

Relationship between Internet addiction and sleep disturbance in high school students: a cross-sectional study

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Abstract

Background: The increase in the number of Internet users has increased Internet dependence worldwide. In adolescents, this dependence may interfere with sleep, which is important for the development of psychophysiological capabilities. However, few large-scale surveys have described the relationship between Internet addiction (IA) and sleep disturbance using standardized questionnaires. We conducted a survey in one prefecture in Japan to determine the relationship between sleep disturbance and IA in adolescents based on the categories of the Young Diagnostic Questionnaire (YDQ).

Methods: In 2016, high school students (N=10,405, age range: 15–16 years) in all 54 daytime high schools in the selected prefecture were surveyed using a self-administered questionnaire. Participants with scores > 5.5 points on the Japanese version of the Pittsburgh Sleep Quality Index were defined as having a sleep disturbance. IA was evaluated using the YDQ: Participants with five to eight YDQ items present were classified as having IA; those with three or four items present were classified as “at risk of IA”; and those with two or less YDQ items were classified as “non-IA”. Multiple logistic regression analysis was performed with sleep disturbance as the dependent variable, IA as the explanatory variable, and adjustments for eight other variables.

Results: High YDQ scores were associated with a high prevalence of sleep disturbance in boys and girls. These findings persisted after controlling for other factors in the multiple regression model.

Conclusions: Among Japanese adolescents, there was a significant independent relationship between IA and sleep disturbance. **Keywords:**

Background

The Internet is a network that connects information devices across the world to provide convenient information and communication technology that enables various activities, ranging from exchanging electronic mail and information to shopping. In 2016, when this study was conducted, 48% of all people worldwide used the Internet [1]. In this context, a large survey of Japanese youth found that 6.2% of boys and 9.8% of girls presented problematic Internet use [2].

Internet addiction (IA) has been defined as "an impulse-control disorder that does not involve an intoxicant" [3]. This survey examined the concept of IA. Generalized IA is a concept that was initially introduced by Davis et al. [4] based on a cognitive-behavioral model. More recently, a meta-analysis of 89,281 individuals in 31 countries from 1996 to 2012 reported an IA prevalence of 6%, with a median age of 18.42 years (standard deviation [SD], 5.02; range, 12–41) [5]; individuals aged between 15 and 24 years account for approximately 25% of Internet users worldwide [1]. Moreover, this age range includes adolescents, which means that policies regarding IA must consider this population.

A previous study on IA among adolescents reported a significant relationship between this addiction and psychiatric disturbances, including "interpersonal sensitivity," "depression," "anxiety," "hostility," and

"psychoticism." [6]. Furthermore, adolescent IA has been reported to be a risk factor for problematic alcohol use in adulthood [7, 8]. Recent studies using functional magnetic resonance imaging have reported that IA is related to structural and functional damage in the prefrontal cortex [9]. With such severe negative impacts on life, the seriousness of this problem has been increasingly recognized, and several epidemiological studies have been conducted to determine factors related to IA. For example, a study that examined the data of 100,000 Japanese youth found that IA was related to the frequency and amount of alcohol consumption [10]. A study of 2,620 Chinese high school students reported a relationship between IA and emotional anxiety and a lack of empathy [11]. Excessive smartphone use may be associated with musculoskeletal discomfort and mental health problems [12, 13].

For adolescents, sleep behavior is a component of daily life that has a major impact on physical and mental health [14]. Moreover, adolescent sleep is important because of its significant effects on the development of vital psychophysiological functions, including behavior, emotions, and attention [15-21]. Therefore, it is important to investigate the relationship between sleep and IA. Some studies have reported an association between IA and depression and sleep disturbance [22, 23], nighttime sleep duration and subjective insomnia [24], poor sleeping habits [25], smartphone dependence [26], and sleep quality [27]. Sleeping habits are associated with other lifestyle habits, such as extracurricular activities and skipped meals [28, 29]. However, the relationship between IA and sleep disturbance in adolescents has not yet been comprehensively investigated, because few large-scale surveys have been undertaken using standard indicators, such as the Pittsburgh Sleep Quality Index (PSQI) [30].

