Nonlinear Relationship between Sleep Duration and Non-suicidal Self-injurious Behaviour among Chinese Adolescents

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Abstract

Background

Previous researches showed a positive association between short sleep duration and non-suicidal self-injury (NSSI) among adolescents, but few studies have described the effects of oversleeping and weekend catch-up sleep duration on NSSI. The present study aims to explore the nonlinear relationship between sleep duration and NSSI among Chinese adolescents.

Methods

China's National Adolescent Health Surveillance data from 2014 to 2015 were collected from 15,713 students in four provinces within China. A self-report questionnaire was used to assess sleep duration and 12-month NSSI. Binomial logistic regression models were used to examine the associations of NSSI with sleep duration. The locally estimated scatter plot smoothing (LOESS) method was used to help explore the associations of total NSSI number with sleep duration, and binomial regression analysis was used to help test this relationship.

Results

About 68.5% of adolescents reported sleeping less than 8 h on weeknights while 37.8% slept more than 10 h per night during weekends. The 12-month prevalence rate of NSSI was 29.4%. Compared to the weekend catch-up sleeping for 0–1 hours, those who slept < 0 hours (adjusted Odd Ratio (*aOR*) = 1.38, 95% Confidence Interval (95% *CI*): 1.16–1.64) had higher risk of NSSI. Males who reported ≥ 3 hours of weekend catch-up sleep were significantly increased odds of NSSI (*aOR* = 1.20, 95% *CI*: 1.01–1.42). Notably, the positive U-shape association was observed between the entire sleep duration and total NSSI number.

Conclusions

The findings reveals that the nonlinear relationship between sleep duration and non-suicidal self-injurious behaviour among Chinese adolescents. Therefore, it is necessary to be vigilant and screen for sleep duration among adolescents in NSSI treatment or prevention.

Background

Non-suicidal self-injury (NSSI), defined as direct, deliberate destruction of one's own body tissue without suicidal intent [1]. NSSI is a significant global public health issue among adolescents with high prevalence rates [2]. Previous results demonstrate the rates of NSSI in youth significant varies between and within countries [3–5]. Worldwide, the average 12-month prevalence of NSSI were 19.0% [6]. In china,

the average 6–24 months prevalence of NSSI was 23.3% [7]. NSSI leads to both physical and social-emotional harm in the short and long-term, it also may be a gateway for suicide, because its presence is associated with both increased desire and capability for suicide [8]. Given the costs of NSSI and suicide to both society and individuals, accurate identification of the risk factors associated with NSSI is critical.

Adequate sleep is necessary for both physical and mental health among adolescent. However, sleep curtailment is prevalent in modern society [9]. The National Sleep Foundation observed that approximately 61% of American adolescents aged 13–18 years reported sleeping less than the recommended 8–10 hour of sleep [10–12]. A survey of 585 adolescents in a high school in China, the vast majority of the students (over 93%) slept less than 8 hours during week nights, with over 42% sleeping less than 6.5 hours [13]. In another study, approximately 51.0% of 4,801 Chinese adolescents aged 11–20 years in weekdays receive less than 8 hours of sleep [14]. Adolescence is a period characterized by dramatic changes in cognitive, behavioral, social, and emotional functioning Adolescence is a period characterized by dramatic changes in cognitive, behavioral, social, and emotional functioning [15]. The onset of adolescence is also implicated in sleep/wake patterns changes. Sleep/wake patterns changes and changes to the sleep-pressure system (sleep homeostasis) during adolescence both favor later timing of sleep [16]. These changes, combined with prevailing social pressures, are responsible for most teens sleeping too late and too little [16].

Some studies have shown that reduced parental control over bedtime, sleep hygiene such as caffeine consumption, high levels of the social media use, and other behavioral patterns often shape adolescents' lifestyles toward predominantly nighttime behavior, while school schedules require them to be fully awake early in the morning [17–19]. This interaction leads to chronic patterns of sleep deprivation, a tendency for higher rates of daytime sleepiness, and accumulation of sleep debt during the school week[20]. Adolescents typically attempt to oversleep on non-school days to pay back their sleep debt, especially by sleeping in on weekend mornings [20]. In a survey of 9567 secondary school students in New Zealand, the bedtime and rise times during weekdays were 22:17 and 06:57; on the weekend, their bedtime and rise times were 00:09 and 09:31 [21]. In another study, Lee and colleagues found that the mean sleep duration of 3,785 middle- and high-school students in Korean was 7.0 hours on weekdays, 8.9 hours on weekends, and 1.8 hours for weekend catch-up sleep [22]. A survey of 1,629 Chinese adolescents aged 12 to 19 years have shown that the average school-night bedtime was 23:24, and total sleep time was 7.3 hour. During weekends, the average bedtime and rise time was delayed by 64 min and 195 min, respectively [23]. This phenomenon of short, early sleep on weekdays and later, longer sleep on weekends has been called weekend sleep lag or social jet lag [24, 25].

Inadequate sleep durations, sleepiness, and irregular sleep patterns may lead to poor academic performance, psychological symptoms such as depression, physical health problems such as headaches, obesity and cardio-metabolic dysfunction [26]. The effect of sleep pattern on risk-taking behaviors has also been cause for concern in recent years. Several reports suggest that sleep duration was associated with the NSSI in adolescents. In the study of Swedish adolescents, poor sleep was associated prospectively with NSSI among girls, but not among boys [27]. In the study of Norwegian adolescents,

insomnia, short sleep duration, long sleep onset latency, wake after sleep on set as well as large differences between weekdays versus weekends, yielded higher odds of self-harm consistent with a dose–response relationship [28]. However, previous studies have focused on sleep quality and inadequate sleep durations on NSSI, and few studies about oversleeping and weekend catch-up sleep [29, 30]. There has been no evidence the relationship between sleep duration and NSSI is U-shape until now.

