Social Psychiatry and Psychiatric Epidemiology (2018) 53:1241–1251
https://doi.org/10.1007/s00127-018-1576-0

ORIGINAL PAPER

Post-traumatic stress disorder, anxiety and depression symptoms among adolescent earthquake victims: comorbidity and associated sleep-disturbing factors

Wanjie Tang[1,2,3] · Yi Lu[1] · Jiuping Xu[1]

Received: 28 March 2018 / Accepted: 30 July 2018 / Published online: 14 August 2018

Abstract

Purpose Our study aimed to examine the prevalence of psychiatric symptoms and their comorbidity and correlation with sleep problems among adolescent survivors 3 years after the 2013 Ya'an earthquake.

Methods A representative sample of 6132 adolescent students was analysed from 11 primary and high schools in the three counties most severely affected by the earthquake. Students were invited to complete the Pittsburgh Sleep Quality Index, Children's Revised Impact of Event Scale-13, Short Mood and Feelings Questionnaire, the Adolescent Self-Rating Life Events Checklist, and Screen for Child Anxiety-Related Emotional Disorders.

Results Three years after this major earthquake, 1-month prevalence of mental health problems was 13.1% for PTSD, 37.3% for anxiety, and 19.8% for depression. Among the participants who reported PTSD, 71.5% also reported anxiety, and 49.7% also reported depression. At least half of those with any type of mental health problem reported concurrent sleeping problems. Specific sleep risk factors were independently associated with increased risk of PTSD, depression or anxiety. Girls were more likely than boys to exhibit symptoms of PTSD, depression or anxiety. Older adolescents were more likely to have depression and anxiety.

Conclusions Mental health problems are prevalent with high comorbidity and are associated with sleep-related problems among adolescent survivors, even years after the occurrence of a major earthquake. Nightmares and difficulty initiating sleep are independently associated with PTSD. Insufficient sleep is independently associated with anxiety and depression. Sleep-related problems may be effective targets of preventive interventions, which may need to be optimised for gender and age.

Keywords PTSD · Anxiety · Depression · Sleep problems · Adolescents · Earthquake

Introduction

Children and adolescents are susceptible to mental health problems after a disaster [1]. Most adolescent victims display only transient psychological symptoms that represent a normal reaction to traumatic events. Persistent symptoms, in contrast, may be associated with psychiatric disorder and degradation of cognitive functioning and development, mood regulation, and academic and social performance [2]. Researchers have suggested that a high incidence of psychological distress may be prevalent and persistent among adolescent victims of natural disasters, even years after the disaster [3]. Statistics to support this idea are inconsistent, with long-term prevalence varying widely from 1.3% of individuals reporting post-traumatic stress disorder (PTSD) among the population affected by the Wenchuan earthquake [4] to 95% of those affected by the Armenian earthquake [5,

✉ Jiuping Xu
xujiuping@scu.edu.cn

Wanjie Tang
tangwanjie2010@gmail.com

Yi Lu
lyscu2000@163.com

1 Institute of Emergency Management and Post-disaster Reconstruction, Sichuan University, No. 24, South Section 1, Yihuan Road Wuhou District, 610065 Chengdu, China

2 Centre for Educational and Health Psychology, Sichuan University, Chengdu, China

3 Mental Health Center, State Key Lab of Biotherapy, West China Hospital, Sichuan University, Chengdu, China

6]. Identifying the prevalence of psychiatric symptoms and their risk factors among children and adolescents following disasters may guide future interventions targeting this vulnerable population.

PTSD symptoms may be comorbid and may exacerbate depressive and anxiety symptoms. In fact, post-disaster PTSD in children and adolescents may share the same aetiology as depression or anxiety [7, 8], which should be clarified in larger epidemiological studies. These comorbidities may interfere with treatment strategies and compromise their ability to reduce the severity of psychological distress and improve quality of life. This situation highlights the need to clarify the co-occurrence of psychopathology among children and adolescents in the aftermath of traumas.

Subjective sleep problems are frequent post-trauma psychological symptoms in children and adolescents [9–11]. Such problems can persist later in life [12–14], and they can be accompanied by symptoms overlapping with those of PTSD, depression and anxiety [9, 10, 15, 16]. Significant attention has been paid to the relationship of sleep with PTSD, anxiety or depression in adults [17, 18]. Only a few studies, however, have reported a strong association among sleep disturbances, PTSD and depressive symptoms in adolescent trauma survivors [9].

Multiple specific disturbances are common among children and adolescent trauma victims; these include difficulties falling asleep, frequent awakening from sleep and difficulty falling asleep again, nightmares and shorter duration of sleep [10, 11]. These disturbances increase with severity of psychiatry symptoms. Therefore, determining the extent to which these sleeping variables are associated with post-traumatic symptoms may help design interventions that target comorbid sleep problems in children with PTSD, anxiety or depression.

In addition to various potential sleeping risk factors, several studies have examined risk factors associated with mental health problems among children and adolescents after natural disasters. These factors include high levels of trauma exposure [11], age [19], gender [20] and only-child status [21]. The results have been inconsistent. In several studies, girls were at a greater risk than boys of developing PTSD after a major trauma [20, 22, 23], and older adolescents were more likely than younger adolescents to report mental health problems [19, 24]. In contrast, other studies have reported that boys are more symptomatic than girls, and that younger adolescents are more likely than older adolescents to report mental health problems [15, 25]. One study indicated that adults who were only-children were at a higher risk of developing PTSD than adults who grew up in multi-child families [21]. In contrast, another study found that only-child adults were less likely to exhibit PTSD and depression symptoms after an earthquake than were those with at least two siblings [19]. These inconsistent findings should be clarified in larger, representative studies involving samples of children and adolescents after disasters.

The 2013 Ya'an earthquake measured 7.0 on the Richter scale and caused 217 deaths and 11,470 injuries, of which more than 968 were serious. The main tremor occurred at 8:02:46 Beijing time (UTC + 8) on Saturday, June 20, 2013 and lasted approximately 2 min. During the following week, authorities reported 117 aftershocks in these areas, all of which were above magnitude 3.0, and 26 aftershocks were above magnitude 4.0 according to the China Geological Survey. Hundreds of thousands of children and adolescents were exposed to the deadly earthquake and were at risk of developing psychological distress and sleeping problems afterward. Thus, our aim in the present study was to evaluate the prevalence of PTSD, anxiety and depression symptoms in relation to the type of disaster exposure, gender, age, and only-child status in children and adolescents 3 years after the 2013 earthquake in Ya'an, China. The study also examined links among sleep, PTSD, anxiety and depression. Finally, the study assessed the independent and combined effects of multiple sleeping problems on PTSD, depression and anxiety.

