Journal of Behavioral and Brain Science, 2024, 14, 227-239
https://www.scirp.org/journal/jbbs
ISSN Online: 2160-5874
ISSN Print: 2160-5866

# A Proposal on the Novel Method to Estimate Optimal Sleep Duration Based on Self-Reported Survey Data

**Jun Kohyama**

Department of Pediatrics, Tokyo Bay Urayasu Ichikawa Medical Center, Chiba, Japan
Email: info@j-kohyama.jp

**How to cite this paper:** Kohyama, J. (2024) A Proposal on the Novel Method to Estimate Optimal Sleep Duration Based on Self-Reported Survey Data. *Journal of Behavioral and Brain Science*, **14**, 227-239.
https://doi.org/10.4236/jbbs.2024.148014

**Received:** June 19, 2024
**Accepted:** August 3, 2024
**Published:** August 6, 2024



## Abstract

**Background:** Many adolescents have a sleep debt. Individuals sleeping for their optimal sleep duration are expected to experience no sleepiness. Then, it is important to recognize one's optimal sleep duration to reduce sleep debt. However, there is no simple method to determine this value. Since body mass index and sleep duration exhibit a U-shaped association, it is expected that a person taking optimal sleep duration would show no marked deviation from the mean body mass index value for the population evaluated. By using self-reported sleepiness and standardized body mass index, this study aimed to estimate individual optimal sleep duration. **Methods:** Data from 2540 grade 5 - 11 students were used. Students who declared no sleepiness during class and also had a gender- and grade-standardized body mass index of ±1.5 were termed ideal students. The average sleep durations of ideal students were compared with those of non-ideal students. The differences of sleep duration between ideal and no-ideal students were added to habitual sleep duration of each non-ideal student to obtain assumed optimal sleep duration. A multiple regression line to predict assumed optimal sleep duration was calculated using the least squares method. **Results:** The mean sleep duration of 666 ideal students exceeded the lower limit of daily sleep duration proposed as "may be appropriate" for children aged 6 - 17 years by National Sleep Foundation of the USA, being longer than those of non-ideal students. Significant regression formula for assumed optimal sleep duration was obtained (adjusted $R^2$ = 0.996, $p < 0.001$), and the following formula to estimate daily optimal sleep duration was obtained; 0.714*(sleep duration of weekdays) + 0.284*(sleep duration of non-schooldays) + 0.513*(sleepiness score; 1 - 4) + 0.002*(grade; 5 - 11) + 0.009*[gender (male: 1; female: 2)] − 0.005*(social jetlag) + 0.008*(standardized body mass index) − 0.501. **Conclusions:** No contradiction was identified in the sleep duration obtained from ideal students as with optimal sleep duration. Although further studies to confirm the current estimation are

needed, a simple formula to estimate individual optimal sleep duration through easily obtainable parameters was proposed.

## Keywords

Body Mass Index, Catch-Up Sleep, Insufficient Sleep Syndrome, Optimal Sleep Duration, Sleepiness

## 1. Introduction

Sleep is a fundamental physiological process that is indispensable for maintaining physical and mental health [1]. Although both sleep quality and sleep quantity are basic sleep components, not enough studies on the associations between sleep quality and health or diseases have been performed [2]. The commonly obtained objective polysomnographic indices have been known to contribute little to the subjective ratings of sleep quality [3], and recently, subjective measures such as nonrestorative sleep [4] or "feeling fresh" [5] after waking have been paid attention for evaluating sleep quality. However, so far, no recommendation has been proposed on sleep quality. On the other hand, several recommendations on sleep quantity have been published [6] [7].

Most people in the modern society, especially adolescents [8], downplay the importance of sleep and develop insufficient sleep syndrome by accumulating a sleep debt. Among patients aged ≤20 years who attended an outpatient sleep clinic, 31% were diagnosed as having insufficient sleep syndrome [9]. Moreover, the prevalence of insufficient sleep syndrome among adolescents has been reported as 10% - 20% [10]-[12]. To reduce the sleep debt or counteract insufficient sleep syndrome, it is important to recognize one's own optimal sleep duration (OSD). Persons who take their OSD are assumed to show no sleepiness [13] [14]. However, there is no simple method to determine the OSD.

Classically, the OSD is measured by allowing participants to sleep for a long duration over multiple nights prior to accumulating a sleep debt. Their sleep duration shows a gradual decrease to a constant duration, which is assumed to be the OSD. According to Dement [13], Barbato *et al.* [14] monitored the sleep of eight healthy male volunteers with a mean age of 29.0 years for 5 weeks. The daily photoperiod was 16 hours during the first week, which decreased to 10 hours over the following 4 weeks. The subjects were instructed to remain in bed and to sleep whenever possible during the dark period. Their average nightly sleep time during the first week was 7.6 hours. When the dark period increased to 14 hours, their average total daily sleep time increased to more than 12 hours on the first night of the second week, and then gradually declined to an average of 8.25 hours by the fourth week (the third week of the longer dark period session), when they continued to be in bed in the dark for 5.75 hours without obtaining extra sleep. The authors concluded that the real daily OSD for these eight subjects was 8.25 hours. Similarly, the OSD has been estimated to be 8.88 hours

(range, 8.28 - 9.32 hours) for adolescents [15], 8.23 hours [16] and 8.9 hours [17] for young adults, 7.4 hours for older adults [17], and 8.41 hours (range, 7.29 - 9.26 hours) for 15 healthy young men [18], respectively. A major drawback to these methods is the substantial time they require to obtain results.

