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# Exploring the influence of social relationships on adolescents' multiple sleep problems via a school-based China education panel survey: the moderating role of depressive emotion

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## Abstract

**Background** Poor adolescent sleep health is a significant public health issue worldwide. In particular, multiple sleep problems disturb the lives of adolescents. It is urgent to identify the key factors (e.g., parent–child relationships, peer relationships, and teacher–student relationships) and influential moderators (e.g., depressive emotions) that contribute to adolescent sleep problems.

**Methods** Data were derived from the China Education Panel Survey (CEPS) and collected through self-reported questionnaires. A total of 7405 students (3818 boys and 3587 girls) born between 2000 and 2001 were followed from grade 7 through grade 8. Logistic regression was applied to explore the effects of the independent variables and moderating variable on students' sleep problems.

**Results** Remaining fatigued after waking up (17.97%), dreaminess (14.21%) and sleep fragmentation (13.07%) were the three most common sleep problems among the students. Peer relationships, teacher praise, and depressive emotions were related to adolescents' sleep problems (all $p < 0.05$). Notably, depressive emotion served as an influential moderator in the relationship between social relationships and sleep problems among students, exhibiting simultaneous and lasting effects (all $p < 0.05$).

**Conclusions** Reducing adolescents' sleep problems is necessary, and enhancing adolescents' positive social relationships and reducing their depressive emotions should receive increased attention.

**Keywords** Sleep problems, Social relationships, Depressive emotion, Moderating effect, Adolescents

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## Introduction

Optimal sleep, which involves sufficient sleep and the absence of sleep problems [1], plays a crucial role in the development of adolescents. A study analyzing self-report measures completed by middle school students found that their sleep problems were related to school burnout [2]. A study examining sleep behavior in children aged 3.0 to 14.4 using the Children's Sleep Habits Questionnaire (CSHQ) revealed that children with sleep disorders can impact their family functioning [3]. Some systematic reviews also pointed out connection between adolescents' sleep problems and various cognitive, behavioral, emotional, and physical issues [4, 5]. Further research on adolescent sleep problems is needed to guide intervention and prevention strategies. The Health Behavior Study of School-Age Children (HBSC), which included more than 40 countries and regions in Europe, Central Asia, and North America, showed that from 2001 to 2002 to 2017–2018, the percentage of adolescents with daily sleep difficulties increased from 8.81% to 13.13% across countries, with North America having a higher percentage of daily sleep difficulties than the other two regions (13.24%~14.20%) (Fig. 1) [6]. Moreover, a study revealed that children face multiple sleep problems, including difficulties falling asleep, sleep talking, restless sleep, and daytime sleepiness. The results of this study also indicated a high prevalence of sleep problems among schoolchildren in both China and the United States [7]. According to the Mater-University Study of Pregnancy (MUSP) cohort, 34.7% of adolescents self-reported sometimes having trouble sleeping [8]. Therefore, adolescent sleep health is a significant public health issue worldwide [9, 10]. It is urgent to discover the key factors affecting sleep problems in adolescents. A previous study has shown that social ties are important in promoting teenagers' healthy sleep behaviors [11]. Parent–child conflict was positively related to more difficulties maintaining sleep [12]. Greater teacher–student conflict [13] and discordant peer relationships [14] were also found to be associated with sleep problems. In addition, evidence suggests that depressive emotions, including depression and sadness, are also associated with sleep health [15–17]. Social-relational factors and emotional status are vital to adolescent sleep.

### Theoretical background and effects of social relationships on adolescents' sleep problems

Bronfenbrenner's ecological systems theory provides a framework for understanding how individuals interact with their environment (e.g., family, school, and neighborhood). One of the theory's systematic hierarchies, the microsystem, includes the life environment closest to the