Methods

Participants

The data analysed here were collected as part of an ongoing large-scale study investigating psychological adjustment among child and adolescent survivors of the Ya'an earthquake that struck Southwest China in 2013. The participants were selected by performing stratified random sampling in Baoxing, Lushan and Tianquan Counties. These counties were the most severely affected by the earthquake, with 99% of houses severely or completely destroyed, infrastructure severely damaged, and schools demolished. The details of data collection have been described [26]. In brief, participants included 6132 adolescents aged from 9 to 18 years from 11 primary and secondary schools. In the three counties in 2016, the total population was 320,000, of whom approximately 24,000 were aged 9–18 years. Data were collected between April 25 and May 20, 2016.

Parental written consent and oral consent from the subjects were obtained before the study. This project was designed according to the tenets of the Declaration of Helsinki and approved by the Department of Education of Ya'an District, the principals and teachers of the schools involved, and the Research Ethics Committee of Sichuan University. The questionnaires were coded to ensure anonymity in the subsequent analysis.

Measures

PTSD

The severity of post-traumatic stress symptoms was assessed using the Children's Revised Impact of Event Scale (CRIES)-13, which was adapted from the Impact of Event Scale [27]. The total CRIES-13 score can range from 0 to 65. Scores ≥ 30 are considered indicative of probable PTSD [28]. A score ≥ 17 for the sum of the eight items related to intrusion and avoidance (CRIES-8) was used here as a cut-off score [29] to maximise sensitivity and specificity [28]. This scale has shown reasonably good psychometric properties among Chinese children and adolescents [30, 31]. Cronbach's α in the present study was 0.90.

Depression

Probable depressive symptoms were measured using the Short Mood and Feelings Questionnaire (SMFQ) [32]. This scale comprises 13 items that assess the degree of depression, including feeling very tired, having no interest in anything, restlessness, crying, feelings of loneliness, and feelings of doing things incorrectly. The depressive symptoms were evaluated on a 3-point scale (0 = no, 1 = sometimes, 2 = yes). Total scores of 11 or higher were considered indicative of probable depression. The scale has shown reasonably good psychometric properties among Chinese children and adolescents [33, 34]. Cronbach's α in the present study was 0.91.

Anxiety problems

Anxiety symptoms were measured using the Chinese version of the Screen for Child Anxiety-Related Emotional Disorders. This scale consists of 41 items, with responses on a 3-point Likert scale ranging from 0 to 2. The scale has shown reasonably good psychometric properties among Chinese children and adolescents [10, 19, 35]. A total score of 25 or higher is indicative of probable anxiety disorder. In the current study, Cronbach's α was 0.94.

Sleeping problems

Sleep problems were measured using the Chinese version of the Pittsburgh Sleep Quality Index (PSQI). This index consists of 19 self-report items and five clinician-rated items; the 19th self-report item and all five clinician-rated items were not scored. The remaining 18 self-report items were used to calculate the following seven-dimensional scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, sleep medication use, and daytime dysfunction. Each dimension was scored on a scale from 0 to 3, and the total scores were obtained by summing all seven dimensional scores. A global PSQI score of 8 or greater is indicative of sleep problems. The present sample showed acceptable internal consistency. The Chinese version of the PSQI has satisfactory psychometric properties [9, 36]. In the current study, Cronbach's α was 0.83.

Negative life events

The Adolescent Self-Rating Life Events Checklist (ASLEC) was used to assess the severity of recent adverse life events [37]. The ASLEC has acceptable reliability and validity and has been applied successfully to Chinese adolescents [38, 39]. The scale consists of 26 self-reported stressors in the following five categories: interpersonal difficulties, academic pressure, being punished, personal loss, and health and adaptability. Respondents are asked whether specific stressors have occurred in their life during the past 1 month. If the event has occurred, respondents assess the impact of that event on their life using a five-point Likert scale (1 = not at all, 5 = severely bothered). A cut-off has not been reported for the ASLEC, so low and high categories were defined in the present study using the 27th and 73rd percentiles [40, 41]. Cronbach's α was 0.92 for this scale.

Earthquake exposure

To stratify the results based on the type of earthquake exposure, we developed an 8-item scale [8, 26] evaluating the following objective and subjective features of exposure: feeling extremely scared; being trapped; being injured; having parents, relatives or friends who were injured; witnessing people trapped; witnessing bloody injuries; suffering the loss of a loved one; and witnessing death. The respondents answered these items with "yes" or "no".

Data quality control

Since the data were based on self-reporting, special steps were taken to ensure adequate data quality before conducting the analyses. Of the 6,132 participants, 5,657 (92.3%) completed all the questionnaires. A total of 475 participants were excluded from the analyses because they failed to complete all the questionnaires or their responses appeared to show systematic bias (e.g., all responses were "yes" or "no"). In addition, 94 respondents were excluded because they were older than 18 years. In the final analysis, 5,563 respondents (90.7%) were included.

Statistical analysis

The differences in PTSD, depression, anxiety, exposure and sociodemographic characteristics among the subgroups were assessed for significance using a chi-squared test. The same test was also used to assess mental health comorbidities associated with overall sleep problems. Multinomial logistic regression was performed to adjust for the confounding effects of the other variables, and a final multiple logistic regression model was generated using all the variables that remained significant after the adjustment. The threshold of significance was defined as $p < 0.05$. All statistical analyses were performed using SPSS for Windows 22.0 (IBM, Chicago, IL, USA).

Results

The sample consisted of 2574 (46.3%) boys with a mean age of 14.33 years (SD = 1.99) and 2989 (53.7%) girls with a mean age of 14.49 years (SD = 1.97). The mean age of the entire sample was 14.41 years (SD = 1.98 years; range 9–18 years); 912 participants were aged between 9 and 12 years, 2854 participants were aged between 13 and 15 years, and 1797 participants were aged between 16 and 18 years. Most (81.1%) participants were not only-children. Visual exposure to earthquake damage was common: 50.6% of the participants had witnessed bloody injuries, 29.7% had witnessed people trapped, and 31.2% had witnessed death. A substantial proportion (39.9%) reported injured parents, relatives or friends, while 4.8% reported dead or missing family members. Moreover, 14.1% had been injured, and 3.8% had been trapped by the earthquake. Altogether, 37.2% of the sample reported feeling extremely scared during the immediate aftermath of the earthquake.

