ORIGINAL RESEARCH

Relationships between Internet addiction and clinicodemographic and behavioral factors

Muhammad ElSalhy[1,2]
Takahiro Miyazaki[1]
Yoshihiro Noda[1]
Shinichiro Nakajima[1]
Hideki Nakayama[2]
Satoko Mihara[2]
Takashi Kitayuguchi[2]
Susumu Higuchi[2]
Taro Muramatsu[1,2]
Masaru Mimura[1]

[1]Department of Neuropsychiatry, Keio University School of Medicine, Tokyo, Japan; [2]National Hospital Organization Kurihama Medical and Addiction Center, Tokyo, Japan

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Correspondence: Masaru Mimura
Department of Neuropsychiatry, Keio University School of Medicine, 35 Shinanomachi, Shinjuku-ku, Tokyo 160-8582, Japan
Tel +81 3 5363 3828
Fax +81 3 5379 0187
Email mimura@a7.keio.jp

Backgrounds and aims: While the Internet became an indispensable component of our contemporary life, public and academic attention is also gathered to its negative impact, namely Internet addiction (IA). Although clinicodemographic and behavioral factors are hypothetically implicated in the mechanism of IA, it still remains largely unknown how such factors are linked to IA severity. Thus, this study sought to examine relationships among IA severity and factors potentially associated with IA in Japanese students in different educational stages.

Methods: We conducted a questionnaire-based survey, which included questions about types of online activities and clinicodemographic information, the IA test for IA severity, and the K6 scale for psychological distress in 3,224 students at elementary, junior, and senior high schools, and universities. A multiple regression analysis was performed to predict IA severity with clinicodemographic and behavioral factors.

Results: IA severity was significantly positively related to the following factors: e-messaging, social networking services (SNS), games, holiday Internet usage, and K6 scores, while IA severity had negative correlation with using Internet for educational purposes, age of first exposure to the Internet, and sleep duration. Age was not related to IA severity among participants using both SNS and e-messaging.

Conclusions: IA was linked to various online activities and the degree of psychological distress. This indicates the importance of comprehensive assessment of online behavior and psychological factors for further understanding of IA.

Keywords: depression, Internet addiction, Internet gaming disorder, psychological distress, students

Introduction

The Internet changed our daily life across the world. Today, many people work, learn, shop, and even interact with each other online. Although the beneficial impact of the Internet is huge, problematic usage of the Internet gathers public attention, leading itself to a research topic in psychiatry.[1,2] The concept of Internet addiction (IA) or problematic Internet usage is proposed, yet its validity as diagnostic entity is still debated.[3–5]

IA is generally defined as a maladaptive preoccupation with Internet use that interferes with everyday life. Such behavior frequently accompanies a set of clinical symptoms similar to substance use disorders, like mood modification, salience, impaired tolerance, social withdrawal, and conflict.[6] Symptoms are recurrent in nature, and IA leads to significant impairment in personal, social, and occupational functioning and multiple facets of well-being.[2,7] Especially, IA in children and adolescents is of great social concern.

While the concept of IA involves various online activities including gaming and use of social networking services (SNS), *Diagnostic and Statistical Manual of*

Mental Disorders, Fifth Edition, proposed the concept of Internet Gaming Disorder specifically focusing on addictive behaviors in online gaming.[3] However, it still remains largely unknown how various online activities are linked to disturbances in real life.

How individuals engage in online activities may reflect multiple factors such as social background and relationships, and psychological and cognitive functioning. Many theoretical models of IA were proposed.[8,9] Brand et al proposed that certain personality factors, psychopathological symptoms, and social cognitions would predispose IA in the presence of mediating factors like dysfunctional coping styles and Internet use expectancies.[10] Dong and Potenza introduced a model that connects Internet gaming disorder with cognitive functioning, such as decision-making style, executive control, stress relief, and reward sensation on craving for IA.[8,9]

Several studies examined how IA is related to clinicodemographic factors including age, sex, anxiety, and depression.[11,12] These factors involve clinical factors such as psychological symptoms and disorders including anxiety and depression, and demographic factors such as age and sex. For example, one study on university students in the United States, China, and Singapore showed that male students were more addicted to games, while female students were more addicted to SNS.[13] These results may suggest that age and sex indirectly affect IA via differential involvement in online activities.