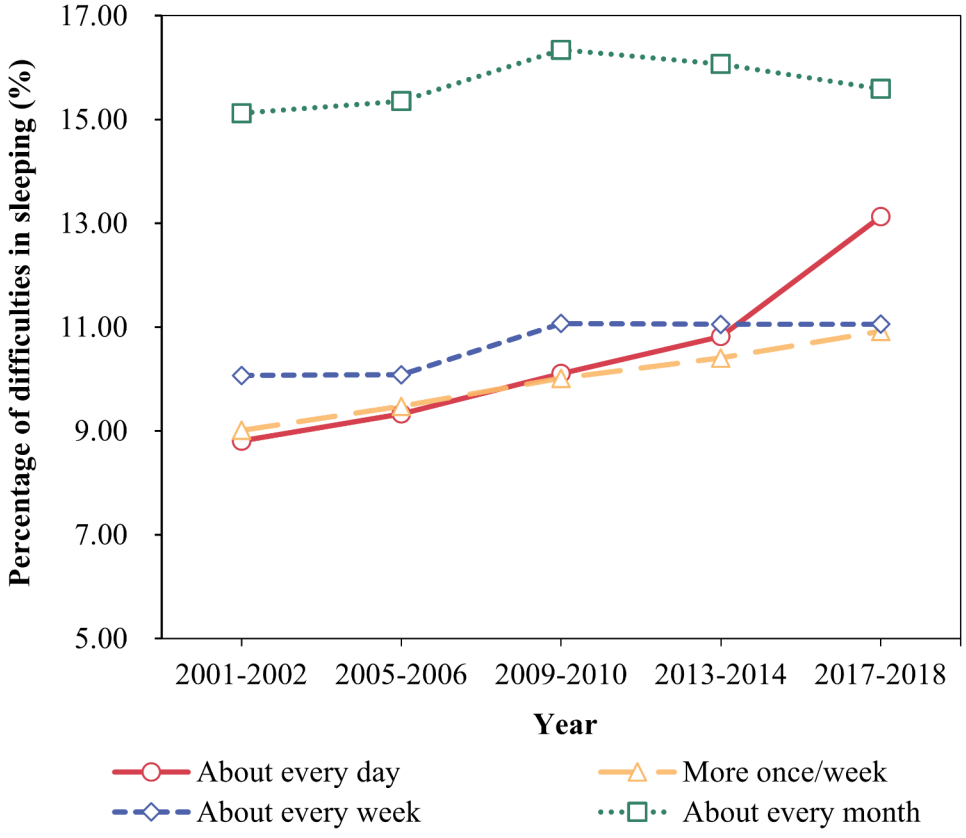


**Fig. 1** Percentage of adolescents' difficulties in sleeping, 2001–2018 (Data source: HBSC) [6]

individual [18]. For teenagers, the microsystem encompasses their family and school settings, and the main social relationships during adolescence involve parental relationships, peer relationships, and teacher–student relationships [11, 13]. Social relationships refer to relationships between people who interact regularly and are considered meaningful by participants [19]. The content of these relationships affects adolescent health behaviors [20]. Furthermore, social capital, defined as a resource that provides support in social networks and connections between people [21], is considered embedded in adolescents' social life contexts and, thus, is classified as family, school, peer, and community social capital, all of which have been found to have implications for adolescent mental health [22]. Researchers are increasingly recognizing the importance of the environment of life and social relationships on adolescent health, particularly about sleep. Notably, the one-child policy implemented in China from 1979 to 2015 was unique, and its impact on the development of Chinese children has received widespread attention [23]. In terms of sleep health, being the only child has been proven to be a protective factor against poor sleep quality compared with not being the only child [24]. This may be attributed to the fact that in single-child families, children receive better parental guidance and individual care [25], leading to improved behavioral health. With respect to social relationships, research has indicated that only children are more likely to have a close relationship with their parents [26] and experience better feelings toward school [27]. Building upon these theories and previous research, this study further explores the mechanisms through which adolescents' social relationships influence their sleep while controlling for factors such as only child status.

The family is the first and most critical social tie in teenagers' lives, and it can be a source of social support and stress that shapes adolescent health behaviors. Warm connections with parents are a significant deterrent to problem behaviors in adolescence [28]. Recent studies have indicated that the parent–child relationship predicts sleep problems [29]. Children with positive parent–child relationships and supportive family environments tend to have longer sleep durations and better sleep quality [30]. Poor parent–child relationships in the family (as reflected by the absence of a father, less closeness and greater conflict in the mother–child relationship) undermine sleep health [31]. Thus, we propose hypothesis 1 (H1): A good parent–child relationship is negatively correlated with multiple sleep problems.

Peer relationships are interpersonal relationships established and developed through communication between individuals based on common interests and friendships [32]. Teenagers' peer associations are important determinants of health-related behaviors [33]. From the vigilance–arousal perspective [34], experiences of peer victimization may lead to sleep problems via distress. In contrast, adolescents who have positive peer relationships are less likely to experience heightened arousal, distress, or worries that might interfere with sleep [35]. Research has suggested that peer relationships are positively correlated with sleep duration [36]. Therefore, we propose hypothesis 2 (H2): A good peer relationship is negatively related to multiple sleep problems.

Additionally, attachment to schools may foster positive mental health in adolescence [37]. In school, students can bond with teachers and other people who provide them with a sense of connectedness and security. The quality of the teacher–student relationship is defined by student–teacher closeness and conflict [38]. Students' sleep problems were associated with reduced student–teacher closeness and greater teacher–student conflict [13]. Research has shown that students who are not frequently praised by teachers have poorer sleep quality [39]. As a result, we propose hypothesis 3: Teacher praise is negatively associated with multiple sleep problems (H3-1), while teacher criticism can increase multiple sleep problems (H3-2).

#### Depressive emotion

Emotion is divided into two dimensions: arousal and pleasure [40]. Depressive emotions are generally characterized by low arousal and low pleasure, including sadness and gloominess. A growing body of research has focused on the association between insufficient sleep, poor sleep quality, and negative emotions [41, 42]. A study showed that adolescent sleep is strongly associated with depressive emotion, and there are significant differences in objective sleep measurements between those with and without depressive emotion; that is, adolescents with depressive emotion have longer sleep latency, more postsleep awakenings, less efficient sleep and a more fragmented sleep structure [43]. Adolescents with depressive emotions have significantly more severe subjective sleep problems than those without depressive emotions, mainly manifesting as more difficulty falling asleep, easy and early awakening, and more severe daytime sleepiness [44]. A previous study revealed an association between sleep disturbances and depressive symptoms during adolescence [45], such as the emergence of insomnia with depression [46]. Hence, we propose hypothesis 4 (H4): Depressive emotion is positively correlated with multiple sleep problems.

The interpersonal theory of depression proposes that interpersonal relationships that lack emotional support and interaction can lead to depression and exacerbate depressive feelings [47]. A study suggested that relationship quality with both parents might impact girls' and boys' depressive symptoms [48]. Moreover, declining

classmate and teacher support was associated with worsening self-esteem and depressive emotions [49]. Poor peer relationship quality, difficulty being close to others, and difficulty depending on others predicted depressive symptoms over six months [50]. Moreover, it was found that teacher feedback influences students' well-being in school [51]. Based on the above, we propose hypothesis 5 (H5): Depressive emotion has a moderating effect between social relationships (parent–child, peer and teacher–student relationships) and adolescent multiple sleep problems.

## Methods

### Study design and participants

Data were derived from the China Education Panel Survey (CEPS). The CEPS is a nationally representative large-scale follow-up survey project designed and implemented by the National Survey Research Center at Renmin University of China and was approved by the Institutional Review Board at Renmin University of China (Project No. 72810330, Project No. 61662993). The baseline survey was conducted in the 2013–2014 academic year, and the baseline sample included seventh and ninth graders. The survey employed a multistage probability proportionate to size (PPS) sampling method. The average education level of the population and the proportion of the floating population as stratification variables selected 438 classes in 112 schools from 28 county-level units. A self-administered questionnaire was distributed to all of the students in the selected classes [52].

In the CEPS, ninth-grade students were selected as the experimental sample. Therefore, our study utilized two-year follow-up data starting from the seventh grade. A total of 10,279 students were initially selected for participation. By the 2014–2015 academic year, successful follow-up was achieved with 9449 individuals, resulting in a follow-up rate of 91.93%. The main reasons for the loss to follow-up included transferring to other schools and dropping out. Due to the lack of responses to key questions relevant to our study, 7405 students were ultimately included in the final sample, resulting in a valid sample rate of 72.04%. Written informed consent was obtained from the study participants before the baseline survey. More details about the sampling, questionnaires, and other issues can be retrieved from the CEPS website (http://ceps.ruc.edu.cn/English/Home.htm).

