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Original Article

Assessing insomnia in adolescents: Comparison of Insomnia Severity Index, Athens Insomnia Scale and Sleep Quality Index

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ABSTRACT

Objectives: To compare the psychometric properties of the Chinese versions of Insomnia Severity Index (ISI), Athens Insomnia Scale (AIS) and Sleep Quality Index (SQI) for assessment and screening of insomnia in adolescents.
Methods: This is a school-based survey of 1516 adolescents aged 12–19 years. Sleep-wake habit questionnaire, ISI, AIS, SQI, Epworth Sleepiness Scale (ESS) and 12-item General Health Questionnaire (GHQ-12) were administered. Insomnia Interview Schedule was used to assess the severity of insomnia symptoms and DSM-IV-TR diagnosis of insomnia.
Results: The Cronbach's alpha of ISI, AIS and SQI were 0.83, 0.81 and 0.65, respectively, and the 2-week test–retest reliability were 0.79, 0.80 and 0.72. All three scales had a 2-factor structure, and their scores were significantly correlated with sleep-wake variables, ESS and GHQ-12 scores, smoking and drinking habits, and academic performance. The areas under curve of ISI, AIS and SQI for detecting clinical insomnia were 0.85, 0.80 and 0.85, respectively. The optimal cut-offs for ISI, AIS and SQI were a total score of nine (sensitivity/specificity: 0.87/0.75), seven (sensitivity/specificity: 0.78/0.74) and five (sensitivity/specificity: 0.83/0.79), respectively.
Conclusion: The Chinese versions of ISI, AIS and SQI are reliable and valid instruments. The ISI and AIS appear to have better psychometric properties than the SQI.

1. Introduction

Adolescence is a time of extensive biological, personal, and psychosocial changes [1]. Sleep-wake disturbances manifested as irregular sleep-wake schedules, insufficient sleep, insomnia, and daytime sleepiness are frequently found in adolescents. Although the actual prevalence of insomnia symptoms recorded varies depending on the methodology and country sampled, most estimates range from 10% to 30% [2–6]. Cross-sectional studies have found insomnia to be linked with behavioral and emotional problems, such as depression, suicidal ideation and attempts, alcohol and substance abuse, and poor social competence [7,8]. Prospective studies confirmed an association between insomnia and impaired interpersonal and psychological functioning at one to two-year follow-up [9,10] and the onset of depression and substance abuse in young adulthood [8].

There are many controversies regarding the nosology of insomnia in children and adolescents. Some inherent challenges include patient versus parent report, changes in sleep need, circadian timing across development, individual differences in neurodevelopmental processes, and cultural differences [11]. In clinical practice, adult diagnostic criteria are often applied to older children and adolescents. Using the Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition (DSM-IV) criteria in a US sample of adolescents aged 13–16 years, the prevalence of current insomnia was 9.4% [12].

Because of the high prevalence of insomnia in adolescents and the significant health risk, suitable screening tools could be very useful. There are several brief, self- or parent-report questionnaires for evaluating sleep disturbances in adolescents, including Pediatric Sleep Questionnaire [13], Sleep Habits Survey [14], Sleep Disorders Inventory for Students [15], and Sleep Disturbance Scale for Children [16], but none of them are validated measures for insomnia. On the other hand, a variety of insomnia-related self-report instruments are available for use in adults [17]. The Insomnia Severity Index (ISI) [18] and Athens Insomnia Scale (AIS) [19] are two commonly-used, validated global insomnia symptom questionnaires. The Pittsburgh Sleep Quality Index (PSQI) is another excellent self-report scale for evaluating sleep disturbances in adults; however, it is slightly longer than ISI and AIS, and it is not specifically designed for insomnia [20]. The Sleep Quality Index (SQI), an 8-item self-report questionnaire, is less often mentioned in the literature [21,22]. The SQI is quick and simple to administer.

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In a pilot study of 41 Hong Kong Chinese adolescents, we found that SQI was a valid and reliable measure [6].

The present study compared the psychometric properties and screening performance of three self-report measures of insomnia in a sample of secondary school students in Hong Kong. It was expected that the measures would have sufficient internal consistency, test–retest reliability, convergent validity, and adequately discriminate DSM-IV cases of clinical insomnia in adolescent population.

2. Methods

2.1. Subjects

The study was carried out in the 2007/08 school year. We preselected three schools with different levels of academic achievement and conducted the survey among all 7th–10th and 12th grade students at each school. Eleventh-grade students were preparing for public examination during the study period, so they were not recruited. There were 614, 635, and 873 eligible students in the focus schools, and the number of students and their parents who consented to the study were 387 (63.0%), 413 (65.0%), and 721 (82.6%), respectively. The overall response rate was 71.7%. We excluded the data from five students who were $\leqslant$11 years or $\geqslant$20 years of age. A total of 1516 students were included in the final analysis.

2.2. Procedures

All procedures used in the present study were reviewed and approved by the local institutional review board. Questionnaires were distributed to the students in their classroom by the investigators with the help of teachers. The investigators were available to answer the students' questions regarding the study and questionnaires; however, the students completed the questionnaires on their own with no time limit. The questionnaires were presented in Chinese, the mother tongue of the students (available on request from the corresponding author).