Van Dongen *et al.* [19] and Short *et al.* [15] estimated the maximum length of daily wakefulness that would not lead to deficits in sustained attention measured by a psychomotor vigilance task test. The estimated value was 15.84 hours for adults and 14.65 hours for adolescents. Thus, a sleep duration of 8.16 hours [19] and 9.35 hours [15] was needed to maintain optimal sustained attention performance. Eide and Showalter [20] and Fuligni *et al.* [21] estimated the OSD among adolescents based on the hypothesis that students with the highest academic performance score have an OSD. However, it is questionable whether students with an OSD always display a high academic performance level. Although a sleep debt might be associated with poor academic performance, it might also be affected by each individual's capabilities. In fact, sleep duration has shown a weaker correlation to school performance than to sleepiness [22]-[24]. The National Sleep Foundation of the USA indicates that sleep duration varies by age [6]. According to this recommendation, the lower limit of daily sleep duration proposed as "may be appropriate" is 7 hours for children aged 6 - 17 years and the upper limit is 12 hours for children aged 6 - 13 years and 11 hours for those aged 14 - 17 years, respectively.

With respect to the OSD, body mass index (BMI) has been paid little attention. BMI is known to exhibit a U-shaped association with sleep duration [25]. Similar results have been obtained for adolescents [26] [27], although a different finding has also been reported [28]. On this U-shaped curve, sleep duration where BMI shows its trough value could be assumed as an OSD for the population. Thus, it could also be assumed that a person who sleeps for his/hers OSD shows no large deviation from the average BMI value for that population.

This study aimed to estimate individual optimal sleep duration on the basis of two assumptions; persons who take their OSD show no sleepiness, and those sleep for their OSD show no large deviation from the average BMI value for that population.

## 2. Materials and Methods

This cross-sectional study was approved in 2016 by the Committee for Medical Research Ethics of Tokyo Bay Urayasu Ichikawa Medical Center (Approval No. 199). It was conducted between October 2016 and November 2018 from 28 public schools (15 elementary schools, 8 junior high schools, and 5 senior high schools) located in Kanto district of Japan [24] [29]-[32]. Though the originally collected data were obtained from grade 5 - 12 students, the present analysis used a part of those data obtained in the same survey, because the recommended criteria [6] used as references in this study demonstrated the lower limit of daily sleep duration proposed as "may be appropriate" is 7 hours for children aged 6 - 17 years. Then, this study used data from grade 5 - 11 students (corresponding years of age ranged 10 - 17), because grade 12 included students aged 18 years old. The teachers

handed out the questionnaires (Table 1) with a letter stating that the responses would be anonymous and confidential and that participation was voluntary. The teachers collected written informed consent from each pupil (signed by his/her guardian) as well as the completed questionnaires and sent them to the author.

Table 1. Questionnaire.