### Measures

#### *Sleep problems*

In this study, sleep problems were only investigated in the second wave of CEPS and were measured by asking participants entering the eighth grade, "Generally speaking, do you have any of the following sleep problems (please mark all that apply)?" The response options included "I have no sleep problems" "insomnia, difficulty falling asleep" "sleep fragmentation" "drowsiness" "remaining fatigued after waking up" "snoring" "grinding teeth in sleep" "sleepwalking" "dreaminess" and "talking in sleep". Among these, "dreaminess" refers to having many dreams or being prone to dreaming.

#### *Depressive emotion*

Two waves of depressive emotion in the CEPS served as moderators, which included four items "depressed" "unhappy" "not enjoying life" and "sad", and the items were scored on a 5-point scale ranging from "never" to "always". The Cronbach's α was 0.89, indicating good reliability.

#### *Social relationships*

This study focused on adolescents' parent–child relationships, peer relationships, and teacher–student relationships in two survey waves. Data on parent–child relationships were collected by asking students two items: "How is the general relationship between you and your father/mother?" There were three possible responses: "not close" "neither too close nor too far" and "very close". Cronbach's α was 0.60.

Peer relationships were measured by asking students how much they agreed that "most of my classmates are nice to me", and the responses included "strongly disagree" "somewhat disagree" "somewhat agree" and "strongly agree".

The teacher–student relationship measure assessed situations in which students were praised or criticized by teachers, and the items were scored on a 4-point scale ranging from "strongly disagree" to "strongly agree". Teacher praise included four items: "My mathematics teacher/Chinese teacher/English teacher/homeroom teacher always praises me". Cronbach's α was 0.89. Teacher criticism included two items: "My parents always receive criticism about me from my teacher" and "My homeroom teacher always criticizes me". Cronbach's α was 0.77.

#### *Control variables*

Students' self-evaluated health status and demographic characteristics, including sex, only child status, self-assessed family financial conditions and Hukou, were used as control variables. Self-evaluated health status was measured by asking the students "Which one of the following best describes your general health condition at present?", and the responses included "very poor", "not very good", "moderate", "good" and "very good". Self-assessed family financial conditions included poor, moderate and rich. China's household registration (Hukou) system divides the population based on geography and family relations. In this study, Hukou included

agricultural Hukou, nonagricultural Hukou, residential Hukou and others.

### Statistical analysis

Statistical analyses were performed by using STATA version 15.1. Paired *t* test was used to compare depressive emotion, parent–child relationship and teacher–student relationship in two academic years; and *Wilcoxon signed-rank* test was used to compare peer relationship in two academic years. The correlation among key variables were clarified via correlation analysis. *Pearson's* correlation coefficient was used to measure the correlations between continuous variables, *Point-biserial* correlation coefficient was used to measure the correlations between continuous variables and dichotomous variables [53], ordered logit regression was used to test the correlations between dichotomous variables and ordered multicategorical variables, and *Spearman's rank* correlation coefficient was used to test the correlations between continuous variables and ordered multicategorical variables [54]. Logistic regression was applied to explore the effects of the independent variables and moderating variable involved in the second wave of CEPS on students' sleep problems. The interaction terms of depressive emotion in the previous and current academic years and social relationships in the two academic years were included in separate regression models to explore the moderating effects of depressive emotion between adolescents' social relationships and multiple sleep problems. The procedures by Aiken and West [55], Dawson [56] and Dawson and Richter [57] were used to plot the interaction effects of the moderator (http://www.jeremydawson.co.uk/slopes.htm). To draw more accurate plots and avoid collin earity problems, we followed Aiken and West [55], who proposed mean-centering as a solution to the problem of collinearity.

## Results

### Sociodemographic characteristics

The participants in this study included 7405 junior high school students, that is, 3818 boys (51.56%) and 3587 girls (48.44%). All students were between the ages of 12 and 18, with 50.88% born in 2001 and 39.80% born in 2000. In the second wave of the CEPS, 54.56% of students were only children. Most junior high school students' self-assessed family economic conditions were moderate (73.54%). In terms of Hukou, 52.53% of students were in agricultural Hukou, 27.66% were in non-agricultural Hukou, and 19.81% were in residential Hukou and others. The three most common sleep problems among eighth-grade students were remaining fatigued after waking (17.97%), dreaminess (14.21%) and sleep fragmentation (13.07%) (Fig. 2a). Meanwhile, students' mean depressive emotion score rose from 2.02 to 2.15 in two academic years ($p<0.001$), and the mean score increased for 46.55% of students (Fig. 2b). In addition, students' mean parent–child relationship and teacher praise scores decreased, while their mean teacher criticism score increased in both academic years (all $p<0.001$) (Fig. 2c and e). However, there was no significant change in students' perceptions of their classmates being nice to them ($p=0.285$) (Fig. 2d).

### Correlation analyses

The correlations among the key variables are shown in Table 1. Three sleep problems measured in the eighth grade, remaining fatigued after waking up, dreaminess, and sleep fragmentation, were significantly positively correlations with depressive emotions over two academic years (all $p<0.001$). Additionally, these sleep problems were negatively associated with parent–child relationships, peer relationships, and teacher praise during the same two-year period (all $p<0.01$). Moreover, significant positive correlations were observed between the seventh- and eighth-grade variables: depressive emotion and teacher criticism, parent–child relationship and peer relationship, parent–child relationship and teacher praise, and peer relationship and teacher praise (all $p<0.001$). Conversely, significant negative correlations were found between variables measured in the seventh and eighth grades: depressive emotion and parent–child relationship, depressive emotion and peer relationship, depressive emotion and teacher praise, parent–child relationship and teacher criticism, and peer relationship and teacher criticism (all $p<0.05$). Specifically, in the seventh grade, teacher praise exhibited a significant negative association with teacher criticism, while in the eighth grade, a significant positive correlation was observed (all $p<0.001$).

