

SLEEP AND PSYCHIATRIC DISORDERS

Sleep Duration Associated with the Lowest Risk of Depression/Anxiety in Adolescents

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Study Objectives: To investigate sleep duration associated with the least depression/anxiety in adolescence.

Methods: Grades 7–12 Japanese students (n = 18,250, aged 12–18 y) from public junior high/high schools were studied in a cross-sectional design. Due to missing/implausible data, 15,637 out of the 18,250 students were statistically analyzed. Relationship between sleep duration on school nights and depression/anxiety, measured using self-report questionnaires, including the General Health Questionnaire-12 (GHQ-12), were studied by sex and grade, controlling for bedtime regularity.

Results: When sleep duration was classified by 1-h intervals, rate of adolescents with a GHQ-12 score ≥ 4 was the lowest in males and females who slept 8.5–9.5 h and 7.5–8.5 h, respectively, (designated “references”) in both grades 7–9 and 10–12. The rate was significantly higher than the references in both males and females who slept < 7.5 h, regardless of grade (P < 0.05, logistic regression). GHQ-12 tended to be worse in adolescents (2.0%–13.5%) who slept longer than the references. Sleep duration for the minimum GHQ-12 score was estimated to be 8.8 and 8.5 h in males, and 8.0 and 7.5 h in females, in grades 7–9 and 10–12, respectively, using the General Additive Model.

Conclusions: Sleep duration of ≥ 8.5 h on school nights may be associated with the lowest risk of depression/anxiety on average in male adolescents. Although the duration was estimated to be shorter in females (≥ 7.5 h) than males, this should be interpreted carefully. Most adolescents may currently be sleeping less than the optimal duration.

Commentary: A commentary on this article appears in this issue on page 1491.

Keywords: adolescents, age, General Health Questionnaire-12, mental health, sex, sleep duration

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Significance

It is well known that nocturnal sleep is closely related with mental health. The present study estimated specific hours of nocturnal sleep which may be associated with the lowest risk of depression/anxiety in junior-high/high school students (aged 12–18 years), by analyzing a large cross-sectional data. As a result, male students may generally be advised to sleep ≥ 8.5 h on school nights, although required sleep can be influenced by several biological/non-biological factors, with individual differences. The estimation may greatly help mental health education in adolescents. In females, sleep duration associated with the lowest risk was estimated approximately one hour shorter than males, but this needs to be interpreted with caution and further studied.

INTRODUCTION

Sleep duration in adolescents decreases sharply with age.^{1–7} Adolescents tend to stay up later at night as they get older, but need to wake up early enough to attend classes on school days.⁸ Late bedtime and short sleep duration on school nights may lead to a lack of sleep in adolescents. US nationally representative data from the National Longitudinal Study of Adolescent Health showed that the percentage of adolescents who reported sleeping fewer than 6 h on school nights was 1.1% at age 13 y and 8.5% at age 18 y. A decrease in self-reported sleep duration on school nights during adolescence is also observed in studies from Europe, Australia, and Asia.^{1,5–7} A study of adolescents from 23 countries showed that Asian adolescents, including the Japanese, sleep 40–60 min/day less than Americans and 60–120 min/day less than Europeans.^{6,7} The lack of sleep during adolescence may be especially serious in Asian countries.

During adolescence, the prevalence of mental disorders, including mood disorders and anxiety disorders, increases with age.^{9–12} The Dunedin Multidisciplinary Health and Development Study showed that the cumulative rate of major depression may rise from 5% in early adolescence to as high as 20% around the end of adolescence.¹⁰ Regarding anxiety disorders, the National Comorbidity Replication Survey showed that the median age of onset is 11 y, and in 75% of patients disorders develop by age 21 y.¹²

Previous studies have consistently observed that short sleep duration is associated with mental health problems in adolescents.^{13–16} A US longitudinal study showed that sleep duration of 6 h or less on school nights significantly increased the risk of mental difficulties, including major depression and depressed mood.¹⁴ A cross-sectional study from 11 European countries reported a correlation between reduced sleep on school nights and increasing emotional problems.¹⁶ A survey in Japan also observed that the rate of poor mental health was significantly higher in adolescents in grades 7–12 (aged 12–18 y) who slept 6 h or less than those who slept 7 to 9 h.¹³

As mental disorders result in greater difficulties in adolescents' lives than any other disorders,¹⁷ clarifying the specific duration of sleep required for adolescents to maintain good mental health is of great significance. The National Sleep Foundation has released guidelines for the optimal amount of sleep to promote “general health” for people in several age categories, including school-age children (6–13 y; 9–11 h), teenagers (14–17 y; 8–10 h) and young adults (18–25 y; 7–9 h) by systematic reviews of a number of studies on sleep duration and health by experts.^{18,19} The recommended duration was not, however, specific for mental health; the age category was relatively rough for adolescents, as described previously, and sex was not considered.^{18,19} In adolescence, the amount of sleep required may change rapidly with the older age and the change may be different according to

sex, which may have a significant effect on the association between sleep duration and mental health during adolescence.^{2,13–16} Recently, a guideline on a specific sleep duration for mental health was published, but this was for adults, not for adolescents.²⁰ A large Japanese cross-sectional study has shown a U-shaped relationship between sleep duration and mental health (or depression/anxiety) according to sex and grade in adolescence, suggesting the existence of optimal durations of sleep for mental health. The optimal or required durations of sleep were not, however, specifically analyzed or referred to by sex or grade.¹³ To the best of our knowledge, no other individual studies have thus far examined specific durations of sleep required for maintaining good mental health in adolescence. In the current study we, therefore, examined the relationship between sleep duration and mental health (or depression/anxiety symptoms) by sex and age, to reveal the specific duration of sleep on school nights that is associated with the lowest risk of depression/anxiety for adolescents. Regarding age, the participants were stratified into two groups: grade 7–9 adolescents (aged 12–15 y) and grade 10–12 adolescents (aged 15–18 y) (Table 1). In Japan, there is a high correlation between school grade and age of the students (see Table 2 for details). Regularity of bedtime, which can affect sleep quality by disturbing the circadian rhythm²¹ and may be associated with both sleep duration²² and depression/anxiety,²³ was controlled for in the analyses.