| Queries. | Choices for answer |
|---|---|
| Please select your grade. | Elementary school (Grade 5, 6), Junior high school (Grade 1, 2, 3), High school (Grade 1, 2, 3) |
| Please select your gender. | Gender (male, female) |
| Please describe your height and weight. | Height (cm), Weight (kg) |
| Please select your bedtime before schooldays. | 1: <8 PM; 2: 8 - 9 PM; 3: 9 - 10 PM; 4: 10 - 11 PM; 5: 11 PM - 12 AM;6: 12 - 1 AM; 7: 1 - 2 AM; 8: 2 - 3 AM; or 9: >3 AM |
| Please select your bedtime before non-schooldays. | 1: <8 PM; 2: 8 - 9 PM; 3: 9 - 10 PM; 4: 10 - 11 PM; 5: 11 PM - 12 AM;6: 12 - 1 AM; 7: 1 - 2 AM; 8: 2 - 3 AM; or 9: >3 AM |
| Please select your waking time on schooldays. | 1: <5 AM; 2: 5 - 6 AM; 3: 6 - 7 AM; 4: 7 - 8 AM; 5: 8 - 9 AM; 6: 9 - 10 AM; 7: 10 - 11 AM; 8: 11 AM - 12 PM; or 9: >12 PM |
| Please select you waking time on non-schooldays. | 1: <5 AM; 2: 5 - 6 AM; 3: 6 - 7 AM; 4: 7 - 8 AM; 5: 8 - 9 AM; 6: 9 - 10 AM; 7: 10 - 11 AM; 8: 11 AM - 12 PM; or 9: >12 PM |
| Please select the frequency you feel sleepy during class. (sleepiness score) | 1: never; 2: sometimes; 3: often; or 4: always |
| Please select your frequency of eating breakfast. (breakfast taking score) | 1: always; 2: often; 3: sometimes; or 4: never |
| Please select your frequency of defecation. (defecation frequency score) | 1: every day; 2: every other day; 3: once every 2 - 3 days; 4: twice a week or less |
| Please select the time you usually eat dinner. | 1: around 6 PM; 2: around 7 PM; 3: around 8 PM; 4: around 9 PM; 5: around 10 PM; 6: around 11 PM; 7: later than 11 PM; or 8: not determined |
| Do you take part in any kind of after-school activity? | 1: yes; 2: no |
| If yes, please select your frequency of participating in after-school activity. | 1: once a week; 2: twice a week; 3: three times a week; 4: four times a week; 5: five times a week; 6: six times a week; or 7: every day |
| If yes, please select the average duration of a single after-school activity. | 1: 1 hour; 2: 2 hours; 3: 3 hours; 4: 4 hours; or 5: 5 hours or more |
| How many days a week do you engage in habitual exercise except for school lessons? | 0: none; 1: 1 day per week; 2: 2 days per week; 3: 3 days per week; 4: 4 days per week; 5: 5 days per week; 6: 6 days per week; or 7: 7 days per week |
| How long do you use variable media tools (television, video, video game, digital versatile disc, computer, tablet, mobile [cell] phone, smart phone) in a day? Please answer separately for schooldays and non-schooldays. (screen time score) | On a school day:<br>1: <2 hours; 2: 2 - 4 hours; 3: 4 - 6 hours; 4: 6 - 8 hours; or 5: 8 hours or more.<br>On a non-school day:<br>1: <2 hours; 2: 2 - 4 hours; 3: 4 - 6 hours; 4: 6 - 8 hours; or 5: 8 hours or more. |
| Please select the best category for your overall academic performance. | 1: very good; 2: good; 3: not good; or 4: poor. |

The participants provided their grade, gender, height, and weight. The latter two figures were used to calculate the BMI (kg/m$^2$). Both gender- and grade-standardized BMIs (with standard deviations as the units) were used for the analysis. With regard to bedtime and waking times, students were asked to choose one of nine 1-hour interval categories (bedtime: 1, before 20:00; 2, 20:00 - 21:00…8, 02:00 - 3:00, 9, after 3:00; waking time: 1, before 5:00; 2, 5:00 - 6:00…8, 11:00 - 12:00; 9, after 12:00). The representative times for categories 2 - 8 were determined as their means (bedtime: 20:30, 21:30…1:30, 2:30; waking: 5:30, 6:30…10:30, 11:30). For categories 1 and 9, the representative times were 19:30 and 3:30 for bedtime and 4:30 and 12:30 for waking time, respectively. The students provided these bedtimes and waking times separately for schooldays and non-schooldays. Social jetlag (the difference of the midpoint time of sleep between non-schooldays and schooldays [32] [33]) was also calculated from these bedtime and wake-up time data. Furthermore, these times were used to calculate separately the night-time sleep duration of the night before schooldays and non-schooldays. The weekly sleep duration was calculated with the following formula: [(sleep duration before schooldays) × 5] + [(sleep duration before non-schooldays) × 2]. Sleepiness during school class was scored based on four subjective categories (1, never; 2, sometimes; 3, often; and 4, always). Students who declared no sleepiness during class and with a standardized BMI between −1.5 to +1.5 were termed as ideal-students (id-St); all others were named as non-ideal students (non-id-St). The weekly sleep duration was compared between id-ST and non-id-St. In addition, the percentage of id-St and non-id-St students whose weekly sleep duration was less than 49 hours (7 times the value of the lower limit of daily sleep duration proposed as "may be appropriate" for children aged 6 - 17 years by the National Sleep Foundation of the USA [6]) was determined and compared.

In order to examine whether id-St can be regarded as having an OSD, the following two issues were evaluated: 1) Sleep duration of id-St is within the range of the authorized proposal [6]. 2) Sleep duration of id-St is longer than that of non-id-St. After evaluating these two issues, an individual OSD was assumed by using self-reported sleepiness and standardized BMI. Regarding the second issue, extra explanation is needed. Firstly, sleep duration of students who do not experience sleepiness is assumed to be longer compared to that of students who experience sleepiness, since subjective sleepiness increases with decreased sleep duration. Secondary, taking the U-shaped distribution between BMI and sleep duration into consideration [25]-[27], students with a BMI significantly deviating from the mean BMI are presumed to have either longer or shorter sleep duration than the OSD, that is, no consistent result is expected on the latter assumption. Then, by summating the former consistent estimation and the latter inconsistent assumption together, sleep duration of id-St is presumed to be longer than that of non-id-St.