### The main effects of social relationships and depressive emotion on the probability of having multiple sleep problems

With the three most common sleep problems in junior high school students in CEPS as the dependent variable, i.e., remaining fatigued after waking up, dreaminess, and sleep fragmentation, the logistic regression results are shown in Table 2. Depressive emotion, whether from the previous academic year (OR = 1.41, 95% CI 1.30 ~ 1.52; OR = 1.25, 95% CI 1.15 ~ 1.36; OR = 1.25, 95% CI 1.15 ~ 1.37) or the current academic year (OR = 1.57, 95% CI 1.47 ~ 1.68; OR = 1.45, 95% CI 1.35 ~ 1.56; OR = 1.40, 95% CI 1.30 ~ 1.50), was a risk factor for students' sleep problems. Compared with students who had very poor peer relationships in the previous academic year, moderate peer relationships could help reduce the risk of their dreaminess (OR = 0.68, 95% CI 0.47 ~ 0.99). In addition, receiving teacher praise both in the previous academic

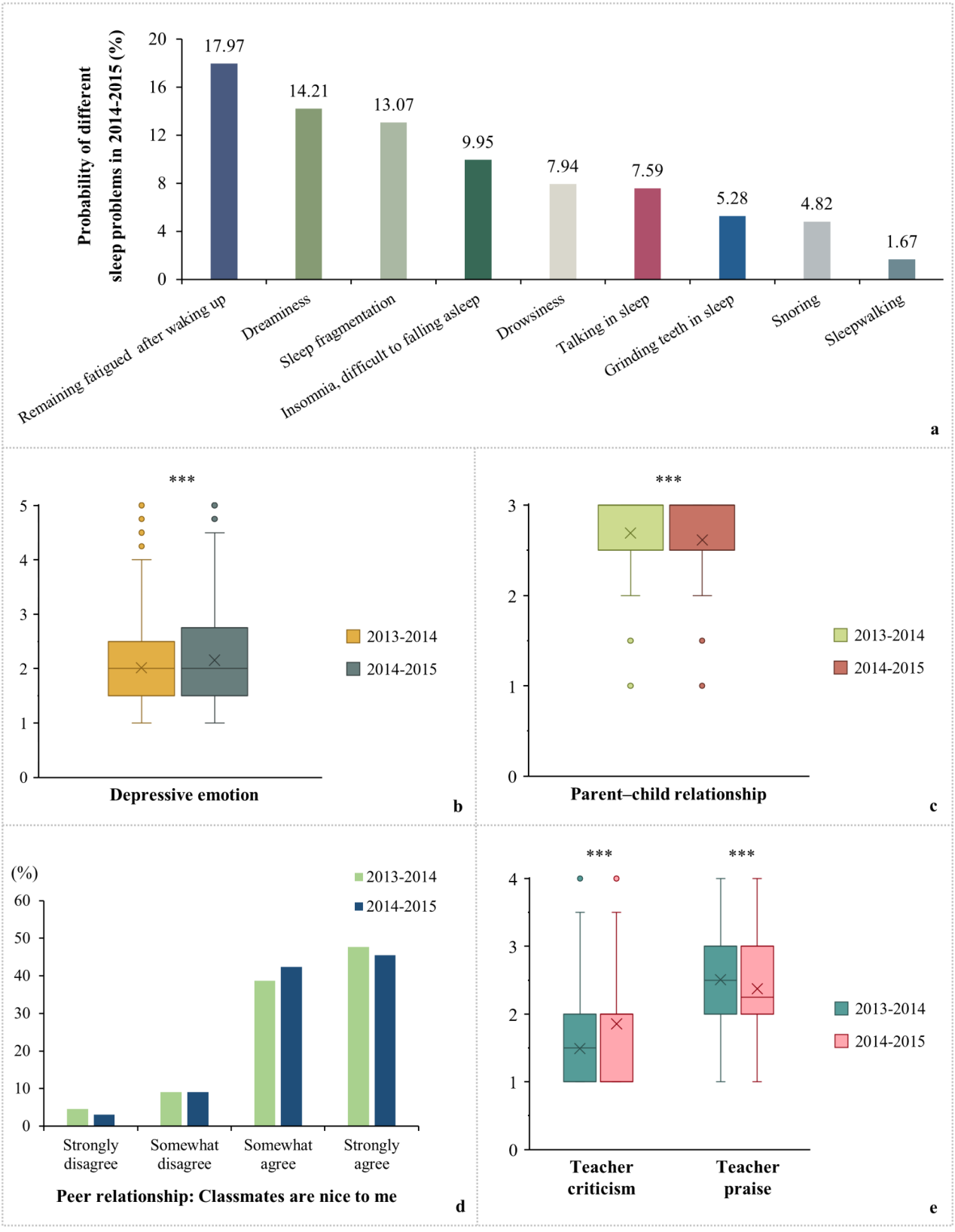


**Fig. 2** Descriptive statistics for variables of the sample. *** $p<0.001$

**Table 1** Bivariate correlations of key variables ($n = 7405$)

| Variables (7th–grade) | Sleep problem (8th–grade) | | | Depressive emotion | Parent–child relationship | Peer relationship | Teacher–student relationship | |
|---|---|---|---|---|---|---|---|---|
| | Remaining fatigued after waking up | Dreaminess | Sleep fragmentation | | | | Teacher praise | Teacher criticism |
| Depressive emotion | 0.1439*** | 0.0929*** | 0.0983*** | | | | | |
| Parent–child relationship | -0.0762*** | -0.0390*** | -0.0506*** | -0.2637*** | | | | |
| Peer relationship | -0.1220** | -0.0369 | -0.1086*** | -0.2092*** | 0.1694*** | | | |
| Teacher–student relationship | | | | | | | | |
| Teacher praise | -0.0596*** | -0.0300** | -0.0532*** | -0.1818*** | 0.2336*** | 0.2851*** | | |
| Teacher criticism | 0.0020 | 0.0092 | 0.0110 | 0.1715*** | -0.0781*** | -0.1365*** | -0.0591*** | |
| Variables (8th–grade) | Sleep problem (8th–grade) | | | Depressive emotion | Parent–child relationship | Peer relationship | Teacher–student relationship | |
| | Remaining fatigued after waking up | Dreaminess | Sleep fragmentation | | | | Teacher praise | Teacher criticism |
| Depressive emotion | 0.2063*** | 0.1655*** | 0.1496*** | | | | | |
| Parent–child relationship | -0.0830*** | -0.0551*** | -0.0544*** | -0.2313*** | | | | |
| Peer relationship | -0.1776*** | -0.1614*** | -0.1235** | -0.1899*** | 0.1906*** | | | |
| Teacher–student relationship | | | | | | | | |
| Teacher praise | -0.0741*** | -0.0490*** | -0.0586*** | -0.1519*** | 0.2383*** | 0.2960*** | | |
| Teacher criticism | 0.0062 | 0.0087 | 0.0079 | 0.1145*** | -0.0231* | -0.0400** | 0.1297*** | |

