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Original Article

An epidemiologic study of sleep problems among adolescents in North Taiwan

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ABSTRACT

Background and purpose: To investigate the prevalence of sleep problems and their association with daytime sleepiness among Taiwanese adolescents by use of a validated questionnaire.

Patients and methods: This is a cross-sectional, community based study with self-reported sleep questionnaires. Completed questionnaires from 1939 adolescent subjects from schools in Lin-Kou district (Taipei, Taiwan) (96.7% responded); 1906 valid questionnaires (62.3% girls) were analyzed. The randomly selected classes included elementary grade 6 (age range: 12–13 years), junior high school (age range: 14–16 years) and senior high school students (age range: 17–18 years).

Result: The mean sleep duration on weekdays was 7.35 ± 1.23 h and on weekends 9.38 ± 1.62 h. Weeknight sleep decreased significantly with increasing school grade (6.87 ± 1.14 h for high school seniors). There was a trend towards increased daytime sleepiness for students in higher school grade levels. Daytime sleepiness directly correlated with shorter total sleep time (TST) on weekdays, longer TST on weekends, snoring, insomnia and nightmares. Coffee intake, smoking, periodic leg movement/restless legs syndrome, body mass index (BMI), mouth breathing and breathing problems were indirect factors that induced daytime sleepiness. Pearson correlation showed no significant correlation between the TST during the weekday and BMI (−0.047, $p = 0.079$) or body weight (BW) (−0.048, $p = 0.072$). But it showed significant negative correlation (−0.103, $p = 0.0001$) for increasing total sleep time on the weekend and decreasing BMI.

Conclusions: Daytime sleepiness correlated with the shorter TST on weekdays, longer TST on weekends, snoring, insomnia and nightmares. There is no significant correlation between the weekday TST and BMI or BW. Meals and food intake of children are still traditional and have not changed as much in Taiwan as in some other western countries, and compared to a similar survey performed 12 years ago in Taiwan among junior high school students, sleep duration was not significantly different but reduced due to school demands.

1. Introduction

Duration of nocturnal sleep plays an important role in the health of children and adolescents and has a significant impact on physical and psychological well-being. The reduction of nocturnal sleep has been linked to behavioral and neuro-cognitive difficulties as well as learning and attention deficits in children and adolescents [1,2]. Sleep patterns and complaints in children and adolescents are not only influenced by physical and psychological factors, but also by cultural and social factors [1–4]. Approximately 11–30% of children experience some type of sleep problem such as difficulty falling asleep, parasomnia events, sleep enuresis, sleep-disordered breathing (SDB) or periodic limb movement disorder (PLMD) [5–7].

More than 40% of adolescents have significant sleep complaints, and it is reported that the majority of adolescents suffer from insufficient sleep and excessive daytime sleepiness (EDS) [8–10]. Prior research has suggested that adolescents need more than 8 h of sleep per night [11–13]. When nightly sleep duration is shorter than 8 h, alertness and school performance subsequently become impaired [14,15], and this impairment can impact normal development and quality of life [8,16]. Recent studies have indicated that later bedtime among teenagers may be the result of decreased parental monitoring and enforcement [5,17,12], increased school work [5,8], and other social pressures [5,8,18,19]. A number of studies have also indicated that chronic sleep shortage may increase daytime sleepiness, inattention, accidents, and mood and behavioral problems. In developed countries, increased caffeine intake and drug use may play a role in the subsequent increase of

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sleeplessness in teenagers and may ultimately result in sleep–wake cycle disturbances [8,9,12,19,20,13,21–26]. Studies have shown that compared to younger children, adolescents are more likely to have shorter duration of nighttime sleep, increased daytime sleepiness, later bedtime and wake time, and longer sleep duration on weekends compared to weekdays [5,8,17,27–29]. Adolescent delayed sleep–wake patterns are associated with several factors such as pubertal development [13,12,20,27,28,30,31], decrease in parental monitoring of bedtime [17], increase in participation in extracurricular activities [32,33], more demanding school schedule [5,9,12,34,35], part-time jobs [12,34], and changes in circadian rhythms [35–40].

Early studies in Taiwan [5,41,42] have demonstrated that sleep problems are common in junior high school. Studies have found increased incidence rate of daytime sleepiness, shorter nocturnal sleep time, and mood changes from childhood to teenage years [41,42]. The more pressure adolescents face academically, the fewer hours dedicated to sleep. The aim of this study is to re-examine the incidence rate of sleep problems and current sleep schedules of adolescents from 12 to 18 years old in order to identify the influence of grade school levels on sleep schedules and sleep problems and to determine the sleep variables that are associated mostly with daytime sleepiness. We validated in Chinese a previously validated European languages questionnaire frequently administered in clinical practice known as the Pediatric Sleep Questionnaire [43]. We compared our results with that of other countries and with data obtained more than 12 years ago from school-aged children in Taiwan [5].