An assumed OSD of each non-id-St was calculated according to the following process. Non-ideal students were divided into 11 categories by means of sleepi-

ness (1, 2, 3, and 4) and standardized BMI [high (1.5 or more), medium (within ±1.5 ), and low (−1.5 or less)]. Differences of averaged sleep duration between each non-id-St category and that of id-St was added to habitual sleep duration of each non-id-St individually. This summated sleep duration was termed as assumed OSD of non-id-ST. For id-St, their own habitual sleep durations were used as assumed OSD. A multiple regression line to predict assumed OSD as the dependent variable was calculated by the least squares method, using grade, gender, sleepiness score, standardized BMI, self-reported academic performance, after-school activity (hours/week), breakfast taking score, defecation frequency score, physical activity (days/week), screen time score both per schooldays and non-schooldays, sleep duration before both schooldays and non-schooldays as the explanatory variables.

The t-test, and the Bonferroni multiple comparison test (BMCT) were used for statistical analysis, as appropriate. A p-value < 0.05 with an effect size (Cohen's d) > 0.20 for the t-test and BMCT [34] were considered to be significant. Analyses were conducted using the BellCurve program for Excel.

## 3. Results

Among 2540 students, 666 (male, 374; female, 292) were categorized as id-St. The mean weekly sleep duration of the id-St group was greater than that of the non-id-St group, although significant differences were observed only in the junior high school students (**Table 2**). The mean sleep duration of id-St was within the range of the authorized proposal [6]. The BMCT indicated a significant difference in the average weekly sleep duration among the three school types for both id-ST and non-id-St.

**Table 2.** Weekly sleep duration of ideal and non-ideal students.

| School type | id-St | | Non-id-St | | p value | d value |
|---|---|---|---|---|---|---|
| | N | mean, SD (hrs.) | N | mean, SD (hrs.) | | |
| Elementary school | 422 | 62.0, 4.7 | 534 | 61.2, 5.4 | 0.02 | <0.2 |
| Junior high school | 212 | 55.6, 6.5 | 837 | 54.1, 7.1 | <0.01 | 0.23 |
| Senior high school | 32 | 50.1, 9.0 | 503 | 48.6, 7.0 | 0.38 | <0.2 |

id-St: ideal students; non-id-St: non-ideal students; SD: standard deviations; N: number; hrs.: hours.

The rates of students whose weekly sleep duration was less than 49 h were 0.9% for id-St and 1.9% for non-id-St among elementary school students, 12.7% and 17.1% among junior high school students, and 39.3% and 47.1% for senior high school students, respectively.

The mean daily sleep durations of id-St and 11 non-id-St categories were shown in **Table 3**. **Table 4** showed regression coefficients obtained by the least square method to calculate multiple regression line, setting assumed OSD as the dependent variable. Significant regression formula for assumed OSD was ob-

tained (adjusted $R^2$ = 0.996, $p < 0.001$), and the following formula to estimate daily OSD was obtained; 0.714*(sleep duration of weekdays) + 0.284*(sleep duration of non-schooldays) + 0.513*(sleepiness score; 1 - 4) + 0.002*(grade; 5 - 11) + 0.009*[gender (male:1; female: 2)] − 0.005*(social jetlag) + 0.008*(standardized body mass index) − 0.501.

**Table 3.** Daily sleep durations of ideal students and 11 non-ideal students' categories.

| Students | Standardized BMI | N | Averaged sleep duration (hrs.) | Standard deviation (hrs.) |
|---|---|---|---|---|
| Ideal students | Medium BMI | 666 | 8.49 | 0.95 |
| Non-id-St with no sleepiness (sleepiness score:1) | High BMI | 56 | 8.45 | 0.87 |
| | Low BMI | 14 | 8.13 | 0.88 |
| Non-id-St with sleepiness score 2 | High BMI | 94 | 7.91 | 1.26 |
| | Medium BMI | 1198 | 7.98 | 1.09 |
| | Low BMI | 36 | 8.14 | 1.07 |
| Non-id-St with sleepiness score 3 | High BMI | 22 | 7.18 | 1.26 |
| | Medium BMI | 296 | 7.34 | 1.16 |
| | Low BMI | 8 | 7.71 | 0.86 |
| Non-id-St with sleepiness score 4 | High BMI | 14 | 7.39 | 1.33 |
| | Medium BMI | 135 | 7.01 | 1.19 |
| | Low BMI | 1 | 6.57 | N/A |

non-id-St: non-ideal students; sleepiness score 1: never felt sleepiness during school class; sleepiness score 2: sometimes felt sleepiness during school class; sleepiness score 3: often felt sleepiness during school class; sleepiness score 4: always felt sleepiness during school class; BMI: body mass index; high BMI: 1.5 or more standardized BMI value; medium BMI: within ±1.5 standardized BMI; low BMI: −1.5 or less standardized BMI; hrs.: hours; N: number; h: hours; N/A: not applicable.