METHODS

Participants

The current study employed data from a school-based cross-sectional survey in Japan, which was conducted in 2006.²⁴ The aim of the survey was to investigate psychopathologies or mental health difficulties and their risk factors in adolescents. The participants comprised junior high/high school students (grades 7–12) in Kochi prefecture and Tsu City, Mie prefecture, Japan. We conducted the survey in these areas because several members of our team were affiliated with departments of psychiatry of medical schools there and were studying adolescents' mental health. All 20 public junior high schools (grades 7–9) in Tsu City, and 25 of 118 public junior high schools and 28 of 36 public high schools (grades 10–12) in Kochi prefecture participated in the survey. Of all the adolescents in these junior high schools and high schools ($n = 19,436$), 798 (4.1%) were absent on the days of the survey and 388 (2.0%) declined to participate. Therefore, a total of 18,250 adolescents (93.9% of 19,436) participated in the study. Among these 18,250 adolescents, 2,522 were excluded from the analysis because of missing answers to questions regarding sex, grade, sleep duration, bedtime regularity, or mental health status. Regarding the self-reported sleep duration, 57 adolescents stated a duration of less than 180 min (3 h), and 34 adolescents indicated a duration of more than 720 min (12 h). These individuals were also excluded. Thus, 15,637 adolescents (80.6% of the 19,436; 7,953 males [51%] and 7,684 females [49%]) were statistically analyzed.

Study Design and Questionnaire

A cross-sectional survey was conducted using a self-report questionnaire regarding sleep habits and mental health. For

the assessment of mental health, the Japanese version of the General Health Questionnaire-12 (GHQ-12) was employed.²⁵ GHQ-12 is a self-report questionnaire on symptoms of depression and anxiety.²⁶ The validity and reliability of the GHQ-12 have been extensively investigated and confirmed in studies, including that conducted in 15 centers worldwide.²⁷ Previous studies suggest that adolescents interpret the GHQ-12 in a manner similar to adults.^{28–30} The validity and reliability of the Japanese version of the GHQ-12 have been confirmed in adolescents.³¹ We also calculated internal consistency using the data obtained, and found that Cronbach alpha was 0.84. We defined participants with GHQ-12 of 4 or higher as being subject to depression/anxiety, in accordance with previous studies.^{13,30,32} Sleep duration was assessed using the question: “How long (hours: minutes) do you usually sleep on school nights?” For the calculation of mean sleep duration, the answer to this question was used directly. For logistic regression analysis to evaluate associations between sleep duration and GHQ-12 (whether the score was ≥ 4 or < 4), the sleep duration was classified in 1-h increments as follows: < 5.5 h, 5.5–6.5 h ($5.5 \leq$ and < 6.5 h), 6.5–7.5 h ($6.5 \leq$ and < 7.5 h), 7.5–8.5 h ($7.5 \leq$ and < 8.5 h), 8.5–9.5 h ($8.5 \leq$ and < 9.5 h), and ≥ 9.5 h. Bedtime and wake-up time on school days were assessed with the question: “At what times (hours: minutes) do you usually go to bed and wake up on school days?” Regularity of bedtime was assessed using the question: “Is your bedtime regular or irregular?”, with a selection of answers: “always regular”, “almost always regular”, “sometimes irregular” and “always irregular”. When the answer was “always irregular”, the bedtime was considered “irregular”. Unlike sleep duration, bedtime, and wake-up time, we did not confine the question on bedtime regularity to school nights. The reason for this was that a difference in bedtimes between school nights and weekends might be a factor in bedtime irregularity. Most previous studies, likewise, have not specified school nights or weekends in the investigation of bedtime regularity.^{21–23}

Statistical Analysis

Two-way analysis of variance was performed to analyze the change and difference in sleep duration, bedtime, and wake-up time across the grades and according to sex. The Bonferroni test was used for *post hoc* analyses to make a comparison between sex and grades (grades 7–12). In other analyses, the participants were stratified into the four categories according to sex and school grade: male and female grades 7–9 (or junior high school, aged 12–15 y) and grades 10–12 (or high school, aged 15–18 y). The reason for this grade categorization was that in the Japanese education system, schools are divided into elementary school (grades 1–6), junior high school (grades 7–9), and senior high school (grades 10–12). Elementary and junior high schools are compulsory, but senior high school is not, although most Japanese adolescents ($> 95\%$) do attend senior high school.³³ Participants with missing data were excluded from all statistical analyses. The percentage of adolescents subject to depression/anxiety ($\text{GHQ-12} \geq 4$) was calculated according to sleep duration and bedtime regularity in each of the four sex/grade categories of adolescents. The associations of sleep duration with $\text{GHQ-12} \geq 4$ were studied using

Table 1—Sleep habits and the General Health Questionnaire-12 score in participants (n = 15,637).

	Grades 7–9		Grades 10–12	
	Males	Females	Males	Females
Sleep duration				
< 5.5 h	122 (3.1)	178 (5.1) ^{***a}	356 (8.8)	483 (11.6) ^{***a}
5.5 to < 6.5 h	350 (8.9)	488 (13.9)	908 (22.6)	1,155 (27.6)
6.5 to < 7.5 h	1,087 (27.7)	1,133 (32.3)	1,474 (36.6)	1,524 (36.5)
7.5 to < 8.5 h	1,557 (39.6)	1,231 (35.1)	1,037 (25.8)	820 (19.6)
8.5 to < 9.5 h	625 (15.9)	374 (10.7)	170 (4.2)	156 (3.7)
≥ 9.5 h	187 (4.8)	99 (2.8)	80 (2.0)	43 (1.0)
Irregular bedtime	637 (16.2)	488 (13.9) ^{**b}	637 (15.8)	694 (16.6)
GHQ-12 score ≥ 4	1,090 (27.7)	1,703 (48.6) ^{***c}	1,529 (38.0)	2,519 (60.1) ^{***c}
GHQ-12 score, mean ± SD	2.47 ± 2.8	3.82 ± 3.2 ^{***d}	3.16 ± 3.0	4.64 ± 3.2 ^{***d}

