J Youth Adolescence (2015) 44:431–446
DOI 10.1007/s10964-014-0169-9

EMPIRICAL RESEARCH

Unhealthy Sleep Practices, Conduct Problems, and Daytime Functioning During Adolescence

Wen-Hsu Lin · Chin-Chun Yi

Received: 19 March 2014 / Accepted: 11 August 2014 / Published online: 23 August 2014

Abstract Although sleep has been linked to activities in various domains of life, one under-studied link is the relationship between unhealthy sleep practices and conduct problems among adolescents. The present study investigates the influence of adolescents' unhealthy sleep practices-short sleep (e.g., less than 6 h a day), inconsistent sleep schedule (e.g., social jetlag), and sleep problems-on conduct problems (e.g., substance use, fighting, and skipping class). In addition, this study examines unhealthy sleep practices in relationship to adolescent emotional well-being, defiant attitudes, and academic performance, as well as these three domains as possible mediators of the longitudinal association between sleep practices and conduct problems. Three waves of the Taiwan Youth Project (n = 2,472) were used in this study. At the first time-point examined in this study, youth (51 % male) were aged 13–17 (M = 13.3). The results indicated that all three measures of unhealthy sleep practices were related to conduct problems, such that short sleep, greater social jetlag, and more serious sleep problems were concurrently associated with greater conduct problems. In addition, short sleep and sleep problems predicted conduct problems one year later. Furthermore, these three unhealthy sleep practices were differently related to poor academic performance, low levels of emotional well-being, and defiant attitudes, and some significant indirect effects on later conduct problems through these three attributes were found. Cultural differences and suggestions for prevention are discussed.

W.-H. Lin (✉) · C.-C. Yi
Institute of Sociology #1017, Academia Sinica, 128 Sec. 2 Academia Rd., Nankang, Taipei 11529, Taiwan
e-mail: mars0512@gate.sinica.edu.tw; mars760512@gmail.com

C.-C. Yi
e-mail: chinyi@gate.sinica.edu.tw

Keywords Unhealthy sleep practices · Conduct problems · Definant attitude · Emotional well-being · Academic performance

Introduction

Studies have shown that most adolescents do not obtain sufficient sleep on school days and weekends (Roberts et al. 2001; Wolfson and Carskadon 1998). One reason for this lack of sleep is the delayed bedtime and delayed wake-up time (i.e., circadian phase delay) that is common during adolescence, for both biological (e.g., puberty) and psychosocial (e.g., seeking autonomy) reasons (Carskadon et al. 1993; Crowley and Carskadon 2010). Besides sleep problems, adolescence is characterized by an increase in conduct problems/delinquency (Gottfredson and Hirschi 1990; Moffitt 1993), as well as various physical, cognitive, and emotional changes (Wolfson and Carskadon 1998). Hence, adolescence is characterized by sleep problems, an increase in conduct problems/delinquency, and various personal changes. Vail-Smith et al. (2009) showed that sleep problems (e.g., insufficient sleep) results in an array of negative consequences. Relatively few studies have examined the association between sleep and conduct problems, however, and none has examined possible mediators of the association.

This study employed a Taiwanese panel sample to examine the relationship between adolescent unhealthy sleep practices, namely short sleep and social jetlag (later weekend bedtimes compared to weekdays), and youth conduct problems, including substance use, skipping class, and fighting. Furthermore, the model tested in this study includes three important measures of adolescent functioning: psychological well-being, defiant attitude, and

academic performance. These variables are not only included as the consequences of unhealthy sleep practices, but they are also treated as possible mediating factors that may intervene between sleep practices and deviance.

Sleep Functioning and Conduct Problems in Adolescence

Understanding the relationship between unhealthy sleep practices and conduct problems during adolescence seems especially important because youth often do not obtain sufficient sleep (Wolfson and Richards 2011) and they are disproportionally engaged in antisocial behaviors (Gottfredson and Hirschi 1990). Kamphuis et al.'s (2012) review demonstrated that sleep problems are related to aggression. Besides this review, only a few studies have focused on this possible linkage among adolescents (Catrett and Gaultney 2009; Christian 2010; Clinkinbeard et al. 2011; Ireland and Culpin 2006; Johnson and Breslau 2001; Mcknight-Eily et al. 2011; O'Brien and Mindell 2005; Pasch et al. 2010; Roberts et al. 2009).

Empirical studies have demonstrated that unhealthy sleep practices are an important risk factor for adolescent conduct problems cross-sectionally (Christian 2010; Clinkinbeard et al. 2011; Ireland and Culpin 2006; Johnson and Breslau 2001; O'Brien and Mindell 2005; Mcknight-Eily et al. 2011; Pasch et al. 2010). The results from these studies have indicated that adolescents whose sleep practices are unhealthy (e.g., short sleep duration) or pathological (e.g., insomnia) are more likely to engage in substance abuse (Pasch et al. 2010), delinquency (Catrett and Gaultney 2009; Clinkinbeard et al. 2011), and risky behaviors (O'Brien and Mindell 2005). Using sleep problems as an example, research has shown that undergraduate students who have low-quality sleep (e.g., night wakening or disturbed sleep) are more likely to fight, drink, and smoke (Vail-Smith et al. 2009), whereas Clinkinbeard et al. (2011) demonstrated that adolescents who sleep less than 8 h per night, especially those sleeping 6 h or less, commit more delinquent acts than students who obtain the recommended number of sleep hours. In addition, Pasch et al. (2010) revealed that youth whose bedtime is irregular (e.g., due to social jetlag) were more likely to experience both internalizing (e.g., depression) and externalizing (e.g., getting drunk and substance use) problems. Hence, unhealthy sleep practices, especially short sleep, irregular bedtime, and sleep problems, are pertinent to the study of conduct problems.

While the reviewed studies have supported a link between unhealthy sleep and conduct problems, the results have rested on cross-sectional data; hence, these results demonstrate only an association between unhealthy sleep practice and conduct problems. Two longitudinal studies provided further insights into this link (Catrett and Gaultney 2009; Roberts et al. 2009). Catrett and Gaultney (2009) used the first two waves of the National Longitudinal Study of Adolescent Health to examine the concurrent and longitudinal relationship between sleep and risk taking. They found that that sleep problem (e.g., insomnia) served as a concurrent risk factor for smoking and other delinquency but as a predictor for later drinking and driving. Roberts et al. (2009) employed a school-based survey (of students aged 11–17) with two waves and found that short sleep (<6 h) on both weeknights and weekends and only on weeknights was related to drug use (e.g., marijuana and other drugs). Interestingly, after adjusting insomnia at wave 1, only short sleep on weeknights mattered to drug use.

Although previous studies have provided evidence of a link between unhealthy sleep practices and conduct problems, further investigation of the connection between unhealthy sleep practice and conduct problem is warranted because of two limitations. First, previous studies seem to have yielded inconsistent results. For example, Fallone et al. (2002) review reported inconclusive results with regard to the relationship between sleep practices and conduct problems. Second, only a few studies have used a prospective longitudinal design, and many of them were limited by relatively small sample sizes.

The above discussion facilitates our understanding of the basic link between unhealthy sleep practices and conduct problems; it is important, however, to understand this relationship in the context of other important and relevant constructs. After presenting the link between sleep problem and substance use, Johnson and Breslau (2001), for example, suggested that future examinations of this relationship must consider other relevant contextual elements, such as psychiatric problems (e.g., depression). As an initial step in elucidating mechanisms that account for the link between sleep and conduct problems, we examined three possible mediators: emotional well-being, defiant attitude, and academic performance.

Sleep Functioning and Emotional Well-Being in Adolescence

Besides the direct effects of unhealthy sleep practices on conduct problems in adolescence, researchers have found that unhealthy sleep practices are related to other aspects of adolescent functioning. Killgore (2010) reported that unhealthy sleep practices are related to cognitive functioning, including emotions (e.g., emotional well-being). Researchers also have found that insufficient sleep or sleep deprivation exerts detrimental effects on brain functions, especially prefrontal cortical functions, which may influence emotional control and arousal (Dumer and Dinges

2005) and that sleep loss or insomnia increases negative emotional reactions (e.g., heightened depression) and decreases positive emotional responses (e.g., low level of happiness) to events (Baglioni et al. 2010; Zohar et al. 2005). Indeed, Fuligni and Hardway (2006) showed that adolescents who spent less time in bed nightly suffered various negative emotions (e.g., depression and anxiety) and experienced fewer positive emotions. Furthermore, studies have shown that sleep problems are conducive to various negative emotions, particularly depression and anxiety (Fallone et al. 2002; Kahn-Greene et al. 2007; Sadeh et al. 2002; Wolfson and Carskadon 1998). Specifically, Wolfson and Carskadon's (1998) study indicated that adolescents who slept fewer hours and had a more irregular sleep schedule than their peers had higher levels of depression. One study (Owens et al. 2010) found that insufficient sleep/sleep deprivation is related to negative emotions. These previous studies indicate that unhealthy sleep practices (e.g., short sleep, sleep problems) are a risk factor for developing poorer emotional well-being in adolescence.

Whereas a direct relationship between emotional well-being and adolescent conduct problems has been less studied, researchers have suggested that depression is related to adolescent conduct problems (Beyers and Loeber 2003; Ford and Schroeder 2009; Ostrowsky and Messner 2005). Beyers and Loeber (2003), for example, demonstrated that adolescents with elevated depressive symptoms are more likely to engage in delinquency, both concurrently and longitudinally. One review study suggested that having too many positive emotions is a risk for conduct problems (Gruber et al. 2011), while another study demonstrated that having a high degree of positive emotions is related to substance use (Cyders and Smith 2008). Taken together, previous research suggests that unhealthy sleep practices may be related to a low level of emotional well-being, which, in turn, may be related to adolescent conduct problems.