Related research have shown that adolescents with psychological symptoms are a group with elevated risks for later NSSI [31]. In addition, the insufficient sleep of adolescents can be affected by excessive screen time use, with insufficient sleep in adolescents having been linked to suicidal ideation/ NSSI [32–34]. Therefore, in this study, we aim to explore the nonlinear relationship between sleep duration and NSSI among Chinese adolescents, with consideration for the influence of sleep quality, psychological symptoms and screen time. It was hoped that this study could help us to provide relevant strategies to support adolescent NSSI prevention.

Methods

Participants

The data were obtained from China's National Adolescent Health Surveillance from 2014 to 2015. This is an annual school-based surveillance system involving adolescents and young adults from the same junior and senior high schools located in Xinxiang (central), Yangjiang (south), Chongqing (west) and Shenyang (north) areas. These areas are broadly representative of the average population within China in terms of economic development and demographic composition. Eight schools (2 junior and 2 senior high schools from urban and rural, respectively) in each geographic region were randomly selected.

A total sample of 15 713 students from grade 7–12 were invited to participate in the study. Of these students, 1 037 (6.6%) were excluded from the study because of (1) absence from school on the day of the survey or unwillingness to respond to the questionnaire, (2) missing data through fictitious or inconsistent responses. Finally, we received 14 676 (93.4%) effective questionnaires, including 7 017 males (47.8%) and 7 377 junior school students (50.3%). The students aged from 10 to 24 years (mean 15.20, SD 1.75). In addition, the participants of four regions were 3 968 (Xinxiang), 3 539 (Yangjiang), 4 007 (Chongqing), and 3 162 (Shenyang), respectively.

Procedure

The study ensured all the participants and their guardians are aware of the purpose and content of this investigation. If students agree to participate in the survey, they stayed in the classroom, and, if not, they were allowed to leave. Each center used an anonymous questionnaire. Completion of the self-reported questionnaire took approximately 25 minutes. A teacher was sitting in a place of the classroom but was unable to observe student responses. The investigators checked the accuracy and completeness of returned questionnaires in time to take out the unqualified questionnaire. Informed consent was sought from parents/ guardians of each student prior to completion. Approval for the design and data collection

procedures was obtained by the Ethics Committee of Anhui Medical University. The detailed survey information can be found in our previous article [38].

Measures

Socio-demographic Information

A self-report questionnaire was used to collect socio-demographic information, including gender (male or female), grade (junior or senior middle school), urban/rural residency, household structure (only-child or more than one child), parents' education level (less than junior middle school, junior middle school, senior middle school, college or more) and self-perceived family socioeconomic status (poor, general or good). The additional file provides a questionnaire (Additional file 1).

Psychological Symptoms and Screen Time

Psychological symptoms, including emotional symptoms (including depression and anxiety symptoms, e.g., 'Do you always feel distressed?'), behavioural symptoms (including paranoid and hostile behaviors, e.g., 'Do you always have the impulse to damage something?') and social adaptation symptoms (including bad relationships with family and friends etc., e.g., 'Could you always not be suited for school life?'), were evaluated by the psychological domain of the Multidimensional Sub-health Questionnaire of Adolescents (MSQA) [31]. The MSQA has been widely used in mainland China and reported by various groups to be a valid and reliable method to explore the current state of adolescents' psychological health status [35, 36]. Cronbach's alpha for the MSQA was 0.951 in the present study.

Screen time was measured by video time and video game time. The subjects reported video time and video game time using the following questions: "On an average school day, how many hours do you watch video (such as watching TV, mobile phone, MP4, DVD/VCD)? " and "On an average school day, how many hours do you play video games (such as game consoles, computer games, mobile games)? " A similar question was used to define the usual weekend video time and weekend video game time[37]. All of these questions have seven answer categories: '0 h', '≤0.5 h', '0.5–1 h', '1–2 h', '2–4 h', '4–6 h', and '> 6 h'.

Sleep Variables

The questionnaire contained 2 questions concerning sleep duration[38]. The first question represents usual weekday sleep duration: "In the last month, how many hours of actual sleep do you usually get at night on weekdays? " A similar question was used to define usual weekend sleep duration. Usual daily sleep duration was calculated as a weighted average of weekday and weekend sleep durations, using the formula: ([{usual weekday sleep duration}×5]+[{usual weekend sleep duration}×2])/7. Weekend catch-up sleep using the formula: ([usual weekend sleep duration]-[usual weekday sleep duration]). For statistical analyses purposes in the present study, sleep duration was collapsed into 6 categories: '<6 h', '6–7 h', '7–8 h', '8–9 h', '9–10 h', and '≥10 h'. Weekend catch-up sleep was collapsed into 5 categories: '<0 h', '0–1 h', '1–2 h', '2–3 h', and '≥3 h'. Sleep quality were obtained from responses on a 4-point Likert scale to the

item “In the past month, what do you think of your sleep quality? ” Response options were very good, good, poor, very poor[38].