^{a-d} Significantly different from males (**P < 0.01, ***P < 0.001, ^{a-c} chi-square test, ^d independent t test). ^a Chi-square value = 138.5 and 83.8 in grades 7–9 and 10–12, respectively (degrees of freedom [df] = 5). ^b Chi-square value = -7.5 and 0.9 in grades 7–9 and 10–12, respectively (df = 1). ^c Chi-square value = 343.7 and 406.6 in grades 7–9 and 10–12, respectively (df = 1). ^d t value (df = 7,249 in grades 7–9 and df = 8,204 in grades 10–12) = 19.6 and 21.9 in grades 7–9 and 10–12, respectively. GHQ-12 = General Health Questionnaire-12. Subjects with a GHQ-12 score ≥ 4 are considered to have poor mental health. SD, standard deviation.

logistic regression, after controlling for grade (7, 8, or 9 and 10, 11, or 12) and bedtime regularity (regular or irregular) in each sex/grade category. The Statistical Package for the Social Sciences (SPSS) version 22.0 was employed in the statistical analyses (SPSS Inc., Chicago, IL, USA). P values of less than 0.05 were considered statistically significant. General Additive Model (GAM)³⁴ was employed to study the nonlinear dose-response relationship between sleep duration and GHQ-12 scores, in order to estimate sleep duration with the minimum GHQ-12 score, in each sex/grade category of the adolescents. GAM uses a nonlinear link function to establish a relationship between the mean of the outcome (GHQ-12 score) and a smoothed function of the exposure variable. Natural cubic splines were applied to detect the best model shape by using the free software R. Grade (7, 8, or 9 and 10, 11, or 12) and bedtime regularity (regular or irregular) were controlled for in the GAM analysis.

Ethical Aspects

The study was approved by the ethics committee of Mie University School of Medicine and Kochi Medical School. The principal investigators approached the school principals regarding participation in the study. They explained that participation was voluntary, and if adolescents, parents, or teachers did not agree, there was no obligation to participate. The principals then consulted with teachers and parents. With their agreement, the teachers were given instructions regarding the method of distribution and collection of the questionnaires. The teachers gave the questionnaire with an envelope to the adolescents. The teachers explained that: (1) participation was voluntary and anonymous and (2) the answered questionnaires would never be seen by any of the teachers. The adolescents were instructed to put the questionnaire in the envelope and seal it when the questionnaire was completed. Research staff collected the sealed questionnaires at each school. The answers were analyzed and studied anonymously.

RESULTS

Table 1 summarizes duration of sleep on school nights, regularity of sleep, and mental health status of the participants. The sleep duration of females was significantly shorter than that of males in both grades 7–9 and grades 10–12 (P < 0.001). The percentage of adolescents with irregular bedtime was higher in males than in females in grades 7–9 (P < 0.01). The GHQ-12 score and the percentage of participants with a GHQ-12 score ≥ 4 were significantly higher in females than in males in both grades 7–9 and grades 10–12 adolescents (P < 0.001).

Table 2 summarizes the sleep habits and GHQ-12 score by grade and sex. Bedtime was delayed and sleep duration on school nights decreased significantly with the advance of grade (P < 0.001). The sleep duration decreased from 7.9 h to 6.8 h in males, and from 7.5 h to 6.6 h in females during the 5 y from grade 7 to 12. The males slept significantly longer than the females in all grades. Wake-up time was significantly different among grades (P < 0.001), but not simply delayed in accordance with the advance of the grade, especially in females. The magnitude of changes in sleep duration and in bedtime appeared to be different between the two grade categories of grades 7–9 and grades 10–12 (27 min versus 12 min in males and 35 min versus 2 min in females, and 58 min versus 22 min in males and 48 min versus 12 min in females, respectively). GHQ-12 score was significantly different by grade, both in males and females (P < 0.001). A *post hoc* test (Bonferroni test) revealed a significant difference in GHQ-12 score between each of the grades 7, 8, and 9 and the grades 10, 11, and 12.

Table 3 summarizes the rates of adolescents with GHQ-12 ≥ 4 according to sleep duration on school nights and regularity of bedtime in each of the four sex/grade categories of the adolescents. In males, the rate was lowest in those who slept 8.5–9.5 h, in both grades 7–9 and grades 10–12. In females, the rate was lowest in those who slept 7.5–8.5 h, in both grades 7–9 and grades 10–12. We therefore designated 8.5–9.5 h and 7.5–8.5 h as the male and female “references”, respectively, in the current

Table 2—Change of sleep habits and mental health status by grade and sex.^a

	Grade						F value ^b (P value) for grade	Bonferroni post-hoc test
	7	8	9	10	11	12		
Males (n = 7,953)	1,284	1,410	1,234	1,598	1,398	1,029		
Age, years	12.8 ± 0.39	13.8 ± 0.43	14.7 ± 0.44	15.7 ± 0.46	16.8 ± 0.43	17.7 ± 0.44		
Sleep duration, min	471 ± 68	458 ± 64	434 ± 71	418 ± 69	410 ± 68	406 ± 76	191.9 (< 0.001)	7 > 8 > 9 > 10 > 11,12
Bedtime, h:min (n)	22:40 ± 1:05 (1,281)	22:59 ± 1:09 (1,410)	23:38 ± 1:23 (1,232)	23:36 ± 1:04 (1,590)	23:47 ± 1:04 (1,397)	23:58 ± 1:14 (1,029)	238.8 (< 0.001)	7 < 8 < 9,10 < 11 < 12
Wake-up time, h:min (n)	06:36 ± 0:38 (1,281)	06:40 ± 0:38 (1,408)	06:57 ± 0:42 (1,233)	06:37 ± 0:45 (1,591)	06:42 ± 0:46 (1,394)	06:49 ± 0:49 (1,029)	43.2 (< 0.001)	7,8,10 < 11 < 12 < 9
GHQ-12 score	2.27 ± 2.7	2.45 ± 2.7	2.68 ± 2.9	3.22 ± 3.0	3.12 ± 2.9	3.15 ± 3.0	26.1 (< 0.001)	7,8,9 < 10,11,12
Females (n = 7,684)	1,099	1,286	1,118	1,698	1,428	1,055		
Age, years	12.8 ± 0.39	13.8 ± 0.43	14.7 ± 0.44	15.7 ± 0.46	16.8 ± 0.42	17.7 ± 0.45		
Sleep duration, min	453 ± 68*	436 ± 65*	418 ± 69*	400 ± 67*	397 ± 65*	398 ± 71*	144.5 (< 0.001)	7 > 8 > 9 > 10,11,12
Bedtime, h:min (n)	22:56 ± 1:07* (1,099)	23:18 ± 1:15* (1,285)	23:44 ± 1:28* (1,114)	23:45 ± 1:03* (1,693)	23:48 ± 1:04 (1,424)	23:57 ± 1:07 (1,053)	123.4 (< 0.001)	7 < 8 < 9,10,11 < 12
Wake-up time, h:min (n)	06:32 ± 0:35* (1,096)	06:40 ± 0:39 (1,282)	06:51 ± 0:34* (1,118)	06:31 ± 0:44* (1,694)	06:34 ± 0:43* (1,427)	06:40 ± 0:42* (1,052)	40.9 (< 0.001)	7,10,11 < 8,12 < 9
GHQ-12 score	3.59 ± 3.2*	3.89 ± 3.1*	3.97 ± 3.1*	4.65 ± 3.2*	4.76 ± 3.1*	4.48 ± 3.2*	28.7 (< 0.001)	7,8,9 < 10,11,12

