adolescents manage daily academic stress and mental issues.

Additionally, sleep and mental health are indisputably closely connected [48]. A study of 46 475 children and adolescents in Korea found that the likelihood of mental health issues was higher among those who slept for 6 h or less than for those who slept for 8 h or more [49]. Similarly, in this study, we found that longer nighttime sleep duration and longer daytime nap duration were correlated with better mental health in children and adolescents. Given the prevalence of sleep deprivation in modern society, daytime naps may serve as a remedy to counteract the adverse effects of chronic nocturnal sleep insufficiency on mental health [50]. This is because regular midday naps can help regulate emotions by enhancing frustration tolerance and decreasing negative affect [51]. Furthermore, we found that, in primary school and junior high school, the association between daytime nap duration and mental health was stronger on weekdays, while, in senior high school, this association was stronger on weekends. This may result from the large discrepancy of study load, diverse schedule and differences of need for sleep on various learning periods [52]. At the same time, according to gender stratification, we found that this association was stronger in girls. Our findings was consistent with previous research, which indicates that girls' mental health is more likely to be affected by problematic sleep habits compared to boys [53, 54]. Furthermore, our findings revealed a significant quadratic relationship, indicating the association of better mental health with an optimal amount of sleep duration. Sleeping too little

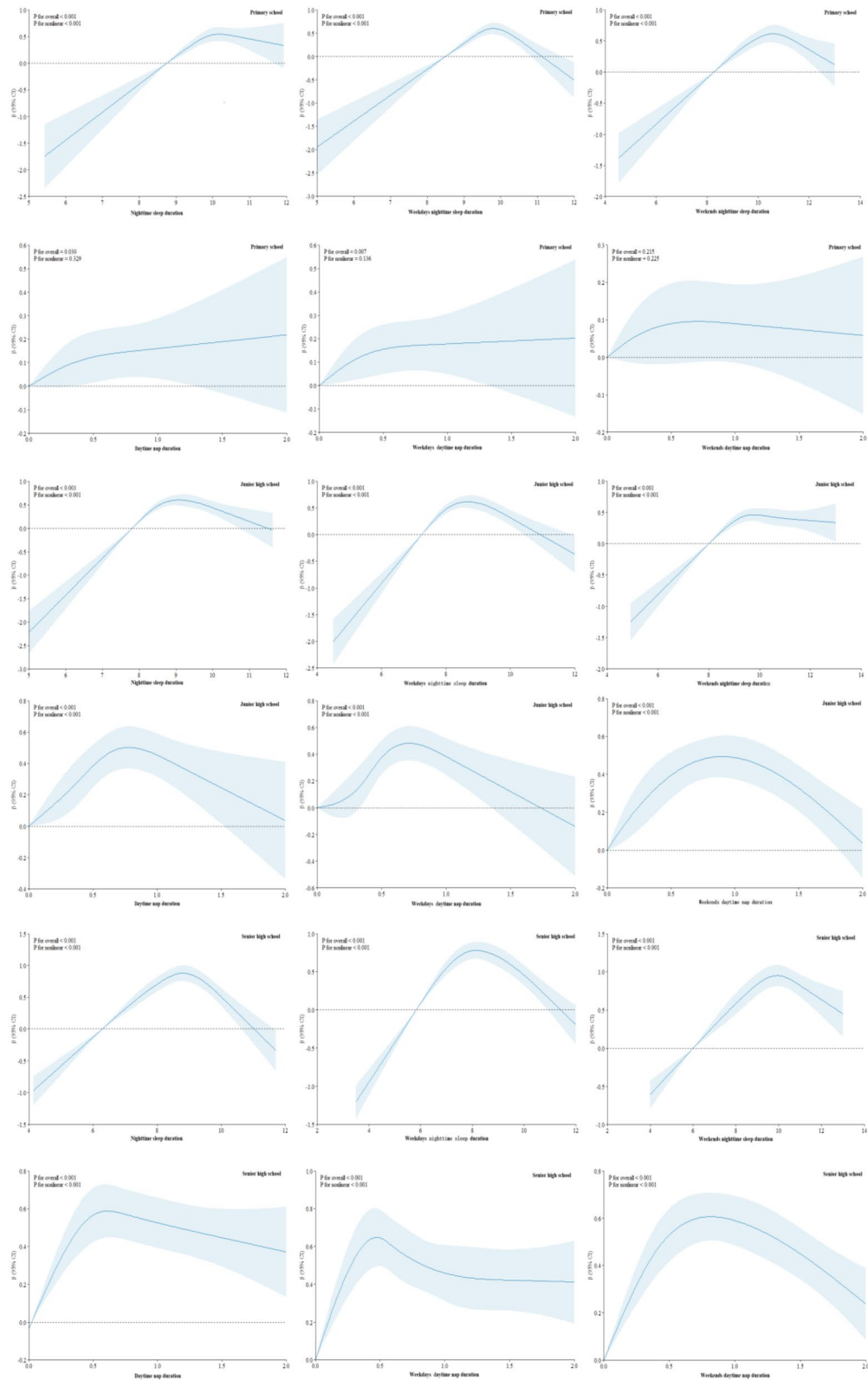


Fig. 4 Association between sleep duration (quadratic) and mental health in children and adolescents. Adjusted for age, gender, ethnicity, self-reported learning burden, arrangement between classes at school, weekdays outdoor time, weekends outdoor time, and sleep latency