We hypothesized that sleep disorders in puberty are associated with a general degree of Internet dependence and that this association is also attributable, in part, to other lifestyle habits. It is important to take lifestyle habits into account, because they can weaken the relationship between sleep disorders and Internet dependence. Therefore, we conducted an epidemiological study to determine the relationship between IA and sleep disturbance in Japanese high school students.

Methods

Study population and design

After obtaining the consent of the President of the Association of High School Principals and the prefectural Education Bureau of one prefecture in Japan, we sent requests for participation to the principals of all 54 daytime high schools within the prefecture and sent the following documents via the postal service to each principal: (1) letter requesting cooperation; (2) planning document containing the study purpose and method; and (3) the questionnaire to be used in the study. We specified that a self-administered questionnaire form would be used in the survey, with assured protection of respondent privacy. A total of 10,405 students were registered at the 54 daytime high schools.

The survey procedure was as follows: (1) the teachers distributed the following three items: an explanatory document, a self-administered questionnaire, and an envelope; (2) after filling in their responses in the questionnaire form, the surveyed students placed the completed questionnaire form in

the provided collection envelope and sealed the envelope; (3) the teachers collected the sealed envelopes; and (4) the envelopes containing the self-administered questionnaires were not unsealed and opened until they were used for data entry at the research facility. The survey period was from June to December 2016.

Measurements

The questionnaire collected information on participant demographic characteristics, sleep disturbance, and IA.

Demographic characteristics

Data were collected on the name of the school, grade, and name and gender of the student. After recording the school names, participants were classified according to whether they were attending a public school or a private school. Questions on daily-life habits included school-commute time, time spent engaging in school sports or clubs, time spent on study outside school hours, television-viewing time, and skipped meals. These questions were similar to those used in previous studies among adolescents [10, 31-33] (Appendix A). The items on emotions and perceptions were measured by assessing depressed mood and school-life satisfaction.

We adopted the measure of depressed mood used in previous studies [31, 33]. The question was: "Over the past 30 days, did you have feelings of heaviness or depression more than usual?" We measured school-life satisfaction using a 2013 survey conducted by the Cabinet Office on the attitudes of young people in Japan and other countries [34]. The question was: "Are you satisfied or dissatisfied with your school life?"

Measurement of sleep disturbance: Japanese version of the Pittsburgh Sleep Inventory.

Sleep disturbance was evaluated using the Japanese version of the PSQI (J-PSQI) [35-37]. Based on previous studies, scores ≥ 5.5 points on the J-PSQI were considered indicative of sleep disturbance [35-37].

Measurement of IA: Japanese version of the Young Diagnostic Questionnaire

We measured IA using the Young Diagnostic Questionnaire (YDQ) [3, 38-44]. We used the Japanese version of the YDQ (J-YDQ) which has been used in previous studies [31]. The J-YDQ is an evaluation tool composed of eight questions, which are scored as 1 point for "yes" and 0 points for "no," with the total score ranging from 0 to 8 points. The participants were grouped into three categories: "IA," if they scored 5–8 points, "at-risk," if they scored 3–4 points, and "no IA," if they scored 0–2 points [25, 33, 39, 43, 45, 46].

Ethical considerations

The participation of students in the present study was voluntary. As our cohort included 15- to 16-year-old adolescents, we obtained written informed consent directly from the students or their parents when their supervising teacher confirmed that their judgment was acceptable or he/she thought that the parents' consent was necessary, respectively. The following statements were included in the consent document distributed to students and their families: (1) the survey was part of an epidemiological study and involved neither an evaluation for school grading nor any type of punishment; (2) students were free to cooperate in the survey, and failure to cooperate would not incur any disadvantage; (3) the school teachers would not view the responses provided; and (4) respondent privacy would be strictly protected. The study questionnaires were stored securely, and data were entered into a password-protected database. Data were anonymized before the analysis by deleting all personal identifiers. The Faculty of Medicine of the Oita University Ethics Committee approved the study (approval no. 932).