2. Methods

2.1. Participants

The study was performed in the Lin-Kou school district located near Taipei in Northern Taiwan. This district has similar school representation as all other districts in Northern Taiwan. There are seven elementary schools, two junior high schools and three senior high schools (including one all girls senior high school). The study was conducted in March 2005, 1 month after the beginning of the semester. We randomly selected two classes of grade 6 from each of seven elementary schools; two classes of grade 7, grade 8, and grade 9 from each of the two junior high schools; and five classes of grade 10 and grade 11 from each of the three senior high schools. Grade 12 (senior) students were not enrolled in our survey due to the possibility of influence from increased stressors and abnormal scheduling in preparation for university entrance examination.

The Institutional Review Board (IRB) approved the study and the informed consents prior to implementation. We contacted the school counseling centers and explained to teachers the purpose of the study and procedures that were necessary. All 2005 eligible students and their respective parents were informed that participation in the survey was completely voluntary, and thereafter parents' approval and signed informed consents were obtained. The survey was completed by students while in class. Trained research assistants distributed questionnaires and gave detailed instructions on how to fill out the questionnaires. Research assistants were available to respond to questions from students during the entire data collection process and to ensure that all students had a clear understanding of the questions and the rating systems used. Of the 2005 eligible students, 1939 (96.7%) consented and returned the self-administered questionnaire survey, but only 1906 (95.1%) were valid, representing 719 boys and 1187 girls (62.3% of the sample). Thirty-three subjects were not included because they did not complete the basic demographic data.

2.2. Instrument: the Pediatric Sleep Questionnaire (PSQ)

This validated sleep questionnaire (English versions of PSQ) [43] has been used previously in studies of children with sleep complaints who were seen in pediatric sleep clinics [43,44]. It is typically completed by parents. The PSQ can be divided into three parts: part A includes nighttime and sleep behavior; part B includes daytime behaviors and other possible problems; and part C includes attention, hyperactivity and impulsivity problems. The PSQ as described by Chervin in 2000 collapsed a 4-point Likert-type scale into positive and negative responses, whereas in this study, responses were limited to three categories (“yes,” “no,” or “unknown”). The detailed questions and psychometric properties of the PSQ have been described in detail elsewhere [43]. The scales showed good internal consistency and in a separate sample, good test–retest stability [43]. For the purpose of our study, a validation of the Chinese translation of the questionnaire and of a few additional questions with administration to parents of children and to children themselves was performed. This validation has been reported [45,46] and we shall briefly summarize it.

2.2.1. Validation of the Chinese version PSQ for parents [46,47]

(1) *Reliability of the Chinese version PSQ for parents.* The internal consistency of Cronbach's α was as follows: for snoring $\alpha = 0.815$; mouth breathing 0.730; daytime sleepiness 0.620; behavior scale (hyperactivity/inattention) 0.852; sleep related breathing disorder (SRBD) 0.826. The results were found to be similar to those of Chervin et al. [43]. (2) The test–retest reliability was performed at 4 weeks interval. Spearman correlation coefficients were presented as follows: for snoring 0.862* ($p = 0.001$); mouth breathing was 0.742* ($p = 0.0001$); SRBD was 0.786* ($p = 0.0001$); daytime sleepiness 0.760* ($p = 0.001$); behavior scale 0.868* ($p = 0.0001$); breathing problem (trouble breathing and observed apneas) 0.693* ($p = 0.0001$); and other symptoms (morning headaches, delayed growth, obesity, and sleep enuresis) 0.685* ($p = 0.0001$). The results suggested that the Chinese version of PSQ is a reliable instrument with good internal consistency and acceptable test–retest correlation. (3) The ROC curve and binary logistic regression model also moderated to high statistics significant of PSQ. It suggested snoring and the scales for sleep related breathing disorder were good predictive instruments of SRBD in adolescent and child [45,46].

2.2.2. Validation of the Chinese version PSQ for children

Our study plan called for administration of the questionnaire directly to children and adolescents. The Chinese version PSQ for children is a self-reported questionnaire. Therefore, the Chinese version of PSQ was translated from Chervin et al.'s English version to Mandarin Chinese [43]. Then questions were addressed directly to the respondent and were modified, e.g., “your child” was changed to “you” for each question. If children and adolescents did not know their sleep problems, they could either discuss it with their family members or leave answers as unknown. The items are shown in Table 1. Moreover, we added questions addressing items such as insomnia (difficulty falling asleep at night, wake up more than twice a night, wake up early in the morning), periodic limb movement and restless legs (restlessness of the legs when in bed, brief kicks of one leg or both legs, repeated kicks or jerks of the legs at regular intervals), nasal allergy, sleep walking, sleep talking, nightmare, grind teeth at night, coffee intake, and smoking. We also recorded the time the subject went to bed and got out of bed during the weekdays and on the weekend.

1. To validate the self-reported Chinese version of PSQ, we used 1906 valid questionnaires completed by adolescents (age range: 12–18 years). After statistical analysis, the internal consistency

Table 1
Questions identified as most useful for recognition of specific sleep disorders.