Sleep Functioning and Academic Performance in Adolescence

With regard to academic performance, previous studies have documented that insufficient sleep, an irregular sleep schedule, and sleep problems (e.g., insomnia) have negative impacts on cognitive and related functioning (Carskadon 1999; Dahl and Lewin 2002; Fallone et al. 2002; Killgore 2010; Perkinson-Gloor et al. 2013; Reynolds and Banks 2010; Stea et al. in press; Taras and Potts-Datema 2005; Wolfson and Carskadon 2003). Dahl and Lewin (2002), for example, showed that sleep deprivation is related to diminished cognitive function and impulse control, which are both related to low academic performance. Similarly, Carskadon (1999) demonstrated that insufficient sleep or short sleep is related to compromised learning, memory, attention, and abstract thinking. All of these impaired cognitive and related functions are damaging to academic performance (Fallone et al. 2002; Roberts et al. 2001). Indeed, Giannotti et al. (2002) showed that high-school students who stayed up late and often did not obtain sufficient sleep had low levels of school achievement, and Lepore and Kliewer (2013) revealed that seventh graders who had sleep disturbances or sleep problems were more likely to experience a declining grade point average (GPA). Finally, Fallone et al. (2002) review showed that children with short sleep duration, sleep problems, and irregular bedtimes, along with other sleep related problems (e.g., daytime sleepiness) have lower academic performance than students who have no such unhealthy practices. Hence, unhealthy sleep practices seem to be related to poorer academic performance in adolescence.

While unhealthy sleep practices may be related to poor academic performance, the influence of these practices continues through poor academic performance towards conduct problems. For example, one of the social bonds in Hirschi's (1969) social control theory is commitment to school, which is often measured by academic performance (e.g., grade point average). Research in criminology and related fields has revealed that poor school performance is a risk factor for delinquency, such as violence (Herrenkohl et al. 2000) and general delinquency (Hirschi 1969; Maguin and Loeber 1996; Najaka et al. 2001). Following this line of research, we could expect that adolescents' unhealthy sleep practices may be related to poor school performance, which is positively related to conduct problems.

Sleep Functioning and Defiant Attitude in Adolescence

Unhealthy sleep practices (e.g., insufficient sleep) also influence one's self-regulation in a way that may result in a low ability to make quality moral decisions (Killgore et al. 2007) and to adhere to social norms (Horne 1993). Unhealthy sleep practices thus may impair moral reasoning and lead to defiant thinking or a defiant attitude. While research on the linkage between sleep problem and defiant attitude is sparse, a few studies have demonstrated that sleep problems are correlated with an oppositional defiant attitude (ODD) (Corkum et al. 1999; Cortese et al. 2009; Stein 1999); in particular, short sleep duration is documented to relate to ODD (Pesonen et al. 2010). Somewhat related to the defiant/oppositional attitude is that researchers have found a relationship between sleep problems and attention-deficit/hyperactivity disorder (ADHD) (Corkum et al. 2001; Mayes et al. 2009), which in turn is highly correlated with ODD (Pliszka 2007). In addition to

impaired moral decision/reasoning, sleep problems are also related to deficits in impulse control. Studies have shown, for example, that impulsivity is related to short sleep among both regular adolescents and young offenders (Ireland and Culpin 2006). Abe et al. (2010) pointed out that unhealthy sleep practices (e.g., midnight bedtime) reduced impulse control among Japanese adolescents. This influence, however, may be limited to "reactive" impulsive control, not proactive control (Becker 2014). As such, unhealthy sleep practices can be expected to lead to a defiant attitude (i.e., deficits in moral reasoning/decision and impulse control).

The relationship between defiant attitude and subsequent conduct problems is expected both theoretically (Hirschi 1969) and empirically (Loeber et al. 2000; Menard and Elliott 1994). Theoretically, Hirschi's social bonding theory argues that adolescents who possess conventional moral beliefs are less deviant. In contrast, students who hold defiant or unmoral attitudes are free to commit delinquency. Empirically, adolescents who possess unconventional beliefs or attitudes have been shown to have high levels of delinquency, because they do not consider social norms to be valid (Longshore et al. 2005; Ngai and Cheung 2005). Furthermore, Loeber et al. (2000) showed that a substantial proportion of children and adolescents who possess ODD developed subsequent conduct problems. Combining the theoretical perspectives and empirical results, we can expect that adolescents' unhealthy sleep practices may exert effects on their deviance through defiant attitude.

Adolescent Sleep Practices in Asia

The above review of previous research indicated that unhealthy practices are detrimental to adolescents. Most of these studies, however, were based on Western samples, such as the United States or European countries. Recent studies have shown that sleep duration in many Asian countries (e.g., Korea, China) is shorter on school nights than that of youth from North America and Europe (Gradisar et al. 2011). Other studies, however, have shown that the difference is minor between U.S. samples and samples of adolescents from Mainland China (Liu et al. 2000); Hong Kong (Chung and Cheung 2008), and Taiwan (Huang et al. 2010). Regardless of the exact differences, the trend is that adolescents in Asia tend not to obtain sufficient sleep, and sometimes the duration is even shorter than that of their counterparts in other countries. Existing studies from Asia (Li et al. 2010), in general, and Taiwan (Gau and Soong 1995), in particular, have shown that adolescents sleep less than their Western peers because of academic competition or pressure. Chinese culture is well-known for emphasizing academic achievement; hence, students in many Chinese-descendent countries (e.g., Taiwan, Chinese, and Hong Kong) face longer school hours and more homework than their Western counterparts (Li et al. 2010).

Given that students in many Asian countries generally face a heavy demand from school, and thus shorter sleep time and irregular sleep schedules, exploring the possible connection between unhealthy sleep practices and negative consequences is important. Only a handful of studies, however, have directly examined the effects of unhealthy sleep practices on adolescent functioning among youth in Asia. Chou (2007) showed that Taiwanese adolescents who had an irregular sleep schedule had lower academic performance than students who had a regular schedule. Yu (2007) also found that low sleep quality (e.g., sleep satisfaction, sleep duration) is related to delinquency, depression, and low academic performance. Among Hong Kong Chinese adolescents, Chung and Cheung (2008) found sleep problems to be associated with increased substance use and poorer academic functioning. Consequently, findings from existing empirical studies conducted in Asian countries seem to support what has been evident in Western countries.

The Present Study

The present study examined the direct effect of unhealthy sleep practices, namely short sleep (6 h or less), irregular sleep schedule (social jetlag), and sleep problems (e.g., insomnia) on adolescent conduct problems and the three outlined adolescent-functioning factors: emotional well-being, academic performance, and defiant attitude. Furthermore, this study tested for indirect effects of unhealthy sleep practices on conduct problems through these three possible mediating variables. Unlike previous studies, this study combined several possible paths from adolescents' unhealthy sleep practice to conduct problems into one model. In addition, we included several measures of important unhealthy sleep practices (Lin and Yen 2012) found to be detrimental to adolescent functioning. Furthermore, all analyses were conducted using longitudinal data from Taiwan. Hence, we not only considered the direct effects of several unhealthy practices on conduct problems and other aspects of adolescent functioning, but also explored more complex relationships among unhealthy sleep practices, adolescent functioning, and conduct problems (see Fig. 1). In addition to testing these important relations, we also controlled for adolescents' initial conduct problems. Taking this approach increased the rigor of our testing for unhealthy sleep practices, conduct problems, and adolescent functioning, and their indirect effects on later conduct problems.

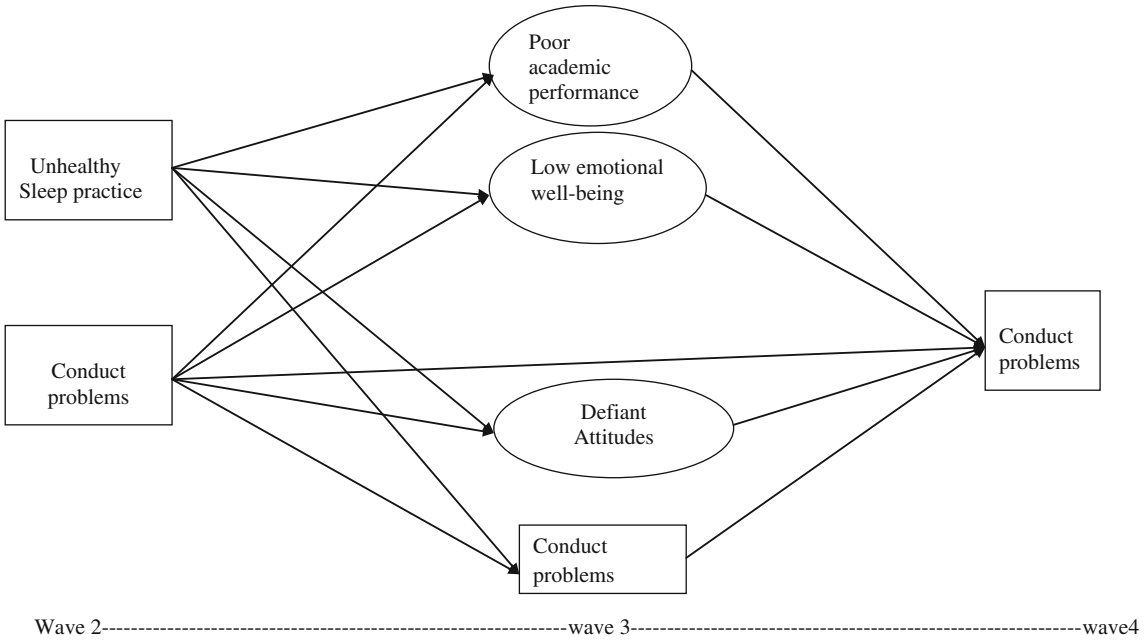

Fig. 1 The proposed model

Methods

Data and Sample

Data for the present study were drawn from the Taiwan Youth Project (TYP), which was conducted by the Institute of Sociology, Academic Sinica, Taiwan. The TYP is an eight-year longitudinal research project that began in 2000 and then followed subjects annually for 8 years. The TYP project included two cohorts: J1 (first year of junior-high school, with an average age of 13) and J3 (third year of junior-high school, with average age of 15).