PTSD scale scores ranged from 0 to 65, with a mean of 12.85 (SD = 12.65). The mean PTSD severity score was significantly higher in girls ($M = 14.21$, SD = 12.88) than in boys ($M = 11.29$, SD = 12.19; $t = -8.64$, $p < 0.001$). The standardised mean difference (Cohen's d) was 0.23, suggesting a small to medium effect size (Cohen, 1988). Based on a CRIES-8 scale score of 17 as a cut-off, 727 (13.1%) children were classified as having probable PTSD. The prevalence of probable PTSD tended to be higher in girls than in boys, although the difference did not achieve significance (Table 1).

Depression scale scores ranged from 0 to 26, with a mean of 5.84 (SD = 5.67). The mean depression severity score was significantly higher in girls ($M = 6.62$, SD = 5.85) than in boys ($M = 4.92$, SD = 5.32; $t = -11.27$, $p < 0.001$). Cohen's d was 0.30, suggesting a small to medium effect size (Cohen, 1988). Using a scale score of 11 as a cut-off, 1099 (19.8%) children were classified as having probable depression. The prevalence of probable depression was significantly higher in girls than in boys (Table 1).

Anxiety scale scores ranged from 0 to 82, with a mean of 21.92 (SD = 14.78). The mean anxiety severity score was significantly higher in girls ($M = 24.72$, SD = 14.76) than in boys ($M = 18.67$, SD = 14.12; $t = -15.558$, $p < 0.001$). Cohen's d was 0.42, suggesting a medium effect size. Based on a scale score of 25 as a cut-off, 2076 (37.3%) children were classified as having probable anxiety. The prevalence of probable anxiety was significantly higher in girls than in boys (Table 1).

The potential univariate associations of PTSD, depression, and anxiety with sociodemographic characteristics and earthquake exposure were assessed using a chi-squared test. Female gender and all types of earthquake exposure were significantly associated with increased prevalence of PTSD, depression and anxiety (Table 1). Older age was significantly associated with increased prevalence of depression ($14.6\%_{9-12y}$ vs. $19.7\%_{13-15y}$ vs. $22.5\%_{16-18y}$, $\chi^2 = 23.82$, $p < 0.001$) and anxiety ($28.1\%_{9-12y}$ vs. $38.6\%_{13-15y}$ vs. $40.0\%_{16-18y}$, $\chi^2 = 40.85$, $p < 0.001$). Younger age was significantly associated with increased prevalence of PTSD ($14.3\%_{9-12y}$ vs. $13.8\%_{13-15y}$ vs. $11.4\%_{16-18y}$, $\chi^2 = 7.03$, $p = 0.03$). No significant differences were observed in the prevalence of any of the three psychiatric conditions between only-children and children from multi-child households.

The overall prevalence of mental health problems, such as PTSD, anxiety, or depression, was 42.2%. The prevalence of psychiatric-comorbid conditions in the sample is summarized in Table 2. Among the 5,563 children and adolescents, 337 (6.1%) scored higher than the cut-off scores on all three measures. Anxiety and depression were more likely to be comorbid (15.7%), followed by comorbidity of PTSD and anxiety (9.3%) and PTSD and depression (6.5%). Among the children and adolescents who reported PTSD, 71.5% also reported anxiety, and 49.7% also reported depression.

In our sample, psychiatric problems were comorbid with sleeping problems in a substantial proportion of survivors (Table 2). Sleeping problems were present in 81.0% of the individuals with all three conditions of PTSD, anxiety and depression; 78.4% of the individuals with PTSD and depression; 72.5% of the individuals with PTSD and anxiety; 65.6% of the individuals with anxiety and depression; 63.0% of the individuals with only depression; 56.5% of the individuals with only PTSD; 51.8% of the individuals with only anxiety; and 49.7% of the individuals with any of the three mental health conditions.

Multinomial logistic regression analyses were then performed to identify independent associations of sociodemographic characteristics, earthquake exposure, negative life events and multiple sleeping problems with PTSD, depression and anxiety. Feeling extremely scared, multiple sleeping problems (difficulties falling asleep, nightmares and daytime

Table 1 Mental health problems in children and adolescent survivors of the Ya'an earthquake ($n = 5563$)

Variable	*N*	PTSD				Depression				Anxiety			
		n	%	χ^2	*p*	*n*	%	χ^2	*p*	*n*	%	χ^2	*p*
Total	5563	727	13.1			1099	19.8			2076	37.3		
Age, year				7.03	0.03			23.82	< 0.001			40.85	< 0.001
9–12 (group 1)	912	130	14.3			133	14.6			256	28.1		
13–15 (group 2)	2854	393	13.8			562	19.7			1101	38.6		
16–18 (group 3)	1797	204	11.4			404	22.5			719	40.0		
Gender				3.19	0.08			30.30	< 0.001			168.63	< 0.001
Male	2574	314	12.2			427	16.6			727	28.2		
Female	2989	413	13.8			672	22.5			1349	45.1		
Only-child				2.68	0.10			4.00	0.048			2.31	0.14
Yes	1049	121	11.5			184	17.5			370	35.3		
No	4514	606	13.4			915	20.3			1706	37.8		
Type of exposure													
Felt extremely scared				176.28	< 0.001			117.88	< 0.001			261.78	< 0.001
Yes	2071	432	43.7			565	27.3			1055	50.9		
No	3492	295	21.5			534	15.3			1021	29.2		
Was trapped				17.17	0.001			7.58	0.008			16.45	< 0.001
Yes	214	48	22.4			58	27.1			108	50.5		
No	5349	679	12.7			1041	19.5			1968	36.8		
Was injured				157.91	< 0.001			44.06	< 0.001			56.41	< 0.001
Yes	782	212	39.8			223	28.5			386	49.4		
No	4781	515	10.8			876	18.3			1690	35.3		
Parents injured				119.04	< 0.001			51.74	< 0.001			118.12	< 0.001
Yes	2224	425	19.1			544	24.5			1022	46.0		
No	3339	303	9.1			555	16.6			1054	31.6		
Witnessed people trapped				105.45	< 0.001			60.36	< 0.001			58.54	< 0.001
Yes	1653	334	20.2			432	26.1			743	45.0		
No	3910	393	10.1			667	17.1			1333	34.1		
Witnessed bloody injuries				89.43	< 0.001			48.58	< 0.001			79.45	< 0.001
Yes	2817	487	17.3			660	23.4			1212	43.0		
No	2746	240	8.7			439	16.0			864	31.5		
Lost a loved one				37.10	< 0.001			10.72	0.002			20.01	< 0.001
Yes	269	68	25.3			74	27.5			135	50.2		
No	5294	659	12.4			1025	19.4			1941	36.7		
Witnessed death				91.03	< 0.001			96.33	< 0.001			83.97	< 0.001
Yes	1736	338	19.5			478	27.5			801	46.1		
No	3827	389	10.2			621	16.2			1275	33.3		