Note. Sleep problems were measured in the 8th grade

*Pearson's* correlation coefficient was used to measure the correlations between continuous variables (depressive emotion, parent–child relationship, teacher–student relationship). *Point-biserial* correlation coefficient was used to measure the correlations between continuous variables and dichotomous variables (sleep problems). Ordered logit regression was used to test the correlations between dichotomous variables and ordered multicategorical variables (peer relationship). *Spearman's rank* correlation coefficient was used to test the correlations between continuous variables and ordered multicategorical variables

*$p<0.05$, **$p<0.01$, ***$p<0.001$

year and in the current academic year was a protective factor for students' remaining fatigued after waking up (OR = 0.90, 95% CI 0.83 ~ 0.98; OR = 0.88, 95% CI 0.81 ~ 0.96) and sleep fragmentation (OR = 0.90, 95% CI 0.81 ~ 0.99; OR = 0.89, 95% CI 0. 0.81 ~ 0.98). These findings fully support H2, H3-1, and H4.

### The interaction effects between depressive emotion and social relationships on multiple sleep problems

Depressive emotion in the previous academic year, as a moderating variable, multiplied with social relationships (parent–child relationship, peer relationship, teacher praise and teacher criticism) in two academic years as interaction terms, were successively brought into the model to test the effect on students' remaining fatigued after waking up (Model A1-1 ~ 8), dreaminess (Model B1-1 ~ 8) and sleep fragmentation (Model C1-1 ~ 8) in the second wave of the CEPS. As shown in Table 3, Model A1-1 indicated that the interaction term of depressive emotion and parent–child relationship in the previous academic year significantly influenced the students' remaining fatigued after waking up ($\beta = 0.140$, $p < 0.05$). Specifically, a better parent–child relationship, along with lower depressive emotion, could protect students from remaining fatigued after waking up (Fig. 3). Model A1-2 and Model B1-2 both showed that for students who had good peer relationships, lower depressive emotion in the previous academic year reduced the likelihood of remaining fatigued after waking up and dreaminess (Table 4). Meanwhile, Model A1-6 showed that when students perceived that their classmates were nice to them in the current academic year, lower depressive emotion in the previous academic year decreased the probability of remaining fatigued after waking up (Table 4). Model C1-5 suggested that higher depressive emotion in the previous academic year increased the probability of sleep fragmentation even if students had a good parent–child relationship in the current academic year ($\beta = 0.183$, $p < 0.05$; Fig. 3 Model C1-5).

Depressive emotion in the current academic year was used as a moderating variable and was multiplied by social relationships in two years to test the effect on students' sleep problems (Model A2-1 ~ 8, Model B2-1 ~ 8, Model C2-1 ~ 8). Model A2-1 showed that the better the parent–child relationship in the previous academic year, the lower the probability of remaining fatigued after waking up among adolescents in the current academic year with low depressive emotion ($\beta = 0.121$, $p < 0.05$; Fig. 2 Model A2-1). Model A2-2 indicated a similar effect of having better peer relationships in the previous academic year with low depressive emotion in the current year (Table 4). Model A2-7 and Model C2-7 both demonstrated that for students who were frequently criticized by teachers, experiencing more depressive emotions at the same time increased the probability of remaining fatigued after waking up ($\beta = -0.106$, $p < 0.01$) and sleep fragmentation ($\beta = -0.164$, $p < 0.001$). These findings suggested that depressive emotions in current and previous academic years are influential moderating factors of multiple sleep problems among junior high school students, i.e., H5 was verified.

## Discussions

Although some previous studies have suggested a link between social relationships and adolescent sleep health, this study further explored how social relationships influence sleep problems using data from CEPS. This study revealed that peer relationships and teacher praise significantly affected adolescents' multiple sleep problems to varying degrees. Moreover, we found that depressive emotions not only had a negative effect on adolescents' sleep problems but also moderated the effect of social relationships on the occurrence of sleep problems. Specifically, during the eighth grade, depressive emotion moderated the impact of teacher criticism on remaining fatigued after waking up and sleep fragmentation. However, when analyzing data collected at other periods, we observed that the moderating effect primarily occurred in the influence of the parent–child and peer relationships. Notably, the moderating effect of depressive emotion on the influence of peer relationships on remaining fatigued after waking persisted. This can be attributed to the significant role of the teacher–student relationship in the school context [58]. As students' progress to higher grades, they face escalating academic pressure, making the interaction between teacher–student relationships and depressive emotions more pronounced. These findings suggest that future research should explore the impact of improving social relationships and reducing depressive emotions on adolescent sleep problems. Moreover, it is essential to consider the long-term effects of depressive emotion and its interactions with different social relationships.

### Friendly parent–child relationships and peer relationships can help with sleep

This study did not find a directly significant effect of the parent–child relationship on the occurrence of sleep problems in adolescents, but the association between the two was presented under the moderating effect of depressive emotion. Previous studies have shown that emotional difficulties derived from parent–child conflict can increase arousal and hypervigilance among adolescents, which interferes with sleep physiology [12]. Moreover, children's healthy sleep patterns could be developed through relevant sleep-promoting parenting practices by their parents to help them establish good sleep hygiene habits [59]. In addition, this study demonstrated that