Anxiety and depression are reported to be linked with IA.[14–17] A meta-analysis demonstrated that loneliness and depression were independently correlated to Internet habit.[18] However, this study reported that 90% of the previous studies surveyed use of only either online games or SNS. They also reported that each study targeted only one or two educational stages, for example, junior and senior high schools. It is hard to reveal the relationships among students' age, types of online activities, mental health, and IA based on past studies, considering likely confounding factors such as cultural background and study designs. Several scales were used to assess IA. Although the Internet addiction test (IAT) is a widely used scale designed to detect realistic disturbances experienced in daily life due to Internet use,[19,20] previous studies adopted the IAT that varied substantially in scoring methods and cutoff scores. Some studies were conducted online, while others conducted paper-based survey either at the schools or by post.[21–23] Thus, a systematic understanding of how IA varies among children and young adults is still lacking. To our knowledge, no single study investigated IA comprehensively across students from a whole range of educational stages.

In the present study, we conducted a systematic survey on the severity of IA and factors potentially linked to IA among students with various ages. We recruited 4,119 students from elementary, junior, and senior high schools, and university. We employed the IAT for assessing IA severity, and the K6 scale for psychological distress. We hypothesized that the risk of IA would be modulated by various clinicodemographic factors including type of activities on the Internet, mental health, behavioral pattern of Internet usage, age, and sex. To draw a global picture on the relative importance of these factors, we examined the effects of these factors in a single multiple regression model.

Methods
Participants
A total of 4,119 students participated in this study: 477 (11.58%) elementary school students of fifth and sixth grade from 2 public schools (A and B) and of fourth, fifth, and sixth grade from 1 private school (C), 1,273 (30.91%) junior high school students of first to third grades from 3 private schools, 1,784 (43.31%) senior high school students of first to third grades from 2 private schools (G and H) and 1 public school (I), and 585 (14.2%) university students from 3 public (J, K, and L) and 2 private (M and N) universities.

Ethical approval
The study procedures were approved by ethical committees in Keio University School of Medicine and National Hospital Organization Kurihama Medical and Addiction Center before commencement of the study. All schools and universities that participated in this study were offered a copy of the approved research protocol with the approval number before starting the questionnaire.

Design and measures
The present study was a cross-sectional study based on an anonymous self-report questionnaire. The severity of IA was assessed with the IAT. All the survey procedures were offline, at the schools or universities. The survey comprised four parts:

a) Demographic part: questions on age, sex, place of living, number of family members with whom the participant lived, the number of hours the participant slept daily (hereinafter, sleep duration).

b) Questions about Internet usage: i) the age when the participant was first exposed to the Internet (age of the first Internet exposure); ii) the number of minutes the participant generally used the Internet on weekdays and

holidays, separately (weekday/holiday Internet usage, hereinafter); iii) the activities in which the participant was generally involved while being online (online activities). Following choices were given: online search, Emailing/e-messaging, Internet phone, SNS, online games, downloading (not further specified), watching videos, studying, and online reading.

c) The K6 scale: screening scale for psychological distress consists of questions on six feelings, that is, nervous, hopeless, restless or fidgety, so depressed that nothing could cheer them up, that everything was an effort, and worthless. Participants rated how often they felt each feeling with 5-point scale between none of the time (coded as 0) and all the time (coded as 4). We used a Japanese version of the K6 scale developed by Furukawa et al using the standard back-translation method, and demonstrated equivalent screening performances to the original English versions.[24,25] A total score of the K6 scale was calculated for statistical analyses.