NSSI

NSSI was assessed using the following question: ‘In the past 12 months, have you ever harmed yourself in a way that was deliberate, but not intended to take your life?’ Eight NSSI behaviors were presented, and the details of the questions were as follows: (1) Have you ever hit yourself?; (2) Have you ever pulled your hair yourself?; (3) Have you ever banged your head or fist against something?; (4) Have you ever pinched or scratched yourself?; (5) Have you ever bitten yourself?; (6) Have you ever cut or pierced yourself?; (7) Have you ever deliberately taken an overdose (e.g. of drugs, alcohol or smoking)?; and (8) Have you ever ingested a toxic substance or object? For those who confirmed that they had engaged in NSSI, the frequency of NSSI was investigated [31]. In the present study, the Cronbach’s alpha coefficient for the NSSI was 0.798.

Statistical Analysis

The statistical analyses were carried out by SPSS version 24.0 and R software version 3.6.1. Means and standard deviations of sleep duration were calculated separately for each gender group as well as for the grade group of participants. For comparisons between gender and grade groups, independent *t*-tests were conducted for sleep duration. Frequencies and percentages of NSSI in different groups were calculated. Pearson’s chi-squared test was used to examine differences in gender, grade, sleep duration and other variables between the adolescents reporting NSSI versus no NSSI. The univariate logistic regression analysis was used to examine the associations between covariates (e.g., gender, sleep duration and so on) with NSSI. Binomial logistic regression models were used to examine the associations of NSSI with daily sleep duration, weekday sleep duration, weekend sleep duration and weekend catch-up sleep, by adjustment for sociodemographic variables and so on. Gender and grade differences in this associations were examined. The locally estimated scatter plot smoothing (LOESS) method was used to help explore the associations of total NSSI number with daily sleep duration, weekday sleep duration, weekend sleep duration and weekend catch-up sleep. This method was especially useful to represent the nonlinear relation between variables, e.g., the U-shaped relation. GetData Graph Digitizer version 2.26 was used to find the nadir point. Binomial regression analysis was used to help test the relationship between total NSSI number and sleep duration by adjustment for sociodemographic variables, sleep quality, psychological symptoms, screen time. The level of significance was set at $P<0.05$.

Results

Comparisons of sleep duration between gender and grade groups

Usual daily sleep duration of the adolescent was 7.6 hours, the mean sleep duration was 7.0 hours on weekdays, 9.0 hours on weekends, and 1.9 hours for weekend catch-up sleep for the total group. Males had longer weekday sleep duration than females, and females had longer weekend sleep duration and

weekend catch-up sleep than males. Junior middle school students slept significantly longer on both weekdays and weekends, and had less weekend catch-up sleep than did senior middle school students ($P < 0.001$ for each, See Table 1). Among adolescents, the percentages of subjects who slept <8 h per night during weeknights were 68.5%, and the percentages of subjects who slept≥10 per night during weekends were 37.8% for the total group (See Table 2). In our survey, about 63.5% of males and 73.1% females reported sleeping less than 8 h on weeknights. Approximately 49.6% of junior middle school students and 87.6% senior middle school students reported sleeping less than 8 h on weeknights.

The prevalence rates and characteristics of NSSI

The 12-month prevalence rates of NSSI was 29.4%. The type of NSSI, of all the self-injuries observed, mainly included banging head/ fisting against subject (18.4%), hitting (13.8%) and pinching/ scratching (11.1%). The significant difference was found in the distribution of NSSI by most sample characteristics, such as regional areas, gender, grade, household structure, parents' education level, self-perceived family socioeconomic status, sleep quality, psychological symptoms and screen time ($P < 0.05$ for each), while NSSI revealed no statistically significant differences by urban/rural residency ($P > 0.05$). In addition, there was a marked difference between sleep duration and catch-up sleep with NSSI ($P < 0.001$ for each, See Table 2).

Univariate logistic regression analyses

The univariate logistic regressions showed that the regional areas (crude odds ratios (*ORs*) = 0.83, 95% Confidence Interval (95% *CI*): 0.76–0.92), gender (*ORs*= 1.24, 95%*CI*: 1.16–1.33), grade (*ORs*= 1.19, 95%*CI*: 1.11–1.28), only child (*ORs*= 1.10, 95%*CI*: 1.02–1.18), mother's education level(*ORs*= 1.15, 95%*CI*: 1.01–1.32), self-reported family economy (*ORs*= 1.35, 95%CI: 1.18–1.54), sleep quality (*ORs*= 0.36, 95%*CI*: 0.31–0.41), psychological symptoms (*ORs*= 3.17, 95%*CI*: 2.93–3.42), weekday video time (*ORs*= 1.10, 95%*CI*: 1.07–1.12), weekend video time(*ORs*= 1.13, 95%*CI*: 1.11–1.15), weekday video game time(*ORs*= 1.07, 95%*CI*: 1.04–1.09) and weekend video game time(*ORs*= 1.10, 95%*CI*: 1.08–1.12) were significantly associated with NSSI. Urban/rural residency and father's education level were no significantly associated with NSSI.

Associations sleep duration and NSSI and gender/ grade difference

After the adjustment of covariates (variables that were significantly associated with each form of NSSI), the multivariable logistic regressions were performed to explore the association between sleep duration and NSSI, and gender/ grade difference. (See Table 3 and Table 4). Compared with 8-9 hours of sleep, less than 6 hour of sleep duration including daily sleep duration (adjusted Odd Ratio (*aOR*) = 1.42, 95%*CI*: 1.18–1.71), weekday sleep (*aOR* = 1.24, 95%*CI*: 1.05–1.45) and weekend sleep (*aOR* = 1.55, 95%*CI*: 1.20–2.01) might have led to higher adjusted odds of NSSI for adolescents. Compared to the weekend catch-up sleeping for 0-1 hours, those who slept <0 hours (*aOR* = 1.38, 95%*CI*: 1.16–1.64) had higher risk of NSSI. Gender and grade differences were found in the effects of sleep duration on NSSI. Males who reported ≥3 hours of weekend catch-up sleep were significantly increased odds of NSSI (*aOR* = 1.20, 95%*CI*: 1.01–

1.42). Senior middle school students who reported 1-2 hours (*aOR* = 1.24 95%*CI*: 1.01–1.52) or 2-3 hours (*aOR* = 1.24, 95%*CI*: 1.02–1.51) of weekend catch-up sleep were significantly increased odds of NSSI. However, this result was not found in females and junior middle school students.

