Sleep-Wake Patterns and Sleep Disturbance among Hong Kong Chinese Adolescents

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Study objectives: To determine sleep-wake patterns and evaluate sleep disturbance in Hong Kong adolescents; to identify factors that are associated with sleep disturbance; and to examine the relationship of sleep-wake variables and academic performance.

Design and Setting: A school-based cross-sectional survey.

Participants: Sample included 1629 adolescents aged 12 to 19 years.

Measurements and Results: Self-report questionnaires, including sleep-wake habit questionnaire, Sleep Quality Index, Morningness/Eveningness scale, Epworth Sleepiness Scale, Perceived Stress Scale, academic performance, and personal data were administered. The average school-night bedtime was 23:24, and total sleep time was 7.3 hr. During weekends, the average bedtime and rise time was delayed by 64 min and 195 min, respectively. The prevalence of sleep disturbances occurring ≥3 days per week in the preceding 3 months were: difficulty falling asleep (5.6%), waking up during the night (7.2%), and waking up too early in the morning (10.4%). The prevalence of ≥1 of these three symptoms was 19.1%. Stepwise regression analyses revealed that circadian phase preference was the most significant predictor for school night bedtime, weekend oversleep, and daytime sleepiness. Perceived stress was the most significant risk factor for sleep disturbance. Students with marginal academic performance reported later bedtimes and shorter sleep during school nights, greater weekend delays in bedtime, and more daytime sleepiness than those with better grades.

Conclusion: The prevalence of sleep deprivation and sleep disturbance among Hong Kong adolescents is comparable to those found in other countries. An intervention program for sleep problems in adolescents should be considered.

Keywords: adolescents; sleep-wake patterns; sleep disturbance; school performance; Chinese.

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INSUFFICIENT SLEEP AND IRREGULAR SLEEP-WAKE SCHEDULES AMONG ADOLESCENTS HAS BECOME A MAJOR INTERNATIONAL HEALTH CONCERN. Self-report studies show that many adolescents do not obtain adequate sleep; they tend to stay up late during school nights and "sleep in" on weekends.[1-7] The evidence suggests that teenagers in Japan and Korea are more severely sleep deprived than those in Western countries and Mainland China. In a survey study of 3478 Japanese high school students, Tagaya and colleagues found that 10th through 12th graders slept an average of 6.3 hr, going to bed at 00:03 and rising at 06:33.[1] A survey of 1457 grade 5 to 12 students in Korea showed that 11th and 12th grade students only slept 5.4 hr on school nights, and 9th and 10th graders slept approximately 6.6 hr. The school night bedtime for 9th and 10th graders and 11th and 12th graders was 00:00 and 00:54, respectively.[2]

Wolfson and Carskadon assessed the sleep-wake habits of 3120 high school students aged 13-19 years in the United States. They found that the average school night sleep duration was 7.3 hr. The school night bedtime and rise time were 22:33 and 06:05; during weekends, the bedtime and rise time were delayed until 00:25 and 09:32.[3] Liu and colleagues reported data on 1365 high school students in Mainland China. Similar to U.S. figures, the mean sleep duration during the previous month was 7.6 hr.[4] In another study, Lazaratou and colleagues found that the weeknight sleep duration of 713 senior high school students in Greece was 7 hr.[5] In a survey of 9567 secondary school students in New Zealand, Dorofaeff and Denny found that the amount students slept was 8.7 hr during the week and 9.4 hr during the weekend. The bedtime and rise times during weekdays were 22:17 and 06:57; on the weekend, their bedtime and rise times were 00:09 and 09:31.[6] In another study, Gibson and colleagues found that the school night sleep duration of 3235 high school students in Canada was 7.8 hr.[7] The amount of sleep on school nights during adolescence decreases with age[1-3] and is substantially less than 9.2 hr.[1-7] This contrasts with the evidence that, when given a nocturnal sleep opportunity of 10 hr per night in laboratory assessments, those going through puberty recorded a total sleep time unchanged at 9.2 hr.[8]

Academic pressure was cited as a major reason for the profound sleep deprivation in Japanese and Korean teenagers.[1,2] However, there are also extensive biological, personal, and psychosocial influences on adolescent sleep.[9] Such sleep disturbance manifested as insomnia, daytime sleepiness, tiredness, and other symptoms is 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%.[10-15] Ohayon et al. reported data on 1125 adolescents from France, Great Britain, Germany, and Italy. In this study, 25.7% of the 15 to 18-year-old adolescents had difficulty initiating or maintaining sleep, early morning wakening, or nonrestorative sleep in the previous 4 weeks; daytime sleepiness was reported by nearly 20% of the adolescents.[10] In a U.S. sample,

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12.4% of 5118 ninth grade students met insomnia criteria on almost every day of the preceding month[11] while Roberts et al. reported that 26.8% of 11 to 17-year-olds had nonrestorative sleep or experienced difficulty initiating or maintaining sleep.[12] In the Middle East and Japan, a sizeable percentage of adolescents also struggle to sleep. In a study of 5044 Kuwaiti adolescents aged 14 to 19 years old, 17.5% of the adolescents had problems getting to sleep during the previous month, and the prevalence of repeated wakening and early morning wakening was 12.3% and 33.8% respectively.[13] Of 106,297 high school students in Japan, approximately 16% had difficulty falling asleep during the previous month.[14] In another group of 102451 Japanese high school students, the prevalence of difficulty initiating sleep, difficulty maintaining sleep, and early morning awakening was 14.8%, 11.3%, and 5.5%, respectively; with 23.5% having one or more insomnia symptoms.[15]

Clearly there is a copious supply of data describing the extent of sleep deprivation, insomnia, and daytime sleepiness in adolescents. However, studies on their impact are few. Cross-sectional studies have found insomnia to be linked with behavioral and emotional problems, such as anxiety, depression, daytime sleepiness, poor social competence, and substance abuse.[16,17] The one prospective study carried out to date confirmed an association between insomnia and impaired interpersonal and psychological functioning at one-year follow-up.[18] Together the existing data suggest that adolescents with daytime sleepiness are likely to experience impairment in mood, performance, learning, and other daytime functioning,[19] making excessive sleepiness among adolescents a significant public health concern.