Values are means ± SD. *Significantly different from males (P < 0.05). ^aTwo-way ANOVA according to grade and sex., ^bdf = 5. h:min, hours and minutes; n, the number of subjects.

Table 3—Rates of adolescents with GHQ-12 ≥ 4 by sleep duration and bedtime regularity.

	Grade 7–9		Grade 10–12	
	Males	Females	Males	Females
Sleep duration				
< 5.5 hours	67/122 (54.9)	126/178 (70.8)	181/356 (50.8)	343/483 (71.0)
5.5 to < 6.5 hours	140/350 (40.0)	270/488 (55.3)	367/908 (40.4)	718/1,155 (62.2)
6.5 to < 7.5 hours	327/1,087 (30.1)	556/1,133 (49.1)	551/1,474 (37.4)	892/1,524 (58.5)
7.5 to < 8.5 hours	374/1,557 (24.0)	519/1,231 (42.2)	346/1,037 (33.4)	440/820 (53.7)
8.5 to < 9.5 hours	132/625 (21.1)	182/374 (48.7)	50/170 (29.4)	101/156 (64.7)
≥ 9.5 hours	50/187 (26.7)	50/99 (50.5)	34/80 (42.5)	25/43 (58.1)
Bedtime regularity				
Regular	852/3,291 (25.9)***	1,412/3,015 (46.8)***	1,217/3,388 (35.9)***	2,020/3,487 (57.9)***
Irregular	238/637 (37.4)	291/488 (59.6)	312/637 (49.0)	499/694 (71.9)

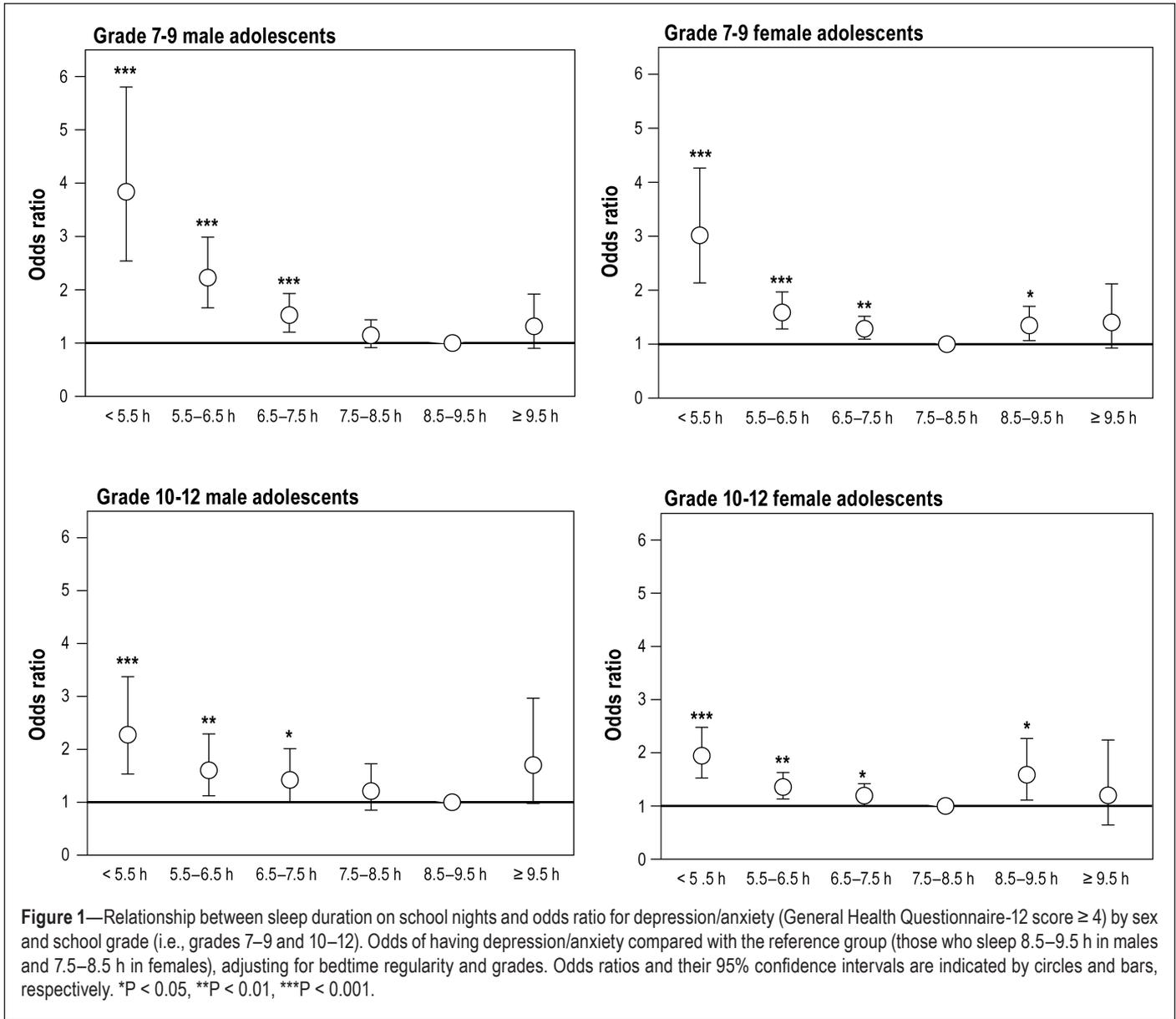
***Significantly different from those with irregular bedtime (P < 0.001, chi-squared test). Chi-square value = 35.0 and 27.5 in grade 7–9 males and females and 38.8 and 47.2 in grade 10–12 males and females, respectively (df = 1).