**Table 4.** Regression coefficients obtained by the least square method to calculate multiple regression line, setting assumed optimal sleep duration as the dependent variable.

| Variables | Regression coefficient | | | | $\beta$ | p |
|---|---|---|---|---|---|---|
| | | 95% CI | | | | |
| Constant | −0.501 | −0.540 | to | −0.462 | −0.501 | 0.001> |
| Grade (5 - 11) | 0.002 | 0.000 | to | 0.004 | 0.004 | 0.038 |
| Gender (male:1; female:2) | 0.009 | 0.003 | to | 0.015 | 0.004 | 0.002 |
| After school activity (hrs./week) | −0.000 | −0.000 | to | 0.000 | −0.000 | 0.960 |
| Breakfast taking score | −0.003 | −0.009 | to | 0.002 | −0.002 | 0.188 |
| Defecation frequency score | 0.001 | −0.002 | to | 0.004 | 0.001 | 0.655 |
| Physical activity (days/week) | 0.000 | −0.001 | to | 0.001 | 0.001 | 0.420 |

**Continued**

| | | | | | | |
|---|---|---|---|---|---|---|
| Self-reported academic performance score | 0.002 | −0.002 | to | 0.006 | 0.002 | 0.259 |
| Screen time score on schooldays | −0.005 | −0.010 | to | 0.000 | −0.004 | 0.053 |
| Screen time score on non-schooldays | 0.001 | −0.003 | to | 0.005 | 0.001 | 0.599 |
| Social jetlag (hrs.) | −0.005 | −0.009 | to | −0.001 | −0.004 | 0.027 |
| Sleep duration on schooldays | 0.714 | 0.710 | to | 0.717 | 0.826 | 0.001> |
| Sleep duration on non-schooldays | 0.284 | 0.281 | to | 0.286 | 0.372 | 0.001> |
| Sleepiness score | 0.513 | 0.509 | to | 0.517 | 0.388 | 0.001> |
| Standardized BMI | 0.008 | 0.005 | to | 0.011 | 0.008 | 0.001> |

BMI: body mass index; CI: confidence interval; $\beta$: standardized regression coefficient.

## 4. Discussion

This study revealed that the average weekly sleep duration of id-St exceeded 49 h, which is the lower sleep duration proposed as "may be appropriate" for children aged 6 to 17 years by the National Sleep Foundation of the USA [6]. Additionally, the mean weekly sleep duration of id-St in all school types was longer than that of non-id-St, and the rate of students whose weekly sleep duration was less than 49 h was higher in the non-id-St group compared to that in the id-St group. Suffice it to say that there was no contradiction to regard sleep duration of id-St as an OSD. However, it should also be noted that the currently obtained values for each school type were lower than reported OSDs [10]-[14]. Additionally, some id-St had a sleep duration of less than 49 hours. Moreover, subjective sleepiness is known to underestimate the real sleep deficiency [19]. Hence, students whose weekly sleep duration is less than 49 hours should be carefully monitored, even if they are considered id-St.

After confirming the above-mentioned two issues (sleep duration of id-St was within the range of the authorized proposal [6], and sleep duration of id-St is longer than that of non-id-St), the formula to estimate daily OSD was calculated. For example, estimated daily OSD of a grade-9-boy-student who had 6 hours sleep on schooldays, 9 hours sleep on non-schooldays, felt sleepiness sometimes in the class, social jetlag of 1.5 hours and had a standardized BMI of +1.3 was calculated as follows; $(0.714 \times 6) + (0.284 \times 9) + (0.513 \times 2) + (0.002 \times 9) + (0.009 \times 1) - (0.005 \times 1.5) + (0.008 \times 1.3) - 0.501 = 7.3949$ hours (=51.7643-hour weekly OSD). Most adolescents are known to sleep longer on the weekend than on weekdays [1] [35] [36]. This phenomenon, called weekend catch-up sleep, has become almost indispensable for modern adolescents [31] [35] [36]. Determining one's own OSD must be the first step to reduce a sleep debt [31], however, authorized proposals for the sleep duration [6] [7] demonstrated wide range due to the marked interindividual variations for each person's daily OSD. Hence, these recommendations tend to be neglected, even though many adolescents know that they are sleep deprived. Taking weekend catch-up sleep into consid-

eration, it may be easier for student to assess their own OSD based on the weekly sleep duration. If 1.5-hour-catch-up sleep is allowed, we could advise the above-mentioned student to take 6.9663 (= [51.7643 − (1.5 × 2)]/7) -hour-sleep on schooldays and 8.4663 (= 6.9663 + 1.5) -hour-sleep on non-schooldays, respectively. If students know their own OSD without difficulty by using currently proposed formula, then students with a sleep debt may pay more attention to increase their sleep duration, resulting in improvements to their physical and mental health, although social pressure to decrease their sleep duration would still exist. If students themselves can recognize even a slight improvement in their mental and physical state by increasing their sleep duration, it is expected that their motivation to increase their sleep duration until reaching their own OSD will be enhanced. It is also important for the surrounding support to encourage students to take a step towards increasing their sleep duration, even if it's just a little.

The mean weekly sleep duration of id-St decreased significantly from elementary school to senior high school. However, a recent review pointed out the possibility that the OSD may not be shortened during adolescence [37]. Additional studies need to be conducted to investigate this issue.