d) The IAT: a self-report questionnaire with 20 questions on behavioral problems related to excessive Internet use. The participants selected the response from 5-point Likert scale, which was later converted into a number ranging from 1 to 5.[20] IAT total score was calculated by summing up the scores of the 20 questions. A total score of 20 indicated no signs of IA, while a total score of 100 represented the most severe IA. We adopted the following criteria, which were used in previous studies: total scores from 20 to 39 were defined as average usage; scores from 40 to 69 were considered to represent frequent problems due to Internet usage; and scores from 70 to 100 were considered to indicate significant problems caused by Internet usage.[26–28] Using the above-mentioned cutoff scores, IAT was validated by Widyanto and McMurran, and psychometric properties were analyzed.[27]

Procedure

We contacted the principals of candidate schools with similar socioeconomic levels and study environment from four prefectures in Japan (Tokyo, Kanagawa, Saitama, and Hokkaido). Nineteen schools and universities were contacted, of which 14 gave consent to cooperate after a thorough explanation on the research protocol was given. After thoroughly explaining the research, parents' written consent was obtained for elementary and junior high school students. The participants were informed that this study was a survey about Internet usage, that they can decide whether to participate at their own will, and that there would be no disadvantages

if they chose not to participate. Students who refused to participate could stay at their places, read something else, study something, or leave the class if they wanted to. They were also informed that there was no correct answer for the questions. Questionnaires were distributed in envelopes and recollected also as such, and the participants were instructed not to talk about the questionnaire with each other in order to avoid biases. No incentives were given to the participants.

Statistical analyses

We analyzed data from a total of 3,224 (78.3%) participants after excluding data from such participants who did not answer all the questions, and those who gave answers that were thought to be inattentive or inconsistent (for example writing the same number to all the questions of K6 scale or IAT, or reporting to use Internet 15 hours per day and sleep 15 hours). The answers to the questions on the eight online activities were treated as binomial variables in the statistical analyses, while the answers for age, number of family members, time spent on the Internet on weekdays and holidays, sleep duration, IAT total scores, and K6 total scores were treated as continuous variables. The names of variables are started with a capital letter hereinafter. Normality of distributions of continuous variables was tested using Shapiro–Wilk test. Then we conducted χ^2 tests and Kruskal–Wallis tests to detect differences in the categorical and continuous variables, respectively, among different educational stages. Subsequently, as the main analysis, we performed a multiple regression analysis with the IAT total score as the dependent variable to assess the relative importance of the factors surveyed. To avoid the risk of finding spurious effects, we constructed a statistical model as follows: based on the findings of previous studies,[12,22,29] age and sex were included. Next, as some online activities were found to be too common or too uncommon among the participants, we limited online activities to be involved in the model so that we included at least 20 male and 20 female participants for any possible combination of the online activities (Figure S1). Then, a multiple linear regression model was constructed with the selected categorical variables and all the available continuous variables as independent variables, and IAT total score as the dependent variable. Low risk of multicollinearity was confirmed with a criterion of variance inflation factor <4. The level of significance was set as 0.05, with a CI of 95%.

The SPSS version 23.0 for iOS was used for the descriptive analyses,[30] and R version 3.5.1 was used for further analysis.[31]

Results

Response rate

The proportion of the participants who answered all the questions was 56.6%, 82.5%, 78.3%, and 86.7% in the elementary schools, junior high and senior high schools, and universities, respectively (Table S1). Cronbach's α indicated a high level of internal consistency for both the IAT (α=0.898) and K6 (α=0.909) among the whole sample.

Descriptive analyses

The IAT total scores were generally higher among participants at higher educational stages (Figure 1). The correlation matrix between the continuous variables is shown in Table 1. Means, SDs, minimum values, maximum values, and skewness of all the used continuous variables are summarized in Table 2. Shapiro–Wilk test showed that any of the continuous variables cannot be assumed to be random samples from a normal distribution ($P<0.001$). Accordingly, nonparametric tests were performed in further analyses. Participants who were classified as having significant problems caused by Internet usage according to the criteria described in the Methods section were 1.9%, 3.5%, 4.1%, and 3.8% among participants in elementary schools, junior high and senior high schools, and universities, respectively, while those classified as with frequent problems caused by Internet usage were 23.7%, 33.8%, 48.6%, and 56.2% in the same order. The numbers and ratios of male and