A quarter of the students were randomly selected and invited to complete the scales once again two weeks after the first administration and to participate in a face-to-face interview. The test–retest reliability and screening performance of the insomnia scales was examined in 290 students. The participation rates for the second test in the focus schools were 87.1%, 76.8%, and 75.6%. There were no significant differences in demographics and total scores of the insomnia scales between the 290 participants and 78 non-participants of the second test.

2.3. Measures

The self-administered questionnaires were presented sequentially in the order of sociodemographic characteristics, academic performance, sleep-wake habit, SQI, ISI, AIS, Epworth Sleepiness Scale (ESS) [23], 12-item General Health Questionnaire (GHQ-12) [24], daytime napping, alcohol use, and smoking habit.

The items of the sleep-wake habit questionnaire originated from a Chinese version of the PSQI [20,25]. The students were asked to fill out their usual bedtime, rising time and total sleep time (TST) on both school days and weekends and estimate the time to fall asleep ("sleep onset latency" or SOL) and the time they spent waking up early and could not get back to sleep ("early morning awakening" or EMA). Total time in bed (TIB), the period between bedtime and rising time and TST were counted as a mean data across a week. We calculated sleep efficiency as TST/TIB $\times$ 100% and wake after sleep onset as TIB minus TST and SOL. But the calculation generated a significant number of erroneous answers, including sleep efficiency greater than 1 and negative wake after sleep onset; hence only the responses to SOL and EMA were used for analysis.

The ISI was developed by Morin and colleagues [26] and has been used by many research teams in the past 20 years. It is a 7-item scale assessing the perceived severity of insomnia symptoms (initial, middle, terminal), the degree of satisfaction with sleep, interference with daytime functioning, noticeability of impairment, and concern caused by the sleep problems [18]. The scale is Likert-type with 5 anchor points ranging from 0 to 4. The usual time frame for responding is the last 2 weeks. There were 223 patients in the initial validation study: 145 patients aged 17–82 years presenting to a sleep clinic with insomnia and 78 older patients who participated in a treatment study for insomnia [18]. The authors showed that the ISI had an acceptable internal consistency, with a Cronbach's alpha of 0.74, a satisfactory convergent validity, with correlation coefficients between ISI individual items and the corresponding variables on sleep diary ranging from 0.32 to 0.91, and a modest level of sensitivity to changes following treatment, with correlation coefficients between change scores from ISI individual items and those on sleep diary and polysomnography ranging from 0.05 to 0.37.

The AIS was developed by Soldatos and colleagues to assess the severity of insomnia based on the ICD-10 diagnostic criteria. It is a self-reported questionnaire consisting of 8 items; the first 5 items assess difficulty with sleep induction, awakening during the night, early morning awakening, total sleep time, and overall quality of sleep, while the last 3 items pertain to the sense of well-being, overall functioning and sleepiness during the day [19]. The usual time frame for responding is the last month. Each item of AIS can be rated 0–3, with 0 corresponding to no problem at all and 3 to very serious problem. The initial validation study was based on a sample of 299 subjects: 105 primary health care patients with primary insomnia, 100 psychiatric outpatients, 44 psychiatric inpatients, and 50 non-patient controls [19]. The Cronbach's alpha for the total group and each subgroup of subjects were high (0.75–0.90). The test–retest reliability over one week was 0.90 for the total score and from 0.70 to 0.86 for individual items. The correlation of AIS with the Sleep Problems Scale, an external validator, was very high (Pearson's $r = 0.90$).

The 8-item SQI was first developed as a tool to study the relationship of sleep quality and subjective health status in an urban population in Finland. The initial validation study was based on a sample of 200 men and 200 women aged 36–50 years [21]. The subjects reported how often they had difficulty falling asleep, waking up during the night, waking up too early in the morning, disturbed night sleep, and insomnia with the response categories: no, <3 days/week, and 3–7 days/week. Time to fall asleep was reported with the responses: $\leqslant$10 min, 11–30 min, and >30 min. Frequency of hypnotics use was assessed using the response categories: no, occasionally, and at least once per week. Morning tiredness was reported with the responses: rather or very alert, don't know, and rather or very tired. The time frame for responding in the validation study was the past 3 months. The SQI score ranged from 0–16 with higher scores indicated more severe sleep disturbance. The internal consistency was acceptable with a Cronbach's alpha of 0.73 for men and 0.75 for women. The initial validation study showed that the SQI score was associated with subjective health. The SQI has also been used in secondary school and college students to examine their sleep disturbances [6,22].

In this study, the first sentence of the sleep-wake habit questionnaire, ISI, AIS, and SQI was phrased to evaluate sleep-wake patterns and sleep disturbances in the past month. We aimed to compare the psychometric properties of the three insomnia scales; hence had used a standardized time frame for responding. The

1-month time frame is in line with the DSM-IV and ICD-10 diagnostic criteria for insomnia. There have been no published data showing that the psychometric properties of an insomnia rating scale can be compromised by a change in the time frame. A study on gambling screening tools found that shortening the time frame would not affect the scales' psychometric properties [27].