Associations sleep duration and total NSSI number

Scatterplots fit with a LOESS curve depicting the relationship between sleep duration and NSSI number are non-linear (Fig. 1). Weekly sleep, weekend catch-up sleep, weekday sleep and weekend sleep duration all have a U-shape relationship with total NSSI number.

GetData Graph Digitizer was used to find the nadir point. The U-shape curve depicting the relationship between daily sleep duration and NSSI with a nadir point at approximately 8.2 hours, the weekend catch-up sleep U-shaped curve is seen with a nadir point approximately 0.9 hours, the weekday sleep U-shaped curve is seen with a nadir point around 7.7 hours, the weekend sleep U-shaped curve is seen with a nadir point around 8.2 hours.

After the adjustment of covariates (regional areas, gender, grade, registered residence, only child, father's education level, mother's education level, self-reported family economy, sleep quality, psychological symptoms, screen time), the binomial regression was performed to test the association between sleep duration and total NSSI number (See Table 5). Results of the binomial regression analysis are shown that a positive U-shape association was observed between the entire sleep duration and total NSSI number ($P < 0.001$).

Discussion

The present study examined the relationship between sleep duration and NSSI among adolescent in China. As hypothesized, our research found that both short and long self-reported sleep durations were associated with an increased risk of NSSI after adjustment for important confounding factors. To our knowledge, this is the first large-sample cross-sectional study reporting the U-shaped association between sleep duration and total NSSI number.

In this study, we found long or short sleep have become increasingly prevalent in china, 68.5% of adolescents sleep 8 or fewer hours on school days, and 37.8% sleep 10 or more hours on weekends. Meanwhile, large discrepancies between weekdays versus weekend sleep duration also common among adolescents, mean weekend catch-up sleep duration of the adolescent was 1.9 hours in our study. Similar results were obtained in previous studies [14, 22]. On one hand, adolescent changes in the sleep-wake pattern might be explained by its unique physiological characteristics. Evidence suggests that at least in part, the sleep pattern in adolescents is influenced by the circadian and homeostatic system [39]. The circadian system, a hierarchically organized network of structures responsible for generating approximately 24 h rhythms, is driven in mammals by a circadian pacemaker located in the suprachiasmatic nuclei (SCN) of the hypothalamus [40]. The homeostatic process regulates sleep pressure which accumulates with wake duration and dissipates during subsequent sleep [41]. Previous

studies suggests that the sensitivity of the circadian timing system to light may differ in adolescence, favoring a blunted phase advance response to light exposure in the morning and an exaggerated phase-delay response to light exposure in the evening [42]. Evidence also indicates that the internal day length may be longer in adolescents than adults, thus contributing to the phase delay [16]. In addition, melatonin is an important mediator in the circadian system, adolescents experience lower amplitude of the daily rhythm of melatonin secretion, which may dampen the signal for sleep [16]. Furthermore, the homeostatic and circadian regulation of sleep are sensitive to gonadal hormones, gonadal hormones are necessary for the development of delayed phase during adolescence [39]. These physiological changes may be part of the reason why adolescent has too long or short sleep. On the other hand, adolescent sleep is also affected by the psychosocial environment. In a survey of 1,101 students aged 13–16 years in Australian, Vernon and colleagues found that increased night-time mobile phone use was directly associated with increased poor sleep behavior [43]. In another study, Buzek et al. reported that negative associations between sleep duration and academic stress among children from families with a low socioeconomic status [44]. Most students wake up before their natural biological rise time because their schools start early. In the study of Singapore female students, greater increase in sleep duration on school nights and lower levels of subjective sleepiness at 1 month after a 45-min delay in school start time, and these positive changes were maintained at 9 months [45]. In this study, we found insufficient sleep duration would be more likely among females than males, approximately 63.5% of males and 73.1% females reported sleeping less than 8 h on weeknights. The result obtained in this study was consistent with most other findings [46–48]. There were still some studies that found no sex-related difference in sleep duration [49, 50]. Differences across gender in this study could be due to girls requiring more preparation time in the morning and advanced onset of puberty in girls may contribute to later bedtimes [48, 51, 52]. Results of the present study suggest that 49.6% of junior middle school students and 87.6% senior middle school students reported sleeping less than 8 h on school days. From this result, The difference observed among different grade groups can be partly explained by the follow facts: firstly, bioregulatory pressures sustain evening alertness later into the night with increasing age; secondly, parental supervision and time spent on sports/ physical training largely reduce, academic demands increase, and social networks expand with increasing age, so is increased risk for insufficient sleep among senior middle school students [53]. The reasons for variable sleep duration across gender or grade require careful consideration in future studies as they may be targets of educational or other interventions.