Symptoms	Questions	Number in questionnaire
Snoring	Snore more than half of the time?	A2
	Always snore?	A3
	Snore loudly?	A4
	Heavy breathing?	A5
Breathing problems	Trouble breathing?	A6
	Observed apnea?	A7
Mouth breathing	Mouth opening during the day?	A24
	Dry mouth on awakening?	A25
Daytime sleepiness	Unrefreshed in the morning?	B1
	Sleepy in the morning?	B2
	Sleepy as witnessed by teacher?	B4
	Difficulty waking up?	B6
Other symptoms	Occasionally wet the bed?	A32
	Morning headaches?	B7
	Delayed growth	B9
	Obesity	B22
Behavioral scale attention deficit hyperactivity disorder	Do not listen?	C3
	Difficulty with organization skills?	C5
	Easily distracted?	C8
	Difficulty staying still?	C10
	On the go often?	C14
	Interrupting?	C18

of Cronbach's α was as follows: snoring scale α: 0.735; breathing problem α: 0.521; mouth breathing α: 0.598; daytime sleepiness α: 0.652; behavior scale α: 0.875; and other symptoms (such as morning headaches, delayed growth, obesity, and sleep enuresis) α: 0.531.

2. The test–retest reliability was performed on 46 subjects. The questionnaires were administered to 46 randomly selected high school students from the above 1906 adolescents (mean age: 15.53 ± 2.23 years) with normal IQ. The test–retest reliability was performed at four weeks interval. Spearman correlation coefficients were presented as follows, for snoring 0.414* ($p = 0.041$); for mouth breathing 0.724* ($p = 0.0001$); for daytime sleepiness 0.764* ($p = 0.0001$); for behavior scale 0.864* ($p = 0.0001$); and for other symptoms 0.941* ($p = 0.0001$); and SRBD 0.873* ($p = 0.005$). For these added questions, the Spearman correlation coefficients were presented for PLM/RLS 0.535* ($p = 0.009$); for insomnia 0.637* ($p = 0.0001$); for sleep walking 0.609* ($p = 0.0001$); for sleep talking 0.637* ($p = 0.0001$); for nightmare 0.811* ($p = 0.0001$); for bruxism 0.995* ($p = 0.0001$); for coffee intake 0.539* ($p = 0.001$); and for smoking 0.998* ($p = 0.0001$).
3. A second validity was performed on 38 subjects from our sleep center within the range of ages as targeted in our study. These subjects (mean age: 14.07 ± 1.98 years) had been diagnosed with obstructive sleep apnea (OSA) based on the presence of clinical symptoms and an apnea–hypopnea index (AHI) $\geqslant 5$ events/h by polysomnography. In this study, we investigated the parent–child agreement by asking both parents and the child to complete the PSQ separately while in clinic. The Pearson correlation coefficient showed a high correlation between parents and children for snoring: 0.833 ($p = 0.001$); for breathing problem: 0.888 ($p = 0.001$); for daytime sleepiness: 0.502 ($p = 0.050$); SRBD: 0.718 ($p = 0.01$); for other symptoms 0.765 ($p = 0.001$); for sleep enuresis: 0.707 ($p = 0.001$); for insomnia: 0.655 ($p = 0.001$); for bruxism: 0.741 ($p = 0.001$); and for behavior problems (including hyperactivity and inattention): 0.802 ($p = 0.001$).

Results suggested that the child self-reported Chinese version of PSQ is a reliable and valid instrument that can be used to evaluate snoring, presence of SRBD, daytime sleepiness, other symptoms (morning headaches, delayed growth, obesity, and sleep enuresis) and behavior scale.

2.3. Data and statistical analyses

Statistical analysis of the data was performed using the English version of SPSS 13.0. The demographic distribution is presented as mean ± SD and frequency. The questionnaire data were presented as mean and SD with 95% confidence intervals. The level of significance was set at $p < 0.05$. Chi-square tests were used for categorical data. In order to determine the presence of significant correlations between sleep problems and hypersomnia, all the results that were significant (as shown by Chi-square statistics) were further analyzed with logistic regression. Odds ratios and 95% confidence intervals were calculated to confirm significant associations. We also used the path analysis "structural equation modeling" (SEM) to analyze the causal models of daytime sleepiness and the strength of variable relationships.

3. Results

As mentioned, 1906 questionnaires were considered valid. The questionnaires were obtained from elementary 6th grade classes (age range: 12–13 years), junior high school students (age range: 14–16 years), and senior high school (age range: 17–18 years). The data for body height and weight were taken in school. Mean body height and weight of the sample cohort were 159.39 ± 9.65 cm and 52.18 ± 13.19 kg, respectively, and the mean body mass index (BMI) was 20.36 ± 3.92 kg/m^2 (see demographics, Table 2). The mean nighttime sleep duration (from bedtime to final awakening) on weekdays was 7.35 ± 1.23 h, which significantly decreased with increasing age. The mean nighttime sleep duration on weekends was 9.38 ± 1.62 h. Both boys' and girls' nighttime sleep duration was over 9 h on weekends for all three groups. Girls' nighttime sleep duration was statistically significantly shorter than boys' duration. Results for each of the three subgroups of students are presented in Table 2. Pearson correlation for BMI (or body weight [BW]) and total nocturnal sleep time showed no significant correlation between total sleep time (TST) on weekdays and BMI (−0.047, $p = 0.079$) or BW (−0.048, $p = 0.072$).