All statistical tests were two-tailed

dysfunction), and high levels of negative life events were significantly associated with increased risk of any of the three disorders (Table 3). For example, participants who reported feeling extremely scared were 1.32–1.83 times more likely to exhibit symptoms of depression, anxiety or PTSD than participants who did not report this feeling. Participants who reported having nightmares at least 1–2 nights/week were 1.42–2.82 times more likely to have symptoms of depression, anxiety or PTSD than participants who had nightmares less often or not at all. Daytime dysfunction presented the strongest association with depression, regardless of whether the dysfunction was infrequent [odds ratio (OR) 1.85], occasional (OR 3.53) or frequent (OR 7.65). The risk of anxiety was higher in individuals who experienced daytime dysfunction occasionally (OR 1.97) or often (OR 4.23). The risk of PTSD was significantly higher in individuals who reported daytime dysfunction as infrequent (OR 1.68), occasional (OR 2.25) or frequent (OR 3.01).

PTSD was associated with certain specific types of earthquake exposure, including being injured (OR 1.48); having

Table 2 Mental health comorbidities and association with overall sleep problems in children and adolescent survivors of the Ya'an earthquake ($n=5563$)

(Co)morbidity	Total ($N=5563$)	Prevalence (%)	Total sleep problems ($n=1620$, 29.1%)	Prevalence (%)	χ^2
Anxiety disorder					827.51***
Yes	2076	37.3	1076	51.8	
No	3487	62.7	544	15.6	
PTSD					304.47***
Yes	727	13.1	411	56.5	
No	4836	86.9	1209	25.0	
Depression					760.08***
Yes	1099	19.8	692	63.0	
No	4464	80.2	928	20.8	
Comorbidity: anxiety and depression					669.41***
Yes	875	15.7	574	65.6	
No	4688	84.3	1046	22.3	
Comorbidity: PTSD and depression					454.08***
Yes	361	6.5	283	78.4	
No	5202	93.5	1337	25.7	
Comorbidity: PTSD and anxiety					886.54***
Yes	520	9.3	377	72.5	
No	5043	90.7	1243	24.6	
Comorbidity: PTSD, depression and anxiety					467.93***
Yes	337	6.1	273	81.0	
No	5226	93.9	1347	25.8	
PTSD or anxiety or depression					830.29***
Yes	2348	42.2	1166	49.7	
No	3215	57.8	454	14.1	

***Significance at the 0.001 level (2-tailed)

parents, relatives or friends injured (OR 1.27); witnessing bloody injuries (OR 1.24); and losing a loved one (OR 1.53). Witnessing bloody injuries was associated with depression (OR 1.22), while being injured was associated with anxiety (OR 1.27). Individuals reporting < 7 h of sleep per night were 1.35–3.57 times more likely to exhibit depression or anxiety symptoms than those reporting at least 9 h of sleep per night. Those reporting poor sleep quality were 1.37–2.34 times more likely to exhibit depression or anxiety symptoms than those reporting very good sleep quality. Individuals encountering high levels of negative life events were 3.42–6.09 times more likely to exhibit PTSD, depression or anxiety symptoms than those reporting low levels of negative life events.

Discussion

This study is one of the most comprehensive epidemiological studies analysing psychiatric symptoms and their comorbidity and correlation with sleeping problems among a large sample of Chinese children and adolescents following a major earthquake. This study examined the potential associations among specific sleep variables and the risk of probable PTSD, depression and anxiety. One of the major study findings is that nearly half the sample had at least one mental health problem. The most frequent problem was anxiety, followed by depression and PTSD. The symptoms of all three disorders were highly comorbid in our sample, and anxiety and depression were most likely to co-occur. Among the children and adolescents who reported PTSD, most of them also reported anxiety, and half of them also reported depression. In addition, at least half of those with any type of mental health problems had concurrent sleeping problems 3 years after the earthquake. Girls were more likely than boys to report psychological distress after the earthquake. Older adolescents were more likely than their younger counterparts to experience symptoms of depression and anxiety, whereas younger adolescents were more likely than their older counterparts to experience PTSD. Mental health problems were significantly greater for those encountering high levels of negative life events. Most sleep-related

Table 3 Independent variables associated with mental health problems based on multinomial logistic regression

Variable	PTSD OR (95%CI)	Depression OR (95%CI)	Anxiety OR (95%CI)
Felt extremely scared			
No	1.00	1.00	1.00
Yes	1.83 (1.59–2.10)***	1.32 (1.13–1.55)***	1.63***
Was injured			
No	1.00	N/A	1.00
Yes	1.48 (1.16–1.87)**	N/A	1.27 (1.11–1.47)**
Parents injured			
No	1.00	N/A	N/A
Yes	1.27 (1.03–1.55)*	N/A	N/A
Witnessed bloody injuries			
No	1.00	1.00	N/A
Yes	1.24 (1.02–1.50)*	1.22 (1.04–1.43)*	N/A
Lost a loved one			
No	1.00	N/A	N/A
Yes	1.53 (1.10–2.12)*	N/A	N/A
Subjective quality of sleep			
Very good	N/A	1.00	1.00
Good	N/A	1.12 (0.85–1.48)	1.03 (0.54–1.94)
Poor	N/A	1.37 (1.01–1.87)*	0.88 (0.43–1.80)
Very poor	N/A	2.34 (1.51–3.63)***	1.95 (0.83–4.58)*
Sleep duration, hours			
≥9	N/A	1.00	1.00
7–9	N/A	1.10 (0.91–1.32)	1.49 (0.82–2.70)
5–7	N/A	1.35 (1.10–1.65)**	2.20 (1.18–4.07)*
<5	N/A	1.41 (1.02–1.94)***	3.57 (1.74–7.30)***
Trouble falling asleep			
No	1.00	1.00	1.00
< 1 Night/week	0.91 (0.70–1.19)	1.36 (1.08–1.77)**	1.00 (0.62–1.63)
1–2 Nights/week	1.58 (1.11–2.24)*	1.74 (1.36–2.24)***	2.11 (1.29–3.47)**
≧3 Nights/week	1.58 (1.20–2.07)**	2.15 (1.55–2.99)***	2.22 (1.14–4.32)*
Sleep disturbance			
No	N/A	1.00	1.00
<1 Night/week	N/A	1.20 (0.87–1.66)	1.02 (0.87–1.20)
1–2 Nights/week	N/A	2.10 (1.02–4.31)*	1.22 (0.98–1.53)
≧3 Nights/week	N/A	2.45 (1.67–4.59)***	1.09 (0.81–1.47)
Nightmares			
No	1.00	1.00	1.00
<1 Night/week	1.31 (1.05–1.63)*	1.27 (1.02–1.57)	1.20 (0.75–1.91)
1–2 Nights/week	2.25 (1.75–2.90)***	1.42 (0.98–2.06)*	1.64 (0.86–3.12)*
≧3 Nights/week	2.82 (2.10–3.80)***	1.55 (1.17–2.05)**	2.00 (1.19–3.38)***
Daytime dysfunction			
No	1.00	1.00	1.00
Occasionally	1.68 (1.15–2.45)*	1.85 (1.26–2.70)**	0.97 (0.44–2.13)
Sometimes	2.25 (1.54–3.29)***	3.53 (2.41–5.17)***	1.97 (0.89–4.34)*
Often	3.01 (2.02–4.48)***	7.65 (5.13–11.43)***	4.23 (1.87–9.57)***
Negative life events			
Low	1.00	1.00	1.00
Medium	0.28 (0.23–0.35)	0.22 (0.16–0.30)	0.24 (0.19–0.28)
High	3.42 (2.97–3.94)***	6.09 (5.19–7.14)***	3.79 (3.29–4.37)***