Participants were selected based on stratified cluster sampling. The research team selected two counties (Taipei County and Yi-Lan County) and one city (Taipei City) from northern Taiwan, and these locations were then stratified into different numbers of strata based on different levels of urbanization: three strata for Taipei City and County and two strata for Yi-Lan county. After the strata were determined, a four-step cluster sampling method was employed to select students. First, the number of students (primary research unit) to be sampled from each stratum was based on the proportion of students registered in each stratum relative to the entire student body in that county or city. Second, the research team divided the number of students (determined by the first step) by the average size of classes in the particular stratum to determine the number of classes to be selected. Third, on the basis of two classes for each school, the team determined the number of schools for each county and city. Finally, in each school, classes were randomly assigned, and all students in selected classes were recruited. Before the survey was administered, each student completed a written consent form. On the survey date, each of the students who had agreed to participate finished a self-administered survey questionnaire during regular class hours. The final sample size for J1 at wave 1 (beginning of the study) was 2,696, for a participation rate of over 90 %.

The present study employed wave 2 (second year of junior-high school) to wave 4 (first year of senior-high school) of the J1 cohort, because items on the survey instrument during these time periods detailed students' bedtime and wake up time (i.e., the time they went to bed and woke up during the week and on the weekend). In addition, each of the mediating variables was measured at wave 3. Because we employed information from wave 2 to wave 4, the total sample size was based on wave 2 ($n = 2{,}683$), with the sample almost evenly split between males and females (51 and 49 %, respectively). Youth were aged 14–18 ($M = 14.3$, $SD = 0.48$) at wave 2, aged 15–19 ($M = 15.3$, $SD = 0.47$) at wave 3, and aged 16–20 ($M = 16.3$, $SD = 0.47$) at wave 4.

Variables

Unhealthy Sleep Practices (Wave 2)

Three unhealthy sleep practices were included in this study–short sleep, social jetlag, and sleep problems–and all of these were measured at wave 2. As our first measure of

sleep practice, we identified short sleep on weekdays and weekends, which is defined as less than 6 h of sleep (Fredriksen et al. 2004). The second unhealthy sleep practice variable, social jetlag, was created by subtracting weekday bedtime from weekend bedtime. For social jetlag, a negative score indicated that students went to sleep earlier on weekends, and a positive score indicated students went to bed later than on regular school days. Finally, we used three items to capture students' sleep problems. These three items were: "insomnia or difficulty falling asleep," "waking early and unable to go back to sleep," and "disturbed night sleep or waking up often during the night." The response categories ranged from it does not happen (0) to it happens to me and is very serious (4). The sleep-problem items were very similar to those described in the Sleep Quality Index (SIQ) (Urponen et al. 1991). We submitted these three items to an exploratory factor analysis (principal axis) and found a one-factor solution ($\alpha = .62$) with 57 % explained variance. Higher scores indicated more sleep problems.

Low Emotional Well-Being (Wave 3)

Both depression and happiness were measured in this study to assess youth's emotional well-being. A short version of the Symptom Checklist-90-Revised (SCL-90-R; Derogatis 1983) was administered in wave 3. This short-version scale consisted of seven items and asked students to report whether they had experienced certain depressive symptoms and how serious the experience was in the past week (no; yes, but not serious; yes, a little bit serious; yes, serious; yes, very serious). These symptoms included, for example, headaches, loneliness, depressed mood, and weakness in some parts of the body. We combined the first two categories as no symptom, and the remaining three categories were maintained. The mean of these items was used to create a depression score, with higher scores indicating a higher level of depression ($\alpha = .88$).

We assessed happiness as a positive emotion. One item that asked students to report their general evaluation of happiness in wave 3 was used. Our respondents were asked, "Overall, have you felt happy recently?" Response categories ranged from 1 (very happy) to 4 (very unhappy). Although this measure is somewhat simple, it is similar to one used in previous studies (Gray et al. 2013; Roberts et al. 2001). The depression and happiness measures were used as a latent emotional well-being variable in the analysis.

Poor Academic Performance (Wave 3)

We used three variables to assess academic performance. The first variable tapped into the extent to which students were keeping up-to-date with their school work by using one item, which asked students to report whether they were able to keep up with their school work. The response categories were: "I fall behind a lot and cannot catch up (5)," "I have fallen behind and might be able to catch up (4)," "I have only fallen behind a little and will soon catch up (3)," "I can keep up with the schedule (2)," and "I am ahead (1)." The second variable measured students' rank in their class based on GPA. Specifically, students were asked to report their class rank, which ranged from "top five (1)" to "after 30th (5)." The final variable was a composite scale created by counting the number of major subjects (math, Chinese, and English) the student had failed. Although our measure may be new, it captured the meaning of poor academic performance, as discussed below.

To check the validity of this measure of academic performance, we submitted these three measures of academic performance to an exploratory factor analysis (EFA) with the principal axis method. A one-factor solution was found, with over 70 % variance explained, and each item loaded very high (.71-catch up; .87-class rank; .73-failing subjects) on this extracted factor. In addition, the validity of this measure was checked through a high correlation between this construct and an important criterion: entrance examination placement. The correlation between the factor score and placement was significant and strong (>.6). Similar to emotional well-being, in the subsequent analysis, we treated these three variables as observable variables measuring latent academic performance. Higher scores indicated poorer academic performance.

Defiant Attitude (Wave 3)

Four items were used to measure this variable: "If someone hits me, I will hit them back," "If someone sets rules that I do not like, I will purposely violate these rules," "If someone gets mad at me, I will respond with anger," and "If someone is nagging at me not to do something, I will do the opposite." As already discussed, in Chinese society, maintaining relationship harmony and obedience are regarded as virtues. Hence, each of these described behaviors contradicts the cultural expectation. As such, these four items captured students' lack of impulse control and attitude that is defiant in nature. We submitted these items to EFA, and a one-factor solution was found that accounted for 59 % of the variance. Each item loaded on this underlying factor well (loadings ranged from .56 to .74). The response categories ranged from definitely would not do (1) to definitely would do (4). These four items were then used to measure the latent concept of defiant attitude. A higher score indicated that students held a higher level of defiant attitudes toward daily interpersonal relationships.

Conduct Problems (Wave 2–Wave 4)

The main outcome variable in this study was conduct problems. We included three items that measured three different problem behaviors: skipping class (status offences), fighting (violent behavior), and substance abuse (including alcohol, tobacco, and illicit drug use). Specifically, students were asked at wave 2 to wave 4 to report whether they had engaged in these problem behaviors during the past year (1 = yes; 0 = no). As expected, the summation of raw scores was highly skewed at each wave; we used item response theory (IRT) to create an IRT score for conduct problems at each of the three waves (Osgood et al. 2002). Higher scores indicate more conduct problems.

Control Variable (Wave 2)

In this study, we used two control variables: family SES and gender. *Family SES* was created by combining parental job prestige and education level (Wu 2011). We first divided job prestige into no job (no job, part-time job, or retired), low (blue-collar full-time job), middle (low-level white-collar full-time job), and high (upper white-collar job) and dichotomized educational level into some college or above and finished high school or below. We then grouped those whose parents held a bachelor's degree and/or whose parents' job prestige was at a high level together as belonging to a high SES family (22.1 %). Those whose parents held a high-school diploma or lower and whose parents' job prestige was at the middle level were categorized as belonging to a middle SES family (40.5 %). Students whose parents held a high-school diploma but whose parents' job prestige was at the low level were counted as belonging to a low SES family (22.1 %). The rest were grouped as belonging to a very low SES family (14.5 %). In the subsequent analysis, SES was represented by three dummy variables, with very low SES family as reference group. *Gender* was coded as male (1) and female (0).

Analytic Strategies

SEM was used to evaluate the hypotheses and was conducted using Mplus 7.1 (Muthén and Muthén 2012). Using SEM as a vehicle to examine the research questions presented here has two advantages. First, SEM and path analysis are commonly used to identify causal relationships and to test theoretical models among variables (Kline 2005). Second, the model here specified mediating effects among theoretical variables, and Baron and Kenny (1986) recommended path analysis to test mediation, noting that the method allows simultaneous testing of all relevant paths. With regard to model fit, because the χ^2 test is sensitive to sample size, scholars have suggested that investigators report multiple fit indices and specify the "critical value" for each (Hoyle and Panter 1995). In the present study, we used an χ^2 test to gauge the fit of a model, along with three alternative fit indexes: the comparative fit index (CFI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). Sivo et al. (2006) recommended two of these three indexes (RMSEA and SRMR) as being sensitive to model misspecification even when the sample size increases. For CFI, values of .95 or over indicate a good fit (Hu and Bentler 1999). For RMSEA, values of .05 or less suggest a good fit (Brown and Cudeck 1993). Finally, SRMR with values .08 or less suggest an acceptable fit (Brown and Cudeck 1993; Hu and Bentler 1999).