There were several limitations in this study. First, the questionnaire was not standardized or validated. The survey, using the questionnaire referred to when creating the one for this study, has been conducted biennially since 1993 with revisions, using as the basic material for policy making [38]. In addition, it has been published describing lifestyles of children in Japan [38]. Although no scientific article discussing generalization of the questionnaire has been found [39], this questionnaire is assumed to be a generalized and established one. Second, the current study relied on self-reports from students and thus it lacked direct measurements of sleep duration, height, weight, and other evaluated factors. This design was one of the biggest limitations to the present study. However, the current sleep duration and the mean BMI values are similar to the results for Japanese schoolchildren [38]. This similarity could support the external validity of this study to some extent. The third problem was on the sleepiness scale. Though there are several standardized scales for assessing sleepiness, the present study used a simple one query with four choices. The Stanford Sleepiness Scale is a one-item self-report rating scale (7-point) specifically focusing on sleepiness [40], and the Epworth Sleepiness Scale evaluates the ease of falling asleep [41]. However, the test–retest reliability of the Epworth Sleepiness Scale has recently been found to be poor [42]. Although the original questionnaire [38] had a single question with two choices as for sleepiness, current study made four choices for a single query. Through the same single question with four choices, factors associated with sleepiness were assessed in a survey introduced above [24] [29]. By using the same simple questionnaire, sleepy pupils were independently associated with not only late bedtime but also poor academic performance and breakfast skipping [30]. There is a description that the scale with a single-item measure is best suited for repeated use over the course of a research study [43].

Forth, the present study also did not measure demographic factors such as family composition, socioeconomic status, sleeping/bedroom arrangements and parents' educational background. Among these factors, socioeconomic status is a crucial issue to examine in association with lifestyle behaviors, including sleep [44]. In addition, it may be important to know features of id-St, however, this study failed to know details on their geographic and economic features. Finally, this study was cross-sectional, and thus the current findings failed to identify a causal relationship. The study failed to obtain enough internal validity.

## 5. Conclusion

In spite of above-mentioned weak points, the current study raised the possibility that BMI in addition to sleepiness score could be used to assess an OSD. After confirming this possibility, this study proposed a simple formula to estimate individual OSD through easily obtainable parameters. Of course, further studies to confirm the current proposal are needed. Recognizing one's own OSD is the first step to reducing sleep debt [31]. It is expected that this study will help students suffering from chronic sleep debt.

## Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

## References

[1] Pérez-Carbonell, L., Mignot, E., Leschziner, G. and Dauvilliers, Y. (2022) Understanding and Approaching Excessive Daytime Sleepiness. *The Lancet*, **400**, 1033-1046. https://doi.org/10.1016/s0140-6736(22)01018-2

[2] Kohyama, J. (2021) Which Is More Important for Health: Sleep Quantity or Sleep Quality? *Children*, **8**, Article 542. https://doi.org/10.3390/children8070542

[3] Kaplan, K.A., Hirshman, J., Hernandez, B., Stefanick, M.L., Hoffman, A.R., Redline, S., *et al.* (2017) When a Gold Standard Isn't So Golden: Lack of Prediction of Subjective Sleep Quality from Sleep Polysomnography. *Biological Psychology*, **123**, 37-46. https://doi.org/10.1016/j.biopsycho.2016.11.010

[4] Yoshiike, T., Utsumi, T., Matsui, K., Nagao, K., Saitoh, K., Otsuki, R., *et al.* (2022) Mortality Associated with Nonrestorative Short Sleep or Nonrestorative Long Time-in-Bed in Middle-Aged and Older Adults. *Scientific Reports*, **12**, Article No. 189. https://doi.org/10.1038/s41598-021-03997-z

[5] Fadzil, A. (2021) Factors Affecting the Quality of Sleep in Children. *Children*, **8**, Article 122. https://doi.org/10.3390/children8020122

[6] Hirshkowitz, M., Whiton, K., Albert, S.M., Alessi, C., Bruni, O., DonCarlos, L., *et al.* (2015) National Sleep Foundation's Sleep Time Duration Recommendations: Methodology and Results Summary. *Sleep Health*, **1**, 40-43. https://doi.org/10.1016/j.sleh.2014.12.010

[7] Paruthi, S., Brooks, L.J., D'Ambrosio, C., Hall, W.A., Kotagal, S., Lloyd, R.M., *et al.* (2016) Recommended Amount of Sleep for Pediatric Populations: A Consensus Statement of the American Academy of Sleep Medicine. *Journal of Clinical Sleep Medicine*, **12**, 785-786. https://doi.org/10.5664/jcsm.5866

[8] Galván, A. (2020) The Need for Sleep in the Adolescent Brain. *Trends in Cognitive Sciences*, **24**, 79-89. https://doi.org/10.1016/j.tics.2019.11.002

[9] Kohyama, J., Anzai, Y., Ono, M., Kishino, A., Tamanuki, K., Takada, K., *et al.* (2018) Insufficient Sleep Syndrome: An Unrecognized but Important Clinical Entity. *Pediatrics International*, **60**, 372-375. https://doi.org/10.1111/ped.13519