Sleep complaints and sleep problems as reported by students are as followed: enuresis = 3%; difficulty falling asleep at night = 24.7%; wake up more than twice a night = 7.4%; wake up early in the morning = 15.1% (in Table 4); sleep walking = 12.7%; sleep talking = 53.4%; nightmare = 17.1%; and bruxism = 11.5%.

As mentioned above, we investigated factors that correlated with reports of excessive daytime sleepiness (EDS) using Chi-square statistics to identify these factors, and odds ratios were calculated. These factors varied by age and school level. We performed logistic regression analysis based on variables reaching significance as shown in Table 3. The variables of snoring, nasal allergy, breathing problems, total sleep time on weekday and insomnia for high school students as factors associated with daytime sleepiness. Only parasomnia events reached statistical significance in 6th grade students as a factor associated with daytime sleepiness. The results of logistic regression analysis are shown in Table 3.

Table 2
Demographics..

	Elementary 6th grade (n = 332, X age: 12.9 ± 0.75 years)				Junior high school (n = 452, X age: 14.71 ± 1.56 years)				Senior high school (n = 1122, X age: 16.58 ± 1.94 years)				Total (n = 1906)	
	Boy n = 159 M (SD)	Girl n = 173 M (SD)	Total M (SD)	p Gender (t-test)	Boy n = 257 M (SD)	Girl n = 195 M (SD)	Total M (SD)	p Gender (t-test)	Boy n = 303 M (SD)	Girl n = 819 M (SD)	Total M (SD)	p Gender (t-test)	M (SD)	p^* (ANOVA)
BMI	19.44 (3.70)	18.00 (3.19)	18.65 (3.50)	**0.001**	20.55 (4.06)	20.26 (4.34)	20.42 (4.19)	0.475	22.04 (4.42)	20.39 (3.45)	20.82 (3.79)	**0.001**	20.36 (3.92)	**0.001**
BH	146.16 (7.88)	146.99 (7.71)	146.62 (7.78)	0.350	163.88 (7.91)	156.91 (5.56)	160.76 (7.80)	**0.001**	171.63 (5.82)	159.27 (5.35)	162.44 (7.69)	**0.001**	159.39 (9.65)	**0.001**
BW	41.95 (10.33)	38.96 (8.39)	40.30 (9.41)	**0.005**	55.56 (13.31)	50.00 (11.42)	53.07 (12.79)	**0.001**	64.98 (14.27)	51.77 (9.48)	55.21 (12.37)	**0.001**	52.18 (13.19)	**0.001**
NTS (weekday)	8.88 (0.85)	8.64 (0.69)	8.74 (0.77)	**0.007**	7.76 (1.13)	7.48 (1.03)	7.63 (1.09)	**0.011**	6.87 (1.14)	6.81 (0.98)	6.83 (1.03)	0.448	7.35 (1.23)	**0.001**
NTS (weekend)	9.53 (1.18)	9.87 (1.19)	9.72 (1.20)	**0.017**	8.95 (1.77)	9.61 (1.73)	9.25 (1.78)	**0.001**	8.81 (1.62)	9.52 (1.62)	9.34 (1.65)	**0.001**	9.38 (1.62)	**0.001**

BMI, body mass index in kg/m^2; BH, body height in cm; BW, body weight in kg; NTS, nighttime sleep in h.
p (gender), t-test; X age, mean age.
p^* (three groups), ANOVA.

Table 3A
Correlation with daytime sleepiness.

Variables	Elementary grade 6 (n = 332) Daytime sleepiness			Junior high school (n = 452) Daytime sleepiness			Senior high school (n = 1122) Daytime sleepiness		
	Chi-square	p-Value	N	Chi-square	p-Value	N	Chi-square	p-Value	N
Snoring	8.482	**0.004**	270	3.351	0.067	272	1.967	0.161	671
Sleep-related breathing problem	0.361	0.548	236	0.324	0.569	168	9.563	**0.002**	441
RLS and PLM	0.117	0.732	249	8.390	**0.004**	237	2.462	0.117	622
Nasal allergy	0.188	0.665	292	14.262	**0.001**	378	12.159	**0.001**	957
Mouth breathing	0.886	0.347	291	11.915	**0.001**	400	5.584	**0.018**	989
Taking naps	7.122	**0.008**	312	6.769	**0.009**	408	47.598	**0.001**	1031
Bruxism	0.108	0.743	300	0.028	0.868	392	3.566	0.059	969
Enuresis	0.921	0.337	317	1.417	0.234	443	0.185	0.667	1031
Parasomnia	19.287	**0.001**	246	3.570	0.059	242	1.302	0.254	667
Insomnia	14.219	**0.001**	285	3.167	0.075	332	1.566	0.211	898
Nighttime sleep (weekday)	0.242	0.623	258	15.139	**0.001**	333	8.914	**0.003**	843
Nighttime sleep (weekend)	0.012	0.914	250	0.001	0.981	329	4.764	0.059	820
Coffee intake	4.778	0.059	268	2.647	0.104	356	12.500	**0.001**	905
Smoking	0.384	0.535	267	1.594	0.207	356	1.320	0.251	906

Chi-square test was used to analyze daytime sleepiness.