Adolescents in Hong Kong, similar to teenagers in other countries, are under biological, personal, and psychosocial influences that may leave them susceptible to inadequate sleep, irregular sleep-wake schedules, and sleep disturbance. Some cross-sectional surveys on sleep problems have been carried out among adults and children in Hong Kong,[20,21] however no comprehensive countrywide assessment of adolescents has been conducted. We therefore performed the first systematic study of sleep-wake patterns and sleep disturbance among secondary school students in Hong Kong. Sleep disturbance manifested as poor sleep and daytime sleepiness was assessed. We recorded the age and sex differences in sleep-wake patterns and sleep disturbance among adolescents aged 12-19 years. We investigated the factors associated with irregular sleep-wake habits and sleep disturbance. The relationship of sleep-wake variables and academic performance was also examined. The findings could add to the database on sleep disturbance in different ethnic groups and would be useful for local preventive sleep medicine programs.

METHODS

Subjects

The study was approved by the local institutional review board and was carried out in the 2003–2004 school year. In Hong Kong, there were 496 secondary schools in the 2001–2002 school year that offered 5-year or 7-year programs. Secondary Forms 1-6 in Hong Kong correspond to 7th through 12th grades in the United States. The school attendance rates for age 12-16 and 17-18

years in the 2001–2002 school year in Hong Kong were 97.5% and 71.0%, respectively.[22] The Hong Kong Education Department divides secondary schools into 3 bands based upon academic achievement, the number of schools in each band comprising one-third of the total. We pre-selected one school from each band and conducted the survey among all 7th through 10th and 12th grade students at each school. Eleventh-grade students were preparing for public examinations during the study period, so were not recruited. All 3 schools had a start time of 08:30. Of 1,900 distributed questionnaires, 1637 (86%) were returned. We excluded the data from 8 students who were ≥20 years of age. A total of 1629 students were included in the final analysis. All participating students and their parents gave informed consent.

Procedures

There were roughly 40 students in each class. Questionnaires were distributed to the students in their classroom by the author (MMC) with the help of teachers. The students completed the questionnaires in class with no time limit. The author answered the questions raised by the students and collected the completed questionnaires. The questionnaires were presented in Chinese, the mother tongue of the students.

Measures

There is a lack of standardized self-reported sleep-wake questionnaires and sleep disturbance scales for adolescents, therefore we selected content that could be understood by adolescents as young as 12 years in the local cultural setting. The questionnaires used in this study were checked by 2 Chinese language teachers, who confirmed they would be appropriate for students 7th grade and above. The self-administered questionnaire included: (1) a sleep-wake habit questionnaire, (2) Sleep Quality Index (SQI),[23] (3) Morningness/Eveningness (M/E) scale for adolescents,[24] (4) Epworth Sleepiness Scale (ESS),[25] (5) Perceived Stress Scale (PSS),[26] (6) self-reported school performance, and (7) personal and family information probes.

The items of our sleep-wake habit questionnaire originated from a Chinese version of the Pittsburgh Sleep Quality Index (PSQI).[27,28] Although the Chinese version of the PSQI was validated to study sleep problems in adults,[28] the items on sleep-wake patterns were considered easy to understand. The students were asked to fill out their usual sleep habits on both school days and weekends during the past month. We derived 2 measures of sleep-wake schedule regularity: weekend oversleep (the difference between weekend total sleep time and school night total sleep time), and weekend delay (the difference between weekend bedtime and school night bedtime).

We used the Sleep Quality Index (SQI), an 8-item questionnaire successfully used in college students and adult population[23,29] to examine the adolescents' sleep disturbance in the preceding 3 months. The students 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. Response categories were: no, <3 days/week, and 3-7 days/week. Time to fall asleep was reported with the responses: ≤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 SQI score ranged from 0-24. Higher scores indicated more severe sleep disturbance.

The M/E scale for adolescents consisted of 10 questions regarding circadian phase preference. Previous studies have shown that the M/E scale for adolescents has good reliability and validity.[24,30] The 10-item scale has a total score ranging from 10 to 43. A higher score indicated a tendency to be a "morning type," whereas a lower score indicated a tendency to be an "evening type."[24]

We used the Chinese version of ESS, known to be a reliable and valid measure of daytime sleepiness in adults,[31] to assess the average daytime sleep propensity of the adolescents. The ESS focuses upon tendency to sleepiness, with a 3-point scale to rate the likelihood of dozing in 8 daily life situations. A recent study in adolescents found that the test-retest reliability of ESS over 2 weeks was high.[7] The 10-item Chinese version of Perceived Stress Scale (PSS) with high internal consistency and test-retest reliability in adults[28] quantified students' levels of subjective stress. The students used a 5-point scale to rate the degree to which they found their lives unpredictable, uncontrollable, and overloaded in the past month (0 = never and 4 = very often). Higher scores indicated higher levels of perceived stress.

In the focus schools, examinations were held after winter break and at the end of the academic year. The results in each subject and the average mark or overall grade were released to the students. Two of the three schools we surveyed also ranked the students. We asked students to report their school performance based on their rank in class. If the rank was not known, the students reported their school performance with an average mark or overall grade. An excellent academic performance referred to a ranking in class from 1-15, average mark ≥81, or overall grade of A or B. A good academic performance referred to a ranking in class from 16-30, average mark between 61-80, or overall grade of C or D. A marginal academic performance referred to ranking in class of 31 or below, average mark <61, or overall grade of E or below.

The students also filled out their age, sex, weight, and height; traveling time from home to school; involvement in part-time jobs; habits of regular exercise; use of cigarettes, alcohol, and coffee; and parents' marital status, occupation, and educational level.