Statistical analysis

Students who did not complete the J-PSQI and the J-YDQ were excluded from the analysis. All analyses were stratified by gender. First, we plotted for the J-PSQI and J-YDQ score distributions. Second, participants were categorized as having a sleep disturbance or not according to their J-PSQI score, and categorized as not having IA, being at risk of IA, or having IA according to their J-YDQ Score. We calculated the prevalence of sleep disturbance according to IA status and determined whether there was a significant association between internet addiction and sleep disturbance using the chi-square test. Third, we conducted multiple logistic regression to measure the association between IA (as an explanatory variable) and sleep disturbance (as the dependent variable). The type of school, school-commute time, sports and club time, outside-class study time, television-viewing time, skipped meals, depressed mood, and school-life satisfaction were used as adjustment variables. The Statistical Package for Social Sciences Version 22 (SPSS, IBM Corp. NY, USA) for Windows was used for all statistical analyses. *P*-values <0.05 were considered statistically significant.

Results

Figure 1 shows a flowchart of the participant-selection process. Of the 54 schools (with a total of 10,405 students) that were requested to participate, 40 schools agreed to participate. At the time of the study, there were 7,186 first-year (of the 3-year program) high school students, of whom 6,950 provided informed consent or their parents provided consent (response rate: 96.7%). Of these, 5,264 students (2,635 boys and 2,629 girls) completed the J-PSQI and J-YDQ (effective response rate: 73.3%).

Figure 2 shows the distribution of J-PSQI and YDQ scores. The J-PSQI scores for boys and girls were symmetrically distributed around a cutoff point value of 5.5 points. The

mean and SD of the total J-PSQI score was 5.51 ± 2.63 (range: 0–17) and 5.98 ± 2.62 points (range: 0–18) for boys and girls, respectively. Regarding the YDQ scores, 0 was the most frequent score for both boys and girls. However, the point distribution varied by gender. Among boys, the number of points decreased as the score increased. Conversely, among girls, the score remained constant among those with 0 to 3 points and then gradually decreased as the number of points increased.

Table 1 shows the prevalence of students with sleep disturbance and the number of participants included in each of the three YDQ categories. Students defined as having sleep disturbance comprised 50.5% of all participants. In boys and girls, we observed a higher percentage of sleep disturbance in the following student groups: private high school students ($p < 0.05$), and those with a long school-commute time ($p < 0.01$), a high frequency of skipped meals per week ($p < 0.001$), depressed mood ($p < 0.001$), or poor school-life satisfaction ($p < 0.001$). Furthermore, boys spent little time engaging in school sports (or club) activities ($p < 0.001$). Regarding IA, the proportion with a YDQ score ≥ 5 and YDQ score of 3–4 was higher in girls than boys. In both boys and girls, the prevalence of IA was high in those with less than one-hour of school sport or club activity, more than seven skipped meals a week ($p < 0.001$), depressed mood ($p < 0.001$), and poor school-life satisfaction ($p < 0.001$). Additionally, the prevalence of IA was higher among girls who had shorter extracurricular learning time ($p < 0.001$). The relationship between television-viewing time and IA differed according to gender. The percentage of boys with a YDQ score ≥ 5 was higher among those who watched TV for ≥ 3 hours per day. Conversely, the percentage of girls with a YDQ score ≥ 5 was higher among those who watched TV for ≤ 1 hour per day.

Table 2 shows the prevalence of students with sleep disturbance for each of the three categories of YDQ. In both boys and girls, students categorized as having IA, or at risk of developing IA, had a higher prevalence of sleep disturbance.