*Significance at the 0.05 level (two-tailed)

**Significance at the 0.01 level (two-tailed)

***Significance at the 0.001 level (two-tailed)

All variables, including exposure, sociodemographics and sleep variables, were entered into the initial model. The model was adjusted for all other variables

parameters were associated with mental health problems, with difficulties falling asleep and nightmares being the strongest risk factors for PTSD. In contrast, shorter sleep duration was associated only with anxiety and depression.

Our data indicate that 3 years after the earthquake, approximately half the sample had symptoms of PTSD, depression, or anxiety, which showed respective 1-month prevalences of 13.1%, 19.8%, and 37.3%. Our results are comparable to those from our previous study in Baoxing County, which was conducted 30 months after the Ya'an earthquake; in that work, 15.7% of 153 adolescent subjects met the criteria for PTSD, and 21.6% of the participants met the criteria for depression based on a diagnostic face-to-face structured interview [3]. In contrast, a study conducted 24 months after the Wenchuan earthquake involving 1,573 adolescents in Dujiangyan showed a slightly higher prevalence of PTSD (14.0%) and a twofold higher prevalence of depressive symptoms (38.3%) [9]. A study involving 373 junior high school students from the areas worst-hit by the Wenchuan earthquake reported prevalences of 29.6% for PTSD, 44.8% for depression, and 37.6% for anxiety 3 years after the disaster [42]. A study involving students at a high school located at the epicentre of the Wenchuan earthquake reported extremely low prevalences of PTSD (1.6%) and depression (29.4%) at 18 months after the disaster [43]. Discrepancies among these studies may reflect sample differences and the relatively small samples involved. Nonetheless, these prevalences among child and adolescent survivors of natural disasters generally exceed the corresponding values for the general Chinese adolescent population. Depressive symptoms are present in approximately 5.9% [44] or 6.4% [45], while anxiety symptoms are present in approximately 6.1% [46].

Post-earthquake studies involving children and adolescents in other countries also indicate variability in the prevalence of psychiatric conditions 2–4 years after the disaster. In a heterogeneous sample of 872 participants aged 7–17 years, of whom 56 were street children, the prevalence of PTSD was 36.9% and the prevalence of depression was 46.2% at 2.5 years after the Haiti earthquake [47]. Much lower rates were reported at four years after the Haiti earthquake in a study of 128 street children: prevalence was 14.9% for PTSD, 13.3% for anxiety and 29.7% for depression [48]. The decreasing prevalence of mental health problems between 2.5 and 4 years after the Haiti earthquake may mean that young people developed specific strategies and resilience to cope with trauma [49]. It is difficult to compare these results with heterogeneous samples, many of whom were street children, with our study of Chinese children living with parents at home. In Greece, prevalence of depression was 8.8% and of anxiety was 13.7% at 32 months among adolescents after the Parnitha earthquake [50]. These various studies highlight the need for research into the effects of major disasters on mental health in the longer term. At the very least, they point to the need for more investment in community- and school-based care and preventive and therapeutic strategies in the immediate aftermath of natural disasters.

The results of our study are consistent with those of previous work reporting that girls are more likely than boys to exhibit symptoms of PTSD, depression or anxiety after a major earthquake [19, 43, 47]. We also found that older adolescents are more likely to suffer from depression and anxiety than their younger counterparts. Conversely, younger adolescents are more likely to suffer from PTSD than their older counterparts. Age and developmental level may influence adolescents' perception and understanding of trauma, coping ability, and memory of the event. This situation likely explains why the younger adolescents in our study were more likely to experience PTSD than the older adolescents, whereas the older adolescents were more likely to experience anxiety and depression than the younger adolescents. After adjusting for earthquake exposure and multiple sleep variables, female gender and older age were not significantly associated with increased risk of any of the three psychiatric conditions. Further studies are needed to investigate the influence of culture, psychosocial state and biology on the observed associations of age and gender with psychological distress after traumatic events.

Consistent with most previous studies, our results showed that adolescents who experienced earthquake exposures were more likely to report symptoms of PTSD, anxiety, and depression than adolescents without such exposure. Directly witnessing earthquake-related trauma was associated with an increased risk of all three psychiatric conditions among children and adolescents. Even after adjusting for demographic, sleep and exposure variables, five of the eight types of earthquake exposure (feeling extremely scared; being injured; having parents, relatives or friends injured; witnessing bloody injuries; and losing a loved one) remained associated with an increased risk of PTSD. Feeling extremely scared and witnessing bloody injuries were associated with increased risk of depression and anxiety. These findings may reflect risk factors, causes and/or mechanisms shared among psychiatric conditions. Another possibility is that depression and anxiety symptoms, even years after the disaster, may be directly and indirectly related to earthquake exposure via PTSD. Our results also confirm previous studies [51, 52] that exposure variables, such as physical injury or loss of relatives, parents or friends, are significantly independently associated with mental health problems. This adds to our understanding of the impact of bereavement and physical health problems on mental health after a major disaster. For example, our results imply that disaster survivors who experience multiple types of exposure may require interventions for PTSD, anxiety and depression.