Table 3B
Logistic regression analysis.

	Variables	p-Value	Odds ratio	95% CI for odds ratio
Elementary 6th grade (n = 332)	Parasomnia	0.001	11.000	(2.877, 42.055)
Junior high school (n = 452)	PLM and RLS	0.023	3.956	(1.092, 10.005)
	Nasal allergy	0.003	4.010	(1.724, 9.603)
	Nighttime sleep (weekday)	0.003	0.311	(0.195, 0.786)
Senior high school (n = 1122)	Breathing problems	0.042	5.108	(1.217, 27.366)
	Nasal allergy	0.048	1.891	(1.701, 9.528)
	Coffee intake	0.031	1.648	(1.072, 2.578)
	Nighttime sleep (weekday)	0.003	0.375	(0.232, 0.801)

All results were significant as shown by Chi-square test and were further analyzed with logistic regression analysis in order to establish a forecasting model.
*P < 0.05.

In path analysis (SEM) of the samples the result showed that daytime sleepiness directly correlated with shorter total sleep time on weekday (−0.341***), longer total sleep time on weekend (0.195***), snoring (0.122*), insomnia (0.111*), and nightmares for younger children (0.168*). Moreover, there were indirect factors that related to daytime sleepiness. Some were related to shorter TST such as coffee intake (−0.079*) and insomnia (0.130*), as were smoking, nasal allergy and PLM/RLS; while others such as BMI, mouth breathing and breathing problem at night were associated with snoring and disturbed sleep (Figs. 1 and 2).

4. Discussion

It is important to have an understanding of how many hours teenagers are sleeping on a regular basis. Sleep duration has been

Table 4
Comparison with reports of sleep disorders from students in different countries.

Sleep problems/country	Age (years old)	Instrument	Insomnia (%)	DIS (%)	DMS (%)	EMA (%)	EDS (%)	NTS (w/d) (h)	NTS (w/e) (h)
Taiwan – Huang (this study)	12–18 years *N* = 1906	PSQ (self)	18.70	24.70	7.40	15.10	35.07	7.35 ± (1.23)	9.38 ± (1.62)
Taiwan – Gau and Soong [5]	6–15 years *N* = 965	SHQ (parent)		27.20	31.90	22.30	23.2	7.00 ± (1.15)	9.14 ± (1.69)
China – Liu et al. [2]	12–18 years *N* = 1365	ASLEC (self)	16.90	10.80	6.30	2.10		7.64 ± (0.86)	
Hong Kong – Chung and Cheung [54]	12–19 years *N* = 1629	SWHQ, SQI, ESSM/E, PSS (self)	19.1	5.60	7.20	10.40	41.9 (ESS > 10)	7.28 h	9.47 h
Korea – Yang et al. [50]	9.4–19.1 years *N* = 1457	DSS, M/E, DMS, SW-PBS (self)					6.60 (2.10–13.90%)	4.9–6.0 h (12–10th)	9.1–8.5 h (12–5th)
Kuwait – Abdel-Khalet [55]	14–19 years *N* = 5044	IS (self)		17.50	12.30	33.80			
Japan – Ohida et al. [49]	13–18 years *N* = 106,297	Anonymous questions (self)		Boy = 15.30 Girl = 16.00			Boy = 33.30 Girl = 39.20	6.3 h (10–12th)	8.5 h (10–12th)
Japan – Kaneita et al. [56]	13–18 years *N* = 102,451	Insomnia questions, GHQ-12J (self)	23.5 (one symptom of insomnia)	14.80	11.30	5.50			
USA – Wolfson and Carskadon [8]	13–19 years *N* = 3120	SSH (self)						7.3 h	9.0 h
USA – Roberts et al. [57]	11–17 years *N* = 4175	DSMIV (self)	4.7 (DSMIV)	7.1	3.1	3.2			
Greece – Lazaratou et al. [58]	16–19 years *N* = 713	AIS-5 (self)					58–68	7.5 h	
Europe – Ohayon et al. [59]	15–18 years *N* = 1125	Telephone (self)	25.70	12.4	9.2	10.5	20	7.97 (f) 7.84 (m)	
France – Vignau et al. [60]	15–23 years *N* = 763	INSERM (self)		20.60	34.60	9.50	11.60		
New Zealand – Dorofaeff and Denny [61]	Secondary school *N* = 9567	Sleep questions (self)						8.7 h	9.4 h
Italian – Manni et al. [62]	17 years *N* = 869	SQ (self)	Poor sleep quality 16.5	46.1 (N) 13.4 (R)	71.8 (N) 55.8 (R)		74.5 (N) 43.6 (R)		

No, number; DIS, difficulty initiating sleep; DMS, difficulty maintaining sleep; EMA, early morning awakenings; EDS, excessive daytime sleepiness; NTS, nighttime sleep; w/d, weekday; w/e, weekend; Europe, includes France, Great Britain, Italy, and Germany; self, self-reported; parent, parent reported; f, female; m, male; N, non-restorative sleep; R, restorative sleep.
PSQ, Pediatric Sleep Questionnaire; SHQ, sleep habit questionnaire; ASLEC, adolescent self-rating life events checklist; SWHQ, sleep–wake habit questionnaire; SQI, sleep quality index; M/E, morningness/eveningness scale for adolescent; ESS, Epworth Sleepiness Scale; PSS, perceived stress scale; DSS, daytime sleepiness scale; DMS, depressive mood scale; SW-PBS, sleep/wake-problems behavior scale; IS, insomnia scale (12 items); GHQ-12J, 12-item general health questionnaire; SSH, school sleep habits; AIS-5, Athens insomnia scale (5-item version); SQ, sleep questionnaire.