The ESS is an 8-item self-reported questionnaire to assess the average daytime sleep propensity [23]. It focuses on tendency to sleepiness, with a 3-point scale to rate the likelihood of dozing in eight daily life situations. A recent study in adolescents found that the test–retest reliability of ESS over 2 weeks was high [28].

The GHQ-12 has been extensively used in different cultures for the assessment of psychological well-being in adults and adolescents [29]. It consists of six positive and six negative statements. Subjects were asked to rate their responses using a 4-point Likert scale (less than usual, no more than usual, rather more than usual, or much more than usual). Each question was scored using a binary code (0, 0, 1, 1) with total score ranging from 0 to 12. Higher scores indicate greater psychological distress. The Chinese version of GHQ-12 has been widely used in different populations [30,31].

We asked students to report their school performance as excellent, good or marginal based on their rank in class, average mark or overall grade [6]. The students also filled out their age; gender; weight; height; previous consultation for sleep problems; number and duration of napping per week; habit of smoking and the number of cigarettes smoked per day; frequency of alcohol use using the response categories never, rarely, sometimes, almost always, and often; and parents' marital status, occupation and educational level. The time frame for responding for napping, smoking and drinking habit was the past month. Previous studies showed that adolescents with sleep disturbance were more likely to have poor mental health, excessive daytime sleepiness, smoking habit, alcohol use, and poor school performance [7,32–35]; hence the ISI, AIS and SQI were tested against these external validators.

The Chinese versions of the sleep-wake habit questionnaire, ISI, SQI, ESS, and GHQ-12 have been used in previous studies [6,25,30,36,37]. Although the process of cross-cultural adaptation of the scales used in this study was not as detailed as the recommended guidelines [38,39], it included forward-translation, back-translation, review by Chinese-language teachers, and pretesting on face validity. The scales were piloted in a class of grade 7 students who were asked to rate each instruction, question and response category based on their understanding on a 7-point scale (1 = extremely easy to understand; 4 = not sure; 7 = not at all understandable). Any item that had a mean score >2.5 was considered unsatisfactory [40,41]. From the pilot test results, three questions having a mean score of understanding over 2.5 had to be reworded until consensus between the investigators was achieved.

The Insomnia Interview Schedule [26], a semi-structured face-to-face interview, was used to assess the adolescents' severity of sleep-wake problems, current sleep-wake schedule, use of sleeping aids, sleeping problem history, bedroom environment, eating, exercise, and substance use habits, functional impairment, symptoms of other sleep disorders, and history of psychopathology. Blind to the questionnaire results, the author (KC) evaluated the severity of insomnia symptoms using a 4-point scale (0 = no, 1 = mild, 2 = moderate or 3 = severe) on a combination of frequency and severity criteria [42]. The minimum criteria for initial, middle, and terminal insomnia symptoms were set based on clinical experience as SOL $\geqslant$ 20 min, WASO $\geqslant$ 10 min, and EMA $\geqslant$ 20 min, respectively, that occurred $\geqslant$3 days per week in the past month. Taking into account both frequency and severity, SOL $\geqslant$ 10 min occurring everyday or SOL $\geqslant$ 30 min that occurred 2 days per week was rated as mild initial insomnia; SOL $\geqslant$ 20 min daily or SOL $\geqslant$ 45 min 2 days per week was rated as moderate initial insomnia; and SOL $\geqslant$ 30 min occurring everyday or SOL $\geqslant$ 60 min 2 days per week was rated as severe initial insomnia. The same approach was used to assess other severities of middle and terminal insomnia. Lastly, we derived the diagnosis of clinical insomnia according to the DSM-IV, Test Revision (DSM-IV-TR) criteria, on the basis of having difficulty initiating or maintaining sleep for at least 1 month that caused clinically significant distress or impairment in daytime functioning [43].

2.4. Data analysis

All statistical analysis was done by SPSS version 17.0 for Windows (SPSS, Chicago, USA). The internal consistency of ISI, AIS and SQI was evaluated by Cronbach's alpha. Test–retest reliability was assessed by Pearson correlation. Factor structure was evaluated by principal component analysis followed by varimax rotation. The factors were selected according to eigenvalues >1 and Scree test. The items with rotated loadings of 0.5 or greater were regarded as representing significant item-factor contributions. Concurrent validity was assessed by correlating ISI, AIS and SQI scores with variables obtained from sleep-wake habit questionnaire and clinical interview and the external validators. Criterion validity of the insomnia scales was tested against the DSM-IV-TR diagnosis of clinical insomnia. The discriminatory capacity was evaluated in terms of sensitivity, specificity, positive and negative predictive values and likelihood ratio for positive and negative tests. The receiver operating characteristic (ROC) analysis was used to compare the scales' discriminatory capacity. The optimal cut-off is the point closest to the left upper corner of the ROC curve and the discriminatory power is measured by the area under curve (AUC) [44]. We compared the psychometric properties of ISI, AIS and SQI using samples of the same number.