Our results revealed high comorbidity rates among sleep, PTSD, anxiety and depression 3 years after the Ya'an earthquake, which is consistent with previous studies [19, 53]. At least half the participants in our sample with any type of mental health problem had concurrent sleeping problems. Our results provide strong evidence that psychiatric disorders, such as PTSD, depression and anxiety, can co-exist among children and adolescents [54] and that sleeping disturbance is a core feature of these disorders. The results of this study further highlight the importance of developing sleep improvement and intervention programmes to reduce psychiatric risk among adolescent survivors of major natural disasters.

We aimed to determine the specific aspects of the sleep variables that may have contributed to PTSD, anxiety or depression in our sample. Our data support the hypothesis that sleep disturbance in general and specific sleep disturbances, including nightmares, shorter sleep duration and insomnia, are risk factors of psychopathology among children and adolescents after a natural disaster. In the present study, difficulties falling asleep and nightmares were the strongest risk factors for PTSD, which is consistent with the DSM-V criteria for PTSD [55]. These criteria consider the following two aspects of sleep disturbances: recurrent nightmares, which are listed in the re-experiencing cluster (criterion B2); and sleep disturbance (e.g., difficulty falling or staying asleep or restless sleep), which is listed in the hyperarousal and reactivity cluster (criterion E6). Night-time may be particularly difficult for children and adolescents with PTSD because of the associations between darkness and fear following a disaster [11]. This finding may explain why the younger adolescents in our sample were more likely to experience PTSD than their older counterparts, which is consistent with findings among adolescents following hurricanes [11]. Since feelings of fear and arousal interfere with sleep onset, these sleep-related problems may chronically disrupt sleep continuity and quality. In the presence of PTSD, nightmares can be a frequent reminder of traumatic events, and being awakened by nightmares in the middle of the night provides an opportunity for negative rumination, which may increase the likelihood of anxiety and depression. Our results help elucidate the interplay between sleep and the expression of psychological symptoms. They suggest a possible causal pathway from sleep disturbance to psychological problems, which should be explored in future research.

Although certain sleep parameters in our study were associated with all three psychiatric conditions, several parameters were associated with only anxiety or depression. One such parameter was shorter sleep duration. In the general population, short sleep duration has been associated with increased risk of mental or behavioural problems, such as anxiety, depression and suicidality [56–59]. Numerous studies have demonstrated that poor sleep habits and insufficient sleep negatively affect adolescents' behaviour and mood during the daytime hours and their ability to think, concentrate and perform in school. These problems also increase the risk of anxiety, depression, self-injury and suicide [60–63]. Thus, our results add to previous studies suggesting that interventions to prevent short sleep may substantially improve mental health of adolescents with anxiety and depression. Routine clinical assessments should include assessments of nightmares or sleep latency to prevent and manage potential PTSD in adolescents, even years after a major earthquake.

Not surprisingly, a high level of negative life events was associated with likelihood of mental health problems in our sample of young earthquake survivors. Our results suggest that children and adolescents who experience multiple difficulties such as earthquake, psychological and social stresses are at greater risk of developing mental health problems and sleeping disturbance. This is consistent with previous studies [10, 26, 49], Thus, children and adolescents at risk of negative events should be aided in developing coping strategies to resolve or avoid them.

The causal nature of the relationship between psychopathology and sleep cannot be determined based on our data; thus, several possibilities remain to be addressed. Longitudinal studies indicate that sleep problems are early markers of the subsequent development of psychopathology, including depression and PTSD, following disasters [9]. Similarly, the presence of increased levels of psychopathology leads to the development of sleep-related problems in children and adolescents. A reciprocal relationship between sleep disruption and psychopathology most likely exists and should be explored in future longitudinal studies. Currently, the specific mechanisms and processes mediating the regulation of sleep and psychopathology are also poorly understood and should be studied in children and adolescents referred to clinics. Other limitations of our study are that we did not assess the pre-earthquake prevalence of sleep problems, PTSD, anxiety or depression, nor did we control for other traumatic experiences that our respondents may have experienced. Future work is needed to clarify the long-term prevalence of psychiatric morbidity among children and adolescents after major disasters, since the literature reports highly variable rates.

In conclusion, the findings of the present study indicate that mental health problems are prevalent and overlap with sleep-related problems in child and adolescent survivors, even years after a major earthquake. We provide strong evidence that nightmares and difficulty initiating sleep are independently associated with PTSD in this population. We further show that insufficient sleep is independently associated with anxiety and depression. Mental health problems are ubiquitous and often co-occur with sleep-related problems, suggesting that sleep-related problems may be effective targets of preventive interventions. Indeed, an intervention targeting specific sleep

disturbances to improve adolescents' mental health may be more acceptable to Chinese adolescents than an intervention directly targeting mental disorders due to the stigma associated with mental health issues in Chinese culture. Interventions may need to be optimised based on gender and age. In addition, there is significant variation in rates of psychiatric morbidity among many studies of post-disaster children, which means that generalising about long-term prevalence in U18s after a disaster is challenging. Whether or not young disaster survivors meet the criteria of mental disorders, they may benefit from well-being programmes that teach potential coping strategies and enhance resilience against stress, such as through taiji quan, yoga, as well as training in coping with stress and in cognitive-behavioural methods and skills.

Acknowledgements The authors thank all participants in this study. We also thank all of our research collaborators in Baoxing County, Tianquan County, Lushan County, and Ya'an City in the Sichuan province of China. This research was supported by the Major Bidding Program of the National Social Science Foundation of China (17ZDA286), the Program of the National Social Science Foundation of China (18BSH121) and a project of the Propaganda Department of the People's Republic of China (2016zybw03).