shown to have an impact on performance, irritability and mood, and possibly food intake and weight increase. Teenagers are especially vulnerable to the consequences of sleep deprivation because they must meet the challenges of puberty, school performance, and university entrance exams. Also, little is known about depression and suicide in teenagers and whether poor sleep may exacerbate these problems. Many aspects of teenage life are linked to quality of nocturnal sleep [47–51]. Taiwan is an example of an industrialized society, and many of the problems observed in this particular country are also seen in other countries [50]. Teenagers usually sleep in their own rooms and are exposed to the same electronic influences seen in most industrialized societies ranging from cell phones to computers. Parents also have similar demands compared to parents in other industrialized countries, and therefore may not be monitoring or dictating the hours dedicated to sleep among their teenage children. Finally, sleep problems that exist in this population are under-recognized and understudied, at least in part because pediatricians often do not see this age group in their clinic on a routine basis.

There are problems to consider when gathering data among a large group of children. Laboratory-based polysomnographic monitoring of large groups in epidemiologic studies is difficult and the use of simpler recording techniques such as actigraphy is not necessarily more efficient when subjects are in the thousands. The use of questionnaires is often the only realistic possibility. Questionnaires, however, have limitations such as issues in length and subsequent respondent fatigue, the clarity of the questions asked and hidden biases that may impact responses. Location and method of administering questionnaires also impact results. In order to avoid some of these biases we used a tool that has been used internationally in sleep clinics [43,44]. The selected questionnaire has been used in our clinical practice for several years [44], and we therefore have prior knowledge and experience with ease of administration. We also recognized responses that are identified with typical patterns of association with sleep disorders as seen on subsequent sleep studies. This questionnaire has been used in several published investigations from different groups [51–53]. We performed several rounds of validation using the Chinese version of the questionnaire, as this process may be helpful to others when using this tool for a similar type of survey [45,46].

The administration of the questionnaire was standardized, as indicated in the methods section. Collaboration with school teachers was established well in advance of the study. The goals of the survey and the techniques employed were explained to parents well beforehand. These efforts were aimed at decreasing the number of invalid questionnaires and responses, which may help explain the large percentage of valid questionnaires we were able to obtain. We had some "unknown" responses to questions and this was taken into consideration during analysis. We acknowledged that if parents had been asked to respond to the