participants. The rates of adolescents with GHQ-12 ≥ 4 were significantly higher in adolescents with irregular bedtimes compared with those with regular bedtimes in all four of the sex/grade categories of adolescents (P < 0.001).

Figure 1 shows the relationship between sleep duration on school nights and the percentage of adolescents with GHQ-12 ≥ 4. Logistic regression was conducted, controlling for grade and bedtime regularity. Males who slept < 7.5 h in both grades 7–9 and 10–12 had significantly higher odds of having GHQ-12 ≥ 4 compared with males who slept 8.5–9.5 h (reference duration in males) (P < 0.05). In females, the odds of having GHQ-12 ≥ 4 were significantly higher in those who slept < 7.5 or 8.5–9.5 h compared with females who slept the reference duration (7.5–8.5 h in females), in both grades 7–9 and 10–12 (P < 0.05). Rates of adolescents who slept shorter than the reference ranged from 51.3% to 93.8%, whereas rates

of adolescents who slept longer than the reference ranged from 2.0 % to 13.5%, as shown in Table 1. The logistic regression also showed that irregular bedtime was significantly associated with higher GHQ-12 scores in all four categories of adolescents (the range of odds ratio: 1.53–1.75, P < 0.001).

Figure 2 shows the results of the GAM to estimate sleep duration on school nights with the minimum GHQ-12 score. The estimated dose-response relations between the sleep duration and GHQ-12 score in each sex/grade group are shown. The sleep duration for the lowest GHQ-12 score was estimated by fitting a cubic spline function controlling for grade and bedtime regularity. The sleep duration and the GHQ-12 score had a nonlinear relationship in all four sex/grade categories of adolescents. In males, adolescents who slept 527 min (8.8 h) and 512 min (8.5 h) were estimated to have the minimum GHQ-12 score (1.78 [95% CI: 1.53–2.02], 2.99 [95% CI: 2.40–3.58]) in



grades 7–9 and grades 10–12, respectively. In females, those who slept 481 min (8.0 h) and 447 min (7.5 h) were estimated to have the minimum GHQ-12 score (3.25 [95% CI: 2.96–3.54], 4.67 [95% CI: 4.08–5.26]) in grades 7–9 and grades 10–12, respectively.

DISCUSSION

We investigated durations of sleep on school nights that may be associated with the least depression/anxiety in adolescents, by sex and school grade (i.e., grades 7–9 and 10–12). Sleep duration on school nights and extent of depression/anxiety were self-reported using a questionnaire. The rate of depression/anxiety (GHQ-12 ≥ 4) was lowest in males who slept 8.5–9.5 h in both grades 7–9 and grades 10–12. In females, the rate was lowest in those who slept 7.5–8.5 h in both categories of grade. Employing the GAM, sleep duration on school nights for the lowest GHQ-12 score was estimated to be 8.8 and 8.5 h in males, and 8.0 and 7.5 h in females, in adolescents in grades 7–9 and 10–12, respectively. These results suggest that

in adolescent males in grades 7–12 (aged 12–18 y), on average, sleep 8.5 h or more on school nights may be associated with the lowest risk of depression/anxiety. This is within the range of sleep duration for general good health in adolescence (8–10 h; for adolescents aged 14–17 y) recommended by the National Sleep Foundation of the US to promote general health.^{18,19} In females, those who slept for 7.5 h or more ran the lowest risk of depression/anxiety on average among the current participants. Whether this duration is adequate for females may, however, need to be cautiously discussed. To our knowledge, this is the first study to specify the duration of sleep associated with the lowest risk of depression/anxiety in adolescence, considering sex and age.

The current results also suggest that most of the adolescents, both in grades 7–9 and grades 10–12, may currently be sleeping less than the duration associated with the least depression/anxiety. As summarized in Table 2, the sleep duration on school nights rapidly decreased with advancing age (and grade), in line with the rapid delay of bedtime. The decrease