3. Results

Table 1 presents the students' sociodemographic, school, and lifestyle variables. Participants had a mean age of 14.5 years, and 55% were female. Their average school night bedtime, rise time, and total sleep time was 11:26, 07:02, and 7 h 2 min, respectively. Among the 290 interviewed subjects, 103 (33.5%), 26 (9.0%), and 19 (6.5%) had initial, middle, and terminal insomnia symptom, respectively, and 27 students (9.3%) had DSM-IV-TR diagnosis of clinical insomnia. Students with clinical insomnia were in grades 7–12, had a mean age of 14.7 years (SD = 1.7, range = 12–18), and 56% were female.

3.1. Descriptive statistics, internal consistency, test–retest reliability and factor analysis

The endorsement rates on the ISI, AIS and SQI are presented as Supplementary data. The average of ISI total score was 7.4 (SD = 4.6); while for AIS and SQI, it was 6.1 (SD = 3.7) and 3.7 (SD = 2.5), respectively (Tables 2–4). The Cronbach's alpha of ISI, AIS and SQI were 0.83, 0.81 and 0.65, respectively. The item-total correlations of ISI, AIS and SQI were ranged from 0.58 to 0.80 (mean = 0.70), 0.46 to 0.78 (mean = 0.65), and 0.25 to 0.67 (mean = 0.54), respectively. Most of the individual items and the total scores of ISI, AIS and SQI had satisfactory test–retest reliability (Tables 2–4). The Pearson correlation coefficients for the total score of ISI, AIS and SQI over 2 weeks were 0.79, 0.80, and 0.72, respectively. The coefficients for the individual item of ISI, AIS and SQI were ranged from 0.47 to 0.67 (mean = 0.59), 0.46 to 0.66 (mean = 0.60), and -0.006 to 0.72 (mean = 0.48), respectively. The items with relatively weak test–retest reliability were SQI item 7 "waking up too early in the morning" and item 8 "frequency of hypnotics use."

Table 1
Sample characteristics.

Variables	Total sample (n = 1516) n (%)/mean (SD, range)
Grade (n = 1516)[a]	
7	337 (22.2)
8	416 (27.4)
9	291 (19.2)
10	428 (28.2)
12	44 (2.9)
Female gender (n = 1515)	834 (55.0)
Age, y (n = 1514)	14.5 (1.5, 12–19)
12–13	413 (27.5)
14	355 (23.6)
15	343 (22.8)
16	249 (16.5)
17–19	145 (9.7)
Parents martial status (n = 1483)	
Single	44 (3.0)
Married/cohabiting	1282 (86.4)
Divorced/widowed	157 (10.6)
Father's education (n = 1144)	
College or above	53 (4.6)
Secondary	792 (69.2)
Primary or below	299 (26.1)
Father's occupation (n = 1344)	
Managers, administrators and professionals	162 (12.1)
Associate professionals, clerks and service workers	112 (8.3)
Skilled and semi-skilled manual workers	703 (52.3)
Unskilled manual workers	143 (10.6)
Unemployed/homemakers	98 (7.3)
Retired/others	126 (9.5)
Had smoking habit (n = 1492)	23 (1.5)
Alcohol use[b] (n = 1492)	89 (5.9)
Self-reported academic performance (n = 1509)	
Excellent	423 (28.0)
Good	622 (41.2)
Marginal	464 (30.7)

[a] Difference from total n reflects omissions on reporting forms.
[b] Often, almost always or sometimes.

Principal component analysis with varimax rotation found two factors in ISI with eigenvalues >1. The same number of factors was indicated by Scree plot. Factor 1 accounted for 35.4% of the variance and comprised of satisfaction with current sleep patterns, interference with daily functioning, noticeability of impairment, and level of distress. Factor 2 explained 30.2% and comprised of severity of sleep-onset, sleep maintenance and early morning awakening difficulties (Table 5).

For AIS, factor analysis yielded a 2-factor structure. Factor 1 explained 37.9% of the variance and comprised sleep duration, sleep quality, daytime well-being, functioning capacity and sleepiness. Factor 2 of AIS was similar to factor 2 of ISI and explained 21.5% of total rotated variance (Table 6). For SQI, factor analysis yielded 2 factors. Factor 1 accounted for 24.6% of the variance and comprised sleep-onset latency, difficulty initiating sleep and insomnia complaint. Factor 2 explained 21.4% and comprised disrupted sleep, sleep maintenance and early morning awakening (Table 7).

3.2. Concurrent validity

There were significant correlations between ISI, AIS and SQI scores and variables obtained from sleep-wake habit questionnaire and clinical interview (Table 8). Among the different types of insomnia (initial, middle, terminal), the correlations between initial insomnia items and the corresponding sleep variables were the strongest. The Pearson's r between the total scores of ISI, AIS and SQI and the presence of DSM-IV-TR diagnosis of clinical insomnia were 0.37, 0.30, and 0.39, respectively.

Table 9 presents the results of correlational analysis between the ISI, AIS and SQI total scores and the external validators. Students with higher insomnia scores had poorer mental health, more severe daytime sleepiness, were more likely to have smoking and drinking habits, more daytime napping and poorer academic performance.