[10] Pallesen, S., Saxvig, I.W., Molde, H., Sorensen, E., Wilhelmsen-Langeland, A. and Bjorvatn, B. (2010) Brief Report: Behaviorally Induced Insufficient Sleep Syndrome in Older Adolescents: Prevalence and Correlates. *Journal of Adolescence*, **34**, 391-395. https://doi.org/10.1016/j.adolescence.2010.02.005

[11] Lee, Y.J., Cho, S., Cho, I.H. and Kim, S.J. (2012) Insufficient Sleep and Suicidality in Adolescents. *Sleep*, **35**, 455-460. https://doi.org/10.5665/sleep.1722

[12] Williams, A.B., Dzierzewski, J.M., Griffin, S.C., Lind, M.J., Dick, D. and Rybarczyk, B.D. (2019) Insomnia Disorder and Behaviorally Induced Insufficient Sleep Syndrome: Prevalence and Relationship to Depression in College Students. *Behavioral Sleep Medicine*, **18**, 275-286. https://doi.org/10.1080/15402002.2019.1578772

[13] Dement, W.C. (2005) Sleep Extension: Getting as Much Extra Sleep as Possible. *Clinics in Sports Medicine*, **24**, 251-268. https://doi.org/10.1016/j.csm.2004.12.014

[14] Barbato, G., Barker, C., Bender, C., Giesen, H.A. and Wehr, T.A. (1994) Extended Sleep in Humans in 14 Hour Nights (LD 10:14): Relationship between REM Density and Spontaneous Awakening. *Electroencephalography and Clinical Neurophysiology*, **90**, 291-297. https://doi.org/10.1016/0013-4694(94)90147-3

[15] Short, M.A., Weber, N., Reynolds, C., Coussens, S. and Carskadon, M.A. (2018) Estimating Adolescent Sleep Need Using Dose-Response Modeling. *Sleep*, **41**, zsy011. https://doi.org/10.1093/sleep/zsy011

[16] Wehr, T.A., Moul, D.E., Barbato, G., Giesen, H.A., Seidel, J.A., Barker, C., *et al.* (1993) Conservation of Photoperiod-Responsive Mechanisms in Humans. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology*, **265**, R846-R857. https://doi.org/10.1152/ajpregu.1993.265.4.r846

[17] Klerman, E.B. and Dijk, D. (2008) Age-Related Reduction in the Maximal Capacity for Sleep—Implications for Insomnia. *Current Biology*, **18**, 1118-1123. https://doi.org/10.1016/j.cub.2008.06.047

[18] Kitamura, S., Katayose, Y., Nakazaki, K., Motomura, Y., Oba, K., Katsunuma, R., *et al.* (2016) Estimating Individual Optimal Sleep Duration and Potential Sleep Debt. *Scientific Reports*, **6**, Article No. 35812. https://doi.org/10.1038/srep35812

[19] Van Dongen, H.P.A., Maislin, G., Mullington, J.M. and Dinges, D.F. (2003) The Cumulative Cost of Additional Wakefulness: Dose-Response Effects on Neurobehavioral Functions and Sleep Physiology from Chronic Sleep Restriction and Total Sleep Deprivation. *Sleep*, **26**, 117-126. https://doi.org/10.1093/sleep/26.2.117

[20] Eide, E.R. and Showalter, M.H. (2012) Sleep and Student Achievement. *Eastern Economic Journal*, **38**, 512-524. https://doi.org/10.1057/eej.2011.33

[21] Fuligni, A.J., Arruda, E.H., Krull, J.L. and Gonzales, N.A. (2017) Adolescent Sleep Duration, Variability, and Peak Levels of Achievement and Mental Health. *Child Development*, **89**, e18-e28. https://doi.org/10.1111/cdev.12729

[22] Dewald, J.F., Meijer, A.M., Oort, F.J., Kerkhof, G.A. and Bögels, S.M. (2010) The Influence of Sleep Quality, Sleep Duration and Sleepiness on School Performance in Children and Adolescents: A Meta-Analytic Review. *Sleep Medicine Reviews*, **14**, 179-189. https://doi.org/10.1016/j.smrv.2009.10.004

[23] Cohen-Zion, M. and Shiloh, E. (2017) Evening Chronotype and Sleepiness Predict Impairment in Executive Abilities and Academic Performance of Adolescents. *Chro-*

*nobiology International*, **35**, 137-145.
https://doi.org/10.1080/07420528.2017.1387792

[24] Kohyama J. (2020) Associations of Adolescents' Lifestyle Habits with Their Daytime Functioning in Japan. *Sleep Science*, **13**, 286-292.
https://doi.org/10.5935/1984-0063.20190151

[25] Taheri, S., Lin, L., Austin, D., Young, T. and Mignot, E. (2004) Short Sleep Duration Is Associated with Reduced Leptin, Elevated Ghrelin, and Increased Body Mass Index. *PLOS Medicine*, **1**, e62. https://doi.org/10.1371/journal.pmed.0010062