**Table 2** The main effects of social relationships and depressive emotion on multiple sleep problems

| Variables | Depressive emotion (7th–grade) Social relationships (7th–grade) | | | | | | Depressive emotion (8th–grade) Social relationships (8th–grade) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Y = Remaining fatigued after waking up | | Y = Dreaminess | | Y = Sleep fragmentation | | Y = Remaining fatigued after waking up | | Y = Dreaminess | | Y = Sleep fragmentation | |
| | Model A | | Model B | | Model C | | Model a | | Model b | | Model c | |
| | OR | (95% CI) | OR | (95% CI) | OR | (95% CI) | OR | (95% CI) | OR | (95% CI) | OR | (95% CI) |
| Depressive emotion | 1.41 | (1.30, 1.52)*** | 1.25 | (1.15, 1.36)*** | 1.25 | (1.15, 1.37)*** | 1.57 | (1.47, 1.68)*** | 1.45 | (1.35, 1.56)*** | 1.40 | (1.30, 1.50)*** |
| Parents-child relationship | 0.90 | (0.78, 1.03) | 1.01 | (0.87, 1.18) | 0.98 | (0.84, 1.15) | 0.89 | (0.78, 1.03) | 0.97 | (0.84, 1.13) | 0.98 | (0.84, 1.14) |
| Peer relationship: Classmates are nice to me | | | | | | | | | | | | |
| Somewhat disagree/Strongly disagree | 0.96 | (0.69, 1.34) | 0.68 | (0.47, 0.99)* | 1.07 | (0.73, 1.56) | 1.08 | (0.74, 1.57) | 0.97 | (0.64, 1.46) | 0.88 | (0.58, 1.33) |
| Somewhat agree/Strongly disagree | 0.99 | (0.74, 1.32) | 0.95 | (0.69, 1.30) | 1.07 | (0.77, 1.49) | 1.23 | (0.87, 1.74) | 1.00 | (0.69, 1.44) | 0.92 | (0.64, 1.34) |
| Strongly agree/Strongly disagree | 1.00 | (0.74, 1.33) | 0.94 | (0.69, 1.30) | 1.07 | (0.77, 1.51) | 1.16 | (0.82, 1.66) | 0.95 | (0.65, 1.38) | 1.04 | (0.71, 1.52) |
| Teacher–student relationship | | | | | | | | | | | | |
| Teacher praise | 0.90 | (0.83, 0.98)* | 0.94 | (0.86, 1.04) | 0.90 | (0.81, 0.99)* | 0.88 | (0.81, 0.96)** | 0.93 | (0.85, 1.02) | 0.89 | (0.81, 0.98)* |
| Teacher criticism | 0.94 | (0.85, 1.03) | 1.07 | (0.96, 1.18) | 0.99 | (0.89, 1.11) | 0.98 | (0.90, 1.06) | 1.05 | (0.96, 1.15) | 1.01 | (0.92, 1.11) |
| C(p) | 0.820 | | 0.858 | | 0.869 | | 0.821 | | 0.858 | | 0.869 | |

*Notes*. Demographic characteristics (sex, only child status, self-assessed family financial conditions, Hukou) and self-evaluated health conditions were controlled in all models

C(p): Overall rate of correct classification

*$p<0.05$, **$p<0.05$, ***$p<0.001$

friendlier peer relationships can reduce multiple sleep problems in adolescents and that there is a lag in this effect. Previous research has explored adolescent sleep problems more in relation to peer conflict and less in relation to peer closeness [14]. On the one hand, a high level of peer relationships can also help reduce the negative effects of academic stress; on the other hand, having supportive friends reduces depression and other emotional problems, which all increase the likelihood that teens will sleep well [60, 61].

Notably, the parent–child relationship serves as an initial and crucial context for children's socialization [62]; it establishes the groundwork for various areas of development. A study conducted in China revealed that parent–child conflict was directly and indirectly associated with poorer peer relationships [63]. Therefore, although group socialization theory [64] emphasizes the significant role of peer relationships in children's development, the influence of the parent–child relationship on adolescent sleep should not be overlooked. The relationship between these two factors and their impact on adolescents' sleep problems also requires further exploration.

### Enhancing positive teacher–student relationships to decrease sleep problems

Past studies have shown that teenagers' sleep is significantly associated with teacher–student relationships [13]. We further found that the negative effect of teacher praise on occurrence of adolescents' sleep problems was sustained and that effect of teacher criticism on sleep problems unfolded under the moderating effect of depressive emotion. Scholars categorized teacher criticism into different types and influenced students' subsequent responses by way of attribution and found that different classes of criticism had different effects on students' responses when faced with setbacks and failures [65]. In contrast, supportive teacher–student relationships may break the developmental process that puts adolescents at risk and have a long-term positive impact on their psychological and behavioral development [66]. These findings encourage teachers to give positive feedback to students and avoid giving negative feedback to students.

For teacher praise, different students have different preferences, and research has shown that junior and senior high school students prefer private praise [67]. Therefore, it is important for teachers to choose the appropriate form and content of praise. Some teacher criticism, on the other hand, can be perceived by students as a personal attack and is far less effective than constructive feedback associated with tasks, processes, and regulations [68]. Teachers should be mindful of the manner and magnitude of criticism, minimize the evaluation of students' abilities and personal traits, and instead adopt measures of guidance and motivation. At the same time, schools and relevant authorities need to monitor this and continuously improve the teaching system to reduce adolescents' sleep problems in a multipronged way.

### Mastering emotional regulation skills to improve sleep health

Previous studies have shown an association between negative emotions and the development of sleep problems in adolescents [15, 43]. This study demonstrated that depressive emotion increased the occurrence of sleep problems. Particularly, depressive emotion with both simultaneous and lasting effects moderated the impact of social relationships on adolescents' remaining fatigue after waking up, dreaminess, and sleep fragmentation. A study revealed that negative emotions are positively correlated with an individual' s emotion regulation difficulties, and people with more negative emotions have poorer sleep quality [69]. Moreover, when individuals have negative emotions, if they choose emotion regulation strategies that reduce the intensity of the emotional experience but do not essentially change its nature, many negative emotions will build up inside them, and the intensity will increase, which will affect interpersonal relationships and increase interpersonal distress [70]. Therefore, we emphasize the importance of emotion regulation.

First, enhancing time spent with family members as prebedtime behaviors may be protective of sleep duration [71], because their support and involvement are keys to facilitating youths' self-regulation [72]. Second, according to positive stress management guiding the identification of depressive, aggressive and assertive communication styles in interactions [73], we recommend adolescent interactive intervention to facilitate their interpersonal interactions and emotion regulation abilities. Third, we encourage regulating emotion with experiential approaches, a theory and method of learning through action [74], which significantly help reduce the impact of negative emotions on sleep problems and also help individuals to understand and attune to others' emotions [75].