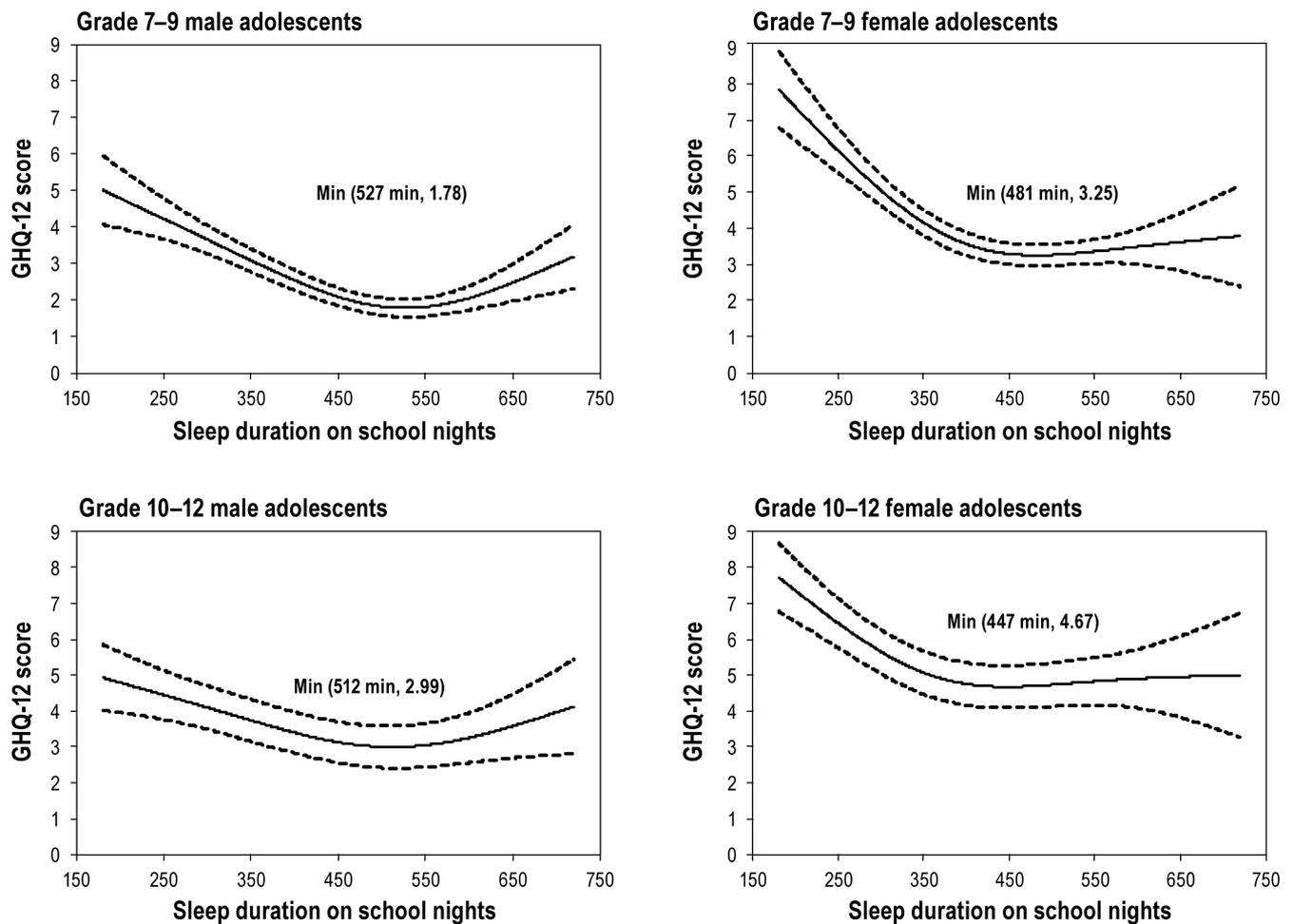


Figure 2—Estimated dose-response relations between sleep duration on school nights and General Health Questionnaire-12 (GHQ-12) score using the General Additive Model by sex and grade (i.e., grades 7–9 and 10–12). Estimated sleep durations on school nights for the minimum GHQ-12 score are also shown. Dotted lines represent the upper and lower 95% confidence intervals. Natural cubic splines were applied to detect the best model shape.

might partly be related to a possible decrease of physiologically required sleep according to age. The level of decrease observed may, however, be beyond that resulting from the physiological change, although we are not sure to what extent we can generalize this discussion given the fact that sleep duration in adolescents varies according to country and ethnicity.^{6,35} The conclusions may, however, be true in East Asian countries/regions^{36–38} and probably in the United States.³

The adolescents with short sleep duration had an increased risk of depression/anxiety, which was consistent with several previous studies.^{13,14} In addition to the association of depression/anxiety and shorter sleep, depression/anxiety was also associated with longer sleep in the current subjects. Males and females who slept longer than 9.5 and 8.5 h, respectively, tended to experience more depression/anxiety than those slept 8.5–9.5 h (male reference) and 7.5–8.5 h (female reference), respectively. The association of depression/anxiety and long sleep duration (e.g., ≥ 9.5 h) has also been observed in several previous studies.^{13,39–41} Associations of mental difficulties at clinical levels and longer sleep duration (or hypersomnia) are also well known in several illnesses, such as depressive phases

of bipolar disorders and atypical depression.^{42–44} However, it remains to be clarified whether the longer sleep duration is a cause or result of mental difficulties. Another point to be noted is that the percentage of adolescents who sleep longer than the reference duration may be relatively small, ranging from 2.0% in males in grades 7–9 to 13.9% in females in grades 10–12 in the current subjects. In practice, therefore, a more important problem is that large numbers of adolescents may be sleeping less than required. In the current study, the percentage of adolescents who slept less than the reference durations ranged from 51.3% (in females in grades 7–9) to 75.7% (in males in grades 10–12). These adolescents may be the focus of interventions in sleep duration.

Both logistic regression and GAM analyses suggest that sleep duration in adolescents with the lowest risk of depression/anxiety was shorter in females than in males, on school nights. Whether this indicates a need for less sleep in females than males in adolescence is unclear. No investigation was made into culturally determined factors that might affect the sleeping or waking times of females but not males. In the current study, the average GHQ-12 scores in females who slept

7.5–8.5 h (duration with the lowest prevalence of GHQ-12 \geq 4, or the reference duration, in females) were 3.39 and 4.21 in grades 7–9 and grades 10–12, respectively, whereas the average scores in males who slept 8.5–9.5 h (the reference in males) were 2.04 and 2.56, respectively. The average GHQ-12 score in adolescents whose sleep duration was estimated to be associated with the minimum GHQ-12 score by the GAM was 1.78 and 2.99 in males and 3.25 and 4.67 in females, in grades 7–9 and 10–12, respectively (Figure 2). It might be possible that the shorter sleep duration plays a role in the higher (or worse) GHQ-12 score in females than males in the current study, although the GHQ-12 score has often been observed to be higher in females than males.^{13,45–47} In addition, it could be that the female adolescents who slept longer than 8.5 h are a combination of those with good mental health promoted by adequate sleep and those with depression/anxiety, which caused longer sleep. This speculation might be partly supported by the distribution of the GHQ-12 score in the females who slept for a long period, especially in those who slept $>$ 9.5 h (see Figure S1 in the supplemental material). In the females who slept for a long period, the percentage of adolescents with a GHQ-12 score of $<$ 2 (or good mental health) were not low, whereas the percentage of those with a score of 4–7 or 4–9 was clearly increased, although not statistically tested due to the limited number of long-sleeping females, especially of those who slept $>$ 9.5 h. As an additional point in this discussion, the sex difference in sleep duration varies according to nation and ethnicity. Males sleep longer than females in Korea, Japan and the United States, as in the current study,^{3,36,37} whereas females sleep slightly longer than males in Australia.¹ In the United States, among African Americans and whites, males sleep longer than females, whereas no difference in sleep duration between sexes was detected in Asians and Hispanics.³⁵ The shorter “required” sleep in females than males in the current result must therefore be interpreted with caution.