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Maeda M, Kato H, Maruoka T (2009) Adolescent vulnerability to PTSD and effects of community-based intervention: longitudinal study among adolescent survivors of the Ehime Maru sea accident. Psychiatry Clin Neurosci 63(6):747–753
2. Costello EJ, Egger H, Angold A (2005) 10-year research update review: the epidemiology of child and adolescent psychiatric disorders: I. Methods and public health burden. J Am Acad Child Adolesc Psychiatry 44(10):972–986
3. Tang W, Zhao J, Lu Y, Yan T, Wang L, Zhang J, Xu J (2017) Mental health problems among children and adolescents experiencing two major earthquakes in remote mountainous regions: a longitudinal study. Compr Psychiatry 72:66–73
4. Zhang Z, Ran M-S, Li Y-H, Ou G-J, Gong R-R, Li R-H, Fan M, Jiang Z, Fang D-Z (2012) Prevalence of post-traumatic stress disorder among adolescents after the Wenchuan earthquake in China. Psychol Med 42(8):1687–1693
5. Goenjian AK, Pynoos RS, Steinberg AM, Najarian LM, Asarnow JR, Karayan I, Ghurabi M, Fairbanks LA (1995) Psychiatric comorbidity in children after the 1988: earthquake in Armenia. J Am Acad Child Adolesc Psychiatry 34(9):1174–1184
6. Wang C-W, Chan CL, Ho RT (2013) Prevalence and trajectory of psychopathology among child and adolescent survivors of disasters: a systematic review of epidemiological studies across 1987–2011. Soc Psychiatry Psychiatr Epidemiol 48(11):1697–1720
7. Tian Y, Wong TK, Li J, Jiang X (2014) Posttraumatic stress disorder and its risk factors among adolescent survivors three years after an 8.0 magnitude earthquake in China. BMC Public Health 14(1):1073
8. Roussos A, Goenjian AK, Steinberg AM, Sotiropoulou C, Kakaki M, Kabakos C, Karagianni S, Manouras V (2005) Posttraumatic stress and depressive reactions among children and adolescents after the 1999 earthquake in Ano Liosia, Greece. Am J Psychiatry 162(3):530–537
9. Fan F, Zhou Y, Liu X (2017) Sleep disturbance predicts posttraumatic stress disorder and depressive symptoms: a cohort study of Chinese adolescents. J Clin Psychiatry 78(7):882–888
10. Geng F, Fan F, Mo L, Simandl I, Liu X (2013) Sleep problems among adolescent survivors following the 2008 Wenchuan earthquake in China: a cohort study. J Clin Psychiatry 74(1):67–74
11. Brown TH, Mellman TA, Alfano CA, Weems CF (2011) Sleep fears, sleep disturbance, and PTSD symptoms in minority youth exposed to Hurricane Katrina. J Trauma Stress 24(5):575–580
12. Brindle RC, Cribbet MR, Samuelsson LB, Gao C, Frank E, Krafty RT, Thayer JF, Buysse DJ, Hall MH (2018) The relationship between childhood trauma and poor sleep health in adulthood. Psychosom Med 80(2):200–207
13. Baiden P, Fallon B, den Dunnen W, Boateng GO (2015) The enduring effects of early-childhood adversities and troubled sleep among Canadian adults: a population-based study. Sleep Med 16(6):760–767
14. Wang Y, Raffeld MR, Slopen N, Hale L, Dunn EC (2016) Childhood adversity and insomnia in adolescence. Sleep Med 21:12–18
15. Ekşi A, Braun KL, Ertem-Vehid H, Peykerli G, Saydam R, Toparlak D, Alyanak B (2007) Risk factors for the development of PTSD and depression among child and adolescent victims following a 7.4 magnitude earthquake. Int J Psychiatry Clin Pract 11(3):190–199
16. Pfefferbaum B (1997) Posttraumatic stress disorder in children: a review of the past 10 years. J Am Acad Child Adolesc Psychiatry 36(11):1503–1511
17. Alvaro PK, Roberts RM, Harris JK (2013) A systematic review assessing bidirectionality between sleep disturbances, anxiety, and depression. Sleep 36(7):1059–1068
18. Spoormaker VI, van den Bout J (2005) Depression and anxiety complaints; relations with sleep disturbances. Eur Psychiatry 20(3):243–245
19. Fan F, Zhang Y, Yang Y, Mo L, Liu X (2011) Symptoms of posttraumatic stress disorder, depression, and anxiety among adolescents following the 2008 Wenchuan earthquake in China. J Trauma Stress 24(1):44–53
20. Pine DS, Cohen JA (2002) Trauma in children and adolescents: risk and treatment of psychiatric sequelae. Biol Psychiatry 51(7):519–531
21. Wang H, Jin H, Nunnink SE, Guo W, Sun J, Shi J, Zhao B, Bi Y, Yan T, Yu H (2011) Identification of post traumatic stress disorder and risk factors in military first responders 6 months after Wen Chuan earthquake in China. J Affect Disord 130(1):213–219
22. Kessler RC, Sonnega A, Bromet E, Hughes M, Nelson CB (1995) Posttraumatic stress disorder in the National Comorbidity Survey. Arch Gen Psychiatry 52(12):1048–1060
23. Dyregrov A, Yule W (2006) A review of PTSD in children. Child Adolesc Ment Health 11(4):176–184
24. Bal A, Jensen B (2007) Post-traumatic stress disorder symptom clusters in Turkish child and adolescent trauma survivors. Eur Child Adolesc Psychiatry 16(7):449–457
25. Schwarz ED, Kowalski JM (1991) Malignant memories: PTSD in children and adults after a school shooting. J Am Acad Child Adolesc Psychiatry 30(6):936–944
26. Tang W, Zhao J, Lu Y, Zha Y, Liu H, Sun Y, Zhang J, Yang Y, Xu J (2018) Suicidality, posttraumatic stress, and depressive reactions after earthquake and maltreatment: a cross-sectional