### Strengths and limitations

One of the strengths of this study is that it is based on the CEPS, China's first large-scale, nationally representative, and multilevel educational survey. This strength is primarily demonstrated through extensive longitudinal data that represent the entire nation, allowing for the examination of adolescent sleep problems from the perspective of adolescents' social relationships. This study further clarifies the simultaneous and lasting moderating effects of depressive emotion on adolescents' sleep problems. Nevertheless, some limitations of our research

**Table 3** The interaction effects between depressive emotion and social relationships on multiple sleep problems

| Variables | Moderator $_1$ = DE $_{(7th–grade)}$ Social relationships $_{(7th–grade)}$ | | | Moderator $_1$ = DE $_{(7th–grade)}$ Social relationships $_{(8th–grade)}$ | | Moderator $_2$ = DE $_{(8th–grade)}$ Social relationships $_{(7th–grade)}$ | | Moderator $_2$ = DE $_{(8th–grade)}$ Social relationships $_{(8th–grade)}$ | |
|---|---|---|---|---|---|---|---|---|---|
| | Y = Remaining fatigued after waking up | | Y = Dreaminess | Y = Remaining fatigued after waking up | Y = Sleep fragmentation | Y = Remaining fatigued after waking up | | Y = Remaining fatigued after waking up | Y = Sleep fragmentation |
| | Model A1-1 | Model A1-2 | Model B1-2 | Model A1-6 | Model C1-5 | Model A2-1 | Model A2-2 | Model A2-7 | Model C2-7 |
| | β | β | β | β | β | β | β | β | β |
| *Moderator* | | | | | | | | | |
| Depressive emotion (DE) | 0.363*** | -0.001 | -0.046 | -0.111 | 0.242*** | 0.465*** | 0.210 | 0.464*** | 0.349*** |
| *Interaction effects* | | | | | | | | | |
| Parent–child relationship × DE | 0.140* | | | | 0.183* | 0.121* | | | |
| Peer relationship×DE | | | | | | | | | |
| P1 × DE | | 0.081 | 0.309 | 0.517** | | | 0.227 | | |
| P2 × DE | | 0.413** | 0.222 | 0.476** | | | 0.253 | | |
| P3 × DE | | 0.421** | 0.348* | 0.457** | | | 0.279* | | |
| Teacher–student relationship × DE | | | | | | | | | |
| Teacher praise × DE | | | | | | | | | |
| Teacher criticism × DE | | | | | | | | -0.106** | -0.164*** |
| C(p) | 0.822 | 0.821 | 0.858 | 0.821 | 0.869 | 0.821 | 0.821 | 0.820 | 0.869 |

*Notes*. Model A: Y = Remaining fatigued after waking up. Model B: Y = Dreaminess. Model C: Y = Sleep fragmentation

Models 1–1 ~ 8: Depressive emotion in 7th grade, as a moderating variable, multiplied with social relationships in two academic years as interaction terms

Models 2–1 ~ 8: Depressive emotion in 8th grade, as a moderating variable, multiplied with social relationships in two academic years as interaction terms

The results only displayed models with significant interaction terms

Peer relationship, teacher–student relationship, parent–child relationship, demographic characteristics (sex, only child status, self-assessed family financial conditions, Hukou) and self-evaluated health conditions were controlled in all models