Several limitations may be noted in the current study. First, using cross-sectional data, the direction of cause-effect is generally unclear in the relationship between sleep duration and depression/anxiety. Second, we used a self-report questionnaire to evaluate sleep habits and mental health. Regarding the length of sleep, we used the answer to a simple question about sleep duration and did not use time in bed, calculated from the bedtime and wake-up time. However, the sleep duration was almost the same as (or 3–9 min shorter than) the time in bed in all grades and in both males and females. For a more accurate estimate of sleep duration and bedtime regularity, objective measures, for example using actigraphy, may help future studies. For the evaluation of mental health, an interview-based survey might be more reliable, although the GHQ-12 is one of the most widely used tools for assessing current status of mental health. It should, in addition, be noted that the participants were asked to report sleep duration only on school nights. Third, sleep duration may fluctuate depending on the extent of bedtime irregularity. Answers about the duration of sleep could therefore be less accurate in those with more irregularity of bedtime, because estimating average sleep duration could be challenging for them. In addition, the regularity of bedtime was assessed using a simple question devised for

the current survey, not a validated questionnaire. The question asked about the frequency of nights with irregular bedtime, but not about the magnitude of the bedtime irregularity. These points should be noted as limitations. Fourth, the number of students who had \geq 9.5 h of sleep may be too small to fully examine the relationships between long sleep duration and mental health status. Fifth, the current participants were Japanese adolescents. Studies in other populations may be required to clarify to what extent the present results can be generalized. Sixth, data on socioeconomic status and genetic information were not available in the current study. Finally, the required durations of sleep in the current study were suggested as averages for the groups of subjects. Individual differences may exist in the required sleep, for which adequate data were not available, and there is little discussion about these differences.

In summary, we have estimated the duration of sleep on school nights that may be associated with the lowest risk of depression/anxiety for grade 7–12 adolescents. In males, sleeping 8.5 h or more may be associated with the least depression/anxiety, whereas in females, the duration was estimated to be 7.5 h or more. The shorter duration of the suggested sleep for females than for males must, however, be carefully interpreted, considering the worse mental health in females than males. A large number of the adolescents may currently be sleeping less than required. Interventions on short sleep might be a great help in improving mental health, although the suggested duration is the average and individual differences may exist.

REFERENCES

- Olds T, Maher C, Blunden S, Matricciani L. Normative data on the sleep habits of Australian children and adolescents. *Sleep* 2010;33:1381–8.
- Carskadon MA. Sleep in adolescents: the perfect storm. *Pediatr Clin North Am* 2011;58:637–47.
- Maslowsky J, Ozer EJ. Developmental trends in sleep duration in adolescence and young adulthood: evidence from a national United States sample. *J Adolesc Health* 2014;54:691–7.
- National Sleep Foundation. 2006 Sleep in America Poll, Summary of findings. Accessed August 5, 2014. <http://sleepfoundation.org/sleep-polls-data/sleep-in-america-poll/2006-teens-and-sleep>.
- Ohida T, Osaka Y, Doi Y, et al. An epidemiologic study of self-reported sleep problems among Japanese adolescents. *Sleep* 2004;27:978–85.
- Olds T, Blunden S, Petkov J, Forchino F. The relationships between sex, age, geography and time in bed in adolescents: a meta-analysis of data from 23 countries. *Sleep Med Rev* 2010;14:371–8.
- Matricciani L, Blunden S, Rigney G, Williams MT, Olds TS. Children’s sleep needs: is there sufficient evidence to recommend optimal sleep for children? *Sleep* 2013;36:527–34.
- Adolescent Sleep Working Group; Committee on Adolescence; Council on School Health. School start times for adolescents. *Pediatrics* 2014;134:642–9.
- Thapar A, Collishaw S, Pine DS, Thapar AK. Depression in adolescence. *Lancet* 2012;379:1056–67.
- Hankin B, Abramson L, Moffitt T, et al. Development of depression from preadolescence to young adulthood: emerging gender differences in a 10-year longitudinal study. *J Abnorm Psychol* 1998;107:128–40.
- Lewinsohn PM, Rohde P, Seeley JR, Klein DN, Gotlib IH. Natural course of adolescent major depressive disorder in a community sample: predictors of recurrence in young adults. *Am J Psychiatry* 2000;157:1584–91.