3.3. ROC analysis

The AUCs of the ROC curves for ISI, AIS and SQI were 0.85 (95% CI: 0.77–0.92), 0.80 (95% CI: 0.72–0.89), and 0.85 (95% CI: 0.76–0.93), respectively, indicating good discriminatory power (Fig. 1). The optimal cut-off point for ISI, as determined by the ROC analysis, was a total score $\geqslant$9, which had a sensitivity of 0.87 and specificity of 0.75 (Table 10). The optimal cut-off for AIS was a total score $\geqslant$7, yielding a sensitivity of 0.78 and a specificity of 0.74; for SQI, it was a total score $\geqslant$5, which obtained a sensitivity of 0.83 and a specificity of 0.79.

4. Discussion

The present study establishes the Chinese versions of ISI, AIS and SQI as reliable and valid for assessment and screening of insomnia in adolescents. The scales are brief, easy-to-use and possess satisfactory internal consistency, test–retest reliability and concurrent validity, with favorable sensitivity and specificity against DSM-IV-TR diagnosis of clinical insomnia.

The internal consistency of ISI with an adolescent population in this study (α = 0.83) was good and in line with those obtained in adults with insomnia and patients with cancer (α = 0.74 and 0.90, respectively) [18,45]. The test–retest reliability for the individual items and total score of ISI over 2 weeks (r = 0.47–0.67 and 0.79, respectively) was adequate and consistent with a correlation coefficient of 0.83 for the ISI total score over 1 month in cancer patients [45]. Factor analysis of the Chinese version of ISI indicated two distinct factors, involving the severity and impact

Table 2
Descriptive statistics, item-total correlation (R-total) and test–retest reliability (T-retest r) of Insomnia Severity Index.

Insomnia Severity Index item (range = 0–4)		Total (n = 1431)[a]			2-week test–retest (n = 258)[a]
		Mean	SD	R-total	T-retest r
1a	Difficulty falling asleep	0.86	0.95	0.70	0.67
1b	Difficulty staying asleep	0.58	0.87	0.70	0.63
1c	Problem waking up too early	0.67	0.86	0.58	0.47
2	Satisfaction	1.71	1.09	0.73	0.61
3	Interference	1.50	0.94	0.74	0.60
4	Noticeability	1.12	0.92	0.65	0.53
5	Distress	0.92	0.96	0.80	0.59
	Total score (range = 0–28)	7.4	4.6		0.79

[a] Difference from the total n/total n interviewed reflects omissions on reporting forms.

Table 3
Descriptive statistics, item-total correlation (*R*-total) and test–retest reliability (*T*-retest *r*) of Athens Insomnia Scale.

Athens Insomnia Scale item (range = 0–3)		Total (n = 1431)[a]			2-week test–retest (n = 258)[a]
		Mean	SD	*R*-total	*T*-retest *r*
1	Sleep induction	0.78	0.76	0.58	0.62
2	Awakening during the night	0.59	0.63	0.51	0.49
3	Final awakening earlier than desired	0.62	0.68	0.46	0.46
4	Total sleep duration	0.89	0.76	0.72	0.65
5	Overall sleep quality	0.70	0.73	0.74	0.62
6	Well-being during the day	0.59	0.70	0.78	0.66
7	Functioning during the day	0.65	0.72	0.77	0.64
8	Sleepiness during the day	1.30	0.73	0.63	0.65
	Total score (range = 0–24)	6.1	3.7		0.80

[a] Difference from the total *n*/total *n* interviewed reflects omissions on reporting forms.

Table 4
Descriptive statistics, item-total correlation (*R*-total) and test–retest reliability (*T*-retest *r*) of Sleep Quality Index.

Sleep Quality Index item (range = 0–2)		Total (n = 1431)[a]			2-week test–retest (n = 258)[a]
		Mean	SD	*R*-total	*T*-retest *r*
1	Time to fall asleep	0.66	0.69	0.61	0.72
2	Insomnia	0.32	0.53	0.66	0.60
3	Difficulty falling asleep	0.38	0.56	0.67	0.60
4	Disturbed night sleep	0.30	0.56	0.57	0.56
5	Waking up during the night	0.44	0.59	0.57	0.47
6	Morning tiredness	1.14	0.84	0.50	0.55
7	Waking up too early in the morning	0.43	0.57	0.50	0.33
8	Frequency of hypnotics use	0.013	0.13	0.25	−0.006
	Total score (range = 0–16)	3.7	2.5		0.72

[a] Difference from the total *n*/total *n* interviewed reflects omissions on reporting forms.

Table 5
Principal component analysis (varimax rotation) of Insomnia Severity Index.

Insomnia Severity Index item (n = 1431)[b]		Factor loadings[a]	
		Factor 1	Factor 2
1a	Difficulty falling asleep	0.30	**0.72**
1b	Difficulty staying asleep	0.23	**0.82**
1c	Problem waking up too early	0.07	**0.79**
2	Satisfaction	0.62	0.38
3	Interference	0.83	0.18
4	Noticeability	0.82	0.04
5	Distress	0.77	0.36
	Explained Variance: 65.9%	35.4%	30.2%
	Eigenvalue	2.48	2.12

[a] Items with rotated factor loading ⩾0.5 are bolded.
[b] Difference from the total *n* reflects omissions on reporting forms.

Table 6
Principal component analysis (varimax rotation) of Athens Insomnia Scale.