[26] Chaput, J., Lambert, M., Gray-Donald, K., McGrath, J.J., Tremblay, M.S., O'Loughlin, J., *et al.* (2011) Short Sleep Duration Is Independently Associated with Overweight and Obesity in Quebec Children. *Canadian Journal of Public Health*, **102**, 369-374.
https://doi.org/10.1007/bf03404179

[27] Danielsen, Y.S., Pallesen, S., Stormark, K.M., Nordhus, I.H. and Bjorvatn, B. (2010) The Relationship between School Day Sleep Duration and Body Mass Index in Norwegian Children (Aged 10-12). *International Journal of Pediatric Obesity*, **5**, 214-220. https://doi.org/10.3109/17477160903473739

[28] Grandner, M.A., Schopfer, E.A., Sands-Lincoln, M., Jackson, N. and Malhotra, A. (2015) Relationship between Sleep Duration and Body Mass Index Depends on Age. *Obesity*, **23**, 2491-2498. https://doi.org/10.1002/oby.21247

[29] Kohyama, J., Ono, M., Anzai, Y., Kishino, A., Tamanuki, K., Moriyama, K., *et al.* (2020) Factors Associated with Sleep Duration among Pupils. *Pediatrics International*, **62**, 716-724. https://doi.org/10.1111/ped.14178

[30] Kohyama, J. (2021) Determinants of Sleepiness among Pupils in Kanto District of Japan. *Journal of Behavioral and Brain Science*, **11**, 97-106.
https://doi.org/10.4236/jbbs.2021.115008

[31] Kohyama, J. (2023) Non-School Day Catch-Up Sleep among Pupils in Japan. *Journal of Behavioral and Brain Science*, **13**, 113-125.
https://doi.org/10.4236/jbbs.2023.136008

[32] Kohyama, J. (2020) Pupils with Negative Social Jetlag in Japan Are Hypothesised to Constitute a Discrete Population. *Medical Hypotheses*, **144**, Article ID: 110249.
https://doi.org/10.1016/j.mehy.2020.110249

[33] Wittmann, M., Dinich, J., Merrow, M. and Roenneberg, T. (2006) Social Jetlag: Misalignment of Biological and Social Time. *Chronobiology International*, **23**, 497-509. https://doi.org/10.1080/07420520500545979

[34] Mizumoto, A. and Takeuchi, O. (2008) Basics and Considerations for Reporting Effect Sizes in Research Papers. *English Education and Research*, **31**, 57-66.

[35] Park, G. and Kim, J. (2023) Short Sleep Duration and Adolescent Health: Does Weekend Catch-Up Sleep Work and for Whom? *Public Health*, **214**, 91-95.
https://doi.org/10.1016/j.puhe.2022.11.008

[36] Shen, L., Wiley, J.F. and Bei, B. (2021) Perceived Daily Sleep Need and Sleep Debt in Adolescents: Associations with Daily Affect over School and Vacation Periods. *Sleep*, **44**, zsab190. https://doi.org/10.1093/sleep/zsab190

[37] Kohyama, J. and Anzai, Y. (2024) Weekend Catch-Up Sleep/Weekend over Sleep among Adolescents: Current Status and Future Problems. *No to Hattatsu*, **56**, 103-113.

[38] Japan Society of School Health (2018) Annual Reports on Health of Children Attending Elementary Schools and Junior High Schools in 2015-17.

[39] Hagiwara, A. (2014) Construction and Validation of Psychological Scale and Its Ef-

fective Utilization in Global Health Research (Mini-Symposium). *Journal of International Health*, **28**, 7-9.

[40] Hoddes, E., Zarcone, V., Smythe, H., Phillips, R. and Dement, W.C. (1973) Quantification of Sleepiness: A New Approach. *Psychophysiology*, **10**, 431-436. https://doi.org/10.1111/j.1469-8986.1973.tb00801.x

[41] Johns, M.W. (1991) A New Method for Measuring Daytime Sleepiness: The Epworth Sleepiness Scale. *Sleep*, **14**, 540-545. https://doi.org/10.1093/sleep/14.6.540

[42] Rozgonyi, R., Dombi, I., Janszky, J., Kovács, N. and Faludi, B. (2021) Low Test-Retest Reliability of the Epworth Sleepiness Scale within a Substantial Short Time Frame. *Journal of Sleep Research*, **30**, e13277. https://doi.org/10.1111/jsr.13277

[43] Shahid, A., Wilkinson, K., Marcu, S. and Shapiro, C.M. (2011) Stanford Sleepiness Scale (SSS). In: Shahid, A., Wilkinson, K., Marcu, S. and Shapiro, C., Eds., *STOP, THAT and One Hundred Other Sleep Scales*, Springer, 369-370. https://doi.org/10.1007/978-1-4419-9893-4_91

[44] Kohyama, J. (2016) Good Daily Habits during the Early Stages of Life Determine Success Throughout Life. *Sleep Science*, **9**, 153-157. https://doi.org/10.1016/j.slsci.2016.09.002