In recent years, the prevalence rates of NSSI were still high, the present results showed that the 12-month prevalence rates of NSSI was 29.4%. Until now, however, few researches have studied the association between sleep duration and NSSI. Previous studies have shown that the close link between sleep problems and self-harm; Difficulties initiating sleep, early morning wakening, short sleep duration, severe sleep complaints, daytime sleepiness, and nightmares were associated with increased risk of self-harm in a dose-dependent manner [28, 29, 54, 55]. In this study, we found that, after controlling for potential confounding factors, compared to the weekend catch-up sleeping for 0–1 hours, males who slept < 0 hours or ≥ 3 hours had higher risk of NSSI. The results of this study indicate either excessive or restricted weekend catch-up sleep in males was associated with increased risk of NSSI. Furthermore, we found

daily sleep, weekend catch-up sleep, weekday sleep and weekend sleep duration all have a U-shape relationship with total NSSI number. However, the underlying mechanism is not clear. There are several possible mechanisms, as follows. It seems plausible that the improper sleep duration may disrupt the circadian clock, leading to subsequent increase of inflammatory biomarkers. In addition, inflammatory markers were shown to be one of the key markers associated with NSSI. Many studies suggest that the extreme of long sleep duration/shorter sleep duration or circadian misalignment significantly increased plasma tumor necrosis factor-alpha (TNF-α), interleukin 10 (IL-10) and C-reactive protein (CRP) [56, 57]. Increased inflammation might change major neurotransmitter metabolism, which subsequent affects frontal function and decreases response inhibition. Additionally, NSSI was related to greater behavioral impulsivity and increased serum TNF-α level. Therefore, frontal dysfunction associated with greater inflammation might explain the neurobiological basis of NSSI [58]. The hypothalamic-pituitary-adrenal (HPA) axis seems as one potential mechanism that may explain the link between sleep deprivation and NSSI. Previous findings suggest that total sleep deprivation and chronic circadian misalignment differentially influence cortisol levels. The acute total sleep deprivation increases cortisol levels, whereas the circadian misalignment decreases cortisol levels. Regarding the effect of HPA axis on NSSI, the current research results are not consistent. Reichl and colleagues reported that adolescents engaging in NSSI exhibited significantly higher cortisol awakening responses compared to healthy controls [59]. However, another study has shown that the HPA axis is hyporesponsive in adolescents with NSSI. Therefore, reduced secretion of cortisol could play a role in promoting vulnerability of these individuals to acute stress and maladaptive stress responses [60]. Furthermore, sleep deprivation and NSSI are may linked to reduced connectivity of the default mode network (DMN). Irregular sleep patterns are associated with increased path length within the DMN – specifically in the right and left lateral parietal lobule – among adolescents, suggesting that sleep regularity may be vital for optimal brain functioning during this developmental period [61]. In addition, reduced DMN connectivity is often observed among adolescents with neuropsychiatric conditions, such as attention-deficit hyperactivity disorder (ADHD), depression, and emerging psychosis [62]. Therefore, sleep irregularity is may impact NSSI through alterations in brain connectivity.

This study extends our knowledge of the association between sleep duration and NSSI by examining gender and grade differences. To our knowledge, the present study is the first to show that the U-shaped association between sleep duration and total NSSI number. Another major strength of this investigation was the large representative sample and age range studied representing late childhood through adolescence. In addition, we fully considered potential covariates, especially sleep quality, psychological symptoms, screen time. We believe that this study has provided insights for prevention adolescent NSSI.

Several limitations may be considered in the present study. Firstly, this study was cross-sectional, and thus causality cannot be inferred. Further longitudinal studies may be needed to clarify the aetiology of the association. Second, we used simple self-report questions with a relatively small number of items to evaluate sleep duration and NSSI, therefore, recalling bias is inevitable. An interview-based survey of NSSI and measurement of sleep duration using polysomnography or actigraphy might be recommended for future studies. Thirdly, the association between sleep duration and NSSI maybe is partly accounted for by

other parameters such as childhood physical or sexual abuse. Future studies need to examine mediators and moderators between sleep duration and NSSI of adolescent, aiming to provide more clues for adolescent NSSI prevention.

Conclusion

This study provides insight into the association between sleep duration and NSSI among Chinese adolescents. Our findings show that either excessive or restricted sleep duration was associated with increased risk of NSSI. Parents, teachers, and child health workers are encouraged to be vigilant and screen for sleep problems in young adolescents. Future research should determine if early intervention with sleep duration reduces the risk for NSSI in adolescents.

Abbreviations

NSSI
Non-Suicidal Self-Injury
ORs
Crude Odds Ratios
aOR
Adjusted Odd Ratio
CI
Confidence Interval
SCN
Suprachiasmatic Nuclei
TNF-α
Tumor Necrosis Factor-alpha
IL-10
Interleukin 10;
CRP
C-Reactive Protein
HPA
Hypothalamic-Pituitary-Adrenal
DMN
Default Mode Network
LOESS
Locally Estimated Scatterplot Smoothing
ADHD
Attention-Deficit Hyperactivity Disorder
MSQA
Multidimensional Sub-health Questionnaire of Adolescents;

Declarations

Ethics approval and consent to participate

The study was approved by the ethics committee of Anhui Medical University (2012534). Permission for the study was requested from schools, parents, and students before completion of the surveys. During the organization period, we got “written informed consent” from school principal of each school and head teacher of each class for this health questionnaire survey. The students were allowed to participate in the study upon receiving completed consent form from their parents. One week prior to screening day, the parents or guardians of the students were informed of the study through a notice sent home from the schools asking them to contact the teachers by phone if they wish their child to participate in the survey. Prior to the formal investigation, the team members explained the anonymous and confidential nature of the data to the students, and provided an opportunity for them to ask questions. If they were not willing to participate, they were allowed to withdraw from the study. Consent to participate in the study was recorded in a separate consent form with the questionnaire, and it was confirmed upon completion and return of the questionnaire.

Consent for publication

Not Applicable.