Athens Insomnia Scale item (total n = 1431)[b]		Factor loadings[a]	
		Factor 1	Factor 2
1	Sleep induction	0.28	**0.60**
2	Awakening during the night	0.12	**0.77**
3	Final awakening earlier than desired	0.04	**0.76**
4	Total sleep duration	0.79	0.11
5	Overall sleep quality	0.68	0.34
6	Well-being during the day	0.83	0.19
7	Functioning during the day	0.82	0.17
8	Sleepiness during the day	0.70	0.03
	Explained Variance: 59.7%	37.9%	21.5%
	Eigenvalue	3.03	1.72

[a] Items with rotated factor loading ⩾0.5 are bolded.
[b] Difference from the total *n* reflects omissions on reporting forms.

Table 7
Principal component analysis (varimax rotation) of Sleep Quality Index.

Sleep Quality Index item (n = 1431)[b]		Factor loadings[a]	
		Factor 1	Factor 2
1	Time to fall asleep	0.78	0.04
2	Insomnia	0.75	0.28
3	Difficulty falling asleep	0.84	0.17
4	Disturbed night sleep	0.28	**0.58**
5	Waking up during the night	0.11	**0.73**
6	Morning tiredness	0.05	0.39
7	Waking up too early in the morning	0.03	**0.69**
8	Frequency of hypnotics use	0.14	0.34
	Explained Variance: 45.9%	24.6%	21.4%
	Eigenvalue	1.97	1.71

[a] Items with rotated factor loading ⩾0.5 are bolded.
[b] Difference from the total *n* reflects omissions on reporting forms.

of insomnia. The factor structure obtained in our sample was more coherent than those found in previous studies [18,45]. Those authors either found a third factor comprising severity of initial insomnia, satisfaction with sleep and degree of distress or showed that the item on satisfaction clusters with the items on severity of insomnia.

We found a strong correlation between the ISI item on difficulty falling asleep and self-reported SOL and clinician's rating of initial insomnia. The correlation between the ISI item on difficulty staying asleep and clinician's rating of middle insomnia was also satisfactory. However, the ISI item on problem waking up too early was weakly related to self-reported EMA and clinician's rating of terminal insomnia. Unlike the ISI validation studies in adults [18,45], adolescents' rating on problem waking up too early had unsatisfactory concurrent validity. The students might have interpreted the ISI item on problem waking up too early as problems due to waking up too early. In fact, the item had the highest rate of missing data among all items of the three insomnia scales (Supplementary data). However, the validity of ISI was supported by significant correlations between the total score of ISI and the presence of

Table 8
Pearson correlations between the Insomnia Severity Index, Athens Insomnia Scale and Sleep Quality Index scores and sleep-wake habit questionnaire variables and clinician's ratings.

		Sleep-wake habit questionnaire		Clinician rating (n = 264)[a]			
		Sleep-onset latency (n = 1406)[a]	Early morning awakening (n = 1334)[a]	Initial insomnia	Middle insomnia	Terminal insomnia	DSM-IV-TR insomnia
Insomnia Severity Index item							
1a	Difficulty falling asleep	0.36**		0.50**			
1b	Difficulty staying asleep				0.33**		
1c	Problem waking up too early		0.15**			0.11	
	Total score						0.37**
Athens Insomnia Scale item							
1	Sleep induction	0.35**		0.53**			
2	Awakening during the night				0.27**		
3	Final awakening earlier than desired		0.19**			0.18**	
	Total score						0.30**
Sleep Quality Index item							
1	Time to fall asleep	0.55**		0.66**			
3	Difficulty falling asleep	0.31**		0.47**			
4	Disturbed night sleep				0.25**		
5	Waking up during the night				0.36**		
7	Waking up too early in the morning		0.11**			0.24**	
	Total score						0.39**

[a] Difference from the total n/total n interviewed reflects omissions on reporting forms.
** $p < 0.01$.

Table 9
Pearson correlations between the total scores of Insomnia Severity Index (ISI), Athens Insomnia Scale (AIS) and Sleep Quality Index (SQI) and general mental health, daytime sleepiness and personal factors.

	GHQ-12 total score (n = 1406)[a]	ESS total score (n = 1349)[a]	Smoking habit (n = 1412)[a]	Frequency of alcohol use (n = 1412)[a]	Number of napping per week (n = 1400)[a]	Academic performance (n = 1426)[a]
ISI total score	0.47**	0.38**	0.08**	0.18**	0.19**	0.05*
AIS total score	0.51**	0.44**	0.07**	0.19**	0.18**	0.11**
SQI total score	0.40**	0.27**	0.03	0.15**	0.11**	0.04

ESS, Epworth Sleepiness Scale; GHQ-12, 12-item General Health Questionnaire.
[a] Difference from the total n reflects omissions on reporting forms.
* $p < 0.05$.
** $p < 0.01$.