Table 2. Prevalence of sleep disturbance according to gender and Young Diagnostic Questionnaire score

Gender	YDQ score	Sleep disturbance		
		n	%	95% CI
Boys				
	0-2	1776	38.6	36.3-40.9
	3-4	610	57.7	53.8-61.6
	5-8	249	70.3	64.6-76.0
Girls				
	0-2	1501	44.5	42.0-47.0
	3-4	739	63.9	60.4-67.4
	5-8	389	78.4	74.3-82.5

Abbreviations: CI, confidence interval; YDQ, Young Diagnostic Questionnaire

The YDQ scores are interpreted as follows: 0-2, no Internet addiction; 3-4, at risk of Internet addiction; 5-8, Internet addiction.

Table 3 shows the multiple logistic regression analysis of the relationship between YDQ categories and sleep disturbance. In both boys and girls, there was a statistically significant association between sleep disturbance and IA (Table 3). The association between the YDQ scores and sleep disturbance remained significant ($p < 0.001$) after adjustment for potential confounding variables.

Table 3. Results of the multiple logistic regression analysis of the relationship between YDQ score and sleep disturbance

Gender	YDQ score	OR	95% CI OR	p-value	AOR	95% CI AOR	p-value
Boys							
	0-2	1.00			1.00		
	3-4	2.17	1.80-2.61	<0.001	1.81	1.48-2.20	<0.001
	5-8	3.76	2.82-5.01	<0.001	2.37	1.74-3.23	<0.001
Girls							
	0-2	1.00			1.00		
	3-4	2.20	1.84-2.64	<0.001	1.93	1.59-2.33	<0.001
	5-8	4.53	3.48-5.88	<0.001	3.36	2.55-4.43	<0.001

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; OR, odds ratio; YDQ, Youth Diagnostic Questionnaire

The YDQ scores are interpreted as follows: 0-2, no Internet addiction; 3-4, at risk of Internet addiction; 5-8, Internet addiction.

The AOR is adjusted for school type, school-commute time, school sports/clubs, extracurricular learning, television viewing time, skipped meals, depressed mood, and school-life satisfaction

Discussion

This study aimed to clarify the relationship between sleep disturbance in adolescents and IA in one prefecture in Japan. We found an association between adolescent sleep disturbance and IA with sleep disturbance being more prevalent in boys and girls with higher YDQ scores. The results of the multivariate analysis revealed a significantly higher odds of sleep disturbance in students with high YDQ scores.

Despite the importance of adolescent sleep, sleep disturbance was present in more than half of the study participants. The high proportion of adolescents with sleep disturbance is in accordance with the results of recent studies of older adolescents using the PSQI [47, 48]. In this study, sleep disturbance was more frequent among students who did not participate in school sports or clubs, skipped meals, had depressed moods, and were dissatisfied with school-life. These results were similar to those of previous studies linking regular sleep habits to psychological and physical health [14]. Additionally, the prevalence of sleep disturbance was higher among students attending private schools and students with longer commutes. In general, students attending private schools tend to have longer commutes; therefore, they may have less sleep as has been shown previously [49]. Previous studies have suggested that sleep quality is related to health and emotions among youth [14, 50]. Future longitudinal studies should examine secular

changes in these and other variables in order to improve the understanding of the relationship between sleep disturbance and Internet dependence.

Additionally, The proportion of high YDQ scores for extracurricular learning and TV viewing time differed between girls and boys. This may be attributable to gender-related differences in lifestyle and IA onset.

The association between the YDQ scores and sleep disturbance is similar to that reported by Bakken et al. [51] from a study among Norwegians, aged ≥ 16 years in which participants with high YDQ scores had a significantly higher prevalence of sleep disturbance than non-problematic Internet users. Furthermore, this study found differences according to gender, with a stronger association between sleep disturbance and girls than in boys. This finding is similar to the results of a study by Durkee et al. [25], which found a significant relationship between insufficient sleep and IA in girls.