Availability of data and materials

The datasets that were generated analyzed for the current study are not publicly available as the author does not have permission to share the data.

Competing interests:

The authors declare no conflict of interest.

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Authors’ Contributions

YT and YW worked on data analysis, developed the study design, reviewed the topic related literature and wrote the first draft of the manuscript. SX, SZ and JH performed data collection, coordination, and involved in interpretation of the data and revision of the manuscript. FT performed the study design and carried out study supervision and revision of the manuscript. All authors significantly contributed to the project, read and approved the final manuscript of the protocol.

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Tables

Table 1. Comparisons of sleep duration between gender and grade groups.

Variables	Daily sleep duration（h）	Weekday sleep duration（h）	Weekend sleep duration（h）	Weekend catch-up sleep（h）
Gender				
Male(n=7,017)	7.64 ± 1.12	7.15 ± 1.26	8.87 ± 1.72	1.72 ± 1.86
Female(n=7,659)	7.51 ± 1.01	6.91 ± 1.13	9.01 ± 1.57	2.10 ± 1.70
t	7.251	11.941	-5.209	-12.816
P value	<0.001**	<0.001**	<0.001**	<0.001**
Grade				
Junior middle school (n=7,377)	7.95 ± 1.09	7.50 ± 1.21	9.08 ± 1.58	1.59 ± 1.66
Senior middle school(n=7,299)	7.20 ± 0.91	6.55 ± 0.99	8.81 ± 1.70	2.26 ± 1.86
t	45.460	51.745	10.169	-22.953
P value	<0.001**	<0.001**	<0.001**	<0.001**
Total(N=14,676)	7.58 ± 1.07	7.03 ± 1.20	8.95 ± 1.64	1.92 ± 1.79

* $P < 0.05$, ** $P < 0.001$; Statistical methods: independent *t*-tests.

Table 2. Prevalence of NSSI by sample characteristics.

Variables	N(%)	NSSI (%)	Non-NSSI (%)	χ^2	*P* value
Regional areas				21.170	0.001**
YangJiang	3539(24.1)	1103(31.2)	2436(68.8)		
ShenYang	3162(21.5)	935(29.6)	2227(70.4)		
XinXiang	3968(27.0)	1060(26.7)	2908(73.3)		
ChongQing	4007(27.3)	1219(30.4)	2788(69.6)		
Gender				35.341	0.001**
Male	7017(47.8)	2228(31.8)	4789(68.2)		
Female	7659(52.2)	2089(27.3)	5570(72.7)		
Grade				22.538	0.001**
Junior middle school	7377(50.3)	2301(31.2)	5076(68.8)		
Senior middle school	7299(49.7)	2016(27.6)	5283(72.4)		
Urban/rurality				0.001	0.974
Rural	7493(51.1)	2205(29.4)	5288(70.6)		
Urban	7183(48.9)	2112(29.4)	5071(70.6)		
Only child				6.727	0.009*
Yes	6608(45.0)	2015(30.5)	4593(69.5)		
No	8068(55.0)	2302(28.5)	5766(71.5)		
Father’s education level				11.609	0.009*
Less than junior middle school	2158(14.7)	689(31.9)	1469(68.1)		
Junior middle school	6239(42.5)	1840(29.5)	4399(70.5)		
Senior middle school	4256(29.0)	1186(27.9)	3070(72.1)		
College or more	2023(13.8)	602(29.8)	1421(70.2)		
Mother’s education level				15.825	0.001**
Less than junior middle school	2686(18.3)	867(32.3)	1819(67.7)		

Junior middle school	6331(43.1)	1854(29.3)	4477(70.7)		
Senior middle school	4027(27.4)	1119(27.8)	2908(72.2)		
College or more	1632(11.1)	477(29.2)	1155(70.8)		
Self-reported family economy				62.899	0.001**
Poor	2020(13.8)	741(36.7)	1279(63.3)		
General	10860(74.0)	3036(28.0)	7824(72.0)		
Good	1796(12.2)	540(30.1)	1256(69.9)		
Sleep quality				254.451	0.001**
Very Good	2416(16.5)	457(18.9)	1959(81.8)		
Good	6426(43.8)	1788(27.8)	4638(72.7)		
Poor	4500(30.7)	1544(34.3)	2956(65.6)		
Very poor	1334(9.1)	528(39.6)	806(60.6)		
Psychological symptoms				906.125	0.001**
Yes	4027(27.4)	1926(47.8)	2101(52.2)		
No	10649(72.6)	2391(22.5)	8258(77.5)		
Weekday video time (h)				74.449	0.001**
0	6331(43.1)	1701(26.9)	4630(73.1)		
≤0.5	3090(21.1)	874(28.3)	2216(71.7)		
0.5-1	2198(15.0)	696(31.7)	1502(68.3)		
1-2	1387(9.5)	438(31.6)	949(68.4)		
2-4	761(5.2)	258(33.9)	503(66.1)		
4-6	376(2.6)	139(37.0)	237(63.0)		
6	533(3.6)	211(39.6)	322(60.4)		
Weekend video time (h)				167.631	0.001**
0	1737(11.8)	362(20.8)	1375(79.2)		
≤0.5	1818(12.4)	475(26.1)	1343(73.9)		