DSM-IV-TR diagnosis of clinical insomnia and the external validators. We have also demonstrated the ISI's ability to screen for clinical insomnia. The ROC analysis showed an AUC of 0.85, which was similar to the finding in a previous study [45]. The optimal cut-off point of ISI for detecting clinical insomnia with adolescents was a total score of 9, which was close to the optimal cut-off score of 8 in cancer patients [45]. The sensitivity associated with the optimal cut-off in this study was 0.87 and the specificity was 0.75. In a study of 19 young adults who met DSM-IV criteria for primary insomnia and 19 age-, gender- and education-matched normal sleepers, Smith and Trinder (2001) found that that the ISI had excellent discriminatory power (AUC = 0.97) and the optimal cut-off was a total score of 7 (sensitivity = 0.94, specificity = 0.94) [46]. Our study obtained a lower sensitivity and specificity with the ISI as screening for clinical insomnia than the previous studies [45,46]; however, it was improper to directly compare the results because of the difference in the proportion of subjects who met diagnostic criteria of insomnia.

The Chinese version of AIS in an adolescent population also got high internal consistency ($\alpha = 0.81$) and satisfactory test–retest reliability for individual items and total score (r = 0.46–0.66 and 0.80, respectively). Factor analysis of the Chinese version of AIS indicated two distinct factors, including insomnia symptoms, and subjective sleep and daytime distress. The factor structures of the

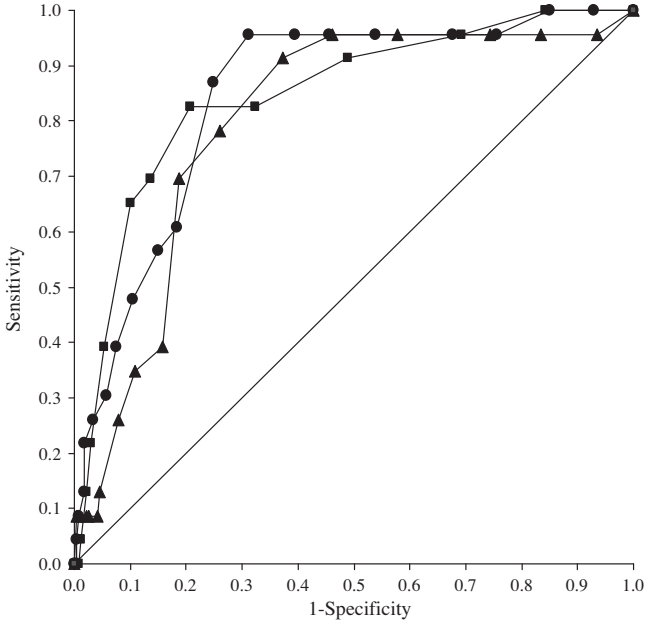

Fig. 1. Receiver operating characteristic curve plots for Insomnia Severity Index (●), Athens Insomnia Scale (▲) and Sleep Quality Index. (■) (n = 264).

Table 10
Sensitivity, specificity, predictive values and likelihood ratios for various cut-offs of Insomnia Severity Index, Athens Insomnia Scale and Sleep Quality Index, with 95% confidence intervals in parentheses (n = 264).

Cut-off points[a]	Sensitivity	Specificity	Positive predictive value	Negative predictive value	Positive likelihood ratio	Negative likelihood ratio
Insomnia Severity Index						
7	0.96 (0.79–0.99)	0.61 (0.54–0.67)	0.19 (0.13–0.27)	0.99 (0.96–1.00)	2.43 (2.03–2.90)	0.07 (0.01–0.49)
8	0.96 (0.79–0.99)	0.69 (0.63–0.74)	0.23 (0.16–0.32)	0.99 (0.97–1.00)	3.07 (2.50–3.78)	0.06 (0.01–0.43)
9	**0.87 (0.68–0.96)**	**0.75 (0.69–0.80)**	**0.25 (0.17–0.36)**	**0.98 (0.95–0.99)**	**3.49 (2.67–4.58)**	**0.17 (0.06–0.50)**
10	0.61 (0.41–0.78)	0.82 (0.76–0.86)	0.24 (0.15–0.37)	0.96 (0.92–0.98)	3.33 (2.19–5.09)	0.48 (0.29–0.80)
11	0.57 (0.37–0.74)	0.85 (0.80–0.89)	0.27 (0.16–0.40)	0.95 (0.92–0.98)	3.78 (2.37–6.04)	0.51 (0.32–0.82)
Athens Insomnia Scale						
5	0.96 (0.79–0.99)	0.54 (0.48–0.60)	0.17 (0.11–0.24)	0.99 (0.96–1.00)	2.08 (1.77–2.44)	0.08 (0.01–0.55)
6	0.91 (0.73–0.98)	0.63 (0.56–0.69)	0.19 (0.13–0.27)	0.99 (0.95–1.00)	2.45 (1.99–3.01)	0.14 (0.04–0.52)
7	**0.78 (0.58–0.90)**	**0.74 (0.68–0.79)**	**0.22 (0.15–0.32)**	**0.97 (0.94–0.99)**	**2.99 (2.21–4.05)**	**0.29 (0.14–0.64)**
8	0.70 (0.49–0.84)	0.81 (0.76–0.86)	0.26 (0.17–0.38)	0.97 (0.93–0.98)	3.73 (2.55–5.43)	0.37 (0.20–0.70)
9	0.39 (0.22–0.59)	0.84 (0.79–0.88)	0.19 (0.10–0.33)	0.94 (0.90–0.96)	2.48 (1.38–4.47)	0.72 (0.52–1.01)
Sleep Quality Index						
3	0.91 (0.73–0.98)	0.51 (0.45–0.57)	0.15 (0.10–0.22)	0.99 (0.94–1.00)	1.87 (1.56–2.23)	0.17 (0.05–0.64)
4	0.83 (0.63–0.93)	0.68 (0.62–0.73)	0.20 (0.13–0.29)	0.98 (0.94–0.99)	2.55 (1.97–3.32)	0.26 (0.11–0.63)
5	**0.83 (0.63–0.93)**	**0.79 (0.74–0.84)**	**0.28 (0.18–0.39)**	**0.98 (0.95–0.99)**	**3.98 (2.92–5.43)**	**0.22 (0.09–0.54)**
6	0.70 (0.49–0.84)	0.86 (0.81–0.90)	0.33 (0.21–0.47)	0.97 (0.93–0.98)	5.08 (3.35–7.71)	0.35 (0.19–0.66)
7	0.65 (0.45–0.81)	0.90 (0.86–0.93)	0.39 (0.25–0.54)	0.96 (0.93–0.98)	6.55 (4.04–10.61)	0.39 (0.22–0.68)