There are several possible mechanisms for the relationship between sleep disturbance and IA. First, a study by Tan et al. [22] found that IA could cause sleep disturbances. Moreover, Chen et al. [30] indicated that IA was associated with a disturbed circadian rhythm, leading to sleep disturbance.

Conversely, a second possible mechanism is that sleep disturbance might lead to the development of IA. In a longitudinal study, Chen et al. reported that falling asleep and nocturnal awakening difficulties were predictors of IA [30].

A third possible mechanism is that both conditions contribute to each other. Several studies on adults using brain imaging have confirmed that sleep disturbance and IA cause changes in the gray matter [52, 53]. A study of retired military personnel showed that individuals with a high PSQI score presented with a reduced volume of the entire cortex and frontal lobes, regardless of their mental health [53]. Another study that did not control for sleep disturbance reported that individuals with IA had reduced gray matter density [52]. These findings suggest that IA may cause organic (structural) changes in sleep-related neural pathways.

This study has the following three strengths: First, the sample size was adequate to ensure statistical power. Second, to investigate the relationship between sleep disturbance and IA, we used the PSQI and YDQ, which have been frequently used as standard indices in several epidemiological surveys [5, 10, 25, 39, 41, 43, 51, 52, 54-59]. Third, in our analysis, we evaluated the relationships between sleep disturbance and IA for each of the three categories of the YDQ, including at-risk Internet use.

This study also had several limitations. First, study was a cross-sectional survey, so it is not possible to formulate any conclusion regarding the direction of causality. Second, the analysis did not take into account schools as cluster units. Third, we did not adjust ORs for all the items that may be related to IA. For example, we did not ask questions regarding other psychiatric disorders, such as attention deficit hyperactivity disorder (ADHD), which has been reported to be associated with IA [60-62] and sleep disturbance [62] in adolescents. In this study, all participants attended daytime high school daily. In this setting, the number of students with ADHD is likely to be low. Fourth, students who were absent from

school on the day of the survey could not participate. Fifth, our survey population was limited to students in a single prefecture in Japan; thus, it was a geographically limited population, so the results may lack generalizability. Finally, we did not investigate specific Internet-use disorders [4, 63-69], which need to be studied in detail for preventive measures to be developed.

Conclusions

In summary, we observed that high Internet dependence was related to sleep disturbance in high school students in a prefecture in Japan. Studies have suggested that sleep disturbance and IA affect the gray matter in the brain. Longitudinal studies are required to further investigate the causal factors for IA and sleep disturbance and to clarify the mechanisms of their interdependence.

Abbreviations

IA, Internet addiction; YDQ, Young Diagnostic Questionnaire; J-PSQI, The Japanese version of the Pittsburgh Sleep Quality Index; J-YDQ, The Japanese version of the Young Diagnostic Questionnaire

Declarations

Ethics approval and consent to participate

The participation of students in the present study was voluntary. Our cohort included 15- to 16-year-old adolescents, and all students eligible to participate in this study had completed junior high school courses. The consent form distributed to the students or their families stated that: (1) the survey was part of an epidemiological study and involved neither an evaluation for school grading nor any type of punishment; (2) the students were free to choose whether to participate in the survey and failure to participate would not incur any disadvantage; (3) the school teachers would not view the responses provided; and (4) the privacy of students would be strictly protected. This survey was conducted among students who provided written voluntary informed consent and had parental consent for study participation. The present study was approved (approval no. 932) by the Oita University Ethics Committee.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and analyzed during the current study are not publicly available due to the sensitive nature of the raw data; however, all relevant study datasets are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no actual or potential competing financial interests.

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Authors' contributions

MT, YK, OI, and YO designed the survey questionnaire, and MT, YK, OI, and YO conducted the survey. MT wrote the initial manuscript draft and was responsible for submission for publication. YK, OI, and YO undertook a critical revision of the manuscript. MT conducted the initial analyses. YK, OI, and YO provided important feedback on aspects to improve the study conduct, and YK shared critical insights and suggestions to optimize the study conduct. All authors have read and approved the final manuscript.