In addition to direct effects, we examined several indirect effects. To evaluate the significance of these indirect effects, we employed bias-corrected bootstrapping to create a 95 % confidence interval for indirect effects with 10,000 draws. We used bootstrapping instead of the traditional Baron and Kenny (1986) approach or the Sobel test (1982), because some studies have shown that these traditional procedures are less effective than other modern methods (e.g., bootstrapping) (Fritz and MacKinnon 2007; MacKinnon et al. 2004). In addition, some scholars have advocated using bootstrapping when assessing indirect effects (Bollen and Stine 1990; Hayes 2009).

When dealing with missing data, two kinds of missingness need to be considered: wave non-response and item non-response. For the former, we detected three patterns of wave non-response: missing only at wave 3 (n = 23), missing only at wave 4 (n = 317), and missing at both waves (n = 58). We deleted students who did not participate in only wave 3 (n = 23) or both wave 3 and wave 4 surveys (n = 58), because a series analysis did not show that these students were statistically different from other students who participated in all three waves in terms of unhealthy sleep practices, gender, or family SES. The only difference found was that those who missed both wave 3 and wave 4 had higher levels of deviance than adolescents who were in the study for all three waves. Moreover, deleting these subjects would reduce the overall missing pattern when applying a missing-data estimation in the subsequent analyses, hence, increasing the efficiency of computation. After deleting these 81 (3 %) cases, we still had students who did not participate in the wave 4 survey (n = 317; 12 %). Again, we conducted similar analyses on these missing cases and found some differences between these students and students who joined the study at all three waves. Deleting all of these 317 cases, however, would have seriously damaged the representativeness of the original sample. As such, the rest of the missing data were handled by the direct maximum likelihood (ML) method for subsequent analyses (Allison 2002). With regard to

Table 1 The descriptive statistics of all variables

Sleep practice	Minimum	Maximum	Mean	SD
Weekday SS	0	1 (20.6 %)[a]	.21	.404
Weekend SS	0	1 (5.5 %)[a]	.05	.227
SJ	−5	9	1.16	1.313
SP	0	12	1.19	1.792
Low emotional well-being				
Depression	0	50	7.81	6.932
Happiness	1	4	2.16	.761
Poor academic performance				
Catch up with school	1	5	3.23	1.195
GPA ranking	1	5	2.99	1.210
# of failed subjects	0	3	1.60	1.254
Defiance attitude				
Hit back	1	4	2.76	.857
Purposely violating rules	1	4	2.01	.794
Get back to someone	1	4	2.85	.814
Do opposite	1	4	2.60	.819
Conduct problems				
W2 conduct problems	−.097	1.659	.086	.407
W3 conduct problems	−.177	1.642	.137	.551
W4 conduct problems	−.076	1.445	.076	.351
Gender				
Male	1,268 (51.3 %)			
Female	1,204 (48.7 %)			
Family SES				
Very low SES	359 (14.5 %)			
Low SES	567 (22.9 %)			
Middle SES	1,001 (40.5 %)			
High SES	545 (22.1 %)			

For control variables we present only frequency distribution

SS short sleep, *SJ* social jetlag, *SP* sleep problems

[a] Percentage of adolescents who slept 6 h or less is in the parentheses

item non-response, most of the item-nonresponses were low, usually less than 1 %, though parental education and job prestige had 130 missing cases. These cases were also not included in the subsequent analyses, because family SES was purely exogenous and so the missing pattern could not be estimated for this variable. Other non-response items were taken into account by using the direct ML method.

Results

As shown in Table 1, adolescents in this study generally experienced unhealthy sleep practices. First, on regular school days, about 20 % of the adolescents slept 6 h or less, but this number dropped to around 5 % on weekends.

Table 2 The path model with all sleep practices variable, control variables, and conduct problems

Predictors	Outcome variable W2 conduct problems
Male	.061 (.016)**
Low SES	ns[a]
Middle SES	−.048 (.024)[†]
High SES	−.057 (.027)*
Weekday SS	.089 (.021)**
Weekend SS	ns
SJ	.050 (.006)**
SP	.021 (.016)**
Predictors	**W3 conduct problems**
Male	.203 (.020)**
Low SES	ns
Middle SES	ns
High SES	−.088 (.033)**
Weekday SS	.080 (.026)**
Weekend SS	ns
SJ	ns
SP	.017 (.006)**
W2 conduct problems	.551 (.025)**

SE are in parentheses

n = 2,472

SS short sleep, *SJ* social jetlag, *SP* sleep problems

[a] *ns* non-significant path

[†] $p < .1$; * $p < .05$; ** $p < .01$

This indicates that some students slept longer on weekends. Second, the mean social jetlag for this sample was 1.16 h. This indicates that students, on average, went to bed 1 h later on weekends than on weekdays. Finally, students experienced, on average, one sleep problem, although the problem was not necessarily at a serious level (e.g., response category 1 for sleep problem items is "yes, experiencing such a symptom but not serious"). Hence, many students may have had different kinds and degrees of unhealthy sleep practices that, as we hypothesized, could negatively influence their behaviors and other functioning.

We submitted the three latent variables (poor academic performance, low emotional well-being, and defiant attitude) into the measurement model, and the model fit the data marginally ($\chi^2 = 323.86(24)$; CFI = .947; RMSEA = .071; SRMR = .034). Checking on the modification indexes, we found that if we were to allow allow the error terms among three items of defiant attitude to be correlated (items 1 and 3 and items 2 and 3), the model would greatly improve. We then modified the model accordingly, resulting in an acceptable model fit ($\chi^2 = 128.27(22)$; CFI = .981; RMSEA = .044; SRMR = .026). The results gave us some confidence for subsequent structural analyses.

Table 3 The path model with all sleep variables, other functioning variables, and conduct problems (standard errors are in parentheses)

Predictors	Outcome variables			
	W3 conduct problems	Low emotional well-being	Poor academic performance	Defiance attitude
Male	.203 (.02)**	−.1751 (.261)**	.131 (.039)**	.065 (.023)**
Low SES	ns[a]	.789 (.428)[†]	ns	ns
Middle SES	ns	ns	ns	−.071 (.034)*
High SES	−.088 (.033)**	1.118 (.433)**	−.461 (.065)**	ns
Weekday SS	.080 (.026)**	1.616 (.336)**	ns	.118 (.029)**
Weekend SS	ns	ns	.268 (.088)**	ns
SJ	ns	ns	.106 (.016)**	.038 (.009)**
SP	.017 (.006)**	1.243 (.072)**	ns	.014 (.006)*
W2 conduct problems	.551 (.025)**	1.589 (.326)**	.412 (.049)**	.315 (.030)**
Low emotional well-being	.171**[b]			
Poor academic performance	.173**	ns		
Defiance attitude	.309**	.233**	.100**	

Predictors	W4 conduct problems
Male	.057 (.014)**
Low SES	−.052 (.023)*
Middle SES	−.038 (.021)[†]
High SES	ns
W2 conduct problems	.183 (.019)**
W3 conduct problems	.110 (.016)**
Low emotional well-being	.004 (.001)*
Poor academic performance	.062 (.009)**
Defiance attitude	.062 (.018)**

n = 2,483

SS short sleep, *SJ* social jetlag, *SP* sleep problems

[a] *ns* non-significant path

[b] These were correlation coefficients

[†] $p < .1$; * $p < .05$; ** $p < .01$

We first examined how the three sleep variables influenced concurrent and later conduct problems after taking gender and SES into account. The results (upper part of Table 2) indicated that the three sleep variables exerted significant effects on conduct problems, as expected. That is, students who had short sleep on weekdays (β = .089), an irregular sleep schedule (social jetlag) (β = .050), and sleep problems (β = .021) were more likely to engage in misconduct, such as substance use. In addition, male students had more conduct problems than female students (β = .060). Turning to the longitudinal effect (bottom part of Table 2), we found that two sleep variables (β = .080-short sleep; β = .017-sleep problems) still significantly influenced students' conduct problems when controlling for prior conduct problems, but social jetlag fell short of the conventional significance level. The strongest effect came from wave 2 conduct problems (β = .551), which indicates that students involved in a high level of conduct problems were also more likely to have such problems a year later.

Next, we turn to our second focus, which was to examine other possible negative consequences of bad sleep practices. The model fit the data acceptably (χ^2 = 349.13(82); CFI = .965; RMSEA = .036; SRMR = .022), and the results are shown in the upper part of Table 3. As can be seen, the sleep variables exerted different effects on emotional well-being, academic performance, and defiant attitude, but in most cases, the effects were significant. With regard to emotional well-being, adolescents who slept 6 h or less (β = 1.616) on weekdays and who experienced sleep problems (β = 1.243) were more likely to have a low level of emotional well-being than adolescents who slept more than 6 h and who did not experience sleep problems. Besides these two variables, males (β = −1.751) and adolescents involved in few conduct problems at wave 2 (β = 1.589) were emotionally better off than both females and adolescents with more conduct problems. Adolescents who were from high SES families (β = 1.118) had higher levels of emotional

problems than adolescents from very low SES families. Weekend short sleep (β = .268) and social jetlag (β = .106) had significant negative impacts on academic performance. Hence, students who slept 6 h or less during the weekend and who had a large discrepancy between weekday bedtime and weekend bedtime were likely to have poorer academic performance. Again, and as expected, males (β = .131) and adolescents with conduct problems (β = .412) performed more poorly in school than their counterparts. In contrast, adolescents from high SES families (β = −.461) had better school performance than very low SES students. Three out of the four unhealthy sleep practices significantly influenced adolescents' defiant attitude. Specifically, adolescents who slept 6 h or less on school days (β = .118) or had social jetlag (β = .038) or sleep problems (β = .014) were more likely to hold defiant attitudes than their counterparts who had healthy sleep practices. Gender (β = .065) and wave-2 conduct problems (β = .315) also exerted significant effects on defiant attitude. In addition to these mentioned results, including these other variables did not change the significant effects of either short sleep on weekdays (β = .080) or sleep problems (β = .017) on conduct problems.