The questionnaires were piloted in a class of 41 7th graders attending another secondary school. We examined the scales' test-retest reliability over 1 month by Pearson product-moment correlation and internal consistency using Cronbach's alpha. The concurrent validity of the SQI was estimated by the intercorrelations among SQI items and self-reported sleep latency.

Data Analysis

All statistical analysis was done using SPSS 14.0 for Windows. Three aspects of the data were analysed: (1) changes in sleep-wake variables according to age and sex; (2) relationship between sleep-wake variables and academic performance; and (3) relationship between sleep-wake variables and student characteristics.

For the first 2 aspects, multivariate analysis of variance (MANOVA) was used to examine age, sex, and academic performance in relation to sleep-wake habits and sleep disturbance variables. Four multivariate analyses were computed: (1) school night sleep variables, (2) weekend sleep variables, (3) weekend delay and weekend oversleep, and (4) SQI total score and ESS total score. When significant multivariate effects were found, univariate effects were then examined using Bonferroni *t* tests to determine significant group mean differences.

The relationship between sleep-wake variables and student characteristics was analysed using Pearson correlations. We selected school night bedtime, school night total sleep time, weekend oversleep, SQI total score, and ESS total score for correlation analysis. The chosen variables represent students' usual sleep habits, sleep-wake schedule regularity, sleep disturbance, and daytime sleepiness. The biological risk factor examined in this study was students' self-reported circadian phase preference as assessed by the M/E scale for adolescents. The personal risk factors examined were age, sex, grade level, body weight, traveling time to school, involvement in part-time work, exercise habit, and use of cigarettes, alcohol, and coffee. The psychosocial risk factors considered were parents' marital status, school academic ranking, and perceived stress level as measured by the PSS. Stepwise multiple linear regression was used to examine the relationship between sleep-wake variables with potential predictors. To be retained in the linear regression, the potential predictor had to show a significant bivariate association with the sleep-wake variables. The potential predictor that had the most significant bivariate association with the sleep-wake variables was first entered into the regression analyses.

RESULTS

Table 1 presents the students' sociodemographic, school, and lifestyle variables. We compared the sex distribution by age of the students with same age group in the general population. The proportion of females in student group aged 12-13, 14, 15, 16, and 17-19 years was 53.2%, 49.6%, 50.8%, 49.1%, and 43.5%, respectively. The respective proportion of females in the general population of the same age group is 48.5%, 48.7%, 48.5%, 48.2%, and 48.8%.[22] In the study population, there was a slightly higher proportion of girls 12-13 years of age and a slightly lower proportion of female students aged 17-19 years. We also compared the occupation of the students' fathers with that of men aged 30-64 years in the general population. The proportion of men aged 30-64 years in the general population who were managers, administrators, or professionals; associate professionals; clerks, service workers, skilled or semi-skilled manual workers; unskilled manual workers; retired; and unemployed or homemakers was 20.2%; 11.4%; 43.3%; 13.2%; 6.0%; and 6.0%, respectively.[22] Compared with the general population, a lower percentage of the students' fathers worked as managers, administrators, or professionals, and more of them were unskilled manual workers (Table 1).

Psychometric Properties of the Measures

The test-retest reliability coefficient for self-reported bedtime, rise time, and total sleep time during schooldays over one

Variables	Total sample (n = 1629) n (%)/mean (SD, range)
Grade (n = 1629)[a]	
7	389 (23.9)
8	444 (27.3)
9	368 (22.6)
10	302 (18.5)
12	126 (7.7)
School band[b] (n = 1629)	
1	688 (42.2)
2	465 (28.5)
3	476 (29.2)
Female gender (n = 1619)	816 (50.4)
Age, yr (n = 1590)	14.8 (1.7, 12-19)
12-13	380 (23.9)
14	371 (23.3)
15	307 (19.3)
16	277 (17.0)
17-19	255 (16.1)
Parents martial status (n = 1589)	
Married/cohabiting	1478 (93.0)
Divorced/widowed	111 (7.0)
Father's occupation (n = 1538)	
Managers, administrators, and professionals	159 (10.3)
Associate professionals	199 (12.9)
Clerks, service workers, skilled and semi-skilled manual workers	600 (39.0)
Unskilled manual workers	347 (22.6)
Retired	91 (5.9)
Unemployed/homemakers	142 (9.2)
Body mass index, kg/m² (n = 1502)	19.0 (3.3, 9.9-42.2)
Overweight[c] (n = 1502)	120 (8.0)
Had smoking habit (n = 1617)	50 (3.1)
Alcohol use[d] (n = 1610)	26 (1.6)
Coffee use[d] (n = 1616)	102 (6.3)
Exercise ≥3 times/week[e] (n = 1616)	488 (30.2)
Part-time work ≥5 hr/week (n = 1608)	95 (5.9)
Self-reported academic performance[f] (n = 1377)	
Excellent	449 (32.6)
Good	694 (50.4)
Marginal	234 (17.0)

[a] Difference from total n reflects omissions on reporting forms.
[b] Lower band indicates higher school academic ranking. [c] International Task Force on Obesity overweight reference, sex-age-specific BMI cut-offs that correspond to BMI = 25 at age 18 yr.
[d] Often or almost always. [e] Each time ≥30 min. [f] Based on ranking in class, average mark or overall grade.

tency was 0.42 and 0.29 respectively, and that between SQI items "waking up during the night" and "disturbed sleep" was 0.29. The correlation coefficient between SQI items "waking up too early in the morning" and "waking up during the night" was 0.29.

The test-retest reliability coefficient for M/E scale, ESS, and PSS over one month was 0.81, 0.78, and 0.74, respectively, showing good temporal stability. The Cronbach's alpha for SQI, M/E scale, ESS, and PSS was 0.57, 0.63, 0.73, and 0.77, respectively, showing moderate internal consistency. The students were consistent in their reports of academic performance. The correlation coefficient of self-reported academic performance over one month was 0.88.