or too much had detrimental effect on mental health in this representative sample of children and adolescents in China. Thus, clinical practitioners and parents should develop more targeted prevention and intervention strategies to help children and adolescents achieve the recommended sleep duration and enhance their mental health.

In addition, among the potential factors affecting the mental health of children and adolescents, social jetlag is receiving increasing attention [55]. The prevalence of social jetlag is at its highest during adolescence, due to the mismatch between delayed biological stages and earlier school start time [56]. Previous studies have established an association between social jetlag and mental health such as anxiety and depression, indicating that a greater social jetlag increases the risk of poor mental health in children and adolescents [57]. For example, a survey conducted among 3 058 children and adolescents in the United States revealed that, in girls, a greater social jetlag during school days was independently linked to more severe depressive symptoms [58]. Similarly, in this study, we found that greater social jetlag was associated with poorer mental health in children and adolescents, as well as this association was stronger in boys. In addition, social jetlag not only affects mental health, but may have negative effects on physical health, such as negative effects on cardiovascular and metabolic diseases [59]. Therefore, to safeguard the health of children and adolescents, it is imperative to maintain regular sleep throughout the week to reduce social jetlag.

Our study has several limitations. First, this study is a cross-sectional survey, which does not allow for reasonable causal inference. Future research is needed to describe the causal relationship between screen time, homework and reading duration, sleep duration, social jetlag, and mental health, as well as the potential mechanisms of their associations. Second, this study used self-reported questionnaires to evaluate screen time, homework and reading duration, sleep duration, social jetlag, and mental health, which may not avoid reporting bias. Future research can utilize objective measures based on distinct samples to further validate the current findings. However, previous studies have demonstrated good consistency between self-reported and objective measures [60, 61]. Third, this study only collected watching TV time and playing smartphones time, other screen time (such as computers, tablets, game consoles) was not investigated. Considering that different types of screen time have different impacts on mental health [41]. Future research is required to investigate the different types of screen time and the impact of each on mental health. Fourth, the correlations revealed by the present study between screen time, homework and reading duration, sleep duration, social jetlag, and mental health are relatively weak. However, mentioning these findings in

the context of existing literature may still be valuable. Despite the above limitations, the strengths of our study include the large sample of participants, which may make our findings convincing. Moreover, we found that the association between screen time, homework and reading duration, sleep duration, social jetlag, and mental health is different on weekdays and weekends, as well as has gender differences. More importantly, this study findings generate some practical implications, which developing psychological interventions aiming at reducing screen time, homework and reading duration, social jetlag, as well as keeping recommended sleep duration may be critical for the prevention of essential mental health problems.

Conclusions

This study showed that screen time, homework and reading duration, sleep duration, and social jetlag were independently associated with mental health in Chinese children and adolescents. The study's results may help target the mental health promotion of children and adolescents, suggesting that future prevention of mental health can be achieved through multipath interventions such as decreasing screen time, near-work time, social jetlag, and keeping recommended sleep duration. Furthermore, educators should strengthen sleep hygiene education for children and adolescents. Schools may consider reducing students' homework and academic burden after class. Parents should set bedtime schedules for their children and impose limits on electronic devices usage.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12888-024-06233-w>.

Supplementary Material 1

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Author contributions

Conceptualization, Formal analysis, Tingting Li; Writing original draft, Tingting Li; Investigation, Tingting Li, Xiaoling Liu, Caiyun Cao, Feng Yang, Peng Ding, Shaojun Xu, Shuman Tao, Xiaoyan Wu, Fangbiao Tao; Methodology, Tingting Li; Supervision, Xiaoyan Wu, Fangbiao Tao; Funding acquisition, Writing-review and editing, Fangbiao Tao; All authors checked interpreted results and approved the final version.

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Data availability

The data supporting this study's findings were available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

The Ethics Committee of Anhui Medical University approved this study (NO: 20210735). Both the adult participants and the parent(s)/guardian(s) of all under-16s received written informed consent. All data procedures were carried out in accordance with relevant ethical guidelines and regulations associated with the declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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