Finally, we included wave 4 conduct problems in the model to further explore the connections among emotional well-being, academic performance, and defiant attitude and conduct problems. The three fit indices indicated that the model fit the data acceptably ($\chi^2 = 376.97(92)$; CFI = .965; RMSEA = .035; SRMR = .022). After considering demographic variables, each of these three variables was significantly related to conduct problems, as expected from existing theories (the bottom part of Table 3). First, adolescents who did not perform well academically were more likely to have conduct problems one year later (β = .062) than their counterparts who performed well in school. Second, youth who possessed a higher level of defiant attitude were more "delinquent" one year later than youth who had lower levels of this attitude (β = .062). Finally, adolescents who had lower levels of emotional well-being were more likely to have conduct problems than students with higher levels of emotional well-being, although this significant effect was small (β = .006). Results also revealed the continuity of conduct problems during adolescence; that is, youth who had conduct problems during the second year (β = .183) and/or final year (β = .110) of junior-high school were also more likely to have such problems in the first year of senior-high school than other students. Furthermore, the demographic variables consistently exerted effects on conduct problems (β = .057-male; β = −.052-low SES; β = −.038-middle SES).

Based on existing theories, existing literature (Baron and Kenny 1986; Preacher et al. 2007), and our full models, we expected to find indirect effects from unhealthy sleep practices through adolescent functioning on conduct problems. We further pursued this route by using a bias-corrected bootstrap procedure with 10,000 bootstrap samples from the original data to examine the significance of each indirect effect. We present the confidence internals in Table 4. If the bias-corrected 95 % confidence interval (CI) does not include zero, the particular examined indirect effect can be rejected at the .05 significance level. As can be seen in Table 4, most of these indirect effects were small, although they were statistically significant. For example, there existed significant indirect effects from weekday short sleep through both low emotional well-being (β = .006) and defiant attitude (β = .006) to wave-4 conduct problems. Similarly, social jetlag had significant indirect effects on wave-4 conduct problems through poor academic performance (β = .007) and defiant attitude (β = .002). The largest indirect effect was found at weekend short sleep → poor academic performance → wave-4 conduct problems (β = .016). These results show that adolescent unhealthy sleep practices had direct influences on adolescent conduct problems, as well as complex, indirect impacts on conduct problems through other functioning (e.g., poor academic performance).

Table 4 The significant indirect effects of sleep practice on wave 4 conduct problems through mediating variables

Paths	W4 conduct problems
Weekday SS → low emotional well-being	.006 [0, .012]
SP → low emotional well-being	.004 [0, .006]
Weekend SS → poor academic performance	.016 [.005, .028]
SJ → poor academic performance	.007 [.004, .010]
Weekday SS → defiance attitude	.007 [.001, .013]
SJ → defiance attitude	.002 [0, .004]
Weekday SS → W3 conduct problem	.009 [.002, .015]
SP → W3 conduct problem	.002 [0, .003]

Bias correct bootstrapping 95 % confidence interval is in the bracket. Non-significant indirect effect is not reported here. The confidence intervals that include zero are only marginally significant

SS short sleep, *SP* sleep problem, *SJ* social jetlag

Discussion

A central concern of life-course criminology is risk factors during adolescence (Farrington 2006), because adolescence is full of changes, including accelerated conduct problems and deviance. Although many risk factors have been identified, health-related risk factors, especially unhealthy sleep practices, have not generated much attention. The current study examined the effects of three unhealthy sleep practices–short sleep duration, social jetlag, and sleep

problems–on youth's conduct problems. In addition, we also explored the effects of these unhealthy sleep practices on other types of adolescent functioning, as well as their mediating effects on the relationship between unhealthy sleep practices and conduct problems. Examining the complex relationships among these variables and the impact of unhealthy sleep practices on these outcome variables responds to Dornbusch's (2002) call for social scientists to examine the impacts of sleep on deviance, school difficulties, and psychological well-being in adolescents.

Overall, we found support for our direct-effect hypothesis. Adolescents who slept 6 h or less during the week were more likely to have conduct problems than students who slept 7 h or more. This direct effect was found in both the cross-sectional model (wave-2 conduct problems as an outcome) and the longitudinal model (wave-3 conduct problems as an outcome with wave-2 conduct problems controlled). The same results could be applied to sleep problems. That is, youth who suffered from sleep problems were more likely to have conduct problems, both immediately and one year later, than their counterparts who did not have sleep problems. Social jetlag, however, was significantly related to wave-2 conduct problems but not later conduct problems. These results echo those from most previous studies, which have found that short sleep duration, social jetlag, and sleep problems had "unwanted" effects (Catrett and Gaultney 2009; Clinkinbeard et al. 2011; Holley et al. 2011; O'Brien and Mindell 2005; Pasch et al. 2010; Roberts et al. 2009). While we found that weekday short sleep had a significant effect on conduct problems, the result revealed no significant relationship between weekend short sleep and conduct problems. Previous studies, however, also have found no significant effects of weekend sleep duration on risky behavior (Dahl and Lewin 2002).

While the above results were significant and consistent with both theoretical expectations and findings from previous studies, some points are worth addressing here. First, whereas we found significant effects, these results had moderate practical significance (Levin 1993). That is, the coefficients for the relationship between unhealthy sleep practices and conduct problems were only modest in size, which indicated that the effect size might be only moderate. Second, while findings from previous studies (Clinkinbeard et al. 2011; Pasch et al. 2010) and our study all indicated that unhealthy sleep practices were risk factors for subsequent conduct problems, there might be other possible explanations for this relationship. Thus, unhealthy sleep practices and conduct problems may be two different kinds of adverse outcomes, both caused by a third variable. One possible candidate is low self-control (Gottfredson and Hirschi 1990), because low self-control has been found to be a risk factor for delinquency (Pratt and Cullen 2000) and might well be influencing adolescent's sleep regulation (Clinkinbeard et al. 2011). Despite this possibility, we included defiant attitude, which was used to capture impulsive responses to rules and was central to low self-control, and we still found significant effects of unhealthy sleep practices.

In terms of other types of adolescent functioning, most of the results were consistent with our hypotheses. Specifically, regarding low emotional well-being, adolescents who had short sleep duration (6 h or less) on school days, or who experienced sleep problems (e.g., insomnia) were more likely to have low emotional well-being (e.g., being unhappy or having a high level of depression) than their counterparts who slept more than 6 h on school days and who had no sleep problems. The results were similar to those of previous studies, which also found that short sleep duration or sleep problems often led to depression and negative emotions (Fredriksen et al. 2004; Roberts et al. 2001, 2009; Sarchiapone et al. 2014). Killgore's (2010) review also suggested that sleep deprivation is likely to produce negative emotions, because sleep deprivation influences effective mood regulation, which eventually leads to a negative-bias judgment in mood. Fuligni and Hardway (2006) found that adolescents who slept less and who had inconsistent sleep schedules reported more negative emotions and fewer positive ones. Similarly, Roberts et al. (2001) found that insomnia was related to both a low level of happiness and a high level of mood disturbance. Hence, the results demonstrated that adolescents who experienced sleep problems and short sleep also experienced deficits in both negative and positive emotions.

With regard to poor academic performance, our results indicated that, instead of short sleep during the weekdays, it was short sleep on weekends that mattered. Furthermore, social jetlag also led to poor academic performance. Hence, youth who slept 6 h or less and had a large bedtime discrepancy between weekdays and weekends were more likely to have poor academic performance (e.g., failing subjects, having a low class ranking, and falling behind on schoolwork) than youth who did not have these unhealthy sleep practices. Many previous studies have documented that unhealthy sleep practices impair cognitive functioning, which causes poor academic performance (Chung and Cheung 2008; Meijer and van den Wittenboer 2004; Perkinson-Gloor et al. 2013; Stea et al. in press; Wolfson and Carskadon 2003; Wolfson and Richards 2011), and our results corroborate the results of these previous studies. The underlying mechanism can be explained by brain and neurobiological research, which has demonstrated that sleep deprivation has a negative influence on various cognitive functions (e.g., executive function, and innovative thinking), many of which are related to academic

performance. Furthermore, Walker's (2010) review showed that sleep is helpful for memory consolidation. Given that many secondary-school exams are based on memory (e.g., vocabulary and scientific rules) and problem solving (e.g., mathematic equations and algorithms), the results from this study provide implicit support for this underlying mechanism.