Sleep-Wake Patterns

The students' average school night bedtime, rise time, and total sleep time was 11:24, 06:58, and 7 hr 17 min, respectively. About 20% of students (n = 335) went to bed after midnight on school days and roughly 10% (n = 159) needed to wake up before 06:00. Five-hundred and one students (32%) had a total sleep time less than 7 hr on school days. During weekends, the average bedtime was delayed by 64 min; only 33% of the students (n = 530) went to bed before midnight. The average weekend rise time was delayed by 195 min, resulting in an average weekend oversleep of 131 min.

Table 2 presents means and standard deviations for the sleep-wake patterns across age groups and sex. With the exception of school night rise time and weekend sleep delay, sleep variables were significantly different across age groups. In general, older students reported shorter sleep, later bedtimes, and longer weekend oversleep. The variable that changed most dramatically was school night total sleep time. Specifically, average school night total sleep time decreased by 73 min, school night bedtime was delayed by 47 min, and weekend oversleep increased by 58 min from ages 12-13 years to 17-19 years. Post hoc analysis by Bonferroni t test confirmed that the differences in sleep habits were greatest between students aged 12-13 years and those ≥14 years. The difference in sleep habits was less obvious between students aged 14-16 years and those 17-19 years. There was no significant difference in weekend bedtime, rise time, or total sleep time among students aged 14-19 years. However, compared to the 14-year-olds, 17 to 19-year-olds had shorter school night sleep length, later school night bedtimes, and longer weekend oversleep. Sleep habits remained relatively unchanged across ages 14 to 16 years, other than a significant reduction in school night total sleep time between 14-year and 16-year age group.

Sex differences in sleep-wake habits were observed in weekend but not school night data. The average rise time of female students on weekends was 10:31, 36 min later than the boys. The girls slept an average of 9 hr 45 min during weekends, 35 min longer than the boys. Overall, female students had weekend oversleeps averaging 46 min longer than male students.

Sleep Disturbance

Table 3 presents the prevalence of sleep disturbance by age and sex, as reported in the SQI. The prevalence of sleep disturbance that occurred ≥3 days per week in the preceding 3 months

month was 0.92, 0.79, and 0.85, respectively. For bedtime, rise time, and total sleep time during weekends it was 0.75, 0.80, and 0.68, respectively. The test-retest reliability coefficient of SQI items was between 0.52 and 0.69; for SQI items "difficulty falling asleep," "waking up during the night," "waking up too early in the morning," and SQI total score it was 0.55, 0.52, 0.61, and 0.71, respectively.

The correlation coefficient between SQI item "difficulty falling asleep" with "time to fall asleep" and self-reported sleep la-

Sleep-wake Variable	Age group					Sex		F Value		Bonferroni t[a]
	12-13 Years (n = 364)	14 Years (n = 364)	15 Years (n = 297)	16 Years (n = 270)	17-19 Years (n = 245)	Male (n = 766)	Female (n = 774)	Age	Sex	
School night bedtime	23:00 (56)	23:23 (63)	23:26 (67)	23:35 (66)	23:47 (76)	23:20 (69)	23:28 (65)	22.6***	3.5	12-13 < 14, 15 < 17-19 12-13 < 16
School night rise time	06:57 (38)	06:59 (43)	07:01 (51)	06:58 (48)	06:52 (35)	06:56 (33)	06:57 (43)	1.7	0.3	---
School night TST[b], min	470 (79)	445 (76)	435 (75)	421 (78)	397 (70)	442 (79)	433 (80)	38.1***	2.1	12-13 > 14 > 16 > 17-19 12-13 > 15 > 17-19
Weekend bedtime	00:03 (90)	00:29 (103)	00:31 (94)	00:40 (96)	00:46 (101)	00:23 (106)	00:32 (89)	10.3***	1.1	12-13 < 14, 15, 16, 17-19
Weekend rise time	09:50 (101)	10:15 (105)	10:23 (111)	10:19 (114)	10:26 (117)	9:55 (118)	10:31 (98)	5.5***	35.4***	12-13 < 14, 15, 16, 17-19
Weekend TST, min	572 (110)	575 (108)	575 (104)	553 (103)	556 (102)	550 (107)	585 (103)	3.4**	40.5***	---
Weekend oversleep, min	101 (119)	128 (114)	143 (110)	133 (113)	160 (116)	107 (115)	153 (112)	9.6***	52.2***	12-13 < 14 < 17-19 12-13 < 15, 16
Weekend delay, min	62 (71)	65 (81)	65 (85)	65 (83)	60 (98)	64 (91)	63 (74)	0.11	0.18	---

[a]Significant difference between age groups, P <0.05. [b]TST refers to total sleep time. **P <0.01, ***P <0.001.

was as follows: difficulty falling asleep (5.6%), waking during the night (7.2%), and waking up too early in the morning (10.4%). There were 310 students (19.1%) who reported difficulties falling asleep, waking up during the night, or waking up too early in the morning. About 20% of students reported that they needed ≥30 min to fall asleep. Only 1% used hypnotics at least once per week. Morning tiredness was common, with over half the students (52.7%) reported to be very or rather tired in the morning.

There were significant age differences in complaints of insomnia, difficulty falling asleep, waking up during the night, morning tiredness, and use of hypnotics. The 16-year-old and 17 to 19-year-old adolescents had the most frequent sleep disturbance (Table 3). The proportion of students aged 12-13, 14, 15, 16, and 17-19 years who reported sleep disturbance on ≥3 nights per week was: 2.4%, 2.7%, 2.9%, 7.2%, and 2.0%, respectively for insomnia; 3.2%, 4.6%, 6.5%, 8.3%, and 6.3%, respectively for difficulty falling asleep; and 6.3%, 4.9%, 7.8%, 9.1%, and 9.1%, respectively for waking up during the night. The respective proportion complaining of feeling rather or very tired in the morning was 48.3%, 48.3%, 52.0%, 54.7%, and 64.2%. However, the 12 to 14-year-old students had the most frequent self-reported use of hypnotics. The proportion in the 12-13, 14, 15, 16, and 17-19 year age group for hypnotic use at least once per week was 0.8%, 3.0%, 0.3%, 0.4%, and 0.0%, respectively.