0.5-1	2276(15.5)	618(27.2)	1658(72.8)		
1-2	2601(17.7)	727(28.0)	1874(72.0)		
2-4	2484(16.9)	784(31.6)	1700(68.4)		
4-6	1692(11.5)	574(33.9)	1118(66.1)		
6	2068(14.1)	777(37.6)	1291(62.4)		
Weekday video game time (h)				32.089	0.001**
0	8334(56.8)	2347(28.2)	5987(71.8)		
≤0.5	2770(18.9)	817(29.5)	1953(70.5)		
0.5-1	1486(10.1)	457(30.8)	1029(69.2)		
1-2	891(6.1)	274(30.8)	617(69.2)		
2-4	472(3.2)	160(33.9)	312(66.1)		
4-6	285(1.9)	93(32.6)	192(67.4)		
6	438(3.0)	169(38.6)	269(61.4)		
Weekend video game time (h)				123.035	0.001**
0	2790(19.0)	698(25.0)	2092(75.0)		
≤0.5	2354(16.0)	635(27.0)	1719(73.0)		
0.5-1	2173(14.8)	560(25.8)	1613(74.2)		
1-2	2330(15.9)	671(28.8)	1659(71.2)		
2-4	1820(12.4)	613(33.7)	1207(66.3)		
4-6	1392(9.5)	475(34.1)	917(65.9)		
6	1817(12.4)	665(36.6)	1152(63.4)		
Daily sleep duration (h)				55.717	0.001**
<6	712(4.9)	284(39.9)	428(60.1)		
6-7	3343(22.8)	1036(31.0)	2307(69.0)		
7-8	5771(39.3)	1688(29.2)	4083(70.8)		
8-9	3359(22.9)	911(27.1)	2448(72.9)		
9-10	1145(7.8)	309(27.0)	836(73.0)		

≥10	346(2.4)	89(25.7)	257(74.3)		
Weekday sleep duration (h)				43.605	0.001**
<6	1125(7.7)	413(36.7)	712(63.3)		
6-7	4386(29.9)	1305(29.8)	3081(70.2)		
7-8	4546(31.0)	1354(29.8)	3192(70.2)		
8-9	3182(21.7)	854(26.8)	2328(73.2)		
9-10	1020(7.0)	284(27.8)	736(72.2)		
≥10	417(2.8)	107(25.7)	310(74.3)		
Weekend sleep duration (h)				49.429	0.001**
<6	287(2.0)	130(45.3)	157(54.7)		
6-7	716(4.9)	244(34.1)	472(65.9)		
7-8	1376(9.4)	431(31.3)	945(68.7)		
8-9	3729(25.4)	1054(28.3)	2675(71.7)		
9-10	3020(20.6)	860(28.5)	2160(71.5)		
≥10	5548(37.8)	1598(28.8)	3950(71.2)		
Weekend catch-up sleep (h)				59.123	0.001**
<0	966(6.6)	365(37.8)	601(62.2)		
0-1	1998(13.6)	529(26.5)	1469(73.5)		
1-2	3101(21.1)	825(26.6)	2276(73.4)		
2-3	4032(27.5)	1174(29.1)	2858(70.9)		
≥3	4579(31.2)	1424(31.1)	3155(68.9)		
Total	14676(100.0)	4317(29.4)	10359(70.6)		

* $P < 0.05$, ** $P < 0.001$; Statistical methods: Chi-square test; NSSI is non-suicidal self-injury.

Table 3. Logistic regression of the effect of sleep duration on NSSI.

Variables	NSSI	
	Crude *OR* (95%*CI*)	Adjusted *OR* (95%*CI*)
Daily sleep duration（h）		
8-9(ref)	1.00	1.00
<6	1.78(1.51,2.11) **	1.42(1.18,1.71) **
6-7	1.21(1.09,1.34) **	1.14(1.02,1.29) *
7-8	1.11(1.01,1.22) *	1.09(0.98,1.20)
9-10	0.99(0.85,1.16)	1.00(0.85,1.17)
≥10	0.93(0.72,1.20)	0.93(0.71,1.21)
Weekday sleep duration（h）		
8-9(ref)	1.00	1.00
<6	1.58(1.37,1.83) **	1.24(1.05,1.45) *
6-7	1.15(1.04,1.28) *	1.09(0.97,1.23)
7-8	1.16(1.05,1.28) *	1.18(1.06,1.31) *
9-10	1.05(0.90,1.23)	1.06(0.90,1.25)
≥10	0.94(0.75,1.19)	0.94(0.74,1.20)
Weekend sleep duration（h）		
8-9(ref)	1.00	1.00
<6	2.10(1.65,1.68) **	1.55(1.20,2.01) *
6-7	1.31(1.11,1.56) *	1.15(0.96,1.38)
7-8	1.16(1.01,1.32) *	1.13(0.98,1.30)
9-10	1.01(0.91,1.12)	1.05(0.93,1.17)
≥10	1.03(0.94,1.13)	0.96(0.87,1.06)
Weekend catch-up sleep（h）		
0-1(ref)	1.00	1.00
<0	1.69(1.43,1.99) **	1.38(1.16,1.64) **
1-2	1.01(0.89,1.14)	1.02(0.90,1.17)

2-3	1.14(1.01,1.29) *	1.11(0.98,1.26)
≥3	1.25(1.11,1.41) **	1.08(0.95,1.22)

* *P*< 0.05, ** *P*< 0.001; OR is odds ratios; CI is confidence interval; NSSI is non-suicidal self-injury; Adjusted model controlled regional areas, gender, grade, only child, father's education level, mother's education level, self-reported family economy, sleep quality, psychological symptoms, weekday video time, weekend video time, weekday video game time, weekend video game time.

Table 4. Adjusted OR (95% CI) of NSSI by gender and grade regrading sleep duration.