One interesting result from this study is that only weekend short sleep had a negative impact on academic performance and not short sleep on weekdays. This is surprising, given previous reviews showing that shortened total sleep time is detrimental to students' academic performance (Wolfson and Carskadon 2003). Two possible explanations exist. First, in Taiwan, students often complain that they spend many extra hours preparing school work, which delays their bedtime on school days (Gau and Soong 1995). Then during the weekend, adolescents sleep longer to catch up on their sleep. Hence, students who still have short sleep during the weekend may be those who chronically experience restricted sleep hours, which significantly hampers cognitive ability, which, in turn, leads to poor academic performance. One could argue that if students spend extra hours studying on the weekdays, short sleep should not be related to conduct problems, because these are students who are committed to conventional societal norms (Hirschi 1969). We conducted extra analyses (not shown) that follow Clinkinbeard et al. (2011) cut-points (8 h or more, 7, 6, 5 h or less); the results indicated no differences between the 7-h group and the reference group (sleeps 8 h or more) on conduct problems. The differences were found only between the reference group and the last two groups (6 and 5 h or less). This result implicitly supports our operationalization of short sleep and, at the same time, indicates that students may spend extra hours studying, but only up to a certain point (7 h of sleep). Consequently, we suspect that those who sleep 6 h or less on school days may spend time on things other than school work, such as computer games. Second, it may be having an irregular schedule that is the most important to school performance (Wolfson and Carskadon 2003), because the social jetlag continually exerts negative impacts on academic performance, regardless which short sleep variable is included in the model.

Our results also revealed that short sleep on weekdays, sleep problems, and social jetlag all are related to defiant attitudes. That is, adolescents who have unhealthy sleep practices (e.g., sleep 6 h or less, sleep disturbance or insomnia, or an irregular bedtime schedule) are at high risk of developing a defiant attitude. Previous studies have shown that insufficient sleep, sleep disturbance, and/or sleep deprivation are related to impulsivity, impulse control, and risky decisions (Ireland and Culpin 2006; Venkatraman et al. 2011). Killgore (2010) found that sleep deprivation influences inhibitory control. Our study echoed this finding, in that students who had unhealthy sleep practices were more likely to make unfit moral decisions, such as purposely violating rules (e.g., "If someone sets rules that I do not like, I will purposely violate these rules"). Becker (2014) demonstrated that sleep problems in children are related only to reactive aggression and not proactive aggression, which may appear to counter our result. We think this may not be the case, however. First, our measure of defiant attitude included a reactive "aggression" (impulsivity) item (e.g., "If someone hits me, I will hit them back"). Second, some items of our defiant attitude describe "purposive" action, which in the Chinese context might be considered "impulsive" because purposely doing something that violates cultural norms (e.g., relationship harmony) is impulsive.

Besides the direct effects of unhealthy sleep practices on these forms of daytime functioning, we also found indirect effects of unhealthy sleep practices on conduct problems through daytime functioning. Short sleep on weekends and social jetlag, for example, exerted indirect effects on later conduct problems (wave 4) through defiant attitudes. In addition, weekend short sleep and social jetlag influenced later conduct problems through poor academic performance. Furthermore, sleep problems and short sleep on school days were connected to wave-4 conduct problems through low emotional well-being. Our study followed the recommendation of Clinkinbeard et al. (2011) and Christian (2010), who argued that studies should consider poor academic performance and defiant attitude (impulse control) as mediators. Christian (2010) argued from the depletion perspective that short sleep could deplete cognitive resources, which are essential to impulse control, which then is a risk factor for workplace deviance. In our study, we broadened the indirect-effect mechanisms by showing that unhealthy sleep practices are related to impaired cognitive ability (e.g., inhibitory control and memory), such as defiant attitude, poor academic performance, and low emotional well-being, all of which are risk factors for conduct problems. Moreover, we have discovered more complex relationships among unhealthy sleep practices, conduct problems, poor academic performance, and defiant attitude. Adolescents who sleep 6 h or less on school days, for example, are more likely to have concurrent conduct problems, which leads to poor academic performance one year later, which in turn is related to later conduct problems. Other recent studies have also revealed these complex relationships among different adolescent functions and deviance (Bao et al. 2014; Lin and Yi in press). These chain-effect results fit into the life course theory (Farrington 2006; Moffitt 1993; Sampson and Laub 1993), which argues that previous events or behavior may have ramifications later in life. In addition, risk and

protective factors that influence individual development may be specific to a particular age period (e.g., school work for adolescents and job performance for adults) or may be general to each life stage (e.g., unhealthy sleep practices).

Notwithstanding the findings mentioned above, our study is limited in several ways. First, our measure of unhealthy sleep practices relied on self-report measures. Although previous studies have shown that the correlation between objective (e.g., actigraphy) and subjective measures is high, using more objective measures could make it possible to examine other aspects of sleep. Our measure, for example, captures sleep duration, not necessarily the true sleep time. One previous study (Holley et al. 2011) showed that the true sleep time is more important than "time in bed" (e.g., self-reported sleep time). Laboratory measures could be used to supplement the reported time with true sleep time. In a review, Lin and Yen (2012) listed six general problematic sleep practices: inadequate sleep duration, difficulty falling asleep, trouble staying asleep, irregular sleep schedule, daytime tiredness, and overall sleep complaints. Our measure included most of the possible unhealthy sleep practices adolescents face, but did not include sleepiness and tiredness during the daytime. Also, circadian rhythm was not directly measured in this study. Second, while we focused on the influence of unhealthy sleep practices on conduct problems, some important factors that cause different sleep practices are not available in the present study, such as electronic media (Cain and Gradisar 2010) and the possibility that individuals have different sleep needs (Moore et al. 2009). Third, other possible mediating factors are not included. For example, one of the hallmarks of conduct problems is delinquent peer association. It appears that association with deviant peers might be another "unconventional" decision that facilitates conduct problems.

Conclusion

Our results suggested that unhealthy sleep practices (e.g., short sleep, sleep problems, and social jetlag) are risk factors for many kinds of negative functioning (e.g., low level of subjective well-being) and conduct problems during adolescence. In addition, our results indicated that short sleep during the week has many negative impacts on adolescents and that there is chain-effect of unhealthy sleep practices on later conduct problems through deteriorating functioning. Thus, sleep duration that is less than 6 h per night may be of a concern.

Promoting healthy sleep practices is a good start for helping adolescents to handle the various changes that occur during puberty. Promoting such practices would require the cooperation of the educational system, family, and other important agents at this life stage. Primary prevention could be launched by educating parents on the importance of sleep on school days; hence, parents could help students establish a regular sleep schedule and maintain it throughout the weekend. Secondary prevention might include changing school schedules so that students do not need to get up so early to go to school. Another prevention tactic might be having schools invite pediatricians to conduct sleep hygiene screening (Carskadon 1990) and workshops for their students. Besides preventive strategies, actively promoting other protective factors might also be effective. One recent study (Brand et al. 2014), for example, showed that college students with mental toughness (displaying confidence, commitment, challenge, and control) enjoy a good and efficient sleep (e.g., long deep sleep duration). Hence, parents and school officials may wish to help adolescents to build these qualities, which may enhance sleep quality. In the end, healthy sleep practices are a protective factor that can reduce the risk of many negative outcomes, thus helping to ensure a "safe passage" (Dryfoos 2000) for youth as they move through adolescence to adulthood.

Author contributions W-H L's main contribution included data analysis and interpretations of data; he also developed the research model and manuscript. C-C Y's is a principle investigator of the Taiwan Youth Project; she provided the data and gave important and critical responses to the revision. Both authors have read and approved the final manuscript.

References

Abe, T., Hagihara, A., & Nobutomo, K. (2010). Sleep patterns and impulse control among Japanese junior high school students. *Journal of Adolescence, 33*, 633–641.

Allison, P. D. (2002). *Missing data.* Sage University Paper Series on Quantitative Applications in the Social Sciences, 07-136. Thousand Oaks, CA: Sage.

Baglioni, C., Spiegelhalder, K., Lombardo, C., & Riemann, D. (2010). Sleep and emotions: A focus on insomnia. *Sleep Medicine Review, 14*, 227–238.

Bao, W.-N., Haas, A., Chen, X., & Pi, Y. (2014). Repeated strains, social control, social learning and delinquency: Testing and integrated model of general strain theory in China. *Youth & Society, 48*, 402–424. doi:10.1177/0044118X11436189.

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*, 1173–1182.

Becker, S. P. (2014). External validity of children's self-reported sleep functioning: Association with academic, social, and behavioral adjustment. *Sleep Medicine,*. doi:10.1016/j.sleep.2014.06.001.

Beyers, J. M., & Loeber, R. (2003). Untangling developmental relations between depressed mood and delinquency in male adolescents. *Journal of Abnormal Child Psychology, 31*, 247–266.

Bollen, K. A., & Stine, R. (1990). Direct and indirect effects: Classical and bootstrap estimates of variability. *Sociological Methodology, 20*, 115–140.

Brand, S., Gerber, M., Kalak, N., Kirov, R., Lemola, S., Clough, P. J., et al. (2014). Adolescents with greater mental toughness show higher sleep efficiency, more deep sleep and fewer awakenings after sleep onset. *Journal of Adolescent Health, 54*, 109–113.

Brown, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen & J. S. Long (Eds.), *Testing structure equation models* (pp. 136–162). New Bury Park, CA: Sage.

Cain, N., & Gradisar, M. (2010). Electronic media use and sleep in school-aged children and adolescents: A review. *Sleep Medicine, 11*, 735–742.

Carskadon, M. A. (1990). Patterns of sleep and sleepiness in adolescents. *Pediatrician, 17*, 5–12.

Carskadon, M. A. (1999). When worlds collide-adolescent need for sleep versus societal demands. *Phi Delta Kappan, 8*, 348–353.

Carskadon, M. A., Vieira, C., & Acebo, C. (1993). Association between puberty and delayed phase preference. *Sleep, 16*, 258–262.

Catrett, C. D., & Gaultney, J. F. (2009). Possible insomnia predicts some risky behavior among adolescents when controlling for depressive symptoms. *Journal of Genetic Psychology, 170*, 287–309.

Chou, S.-L. (2007). *The relationship between sleep pattern and academic performance in senior high school students* (Unpublished master's thesis, Taipei, Taiwan). Retrieve from http://nccuir.lib.nccu.edu.tw/handle/140.119/32493.