We found sex differences for the complaint of insomnia, difficulty falling asleep, disturbed night sleep, and morning tiredness. The girls had significantly more frequent sleep disturbance than the boys (Table 3). The proportion of male and female students who reported sleep disturbance on ≥3 nights per week was 2.4% and 4.4%, respectively, for insomnia; 5.0% and 6.1%, respectively, for difficulty falling asleep; and 3.6% and 5.1%, respectively, for disturbed night sleep. The proportion of the boys and girls complaining of feeling rather or very tired in the morning was 46.6% and 55.8%, respectively.

The mean SQI total score was 4.6 (SD: 2.6, range: 0-14). The SQI total score of girls (mean ± SD: 4.8 ± 2.6) was significantly higher than that of boys (4.3 ± 2.5) ($F = 7.2$, P < 0.001). There was a significant difference in SQI total score across age groups ($F = 6.7$, P < 0.001). The SQI total score of students aged 12-13, 14, 15, 16, and 17-19 years was 4.2 ± 2.4, 4.3 ± 2.5, 4.5 ± 2.6, 5.1 ± 2.7, and 5.0 ± 2.5 (mean ± SD), respectively. Post hoc analysis by Bonferroni t test found that the students aged 16-19 years had significantly more sleep complaints than those aged 12-13 years. In addition, the 16-year-old students had significantly higher SQI scores than those aged 14-15 years.

Excessive Daytime Sleepiness

The mean ESS score was 8.8 (SD: 4.2, range: 0-24). There were 655 students (41.9%) who had a total ESS score >10, a criterion commonly used to define excessive daytime sleepiness.[7,25] The girls were sleepier in the daytime than the boys. The ESS score of female students (mean ± SD: 9.2 ± 4.2) was significantly higher than that of boys (8.3 ± 4.3) ($F = 11.3$, P < 0.0001). There was an increasing severity of self-reported daytime sleepiness across ages 12-13 to 17-19 years ($F = 6.6$, P < 0.001). The ESS score of students aged 12-13, 14, 15, 16, and 17-19 years was 7.9 ± 4.1, 8.6 ± 4.2, 8.7 ± 4.1, 9.2 ± 4.2, and 9.7 ± 4.2 (mean ± SD), respectively. Post hoc analysis found that the students aged 16-19 years were sleepier than those aged 12-13 years. The 17 to 19-year-old students had significantly higher ESS scores than those aged 14 years.

Morningness/Eveningness Type

The median M/E scale score was 26 (SD: 4.8, 10th percentile: 20, 90th percentile: 32). The intervals formed for evening type were from 10-20 and morning type from above 31. There

Table 3—Prevalence of Sleep Disturbance by Age and Sex

Sleep Qualtiy Index item	Total sample	Age group 12-13 Years	14 Years	15 Years	16 Years	17-19 Years	Sex Male	Female	χ² Value Age	Sex
Time to fall asleep									8.7	3.4
10 min or faster	522 (32.1)	131 (34.5)	114 (30.7)	96 (31.4)	77 (27.9)	91 (35.7)	243 (30.3)	273 (33.5)		
11-30 min	775 (47.9)	183 (48.2)	178 (48.0)	153 (50.0)	132 (47.8)	114 (44.7)	401 (50.1)	371 (45.5)		
30 min or longer	329 (20.1)	66 (17.4)	79 (21.3)	57 (18.6)	67 (14.1)	50 (19.6)	157 (19.6)	171 (21.0)		
Suffered from insomnia									49.6***	29.2***
Not during the past 3 months	1091 (67.2)	278 (73.9)	255 (68.7)	218 (71.0)	177 (63.9)	138 (54.1)	586 (73.3)	496 (60.9)		
Less than 3 days/week	478 (29.4)	89 (23.7)	106 (28.6)	80 (26.1)	80 (28.9)	112 (43.9)	194 (24.3)	283 (34.7)		
3 or more days/week	55 (3.3)	9 (2.4)	10 (2.7)	9 (2.9)	20 (7.2)	5 (2.0)	19 (2.4)	36 (4.4)		
Difficulty falling asleep									50.8***	10.2**
Not during the past 3 months	891 (55.0)	241 (63.8)	221 (59.6)	179 (58.3)	127 (46.0)	103 (40.7)	469 (58.7)	414 (50.8)		
Less than 3 days/week	642 (39.5)	125 (33.1)	133 (35.8)	108 (35.2)	126 (45.7)	134 (53.0)	290 (36.3)	351 (43.1)		
3 or more days/week	91 (5.6)	12 (3.2)	17 (4.6)	20 (6.5)	23 (8.3)	16 (6.3)	40 (5.0)	50 (6.1)		
Disturbed night sleep									14.6	14.6**
Not during the past 3 months	1103 (68.0)	259 (68.7)	260 (70.7)	225 (73.5)	167 (60.7)	162 (64.0)	579 (72.6)	516 (63.7)		
Less than 3 days/week	445 (27.7)	104 (27.6)	92 (25.0)	69 (22.5)	94 (34.2)	79 (31.2)	190 (23.8)	253 (31.2)		
3 or more days/week	70 (4.3)	14 (3.7)	16 (4.3)	12 (3.9)	14 (5.1)	12 (4.7)	29 (3.6)	41 (5.1)		
Waking up during the night									17.5*	5.6
Not during the past 3 months	781 (47.7)	180 (47.4)	200 (53.9)	155 (50.5)	112 (40.6)	110 (43.5)	401 (50.1)	374 (45.9)		
Less than 3 days/week	728 (45.1)	176 (46.3)	153 (41.2)	128 (41.7)	139 (50.4)	120 (47.4)	337 (42.1)	389 (47.7)		
3 or more days/week	117 (7.2)	24 (6.3)	18 (4.9)	24 (7.8)	25 (9.1)	23 (9.1)	63 (7.9)	52 (6.4)		
Morning tiredness									21.1**	6.4*
Very or rather alert	423 (26.1)	109 (28.8)	111 (30.0)	80 (26.1)	64 (23.2)	49 (19.3)	223 (27.8)	197 (24.2)		
Cannot say	347 (21.2)	87 (23.0)	79 (21.4)	67 (21.9)	61 (22.1)	42 (16.5)	181 (22.6)	162 (19.9)		
Very or rather tired	854 (52.7)	183 (48.3)	180 (48.6)	159 (52.0)	151 (54.7)	163 (64.2)	397 (49.6)	454 (55.8)		
Waking up too early in the morning									7.1	2.0
Not during the past 3 months	894 (54.4)	207 (54.5)	209 (56.3)	162 (52.8)	138 (49.8)	149 (58.4)	447 (55.7)	439 (53.8)		
Less than 3 days/week	568 (35.2)	134 (35.3)	129 (34.8)	107 (34.9)	110 (39.7)	79 (31.0)	268 (33.4)	298 (36.5)		
3 or more days/week	167 (10.4)	39 (10.3)	33 (8.9)	38 (12.4)	29 (10.5)	27 (10.6)	88 (11.0)	79 (9.7)		
Use of hypnotics									22.6**	2.3
Not during the past 3 months	1585 (97.7)	369 (97.4)	253 (95.4)	304 (99.0)	272 (98.6)	251 (99.2)	784 (97.9)	791 (97.3)		
Occasionally	23 (1.3)	7 (1.8)	6 (1.6)	2 (0.7)	3 (1.1)	2 (0.8)	8 (1.0)	15 (1.8)		
At least once/week	16 (1.0)	3 (0.8)	11 (3.0)	1 (0.3)	1 (0.4)	0 (0.0)	9 (1.1)	7 (0.9)		