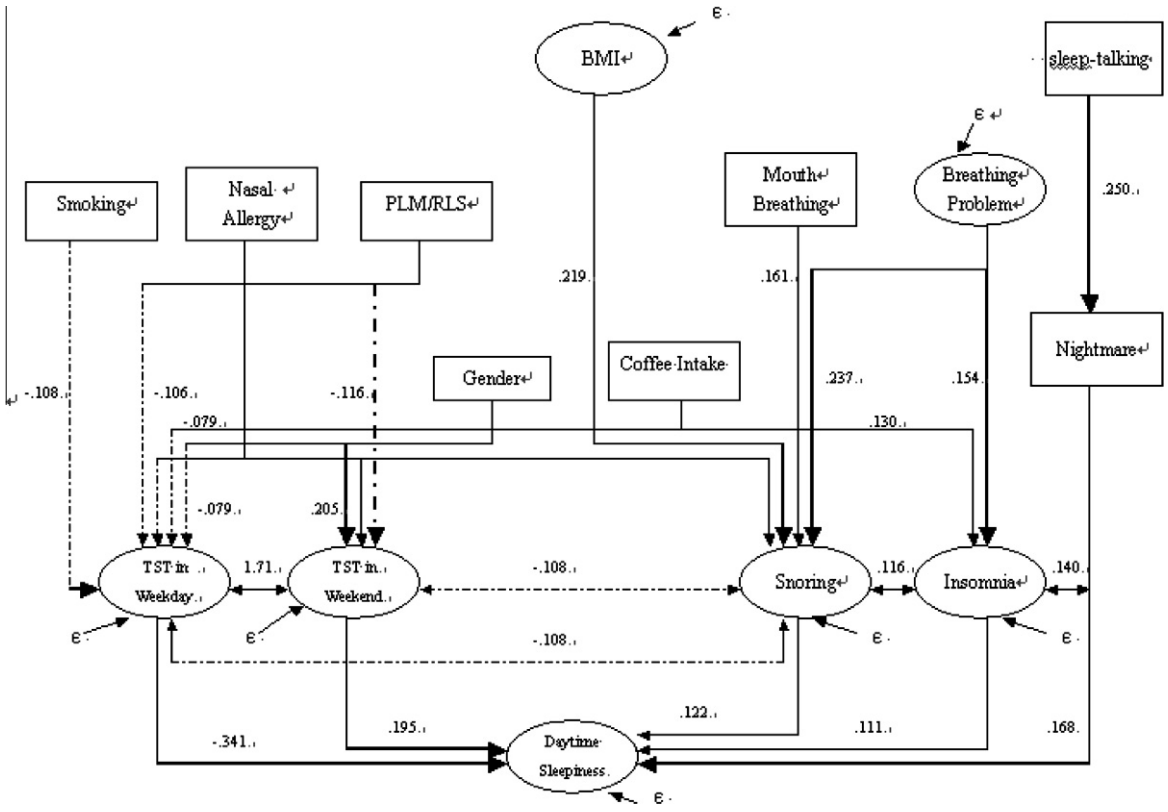

Fig. 1. Results obtained using structural equation modeling. All presented path coefficients are $p < 0.05$; darker lines represent stronger effects. Solid lines represent positive effects; dashed lines represent negative effects. Measured variables are presented in a square, and variables estimated from observational variables or derived from other studied variables (latent variables) are presented in an oval-shape drawing. Residual variances (error), represented by letter 'ε', were estimated for each latent/measured endogenous variable. Single-headed arrows indicate direct paths (the arrow is pointed toward the dependent variable) and the "double-headed" arrows indicate correlations.

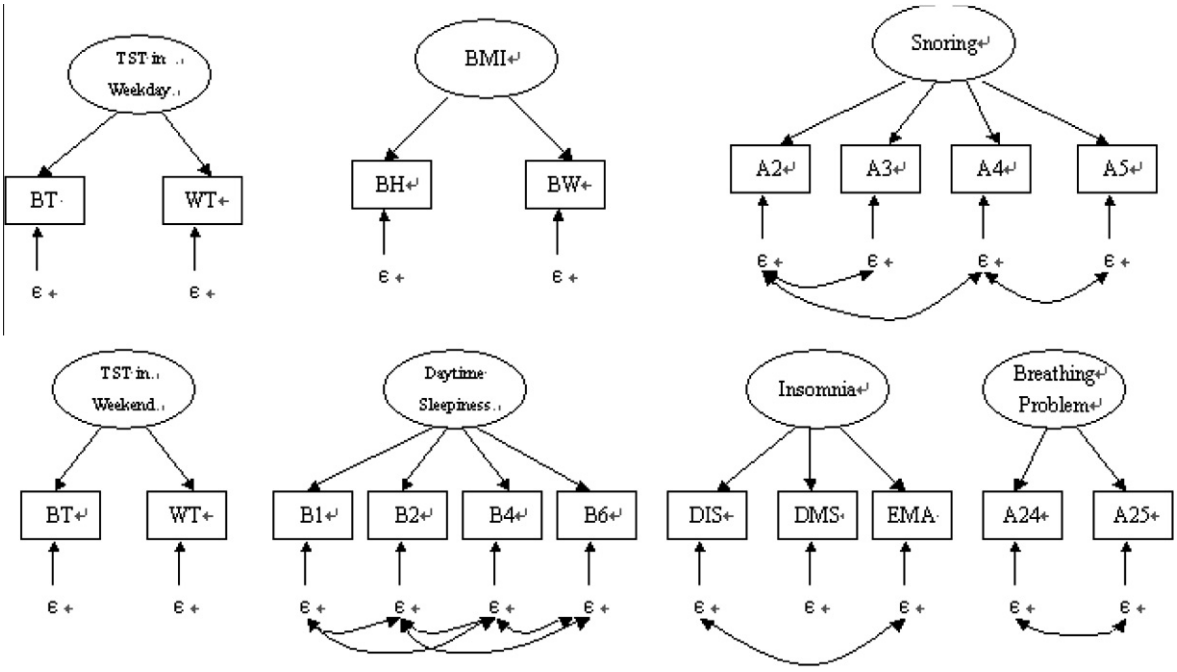

Fig. 2. How the observational variables or complaint related variables ("latent variables") presented in Fig. 1 were derived. Presentation of the variables used to calculate the variables presented in each of the oval-shaped drawing in Fig. 1. Questions or measured variables: BT: what time do you go to bed during the weekday. WT: what time do you get out of bed on weekday morning. BH, body high; BH, body weigh; DIS, difficulty initiating sleep; DMS, difficulty maintaining sleep; EMA, early morning awakenings; A2, snore more than half of the time; A3, always snore; A4, snore loudly; A5, heavy breathing; A24, mouth opening during the day; A25, dry mouth on awakening; B1, unrefreshed in the morning; B2, sleepy in the morning; B4, sleepy as witnessed by teacher; B6, difficulty waking up. Letter 'ε' indicates presence of residual variances (error) that was calculated.

same questionnaire concerning their child, we may have had fewer missing data points. However, parental participation in a group of this size would have complicated our data collection model, and reduction of parental oversight of questionnaire administration allowed more straight-forward responses from teenagers who were not necessarily inclined to reveal their nighttime behavior.