12. Kessler RC, Berglund P, Demler O, et al. Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Arch Gen Psychiatry* 2005;62:593–602.
13. Kaneita Y, Ohida T, Osaki Y, et al. Association between mental health status and sleep status among adolescents in Japan: a nationwide cross-sectional survey. *J Clin Psychiatry* 2007;68:1426–35.
14. Roberts RE, Duong HT. The prospective association between sleep deprivation and depression among adolescents. *Sleep* 2014;37:239–44.
15. Fitzgerald CT, Messias E, Buysse DJ. Teen sleep and suicidality: results from the youth risk behavior surveys of 2007 and 2009. *J Clin Sleep Med* 2011;15:351–6.
16. Sarchiapone M, Mandelli L, Carli V, et al. Hours of sleep in adolescents and its association with anxiety, emotional concerns, and suicidal ideation. *Sleep Med* 2014;15:248–54.
17. Public Health Group. Victorian burden of disease study: mortality and morbidity in 2001. Melbourne: Victorian Government Department of Human Services, 2005. Available at: [https://www2.health.vic.gov.au/getfile/?sc_itemid=%7BF84D614F-47FC-4027-BD0B-777AA49070A7%7D&title=Victorian Burden of Disease Study](https://www2.health.vic.gov.au/getfile/?sc_itemid=%7BF84D614F-47FC-4027-BD0B-777AA49070A7%7D&title=Victorian%20Burden%20of%20Disease%20Study). Accessed May 24, 2016.
18. Hirshkowitz M, Whiton K, Albert SM, et al. National Sleep Foundation's sleep time duration recommendations: methodology and results summary. *Sleep Health* 2015;1:40–3.
19. National Sleep Foundation. How Much Sleep Do We Really Need? Accessed May 21, 2015. Available at: <http://sleepfoundation.org/how-sleep-works/how-much-sleep-do-we-really-need>.
20. Watson NF, Badr MS, Belenky G, et al. Joint consensus statement of the American Academy of Sleep Medicine and Sleep Research Society on the recommended amount of sleep for a healthy adult: methodology and discussion. *Sleep* 2015;38:1161–83.
21. Jiunn-Horng Kang, Shih-Ching Chen. Effects of an irregular bedtime schedule on sleep quality, daytime sleepiness, and fatigue among university students in Taiwan. *BMC Public Health* 2009;9:248.
22. Li S, Zhu S, Jin X, et al. Risk factors associated with short sleep duration among Chinese school-aged children. *Sleep Med* 2010;11:907–16.
23. Lung HG, Reider BD, Whiting AB, Prichard JR. Sleep patterns and predictors of disturbed sleep in a large population of college students. *J Adolesc Health* 2010;46:124–32.
24. Kinoshita Y, Shimodera S, Nishida A, et al. Psychotic-like experiences are associated with violent behavior in adolescents. *Schizophr Res* 2011;126:245–51.
25. Doi Y, Minowa M. Factor structure of the 12-item General Health Questionnaire in the Japanese general adult population. *Psychiatry Clin Neurosci* 2003;57:379–83.
26. Goldberg DP, Rickels K, Downing R, Hesbacher P. A comparison of two psychiatric screening tests. *Br J Psychiatry* 1976;129:61–7.
27. Goldberg DP, Gater R, Sartorius N, et al. The validity of two versions of the GHQ in the WHO study of mental illness in general health care. *Psychol Med* 1997;27:191–7.
28. Tait RJ, French DJ, Hulse GK. Validity and psychometric properties of the General Health Questionnaire-12 in young Australian adolescents. *Aust N Z J Psychiatry* 2003;37:374–81.
29. Baksheev GN, Robinson J, Cosgrave EM, Baker K, Yung AR. Validity of the 12-item General Health Questionnaire (GHQ-12) in detecting depressive and anxiety disorders among high school students. *Psychiatry Res* 2011;187:291–6.
30. Banks MH. Validation of the General Health Questionnaire in a young community sample. *Psychol Med* 1983;13:349–53.
31. Nakagawa Y, Daibo I. Tests of the validity and reliability of the Japanese version General Health Questionnaire and its clinical applications. In: Nakagawa Y, ed. *The theory behind understanding psychiatric and neurotic symptoms using a questionnaire and its clinical applications*, Monograph of National Institute of Mental Health, Part 2: National Institute of Mental Health, 1982. (In Japanese)
32. Matamura M, Tochigi M, Usami S, et al. Associations between sleep habits and mental health status and suicidality in a longitudinal survey of monozygotic twin adolescents. *J Sleep Res* 2014;23:290–4.
33. Ministry of Education, Culture, Sports, Science and Technology in Japan [MEXT]. Statistics. Accessed April 20, 2016. Available at: <http://www.mext.go.jp/english/statistics/>.
34. Hastie T, Tibshirani R. Generalized additive models. *Stat Sci* 1986;1:297–318.
35. Orgonek KDM, Taylor DJ, Petrie T, et al. Adolescent sleep disparities: sex and racial/ethnic differences. *Sleep Health* 2015;1:36–9.
36. Munezawa T, Kaneita Y, Osaki Y, et al. The association between use of mobile phones after lights out and sleep disturbances among Japanese adolescents: a nationwide cross-sectional survey. *Sleep* 2011;34:1013–20.
37. Lee YJ, Cho SJ, Cho IH, Kim SJ. Insufficient sleep and suicidality in adolescents. *Sleep* 2012;35:455–60.
38. Chen T, Wu Z, Shen Z, et al. Sleep duration in Chinese adolescents: biological, environmental, and behavioral predictors. *Sleep Med* 2014;15:1345–53.
39. Watson NF, Harden KP, Buchwald D, et al. Sleep duration and depressive symptoms: a gene-environment intervention. *Sleep* 2014;37:351–8.
40. Van Mill JG, Vogelzangs N, van Someren EJ, et al. Sleep duration, but not insomnia, predicts the 2-year course of depressive and anxiety disorders. *J Clin Psychiatry* 2014;75:119–26.
41. Liu X, Buysse DJ, Gentzler AL, et al. Insomnia and hypersomnia associated with depressive phenomenology and comorbidity in childhood depression. *Sleep* 2007;20:83–90.
42. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders, 4th ed, Text Revision*. Washington, DC: American Psychiatric Association, 2000.
43. Singh T, Williams K. Atypical depression. *Psychiatry* 2006;3:33–9.
44. Dauvilliers Y, Lopez R, Ohayon M, Bayard S. Hypersomnia and depressive symptoms: methodological and clinical aspects. *BMC Med* 2013;11:78.
45. Marinoni A, Degrate A, Villani S, et al. Psychological distress and its correlates in secondary school students in Pavia, Italy. *Eur J Epidemiol* 1997;13:779–86.
46. Saluja G, Iachan R, Scheidt PC, et al. Prevalence of and risk factors for depressive symptoms among young adolescents. *Arch Pediatr Adolesc Med* 2004;158:760–5.
47. Pelkonen M, Marttunen M, Aro H. Risk for depression: 6-year follow-up of Finnish adolescents. *J Affect Disord* 2003;77:41–51.

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