Christian, M. S. (2010). *Over-tired and under control? Sleep deprivation, resource depletion, and workplace deviance* (Unpublished doctoral dissertation). University of Arizona, Tucson, AR.

Chung, K.-F., & Cheung, M.-M. (2008). Sleep-wake patterns and sleep disturbance among Hong Kong Chinese adolescents. *Sleep, 31*, 185–194.

Clinkinbeard, S. S., Simi, P., Evans, M. K., & Anderson, A. L. (2011). Sleep and delinquency: Does the amount of sleep matter?. *Journal of Youth and Adolescence, 40*, 916–930.

Corkum, P., Moldofsku, H., Hogg-Johnson, S., Humphries, T., & Tannock, R. (1999). Sleep problems in children with attention-deficit/hyperactivity disorder: Impact of subtype, comorbidity, and stimulant medication. *Journal of American Academy of Child and Adolescent Psychiatry, 38*, 1285–1293.

Corkum, P., Tannock, R., Moldofsku, H., Hogg-Johnson, S., & Humphries, T. (2001). Actigraphy and parental ratings of sleep in children with attention-deficit/hyperactivity disorder (ADHD). *Sleep, 24*, 303–312.

Cortese, S., Faraone, S. V., Konofal, E., & Lecendreux, M. (2009). Sleep in children with attention-deficit/hyperactive disorder: Meta-analysis of subjective and objective studies. *Journal of American Academy of Child and Adolescent Psychiatry, 48*, 894–908.

Crowley, S. J., & Carskadon, M. A. (2010). Modifications to weekend recovery sleep delay circadian phase in older adolescents. *Chronobiology International, 27*, 1469–1492.

Cyders, M. A., & Smith, G. T. (2008). Emotion-based dispositions to rash action: Positive and negative urgency. *Psychological Bulletin, 134*, 807–828.

Dahl, R. E., & Lewin, D. S. (2002). Pathways to adolescent health: Sleep regulation and behavior. *Journal of Adolescent Health, 31*, 175–184.

Derogatis, L. R. (1983). *SCL-90-R Administration, scoring, and procedure manual- II*. Towson, MD: Clinical Psychometric Research.

Dornbusch, S. M. (2002). Sleep and adolescent: A social psychologist's perspective. In M. A. Carskadon (Ed.): *Adolescent sleep patterns: Biological, social, and psychological influences* (pp. 1–3). Cambridge: Cambridge University Press.

Dryfoos, J. G. (2000). *Safe passage: Making it through adolescence in a risky society: What parents, schools, and communities can do*. New York, NY: Oxford University Press.

Dumer, J. S., & Dinges, D. F. (2005). Neurocognitive consequences of sleep deprivation. *Seminars in Neurology, 25*, 117–129.

Fallone, G., Owens, J. A., & Deane, J. (2002). Sleepiness in children and adolescents: Clinical implications. *Sleep Medicine Reviews, 6*, 287–306. doi:10.1053/smrv.2001.0192.

Farrington, D. P. (2006).Childhood risk factors and risk-focused prevention. In E. Morgan & R. Reiner (Eds.), *The oxford handbook of criminology*, 4th ed. Oxford: Oxford University Press.

Ford, J. A., & Schroeder, R. D. (2009). Academic strain and non-medical use of prescription stimulants among college students. *Deviant Behavior, 30*, 26–53.

Fredriksen, K., Rhodes, J., Reddy, R., & Way, N. (2004). Sleepless in Chicago: Tracking the effects of adolescent sleep loss during the middle school years. *Child Development, 75*, 84–95. doi:10.111/j.1467-8624.2004.00655.x.

Fritz, M. S., & MacKinnon, D. P. (2007). Required sample size to detect the mediated effect. *Psychological Science, 18*, 233–239. doi:10.1111/j.1467-9280.2007.01882.x.

Fuligni, A., & Hardway, C. (2006). Daily variation in adolescents' sleep, activities, and psychological well-being. *Journal of Research on Adolescence, 16*, 353–378. doi:10.1111/j.1532-7795.2006.00498.x.

Gau, S.-F., & Soong, W.-T. (1995). Sleep problems of junior high school students in Taipei. *Sleep, 18*, 667–673.

Giannotti, F., Cortesi, F., Sebastiani, T., & Ottaviano, S. (2002). Circadian preference, sleep and daytime behavior in adolescence. *Journal of Sleep Research, 11*, 191–199.

Gottfredson, M. R., & Hirschi, T. (1990). *A general theory of crime*. Stanford, CA: Stanford University Press.

Gradisar, M., Gardner, G., & Dohnt, H. (2011). Recent worldwide sleep patterns and problems during adolescence: A review and meta-analysis of age, region, and sleep. *Sleep Medicine, 12*, 110–118. doi:10.1016/j.sleep.2010.11.008.

Gray, R. S., Chamratrithirong, A., Pattaravanich, U., & Prasartkul, P. (2013). Happiness among adolescent students in Thailand: Family and non-family factors. *Social Indicator Research, 110*, 706–719.

Gruber, J., Mauss, I. B., & Tamir, M. (2011). A dark side of happiness? How, when and why happiness is not always good. *Perspectives on Psychological Science, 6*, 222–233.

Hayes, A. F. (2009). Beyond Baron and Kenny: Statistical mediation analysis in the new Millennium. *Communication Monographs, 76*, 408–420. doi:10.1080/03637750903310360.

Herrenkohl, T. I., Maguin, E., Hill, K. G., Hawkins, J. D., Abbott, R. D., & Catalano, R. F. (2000). Developmental risk factors for youth violence. *Journal of Adolescent Health, 26*, 176–186.

Hirschi, T. (1969). *Causes of delinquency*. Los Angeles, CA: University of California Press.

Holley, S., Hill, C. M., & Stevenson, J. (2011). An hour less sleep is a risk factor for childhood conduct problems. *Child: Care, Health and Development, 37*, 563–570. doi:10.1111/j.1365-2214.2010.01203.x.

Horne, J. A. (1993). Human sleep, sleep loss, and behaviour: Implications for the prefrontal cortex and psychiatric disorder. *British Journal of Psychiatry, 162*, 413–419.

Hoyle, R. H., & Panter, A. T. (1995). Writing about structural equation models. In R. H. Hoyle (Ed.), *Structural equation*

modeling: Concepts, issues, and applications (pp. 159–176). Thousand Oaks, CA: Sage Publications.

Hu, L.-T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Structural Equation Modeling*, 6, 1–55.

Huang, Y.-S., Wang, C.-H., & Guilleminault, C. (2010). An epidemiologic study of sleep problems among adolescents in North Taiwan. *Sleep Medicine, 11*, 1035–1042. doi:10.1016/j.sleep.2010.04.009.

Ireland, J., & Culpin, V. (2006). The relationship between sleeping problems and aggression, anger, and impulsivity in a population of juvenile and young offenders. *Journal of Adolescent Health, 38*, 649–655.

Johnson, E. O., & Breslau, N. (2001). Sleep problems and substance use in adolescence. *Drug and Alcohol Dependence, 64*, 1–7.

Kahn-Greene, E. T., Killgore, D. B., Kamimori, G. H., Balkin, T. J., & Killgore, W. D. S. (2007). The effects of sleep deprivation on symptoms of psychopathology in healthy adults. *Sleep Medicine, 8*, 215–221.

Kamphuis, J., Meerlo, P., Koolhaas, J. M., & Lancel, M. (2012). Poor sleep as a potential causal factor in aggression and violence. *Sleep Medicine, 13*, 327–334. doi:10.1016/j.sleep.2011.12.006.

Killgore, W. D. S. (2010). Effects of sleep deprivation on cognition. *Progress in Brain Research, 185*, 1105–1129. doi:10.1016/B978-0-444-53702-7.00007-5.

Killgore, W., Killgore, D., Day, L., Li, C., Kamimori, G., & Balkin, T. (2007). The effects of 53 hours of sleep deprivation on moral judgment. *Sleep, 30*, 345–352.

Kline, R. B. (2005). *Principles and practices of structural equation modeling*. New York, NY: Guilford Press.

Lepore, S. J., & Kliewer, W. (2013). Violence exposure, sleep disturbance, and poor academic performance in middle school. *Journal of Abnormal Child Psychology, 41*, 1179–1189.

Levin, J. R. (1993). Statistical significance testing from three perspectives. *Journal of Experimental Education, 61*, 378–382.

Li, S., Zhu, S., & Jin, X. (2010). Risk factors associated with short sleep duration among Chinese school-aged children. *Sleep Medicine, 11*, 907–916. doi:10.1016/j.sleep.2010.03.018.

Lin, L., & Yen, L.-L. (2012). The relationship between sleep problems and substance use in adolescents. *Taiwan Journal of Public Health, 31*, 412–424.

Lin, W. -H., & Yi, C. -C. (in press). Family and school strains and their effects on adolescent deviance: A mediating study. *Youth & Society.*

Liu, X., Uchiyama, M., Okawa, M., & Kurita, H. (2000). Prevalence and correlates of self-reported sleep problems among Chinese adolescents. *Sleep, 23*, 27–34.

Loeber, R., Burker, J. D., Lahey, B. B., Winters, A., & Zera, M. (2000). Oppositional defiant and conduct disorder: A review of the past 10 years, Part I. *Journal of the American Academy of Child and Adolescent Psychiatry, 39*, 1468–1484.

Longshore, D., Chang, E., & Messina, N. (2005). Self-control and social bonds: A combined control perspective on juvenile offending. *Journal of Quantitative Criminology, 21*, 419–437.