Values are expressed in n (%). *P < 0.05, **P < 0.01, ***P < 0.001

Table 4—Correlation Coefficients Between Sleep-Wake Variables and Students' Risk Factors

Variable	School night bedtime	School night total sleep time	Weekend oversleep	Sleep Quality Index score[a]	Epworth Sleepiness Scale score[a]
Age (yr)	0.23**	–0.31**	0.15**	0.12**	0.15**
Sex (0 = girls; 1 = boys)	–0.06**	0.06*	–0.19**	–0.09**	–0.11**
Parents martial status (0 = married or cohabiting, 1 = divorced or widowed)	–0.01	–0.05*	0.05	0.05*	0.05
School band (1 to 3)[b]	–0.15**	0.14**	–0.05*	0.04	–0.02
Grade level (7 to 12)	0.32**	–0.31**	0.16**	0.07**	0.16**
Traveling time to school (min)	–0.09**	–0.20**	0.17**	0.07**	0.11**
Part-time work (hr per week)	0.10**	–0.07**	0.008	0.07**	0.10**
Overweight (0 = no, 1 = yes)[c]	–0.08**	0.007	–0.04	–0.02	–0.08**
Had smoking habit (0 = no, 1 = yes)	0.11**	–0.11**	0.10**	0.07**	0.08**
Alcohol use[d]	0.12**	–0.16**	0.12**	0.16**	0.17**
Coffee use[d]	0.09**	–0.19**	0.08**	0.08**	0.14**
Physical exercise[e]	–0.07**	0.07**	–0.11**	–0.08**	–0.07**
Perceived Stress Scale score[f]	0.12**	–0.14**	0.14**	0.36**	0.26**
M/E scale score[g]	–0.43**	0.26**	–0.34**	–0.25**	–0.33**

[a]Higher scores indicate greater severity of sleep disturbance and daytime sleepiness. [b]Lower band indicates higher school academic ranking. [c]International Task Force on Obesity overweight reference, sex-age-specific BMI cut-offs that correspond to BMI = 25 at age 18 yrs. [d]Self-report of alcohol and coffee use: 0 = never, 1 = rarely, 2 = sometimes, 3 = almost always, 4 = often. [e]Self-report of the frequency of physical exercise per week: 0 = nil, 1 = 1 to 2 times, 2 = 3 to 4 times, 3 = 4 to 5 times, 4 = 6 times or more. [f]Higher scores indicate greater perceived stress. [g]M/E scale, Morningness/Eveningness scale for adolescents. Lower M/E scale scores indicate more extreme evening-type. *P < 0.05; **P < 0.01.

were 208 students (13.1%) of evening type and 202 (12.7%) of morning type. There were significant differences in the prevalence of evening type and morning type between male and female students and across age groups. The proportion of evening type and morning type in boys was 11.5% and 15.7%, respectively, while the respective proportion in girls was 14.8% and 9.8% (χ^2 = 14.7, df = 2, P = 0.001). The proportion of evening type vs morning type in the students aged 12-13, 14, 15, 16, and 17-19 years was 9.4% vs 20.6%, 12.7% vs 10.1%, 14.0% vs 11.0%, 16.3% vs 9.3%, and 13.5% vs 10.4%, respectively (χ^2 = 32.3, df = 8, P = 0.0001).

Correlational and Regression Analyses for Sleep-Wake Variables

Table 4 presents the results of correlational analysis between sleep-wake variables and students' risk factors. Age, grade level, and M/E scale score had the most significant bivariate correlations with bedtime and total sleep time during school nights. Students' sex, traveling time to school, and M/E scale score were the variables that had the most significant associations with weekend oversleep. The frequency of alcohol consumption, PSS score, and M/E scale score had the most significant bivariate correlation with the severity of sleep disturbance as measured by the SQI and the degree of daytime sleepiness as reported in the ESS.