female participants in these IA severity categories in each educational stage are shown in Figure 1. The prevalence of IA defined by the sum of the above two was significantly higher in senior high schools than in junior high schools ($\chi^2(1)$=30.23, $P<0.0001$), and higher in universities than in senior high schools ($\chi^2(1)$=30.23, P=0.0006). There was no significant difference between males and females within each educational stage. Chi-square tests showed significantly different distribution between educational stages in the usage of Internet for online search ($\chi^2(3)$=29.2, $P<0.001$), Emailing/e-messaging ($\chi^2(3)$=284.9, $P<0.001$), Internet phone ($\chi^2(3)$=33.3, $P<0.001$), SNS ($\chi^2(3)$=815.9, $P<0.001$), Games ($\chi^2(3)$=142.3, $P<0.001$), Blog ($\chi^2(3)$=9.5, $P<0.05$), Downloading ($\chi^2(3)$=11.5, $P<0.01$), Watching videos ($\chi^2(3)$=43.5, $P<0.001$), Studying ($\chi^2(3)$=31.5, $P<0.001$), and Online reading ($\chi^2(3)$=13.1, $P<0.01$). Chi-square tests were performed to test the difference in engagement in online activities between males and females among each educational stage, results of which are indicated in Figure 2.

Figure 2 shows the participants' engagement in online activities. Emailing/e-messaging and SNS users tended to increase with age, whereas game users decreased with age, especially among female students (Table 3).

Kruskal–Wallis test provided very strong evidence of a difference ($P<0.001$) between the mean ranks of at least one pair of groups for all continuous variables. Dunn's pairwise tests were carried out for all the six pairs of educational
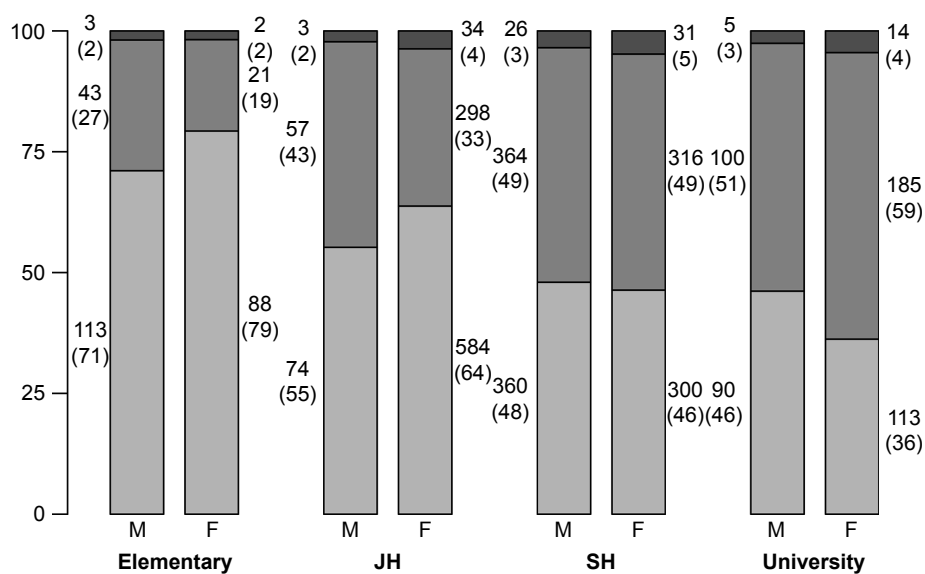

Figure 1 Number and ratio of the participants with normal, problematic, and addictive Internet usage: participants were stratified by their educational stage and sex.
Notes: Internet addiction as measured with IAT scores was classified into normal usage of Internet (light gray), frequent problems due to Internet usage (middle gray), and significant problems caused by Internet usage (dark gray). Numbers besides the bars indicate number (percentage) of participants in the corresponding IAT total score range (see Methods section).
Abbreviations: JH, junior high school; SH, senior high school, M, male; F, female.