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Table 1

Please see the supplementary files section to view the table.

Additional File Legend

Filename: Appendix A _IA & PSQI IndexI

File format: PDF

Title of data: Appendix A: Questions regarding daily-life habits

Description of data: We present questions and responses from the survey form.

Figures

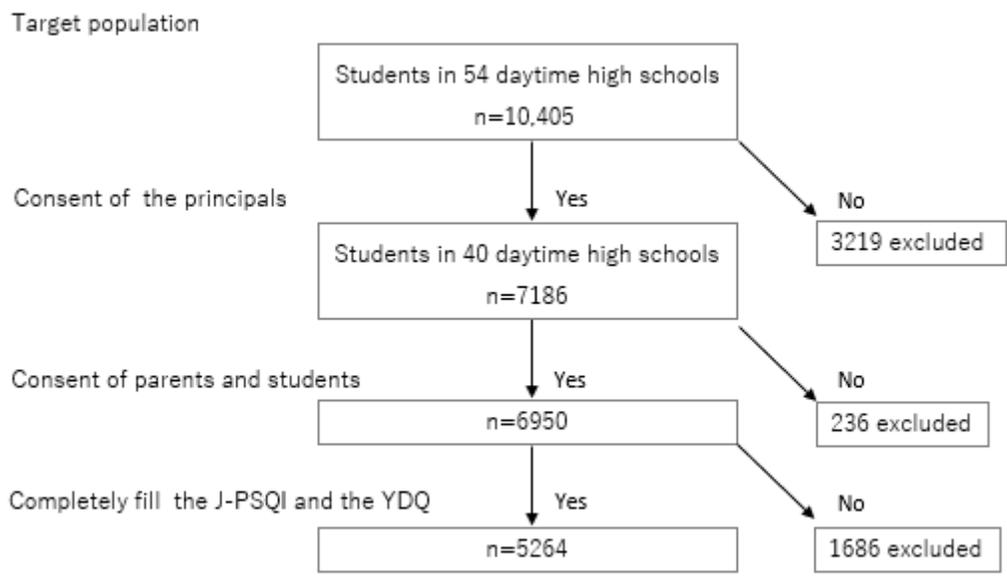


Figure 1

Flowchart of the participant selection process.

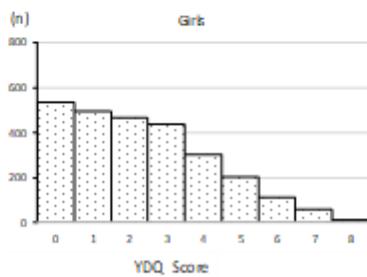
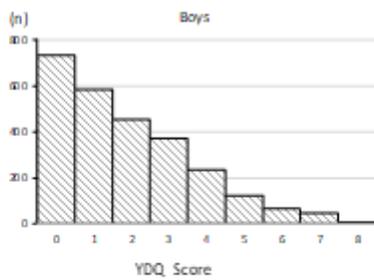
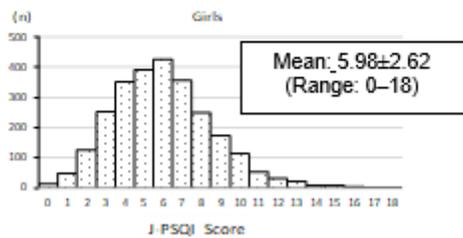
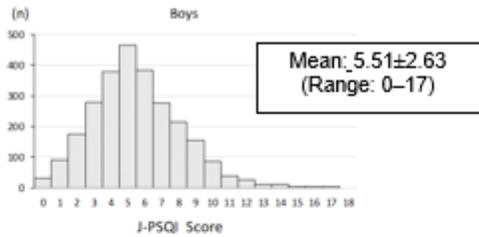


Figure 2

Distribution of J-PSQI and YDQ Internet addiction Score.

Supplementary Files

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- [Tables.docx](#)
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