Although our sample represented the North Taiwan school district fairly well, it was not necessarily representative of Taiwan as a whole, including rural and agrarian regions. Additionally, this is a cross-sectional rather than a longitudinal study. We have no knowledge of long term outcomes on sleep problems as reported in our study subjects. As a proxy, we have compared our results to a study performed 12 years ago in a similar region [5], acknowledging that this does not replace a true longitudinal investigation and does not address the limitations as noted above. Although methods used to obtain data differed from our own, as suggested 12 years ago [5], the presence of sleep restriction on school nights and increasing restriction with increasing school grade level were already present in North Taiwan. This finding has been reported by other studies [5,41,50,54]. Girls on average have shorter nocturnal sleep duration on weekdays compared to boys, while they have longer sleep duration on weekends. This finding indicates weekend "sleep compensation," likely due to the need to compensate for weeknight sleep debt. Insomnia and parasomnia as seen in our study are similar to the findings in Taiwan as noted 12 years ago [5]. Sleep duration was slightly increased at the junior high school level when compared to the data from 12 years ago in Taiwan [5]. But the percentage of daytime sleepiness was higher than 12 years ago in Taiwan [5], maybe due to the age range of our study being higher than in the previous study [5] (Table 4).

In Table 4, we have also added results obtained from high school students in other countries that have been published in the recent past [1,2,8,46–50,54–62]. The tendency to go to bed later and also wake up later, irregular sleep–wake schedules, particularly when comparing weekdays to weekends, seem to be common in industrialized societies and Asian countries including China [47,48], Korea [50] and Hong Kong [54]. Also, complaints of insomnia as seen in our study are similar to the findings in Hong Kong [54]. In particular, gender difference was not seen. Insomnia complaints are still quite high compared to reports from China and Japan [47–49]. Sleep duration in Taiwan on weekdays was shorter than compared to China, Greece, and New Zealand but similar to Hong Kong and the United States (Table 4).

Studies have shown a relationship between daytime sleepiness and nighttime sleep [5,48–50,54,63]. Studies from Korea [50], and Hong Kong [54] which are similar to this survey, showed not only a tendency to go to bed late at night but also more daytime sleepiness among older students. There was a positive association between depressed mood and report of sleep–wake behavioral problems [41]. Use of the Chinese-validated PSQ allowed us to further investigate the association between reports of daytime sleepiness and health problems.

Our study (Figs. 1 and 2) found that daytime sleepiness directly correlated with shorter TST on weekday, longer TST on weekend, snoring, insomnia, and nightmares for younger children. There were also indirect factors that related to daytime sleepiness; some were related to shorter TST such as coffee intake and insomnia as well as smoking, nasal allergy, and PLM/RLS. Others were BMI, mouth breathing and breathing problem at night, which were associated with snoring and also affected presence of daytime sleepiness (Figs. 1 and 2).

Compared to other studies, gender differences in excessive daytime sleepiness were found only in senior high school adolescents, particularly more in girls than boys.

As reported in other studies caffeine use is associated with insufficient sleep and consequently daytime sleepiness [12,18,32]. Caffeine is known to prolong sleep onset, shorten sleep time, and decrease sleep quality, especially when consumed in the evening. In United States caffeine is consumed at least weekly by 98% of 5- to 18-year-old children. Additionally, 18.8% of students consume an average of 100 mg/day or more of caffeine, and it is likely that the main dietary source of caffeine is from soft drinks [64]. Manni et al. reported 62.5% of coffee drinking in poor sleepers [62]. In our study, 51.2% of high school students consumed caffeinated beverages. Although the mean number of daily caffeinated beverage cup intake was 1.58, the maximum was 10 cups/day and we found a positive correlation with daily caffeinated beverage intake with insomnia and shorter TST on weekday and report of daytime sleepiness.

Finally, we compared our data with reports of nocturnal sleep duration from different countries. We found that 50.2% of our high school students not only had a restriction of total nocturnal sleep duration on weekdays, but also had nightly variability in bedtime due to homework or social issues, including cell phone use, computer games, or on-line chat, as reported in other studies [42,50,54,63]. It has been reported that teenagers in United States have a mean sleep duration of 7.3 h on weeknights and 9.0 h on weekends [1,8,64]; while in New Zealand it is 8.7 h and 9.4 h [61]; and in Korea it is 5.4–6.6 h and 8.5–9.1 h [50]. Our study is similar to the study from Hong Kong that reported mean nocturnal total sleep duration of 7.35 h on weekdays and 9.38 h on weekends, indicating a significant "catch-up" time on weekends. We also found the duration gap between weekdays and weekends to increase with increasing school grade. In summary, shorter sleep time led to more excessive daytime sleepiness.

Compared to studies performed in other countries, Taiwanese high school students' sleep times are similar to students from Korea and Hong Kong, but less than China and other western countries. Taiwanese high school students tend to follow sleep patterns that resemble those seen in other parts of industrialized nations, especially those where electronic devices are a part of everyday life. Of note, in our study there is no significant correlation between TST on the weekday and BMI (or BW). But it showed significant negative correlation -0.103 ($p = 0.0001$) for TST on the weekend and BMI (or BW). If electronic gadgets have invaded the nocturnal life of young Taiwanese, social and cultural structures have not lead to important changes in food intake, a factor that probably plays a role in the obesity epidemic seen in several westernized countries.

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