survey of a random sample of 6132 Chinese children and adolescents. J Affect Disord 232, 363–369
27. Smith P, Perrin S, Dyregrov A, Yule W (2003) Principal components analysis of the impact of event scale with children in war. Personal Individ Differ 34(2):315–322
28. Perrin S, Meiser-Stedman R, Smith P (2005) The Children's Revised Impact of Event Scale (CRIES): validity as a screening instrument for PTSD. Behav Cogn Psychother 33(4):487
29. Giannopoulou I, Strouthos M, Smith P, Dikaiakou A, Galanopoulou V, Yule W (2006) Post-traumatic stress reactions of children and adolescents exposed to the Athens 1999 earthquake. Eur Psychiatry 21(3):160–166
30. Jin L, Wen M, Fan JX, Wang G (2012) Trans-local ties, local ties and psychological well-being among rural-to-urban migrants in Shanghai. Soc Sci Med 75(2):288–296
31. Zhang J, Zhu S, Du C, Zhang Y (2015) Posttraumatic stress disorder and somatic symptoms among child and adolescent survivors following the Lushan earthquake in China: a six-month longitudinal study. J Psychosom Res 79(2):100–106
32. Angold A, Costello EJ, Silver D (1995) Development of a short questionnaire for use in epidemiological studies of depression in children and adolescents. Int J Methods Psychiatr Res 5:237–249
33. Yu M, Xu W, Wang J (2017) Automatic thoughts as a predictor of internalizing and externalizing problems in Chinese adolescents: a test of the cognitive content-specificity hypothesis with age effects. Scand J Psychol 58(5):351–358
34. Cheng P-X, Cao F-L, Su L-Y (2009) Reliability and validity of the Short Mood and Feelings Questionnaire in Chinese adolescents. Chin Ment Health J
35. Su L, Wang K, Fan F, Su Y, Gao X (2008) Reliability and validity of the screen for child anxiety related emotional disorders (SCARED) in Chinese children. J Anxiety Disord 22(4):612–621
36. Liu X, Tang M, Hu L (1996) Reliability and validity of the Pittsburgh sleep quality index. Chin J Psychiatry 29:103–107
37. Liu X, Liu L, Yang J, Zhao G (1997) Reliability and validity of the adolescents self-rating life events checklist. Chin J Clin Psychol 5(1):34–36
38. Liu X, Tein J-Y (2005) Life events, psychopathology, and suicidal behavior in Chinese adolescents. J Affect Disord 86(2):195–203
39. Liu X, Oda S, Peng X, Asai K (1997) Life events and anxiety in Chinese medical students. Soc Psychiatry Psychiatr Epidemiol 32(2):63–67
40. Carretero-Dios H, Pérez C, Buela-Casal G (2009) Content validity and metric properties of a pool of items developed to assess humor appreciation. Span J Psychol 12(2):773–787
41. Fan F, Long K, Zhou Y, Zheng Y, Liu X (2015) Longitudinal trajectories of post-traumatic stress disorder symptoms among adolescents after the Wenchuan earthquake in China. Psychol Med 45(13):2885–2896
42. Pan X, Liu W, Deng G, Liu T, Yan J, Tang Y, Dong W, Cui Y, Xu M (2015) Symptoms of posttraumatic stress disorder, depression, and anxiety among junior high school students in worst-hit areas 3 years after the Wenchuan earthquake in China. Asia Pac J Public Health 27(2):NP1985–NP1985P1994
43. Zhang Z, Ran M-S, Li Y-H, Ou G-J, Gong R-R, Li R-H, Fan M, Jiang Z, Fang D-Z (2012) Prevalence of post-traumatic stress disorder among adolescents after the Wenchuan earthquake in China. Psychol Med 42(08):1687–1693
44. Tepper P, Liu X, Guo C, Zhai J, Liu T, Li C (2008) Depressive symptoms in Chinese children and adolescents: parent, teacher, and self reports. J Affect Disord 111(2):291–298
45. Guo L, Deng J, He Y, Deng X, Huang J, Huang G, Gao X, Lu C (2014) Prevalence and correlates of sleep disturbance and depressive symptoms among Chinese adolescents: a cross-sectional survey study. BMJ Open 4(7):e005517
46. Xiaoli Y, Chao J, Wen P, Wenming X, Fang L, Ning L, Huijuan M, Jun N, Ming L, Xiaoxia A (2014) Prevalence of psychiatric disorders among children and adolescents in northeast China. PLoS One 9(10):e111223
47. Cénat JM, Derivois D (2015) Long-term outcomes among child and adolescent survivors of the 2010 Haitian earthquake. Depression Anxiety 32(1):57–63
48. Derivois D, Cénat JM, Joseph NE, Karray A, Chahraoui K (2017) Prevalence and determinants of post-traumatic stress disorder, anxiety and depression symptoms in street children survivors of the 2010 earthquake in Haiti, four years after. Child Abuse Neglect 67:174–181
49. Cénat JM, Derivois D, Hébert M, Amédée LM, Karray A (2018) Multiple traumas and resilience among street children in Haiti: psychopathology of survival. Child Abuse Neglect 79:85–97
50. Goenjian AK, Roussos A, Steinberg AM, Sotiropoulou C, Walling D, Kakaki M, Karagianni S (2011) Longitudinal study of PTSD, depression, and quality of life among adolescents after the Parnitha earthquake. J Affect Disord 133(3):509–515
51. Xiang Y-h, Chi X, Jiang Y-q, Wang R-f, Mo L (2016) Psychosomatic status, personality traits, and coping styles of bereaved and non-bereaved survivors of the 2008 Wenchuan earthquake, China. Front Psychiatry 7:17
52. Yi X, Gao J, Wu C, Bai D, Li Y, Tang N, Liu X (2018) Prevalence and risk factors of prolonged grief disorder among bereaved survivors seven years after the Wenchuan earthquake in China: a cross-sectional study. Int J Nurs Sci 5:157–161
53. Acierno R, Ruggiero KJ, Galea S, Resnick HS, Koenen K, Roitzsch J, de Arellano M, Boyle J, Kilpatrick DG (2007) Psychological sequelae resulting from the 2004 Florida hurricanes: implications for postdisaster intervention. Am J Public Health 97(Supplement_1):S103–S108
54. Starr LR, Stroud CB, Li YI (2016) Predicting the transition from anxiety to depressive symptoms in early adolescence: negative anxiety response style as a moderator of sequential comorbidity. J Affect Disord 190:757–763
55. Association AP (2013) Diagnostic and statistical manual of mental disorders (DSM-5®). American Psychiatric Publishing, Washington, DC
56. Liu X, Zhou H (2002) Sleep duration, insomnia and behavioral problems among Chinese adolescents. Psychiatry Res 111(1):75–85
57. Liu X (2004) Sleep and adolescent suicidal behavior. Sleep 27(7):1351–1358
58. Calhoun SL, Fernandez-Mendoza J, Vgontzas AN, Mayes SD, Liao D, Bixler EO (2017) Behavioral profiles associated with objective sleep duration in young children with insomnia symptoms. J Abnorm Child Psychol 45(2):337–344
59. Tu KM, Erath SA, El-Sheikh M (2015) Peer victimization and adolescent adjustment: the moderating role of sleep. J Abnorm Child Psychol 43(8):1447–1457
60. Sivertsen B, Harvey AG, Lundervold AJ, Hysing M (2014) Sleep problems and depression in adolescence: results from a large population-based study of Norwegian adolescents aged 16–18 years. Eur Child Adolesc Psychiatry 23(8):681–689
61. Raniti MB, Allen NB, Schwartz O, Waloszek JM, Byrne ML, Woods MJ, Bei B, Nicholas CL, Trinder J (2017) Sleep duration and sleep quality: associations with depressive symptoms across adolescence. Behav Sleep Med 15(3):198–215
62. Betts KS, Williams GM, Najman JM, Alati R (2013) The role of sleep disturbance in the relationship between post-traumatic stress disorder and suicidal ideation. J Anxiety Disord 27(7):735–741
63. Cox RC, Olatunji BO (2016) A systematic review of sleep disturbance in anxiety and related disorders. J Anxiety Disord 37:104–129