P1: Classmates are nice to me: Somewhat disagree/Strongly disagree

P2: Classmates are nice to me: Somewhat agree/Strongly disagree

P3: Classmates are nice to me: Strongly agree/Strongly disagree

C(p): Overall rate of correct classification

*$p$<0.05, **$p$<0.01, ***$p$<0.001

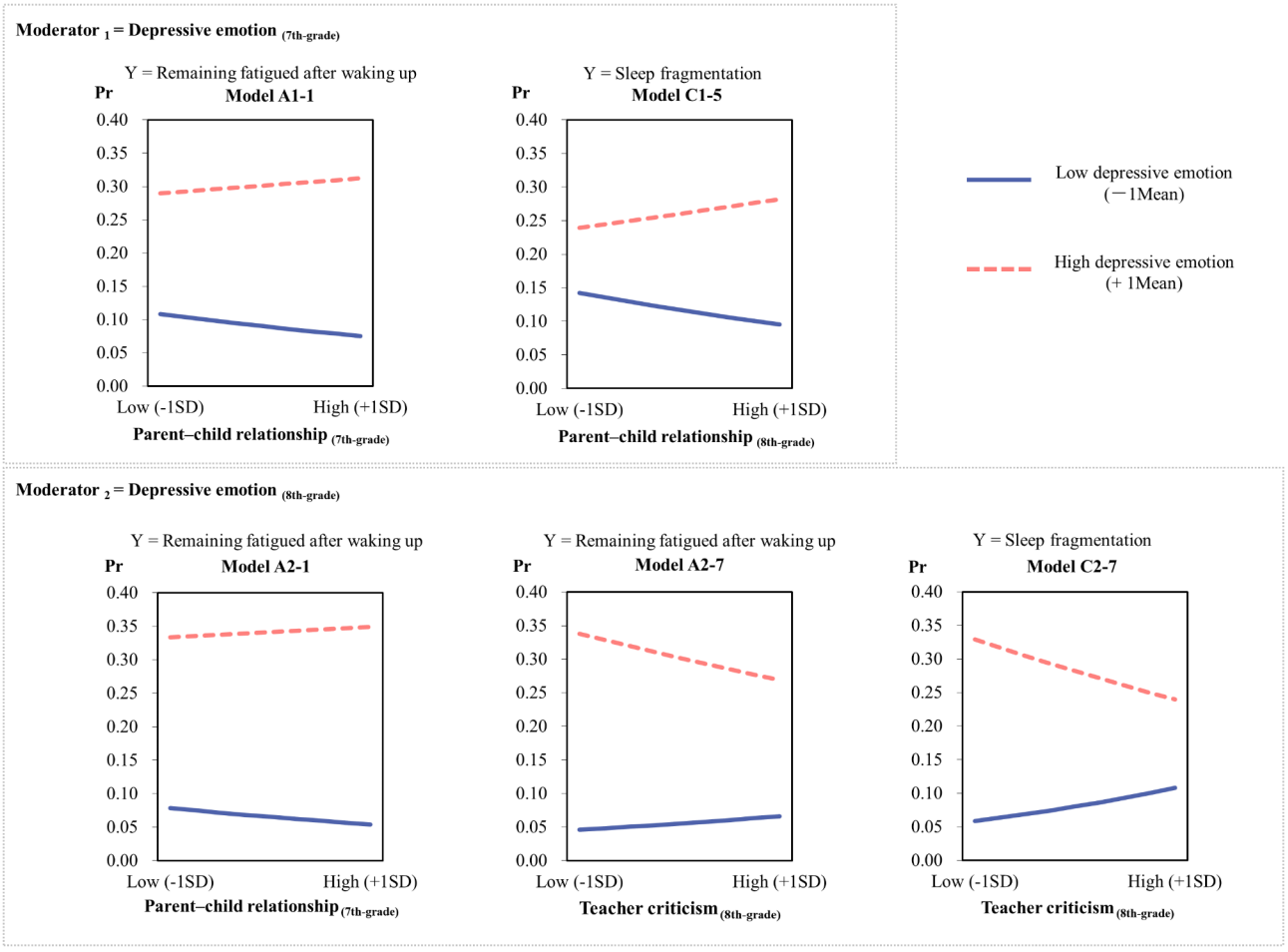


**Fig. 3** The interaction effects on the probability of sleep problems. (Pr: probability of sleep problem.)

deserve comment. First, it is limited by the fact that the CEPS has currently only released two waves of available data. Moreover, as a longitudinal survey, the CEPS inevitably encounters the issue of the failure to follow up, which may result in selection bias. Second, both waves of current publicly available data have investigated adolescent depressive emotions and social relationships, but the evaluation of sleep problems only started in the second wave. Specifically, this allows us to further discuss the simultaneous and lasting moderating effects of depressive emotion on sleep problems, and we expect more waves of CEPS data on sleep to be collected in future follow-up surveys. Third, variables such as peer relationships and parent–child relationships were measured using a limited number of items, which could introduce measurement bias. In addition, sleep problems were assessed using self-report questions. In future research, employing more objective measurement methods can help reduce information bias. Fourth, this study specifically examined the impact and moderating role of depressive emotion on sleep problems. Considering that previous research has suggested a potential bidirectional relationship between them [76], further research is needed. Finally, the sample primarily consisted of Chinese adolescents born between 2000 and 2001, which may limit the generalizability of the study results to other age groups.

## Conclusions

The study revealed that adolescent sleep problems were affected by social relationships, including peer and teacher–student relationships and emotions. In particular, depressive emotion had a simultaneous and lasting moderating role in the relationship between social relationships and adolescents' sleep problems. Notably, the occurrence of this moderating role varied across different social relationships and different sleep problems. Reducing adolescent sleep problems is necessary, and enhancing adolescents' positive social relationships and reducing their depressive emotions should receive increased attention. Additionally, there is a need to explore better teaching strategies to build more beneficial teacher–student relationships through appropriate praise and criticism. For adolescents themselves, it is important to strengthen

**Table 4** The interaction effects between depressive emotion and peer relationship on multiple sleep problems

| Peer relationship: Classmates are nice to me | | Moderator $_1$ = DE $_{(7th\text{-}grade)}$ Social relationships $_{(7th\text{-}grade)}$ | | Moderator $_1$ = DE $_{(7th\text{-}grade)}$ Social relationships $_{(8th\text{-}grade)}$ | | Moderator $_2$ = DE $_{(8th\text{-}grade)}$ Social relationships $_{(7th\text{-}grade)}$ | |
|---|---|---|---|---|---|---|---|
| | | OR [DE(-1Mean)] | OR [DE(−1Mean)] | OR [DE(-1Mean)] | OR [DE(−1Mean)] | OR [DE(-1Mean)] | OR [DE(−1Mean)] |
| **Model A1-2** (Y = Remaining fatigued after waking up) | Somewhat agree/Strongly disagree | 0.35 | 1.87 | — | — | — | — |
| | Strongly agree/Strongly disagree | 0.36 | 1.94 | — | — | — | — |
| **Model B1-2** (Y = Dreaminess) | Strongly agree/Strongly disagree | 0.41 | 1.66 | — | — | — | — |
| **Model A1-6** (Y = Remaining fatigued after waking up) | Somewhat disagree/Strongly disagree | — | — | 0.28 | 2.24 | — | — |
| | Somewhat agree/Strongly disagree | — | — | 0.33 | 2.25 | — | — |
| | Strongly agree/Strongly disagree | — | — | 0.32 | 2.03 | — | — |
| **Model A2-2** (Y = Remaining fatigued after waking up) | Strongly agree/Strongly disagree | — | — | — | — | 0.48 | 1.58 |

*Notes*. Model A: Y = Remaining fatigued after waking up. Model B: Y = Dreaminess. Model C: Y = Sleep fragmentation

Models 1–1 ~ 8: Depressive emotion in 7th grade, as a moderating variable, multiplied with social relationships in two academic years as interaction terms

Models 2–1 ~ 8: Depressive emotion in 8th grade, as a moderating variable, multiplied with social relationships in two academic years as interaction terms

The results only displayed models with significant interaction terms

DE: Depressive emotion; OR: odds ratio

their ability to regulate their emotions, and parents should provide support in this process.

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**Author contributions**
YL and XL participated in study design, data analysis and interpretation, and drafted the manuscript. CYL participated in the design of the study and performed the statistical analysis, and improvements to the manuscript. SHC, LJW and LM participated in literature review and drafted the manuscript. YCC conceived of the study, participated in its design and coordination and reviewed the manuscript, and provided funding acquisition. All authors read and approved the final manuscript.

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**Data availability**
The China Education Panel Survey datasets analysed in the current study are available from the National Survey Research Center at Renmin University of China and were used under license for this study. Data are available from the corresponding author upon reasonable request and with permission of the National Survey Research Center at Renmin University of China. The datasets can also be accessed for authorization after registering an account with the Chinese National Survey Data Archive, http://www.cnsda.org/index.php.

## Declarations

**Ethics approval and consent to participate**
Procedures were approved by the Institutional Review Board at Renmin University of China. All procedures were performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Written informed consent was obtained from parents and participants before the baseline survey.

**Consent for publication**
Not applicable.

**Competing interests**
The authors declare no competing interests.

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## Publisher's note