Variables	NSSI [Adjusted *OR* (95%*CI*)]		NSSI [Adjusted *OR* (95%*CI*)]	
	Female	Male	Junior middle school	Senior middle school
Daily sleep duration（h）				
8-9(ref)	1.00	1.00	1.00	1.00
<6	1.48(1.13,1.93)*	1.38(1.07,1.78)*	1.55(1.15,2.09)*	1.30(1.01,1.67)*
6-7	1.19(1.01,1.41)*	1.10(0.94,1.30)	1.04(0.87,1.23)	1.13(0.94,1.35)
7-8	1.09(0.94,1.27)	1.08(0.94,1.25)	1.12(0.98,1.27)	1.00(0.84,1.19)
9-10	1.02(0.81,1.29)	0.99(0.80,1.22)	1.06(0.89,1.26)	0.80(0.51,1.26)
≥10	1.10(0.72,1.70)	0.85(0.61,1.19)	1.00(0.75,1.36)	0.78(0.44,1.38)
Weekday sleep duration（h）				
8-9(ref)	1.00	1.00	1.00	1.00
<6	1.34(1.07,1.69)*	1.13(0.90,1.43)	1.20(0.92,1.55)	1.28(1.01,1.62)*
6-7	1.18(0.99,1.39)	1.03(0.88,1.21)	0.99(0.85,1.16)	1.16(0.96,1.41)
7-8	1.25(1.06,1.46)*	1.12(0.96,1.30)	1.15(1.00,1.32)*	1.18(0.97,1.44)
9-10	1.07(0.83,1.38)	1.06(0.85,1.31)	1.09(0.91,1.29)	1.04(0.56,1.94)
≥10	1.10(0.73,1.64)	0.87(0.64,1.18)	1.02(0.78,1.35)	0.76(0.44,1.32)
Weekend sleep duration（h）				
8-9(ref)	1.00	1.00	1.00	1.00
<6	1.54(1.01,2.35)*	1.59(1.14,2.20)*	1.20(0.78,1.86)	1.74(1.26,2.40)*
6-7	1.29(0.97,1.72)	1.09(0.86,1.38)	1.39(1.06,1.82)*	0.97(0.76,1.24)
7-8	1.12(0.91,1.37)	1.14(0.94,1.39)	1.24(1.01,1.53)*	1.04(0.86,1.26)
9-10	0.98(0.84,1.14)	1.12(0.95,1.31)	1.14(0.98,1.33)	0.97(0.83,1.14)
≥10	0.94(0.82,1.08)	0.98(0.85,1.12)	1.04(0.91,1.19)	0.90(0.78,1.03)

Weekend catch-up sleep				
0-1(ref)	1.00	1.00	1.00	1.00
<0	1.29(0.97,1.72)	1.49(1.20,1.85)**	1.15(0.92,1.43)	1.92(1.45,2.54)**
1-2	0.96(0.79,1.17)	1.08(0.90,1.30)	0.89(0.75,1.06)	1.24(1.01,1.52)*
2-3	1.10(0.91,1.32)	1.11(0.94,1.32)	1.02(0.86,1.20)	1.24(1.02,1.51)*
≥3	0.97(0.81,1.17)	1.20(1.01,1.42)*	1.06(0.89,1.26)	1.15(0.95,1.38)

* *P*< 0.05, ** *P*< 0.001; OR is odds ratios; CI is confidence interval; NSSI is non-suicidal self-injury; Adjusted model controlled regional areas, gender, grade, only child, father's education level, mother's education level, self-reported family economy, sleep quality, psychological symptoms, weekday video time, weekend video time, weekday video game time, weekend video game time.

Table 5. Binomial regression analysis of the effect of sleep duration on total NSSI number

Variables	Total NSSI number					
	Crude *OR(95%CI)*	*F*	*P* value	Adjusted *OR*(95%CI)	*F*	*P* value
Total number of NSSI						
Daily sleep (h)	-4.01(-4.90, -3.12)**	63.68	< 0.001	-2.76(-3.62, -1.91) **	88.36	< 0.001
Daily sleep (h) ^{2}	0.23(0.18,0.29) **			0.17(0.11,0.22) **		
Total number of NSSI						
Weekday sleep (h)	-3.91(-4.58,-3.24) **	86.48	< 0.001	-2.59(-3.25,-1.94) **	89.48	< 0.001
Weekday sleep (h) ^{2}	0.24(0.20,0.29) **			0.17(0.12,0.21) **		
Total number of NSSI						
Weekend sleep (h)	-2.14(-2.61,-1.67)**	42.74	< 0.001	-1.14(-1.60,-0.69) **	86.95	< 0.001
Weekend sleep (h) ^{2}	0.11(0.09,0.14) **			0.06(0.03,0.08) **		
Total number of NSSI						
catch-up sleep (h)	-0.36(-0.47,-0.26) **	52.88	< 0.001	-0.24(-0.34,-0.15) **	87.36	< 0.001
catch-up sleep (h) ^{2}	0.10(0.08,0.12) **			0.05(0.04,0.07) **		

* *P*< 0.05, ** *P*< 0.001; OR is odds ratios; CI is confidence interval; NSSI is non-suicidal self-injury; Adjusted model controlled regional areas, gender, grade, registered residence, only child, father's education level, mother's education level, self-reported family economy, sleep quality, psychological symptoms, weekday video time, weekend video time, weekday video game time, weekend video game time.

Figures

Image not available with this version

Figure 1

Scatterplots fit with a LOESS curve depicting the relationship between sleep duration and NSSI number are non-linear (Fig. 1). Weekly sleep, weekend catch-up sleep, weekday sleep and weekend sleep duration all have a U-shape relationship with total NSSI number.