Table 5 shows the multiple regressions predicting school night bedtime, school night total sleep time, weekend oversleep, SQI total score, and ESS total score. The significant predictors for both school night bedtime and school night total sleep time were students' circadian phase preference, grade level, traveling time to school, school academic ranking, and alcohol use. The multiple regression model for weekend oversleep showed that circadian phase preference, traveling time to school, sex, age, and smoking habit were significant predictors. We found

that sleep disturbance as measured by the SQI and daytime sleepiness as reported in the ESS had many common predictors including students' age, traveling time to school, alcohol use, PSS score, and M/E scale score.

Academic Performance and Sleep-Wake Variables

Table 6 presents the analyses of sleep-wake habits and sleep disturbance based on self-reported academic performance. In general, students with excellent academic performance had earlier bedtimes and longer sleep on weekdays, earlier bedtimes and rise times on weekends, less delay in bedtime during weekends, and less severe daytime sleepiness than those with poor grades. There was no significant difference in school night rise time, weekend total sleep time, weekend oversleep, and SQI score among students with self-reported excellent, good, or marginal academic performance.

DISCUSSION

This study represents the first systematic analysis of sleep-wake patterns and sleep disturbance among Hong Kong teenagers. We found that the adolescents slept around 7.3 hours on school nights. Excessive daytime sleepiness was common, with 41.9% of the students reporting ESS score greater than 10. It is not possible to directly compare our results with those of previous studies because the samples differed in demographic variables. Nevertheless, the school night total sleep time among Hong Kong adolescents is roughly the same as reported in Greece and the United States,[3,5] shorter than in Canada, Mainland China and New Zealand (7.6-8.7 hr),[4,6,7] but longer than those of teenagers in Japan and Korea.[1,2] The prevalence of excessive daytime sleepiness among Hong Kong adolescents is

Table 5—Stepwise Multiple Regressions Predicting Sleep-Wake Variables from Students' Risk Factors (Unstandardized Regression Coefficients and SEs)

School night bedtime
R² = 30.4%

M/E scale score[a] (19.8)[b]	−0.09*** (0.005)
Grade level (6.6%)	0.20*** (0.02)
Traveling time to school (1.9%)	−0.01*** (0.001)
School band[c] (0.6%)	−0.13*** (0.03)
Alcohol use[d] (0.4%)	0.11** (0.03)
Overweight[e] (0.4%)	−0.23* (0.09)
Part-time work (0.3%)	0.02* (0.008)

School night total sleep time
R² = 21.6%

Grade level (10.1%)	−0.11** (0.04)
M/E scale score (5.1%)	0.06*** (0.007)
Traveling time to school (3.0%)	−0.01*** (0.002)
Coffee use[d] (1.6%)	−0.14*** 0.04
Age (0.7%)	−0.11*** (0.03)
Had smoking habit[f] (0.5%)	−0.47* (0.19)
School band (0.4%)	0.12** (0.04)
Alcohol use (0.2%)	−0.09* (0.05)

Weekend oversleep
R² = 17.7%

M/E scale score (11.4%)	−0.12*** (0.01)
Traveling time to school (3.4%)	0.02*** (0.003)
Sex (2.0%)	−0.54*** (0.09)
Age (0.6%)	0.09** (0.03)
Had smoking habit (0.3%)	0.60* (0.28)

Sleep Quality Index score[g]
R² = 18.4%

PSS score[h] (13.5%)	0.15*** (0.01)
M/E scale score (2.6%)	−0.08*** (0.01)
Alcohol use (0.8%)	0.30*** (0.08)
Grade level (0.7%)	−0.24*** (0.07)
Traveling time to school (0.5%)	0.009* (0.003)
Age (0.3%)	0.25*** (0.06)

Epworth Sleepiness Scale score[g]
R² = 18.0%

M/E scale score (11.2%)	−0.23*** (0.02)
PSS score (3.5%)	0.14*** (0.02)
Age (1.3%)	0.21** (0.06)
Traveling time to school (0.8%)	0.02*** (0.006)
Part-time work (0.5%)	0.09** (0.03)
Alcohol use (0.4%)	0.35* (0.14)
Overweight (0.3%)	−0.93* (0.38)

[a]M/E scale, Morningness/Eveningness scale for adolescents. Lower M/E scale scores indicate more extreme evening-type. [b]% variance accounted by each variable. [c]Band 1-3. Lower band indicates higher school academic ranking [d]Self-report of alcohol and coffee use: 0 = never, 1 = rarely, 2 = sometimes, 3 = almost always, 4 = often. [e]International Task Force on Obesity overweight reference, sex-age-specific BMI cut-offs that correspond to BMI = 25 at age 18 yrs: 0 = no, 1 = yes. [f]Smoking habit: 0 = no, 1 = yes. [g]Higher scores indicate greater severity of sleep disturbance and daytime sleepiness. [h]Higher scores indicate greater perceived stress. *P < 0.05; **P < 0.01; ***P < 0.001.

The sleep duration decreased from 7.8 hours to 6.6 hours across ages 12 to 19 years; average bedtime was delayed from 23:00 to 23:47; and mean weekend oversleep increased from 1.7 hours to 2.7 hours. These changes in sleep habits were most marked between 12-13 years and 14 years, and with more gradual changes from 14 years to 17-19 years. It is likely that the adolescents aged 12-13 years are middle school students in early pubertal stage.[33,34] With pubertal development around 14 years of age, teenagers' circadian phases undergo a significant delay.[9] In addition to increasing academic demand, by this age they may be more inclined toward setting their own bedtimes and rise times, resulting in this marked change in sleep habits.