[a] The optimal cut-offs are bolded.

Chinese versions of AIS and ISI were very similar; both had a factor involving insomnia symptoms and another factor composed of satisfaction with sleep, sleep quality, and distress and impairment associated with insomnia. The factor structure of AIS obtained in our sample was the same as a recent study among adolescents in Taiwan [47], but different from the 1-factor structure reported in the AIS original study [19].

We found that the AIS item on final awakening earlier than desired had a stronger correlation with self-reported EMA and clinician's rating of terminal insomnia than the ISI item on problem waking up too early. It was possible that the wording of AIS on EMA was easier to understand than the description in ISI. However, the AIS was less capable of detecting DSM-IV-TR diagnosis of clinical insomnia when compared to ISI (AUC = 0.80 vs. 0.85). The optimal cut-off point of AIS was a total score of 7, which was close to the optimal cut-off score of 6 in the AIS original study [48]. Although we obtained a lower sensitivity and specificity for the Chinese version of AIS when compared to the original study [48], the difference in study population could not allow a fair comparison between studies.

The internal consistency of SQI with an adolescent population in this study was worse than those obtained for ISI and AIS, but it was comparable to those reported in the SQI original paper [21] and our pilot study involving 41 7th grade students [6]. The test–retest reliability for the total score of SQI in our sample was satisfactory and similar to those of ISI and AIS. However, the test–retest coefficients for the items on waking up too early in the morning and frequency of hypnotics use were rather weak. In addition, the factor structure of SQI was less homogenous than those of ISI and AIS. The SQI items on difficulty initiating sleep were loaded on a different factor from the items on sleep maintenance and early morning awakening difficulties. Besides these limitations, the SQI had similar concurrent validity and discriminatory capacity when compared to ISI and AIS.

There are a number of strengths of our study as well as several methodologic limitations. We examined the psychometric properties and screening performance of ISI, AIS and SQI in one sample, allowing direct comparison between the measures. We used a relatively large community sample of adolescents with varying degree of sleep disturbance; hence our sample was representative of real-life setting where screening was performed. The major limitation was the inaccuracy in the adolescents' estimates of sleep-wake habit and lack of information from parents and teachers. However, we were uncertain about the role of informants in the diagnosis of insomnia in the adolescent population. Observer bias was possible because the author designed and conducted the interview. Systematic bias in the rating of symptoms and hence classification of case/non-case may be introduced. It was minimized by using a standardized semi-structured interview in ascertaining insomnia diagnosis. We found that the prevalence of clinical insomnia was the same as that obtained in a previous study employing similar diagnostic criteria [12], suggesting that systematic bias was unlikely. Although the questionnaire was arranged in a socially acceptable sequential order, we were uncertain whether the order of scales could produce different results [49]. It would be better to present the three insomnia scales in a random manner. The response rate was only 71.7%, although it was similar to previous studies of insomnia in adolescents [3–5,12].

In conclusion, the Chinese versions of ISI, AIS and SQI are valuable instruments for assessment and screening of insomnia in adolescents. The ISI and AIS had better psychometric properties among the three scales and were preferred for assessment and screening of insomnia in the Hong Kong adolescent population. The ISI item on problem waking up too early had fair concurrent validity against self-report and clinician's rating of terminal insomnia. The AIS had the worst discriminatory capacity against DSM-IV-TR diagnosis of insomnia, while the limitation of SQI was the relatively weak internal consistency, factor structure, and test–retest reliability for the items on waking up too early in the morning and hypnotics use. We were uncertain whether the translation of "problem waking up too early" into Chinese had produced erroneous semantic meanings, resulting in the weak concurrent validity of the ISI item. Additional studies are needed to further validate the instruments in adolescents and to evaluate their sensitivity to changes as outcome measures of intervention studies.

Conflict of Interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: doi:10.1016/j.sleep.2010.09.019.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.sleep.2010.09.019.

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