MacKinnon, D. P., Lockwood, C. M., & Williams, J. (2004). Confidence limits for the indirect effect: Distribution of the product and resampling methods. *Multivariate Behavioral Research, 39*, 99–128.

Maguin, E., & Loeber, R. (1996). Academic performance and delinquency. In Tonry M. (Ed.), *Crime and justice: A review of research,* Vol. 20 (pp. 145–264). Chicago, IL: Chicago University Press.

Mayes, S. D., Calhoun, S. L., Bixler, E. O., Vgontzas, A. N., Mahr, F., Hillwig-Garcia, J., et al. (2009). ADHD subtypes and comorbid anxiety, depression, and oppositional-defiant disorder: Differences in sleep problems. *Journal of Pediatric Psychology, 34*, 328–337.

McKnight-Eily, L., Eaton, D. K., Lowry, R., Croft, J. B., Presley-Cantrell, L., & Perry, G. S. (2011). Relationships between hours of sleep and health risk behaviors in US adolescent students. *Preventive Medicine, 53*, 271–273. doi:10.1016/j.ypmed.2011.06.020.

Meijer, A. M., & van den Wittenboer, G. L. H. (2004). The joint contribution of sleep, intelligence and motivation to school performance. *Personality and Individual Differences, 37*, 95–106. doi:10.1016/j.paid.2003.08.002.

Menard, S., & Elliott, D. (1994). Delinquent bounding, moral beliefs, and illegal behavior: A three-wave panel model. *Justice Quarterly, 11*, 173–188.

Moffitt, T. E. (1993). Adolescence-limited and life-course-persistent antisocial behavior: A developmental taxonomy. *Psychological Review, 100*, 674–701.

Moore, M., Kirchner, H. L., & Drotar, D. (2009). Relationships among sleepiness, sleep time, and psychological functioning in adolescents. *Journal of Pediatric Psychology, 34*, 1175–1183. doi:10.1093/jpepsy/jsp039.

Muthén, L. K., & Muthén, B. O. (2012). *Mplus: Statistical analysis with latent variables user's guide*. Los Angeles, CA: Muthén & Muthén.

Najaka, S. S., Gottfredson, D. C., & Wilson, D. B. (2001). A meta-analytic inquiry into the relationship between selected risk factors and problem behavior. *Prevention Science, 2*, 257–271.

Ngai, N.-P., & Cheung, C.-K. (2005). Predictors of the likelihood of delinquency: A study of marginal youth in Hong Kong, China. *Youth & Society, 38*, 445–470.

O'Brien, E. M., & Mindell, J. A. (2005). Sleep and risk-taking behavior in adolescents. *Behavioral Sleep Medicine, 3*, 113–133.

Osgood, D. W., McMorris, B. J., & Potenza, M. T. (2002). Analyzing multiple-item measure of crime and deviance I: Item response theory scaling. *Journal of Quantitative Criminology, 18*, 267–296.

Ostrowsky, M. K., & Messner, S. F. (2005). Explaining crime for a young adult population: An application of general strain theory. *Journal of Criminal Justice, 33*, 463–476.

Owens, J. A., Belon, K., & Moss, P. (2010). Impact of delaying school start time on adolescent sleep, mood, and behavior. *Archives of Pediatrics and Adolescent Medicine, 164*, 608–614.

Pasch, K. E., Laska, M. N., Lytle, L. A., & Moe, S. G. (2010). Adolescent sleep, risk behavior, and depressive symptoms: Are they linked? *American Journal of Health Behavior, 34*, 237–248.

Perkinson-Gloor, N., Lemola, S., & Grob, A. (2013). Sleep duration, positive attitude toward life, and academic achievement: The role of daytime tiredness, behavioral persistence, and school start time. *Journal of Adolescence, 36*, 311–318.

Pesonen, A.-K., Raikkonen, K., Paavonen, E. J., et al. (2010). Sleep duration and regularity are associated with behavioral problems in 8-year-old children. *International Journal of Behavioral Medicine, 17*, 298–305.

Pliszka, S. (2007). Practice parameter for the assessment and treatment of children and adolescents with attention-deficit/hyperactivity disorder. *Journal of American Academy of Child and Adolescent Psychiatry, 46*, 894–921.

Pratt, T. C., & Cullen, F. T. (2000). The empirical status of Gottfredson and Hirschi's general theory of crime: A meta-analysis. *Criminology, 38*, 931–964. doi:10.111/j.1745-9125.2000.tb00911.x.

Preacher, K. J., Rucker, D. D., & Hayes, A. F. (2007). Addressing moderated mediation hypotheses: Theory, methods, and prescriptions. *Multivariate Behavior Research, 42*, 185–227. doi:10.1080/00273170701341316.

Reynolds, A. C., & Banks, S. (2010). Total sleep deprivation, chronic sleep restriction and sleep disruption. *Progress in Brain Research, 185*, 91–103. doi:10.1016/B978-0-444-53702-7.00006-3.

Roberts, R. E., Roberts, C. R., & Chen, I. G. (2001). Functioning of adolescents with symptoms of disturbed sleep. *Journal of Youth and Adolescence, 30*, 1–18.

Roberts, R. E., Roberts, C. R., & Duong, H. T. (2009). Sleepless in adolescence: Prospective data on sleep deprivation, health and functioning. *Journal of Adolescence, 32*, 1045–1057.

Sadeh, A., Gruber, R., & Raviv, A. (2002). Sleep, neurobehavioral functioning, and behavior problems in school-age children. *Child Development, 73*, 405–417.

Sampson, R. J., & Laub, J. H. (1993). *Crime in the making: Pathways and turning points through life*. Cambridge, MA: Harvard University Press.

Sarchiapone, M., Mandelli, L., Carli, V., Iosu, M., Wasserman, C., Hadlaczky, G., et al. (2014). Hours of sleep in adolescents and its association with anxiety, emotional concerns, and suicidal ideation. *Sleep Medicine, 15*, 248–254.

Sivo, S. A., Fan, X., Lea Witta, E., & Willse, J. T. (2006). The search for "optimal" cutoff properties: Fit index criteria in structural equation modeling. *The Journal of Experimental Education, 74*, 267–288. doi:10.3200/JEXE.74.3.267-288.

Sobel, M. E. (1982). Asymptotic confidence intervals for indirect effects in structural equation models. *Sociological Methodology, 13*, 290–312.

Stea, T. H., Knutsen, T., & Torstveit, M. K. (in press). Association between short time in bed, health-risk behaviors and poor academic achievement among Norwegian adolescents. *Sleep Medicine.*

Stein, M. A. (1999). Unraveling sleep problems in treated and untreated children with ADHD. *Journal of Child and Adolescent Psychopharmacology, 9*, 157–168.

Taras, H., & Potts-Datema, W. (2005). Sleep and student performance at school. *Journal of School Health, 75*, 248–254.

Urponen, H., Partinen, M., Vuori, I., & Hasan, J. (1991). Sleep quality and health: Description of the Sleep Quality Index. In J. H. Peter, P. T. Penzel, T. Podszus, & P. von Wichert (Eds.), *Sleep and health risk* (pp. 555–558). Berlin: Springer.

Vail-Smith, K., Felts, W. M., & Becker, C. (2009). Relationship between sleep quality and health risk behaviors in undergraduate college students. *College Student Journal, 43*, 924–930.

Venkatraman, V., Huettel, S. A., Chuah, L. Y. M., Payne, J. W., & Chee, M. W. L. (2011). Sleep deprivation biases the neural mechanisms underlying economic preferences. *The Journal of Neuroscience, 31*, 3712–3718. doi:10.1523/JNEUROSCI.4407-10.2011.

Walker, M. P. (2010). Sleep, memory and emotion. *Progress in Brain Research, 185*, 49–68. doi:10.1016/B978-0-444-53702-7.00004-X.

Wolfson, A. R., & Carskadon, M. A. (1998). Sleep schedules and daytime functioning in adolescents. *Child Development, 69*, 857–887.

Wolfson, A. R., & Carskadon, M. A. (2003). Understanding adolescents' sleep patterns and school performance: A critical appraisal. *Sleep Medicine Reviews, 7*, 491–506.

Wolfson, A. R., & Richards, M. (2011). Young adolescents struggles with insufficient sleep. In M. El-Sheikh (Ed.), *Sleep and development: Familial and socio-cultural consideration* (pp. 265–295). NY: Oxford University Press.

Wu, M.-Y. (2011). Style of upbringing and educational attainment: Comparing middle class family and working class family. In *Paper presented at the 4th Conference of Taiwan Youth Project*, Taipei, Taiwan.

Yu, C.-F. (2007). *The relationships among sleep, negative emotion, school adjustment, and adolescent deviance* (Master thesis, Tainan, Taiwan). Available from National Digital Library of Theses and Dissertations in Taiwan.

Zohar, D., Tzischinsky, O., Epstein, R., & Lavie, P. (2005). The effects of sleep loss on medical residents' emotional reaction to work events: A cognitive-energy model. *Journal of Sleep and Sleep Disorders Research, 28*, 47–51.

Wen-Hsu Lin, Ph.D is a post doctoral research fellow at the Institute of Sociology, Academia Sinica, Taipei, Taiwan. He received his doctorate in criminology from University of South Florida. His research focuses on adolescent development, juvenile delinquency and quantitative research methods.

Chin-Chun Yi, Ph.D is a research fellow at the Institute of Sociology, Academia Sinica, Taiwan. She received her doctorate in sociology from University of Minnesota. Her research interests include marital power and marital relations, intergenerational relations and youth development.