We found that 19.1% of the adolescents in our study reported either difficulty falling asleep, waking up during the night, or waking up too early in the morning on three or more nights per week for the past three months. A uniform definition of insomnia was not followed in previous epidemiological studies of adolescents. However, in many investigations,[10-15] similar sleep complaints were addressed, and the prevalence of insomnia symptoms was compatible with the results of our study. Using a standardized telephone interview, Ohayon et al. found that only 4% met DSM-IV criteria for current insomnia.[10] Another study found that 9.4% of a random sample of adolescents aged 13-16 years met DSM-IV criteria for current insomnia.[35] We found that 3% of the students reported that they suffered from insomnia, and 1% used hypnotics at least once per week. It is possible that the sleep disturbances in a proportion of teenagers who report insomnia symptoms may not be severe enough to cause significant distress. The discrepancy between the prevalence of insomnia symptoms and insomnia disorder highlights the importance of standardized instruments and criteria in epidemiological surveys of sleep disturbance among adolescents.

We found that the prevalence of sleep disturbance increased with age during adolescence and was higher among females. The greater prevalence in older adolescents observed here is in line with previous studies showing that older age or higher grade level is associated with more insomnia symptoms.[4,12] Most of the previous studies found that girls were more likely to report sleep disturbance.[10-14] One study found no gender difference in the risk of insomnia among girls prior to the onset of menses, but a difference after.[35] The greater prevalence of sleep disturbance in girls has been attributed to a greater prevalence of major depressive disorder in adolescent females.[36,37]

Our stepwise regression analyses revealed that sleep-wake patterns were influenced by adolescents' circadian phase preference, school, and personal factors. We found that evening circadian type was predictive of late bedtimes, short sleep length, and long weekend oversleep. Previous studies have shown that circadian phase preference, based on self-report questionnaire, is related to endogenous melatonin and temperature rhythms.[38,39] Evening circadian type is associated with emotional and behavioral problems, impaired academic performance, and injuries and accidents.[30,40] Early identification of adolescents with evening circadian type and intervention with sleep hygiene education might help to reverse the negative impacts of insufficient sleep and erratic sleep-wake schedules on mood, cognitive, and motor function.

The current study showed that high perceived stress was the most significant risk factor for sleep disturbance among sec-

similar to that of high school students in Canada.[7] Thus our data suggest that most adolescents in Hong Kong do not get enough sleep. Previous studies report that adolescents feel they need almost 9 hours of sleep.[2,3,32]

Table 6—Means and Standard Deviations for Sleep-Wake Habit and Sleep Disturbance Variables by Academic Performance

	Self-reported academic performance				
Sleep-wake Variables	Excellent (n = 435)	Good (n = 680)	Marginal (n = 224)	F Value	Bonferroni t^a
School night bedtime	23:24 (60)	23:25 (68)	23:42 (70)	6.8**	Excellent, Good < Marginal
School night rise time	07:57 (42)	06:58 (43)	07:01 (50)	0.5	---
School night total sleep time, min	439 (73)	436 (80)	420 (81)	4.6*	Excellent, Good > Marginal
Weekend bedtime	00:15 (86)	00:30 (97)	00:49 (97)	21.9***	Excellent < Good < Marginal
Weekend rise time	09:54 (97)	10:16 (105)	10:34 (125)	11.6***	Excellent < Good, Marginal
Weekend total sleep time, min	563 (99)	569 (106)	564 (113)	0.44	---
Weekend oversleep, min	124 (109)	131 (112)	144 (127)	2.1	---
Weekend delay, min	51 (66)	66 (88)	83 (76)	12.6***	Excellent < Good < Marginal
Sleep Quality Index score ^{b}	4.5 (2.6)	4.7 (2.6)	4.8 (2.4)	1.2	---
Epworth Sleepiness Scale score ^{b}	8.6 (4.2)	8.6 (4.2)	9.8 (4.5)	7.0**	Excellent, Good < Marginal

[a]Significant difference between students with excellent, good, or marginal academic performance, $P < 0.05$. [b]Higher scores indicate greater severity of sleep disturbance and daytime sleepiness. *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

ondary school students in Hong Kong. Although we cannot specify the causal relationship between perceived stress and sleep disturbance in our subjects, disturbed sleep in adolescents is predictive of impaired psychosocial functioning at one-year follow-up.[18] We showed that students with marginal academic performance had shorter sleep during school nights and more daytime sleepiness than those with better grades. Given the importance of sleep to the adolescents' psychosocial functioning and academic performance,[41] it is important to tackle sleep problems early in order to prevent further deterioration.

There are several methodologic limitations that limit interpretation of our findings. First, the sample was not randomly selected from the general population; it did not include older adolescents who had left school or students preparing for public examinations. Second, the cross-sectional design of this study restricts our ability to make causal inferences on the relationship between sleep-wake variables and academic performance. Third, the questionnaires used in this study were translated into Chinese, and although they had moderate internal consistency, test-retest reliability, and some support of concurrent validity; the exact relationship of the self-reported sleep-wake variables with results from sleep diary, structured interview, and objective assessment is uncertain. Knutson and Lauderdale showed that self-reported usual sleep duration and 24-hour diary data were weakly correlated.[42] Wolfson et al. found that the validity of the Sleep Habits Survey data for adolescents during weekends was not confirmed.[43] The validity of self-reported scales in assessing sleep-wake patterns and sleep disturbance in adolescents of different age groups and ethnic background remains to be ascertained. Our finding of low test-retest reliability of some SQI items may be due to an overlap in their meaning. Fourth, our data reflected students' subjective and retrospective experiences on sleep. Cognitive and situational factors may affect the validity of adolescents' self-report data.[44]

Despite these limitations, our findings add to the database on sleep-wake patterns and sleep disturbance among adolescents in different societies. Many adolescents did not complain of sleep disturbance, but the high rates of excessive daytime sleepiness and morning tiredness could indicate problems with their sleep-wake habits. Parents, educators, clinicians, and researchers should be advised about the importance of sleep in adolescents. Future studies should involve prospective design and intervention and include an examination of the relationship between sleep and health-risk behavior among adolescents.

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