Table 1 The correlation matrix between age, number of family members, time spent on the Internet on weekdays and holidays, sleep duration, total scores of IAT test, and total scores of K6 scale

		IAT total scores	K6 scale total scores	Number of family members	Age	Internet first exposure	Weekday Internet usage	Holiday Internet usage	Sleep duration
IAT total scores	ρ	I	0.476**	0.025	0.269**	−0.002	0.433**	0.458**	−0.244**
	P		<0.001	0.162	<0.001	0.927	<0.001	< 0.001	<0.001
K6 scale total scores	ρ	0.476**	I	0.038*	0.187**	−0.02	0.194**	0.179**	−0.123**
	P	<0.001		0.031	<0.001	0.259	<0.001	< 0.001	<0.001
Number of family members	ρ	0.025	0.038*	I	0.122**	0.114**	0.052**	0.092**	−0.078**
	P	0.162	0.031		<0.001	<0.001	0.003	<0.001	<0.001
Age	ρ	0.269**	0.187**	0.122**	I	0.265**	0.449**	0.369**	−0.336**
	P	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001
Internet first exposure	ρ	−0.002	−0.02	0.114**	0.265**	I	0.081**	0.075**	−0.114**
	P	0.927	0.259	<0.001	<0.001		<0.001	<0.001	<0.001
Weekday Internet usage	ρ	0.433**	0.194**	0.052**	0.449**	0.081**	I	0.800**	−0.269**
	P	<0.001	<0.001	0.003	<0.001	<0.001		<0.001	<0.001
Holiday Internet usage	ρ	0.458**	0.179**	0.092**	0.369**	0.075**	0.800**	I	−0.261**
	P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001
Sleep duration	ρ	−0.244**	−0.123**	−0.078**	−0.336**	−0.114**	−0.269**	−0.261**	I
	P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	

Notes: ρ: Spearman's rank correlation coefficient, p: P-value. *$P<0.05$, **$P<0.01$.
Abbreviation: IAT, Internet addiction test.

stage groups. There was very strong evidence ($P<0.001$, adjusted using the Bonferroni correction) of a difference between most of the pairs of educational stages in the continuous variables, that is, Internet first exposure, weekday Internet usage, holiday Internet usage, Sleep duration, and K6 total sore, whereas significant difference was not found in holiday Internet usage between senior high school and university, Sleep duration between senior high school and university, or K6 total scores between elementary and junior high schools or between elementary and senior high schools. Time spent on Internet on both weekdays and holidays tended to increase with age and sleep duration tended to decrease with age from elementary to senior high schools. K6 total scores were the highest among university students (Table 4 and Figure S2). Mann–Whitney's U-tests were performed

to test the difference in continuous variables between males and females among each educational stage, results of which are indicated in Table 4 and Figure S2.

Multiple regression analyses

Sex, Emailing/e-messaging, SNS, Games, and Study were selected as independent variables in the multiple regression model, while the other binomial variables were excluded because the participants' responses were highly biased toward either yes or no. A significant regression relationship was found ($F(12, 3211)=158.5$, adjusted $R^2=0.37$, $P<0.001$) to predict IAT total score (Table 5). The strongest predictive variable was SNS, followed by Games, and K6 total score that reflects psychological distress. One point higher K6 total score predicted 1.06 point higher IAT total score. Next were

Table 2 The descriptive statistics of age, K6 scale total scores, IAT total scores, Internet first exposure, weekday Internet usage, holiday Internet usage, and sleep duration

|	Minimum	Maximum	Mean	SD	Skewness
Age	9.00	25.00	15.64	2.75	0.09
K6 total scores	0.00	24.00	4.77	5.15	1.23
IAT total scores	20.00	100.00	40.59	13.86	0.83
Internet first exposure	3.00	18.00	10.21	2.45	−0.35
Weekday Internet usage (min)	10.00	900.00	162.52	118.51	1.94
Holiday Internet usage (min)	10.00	960.00	229.57	163.54	1.47
Sleep duration	240.00	600.00	397.46	62.56	0.30

Abbreviation: IAT, internet addiction test.
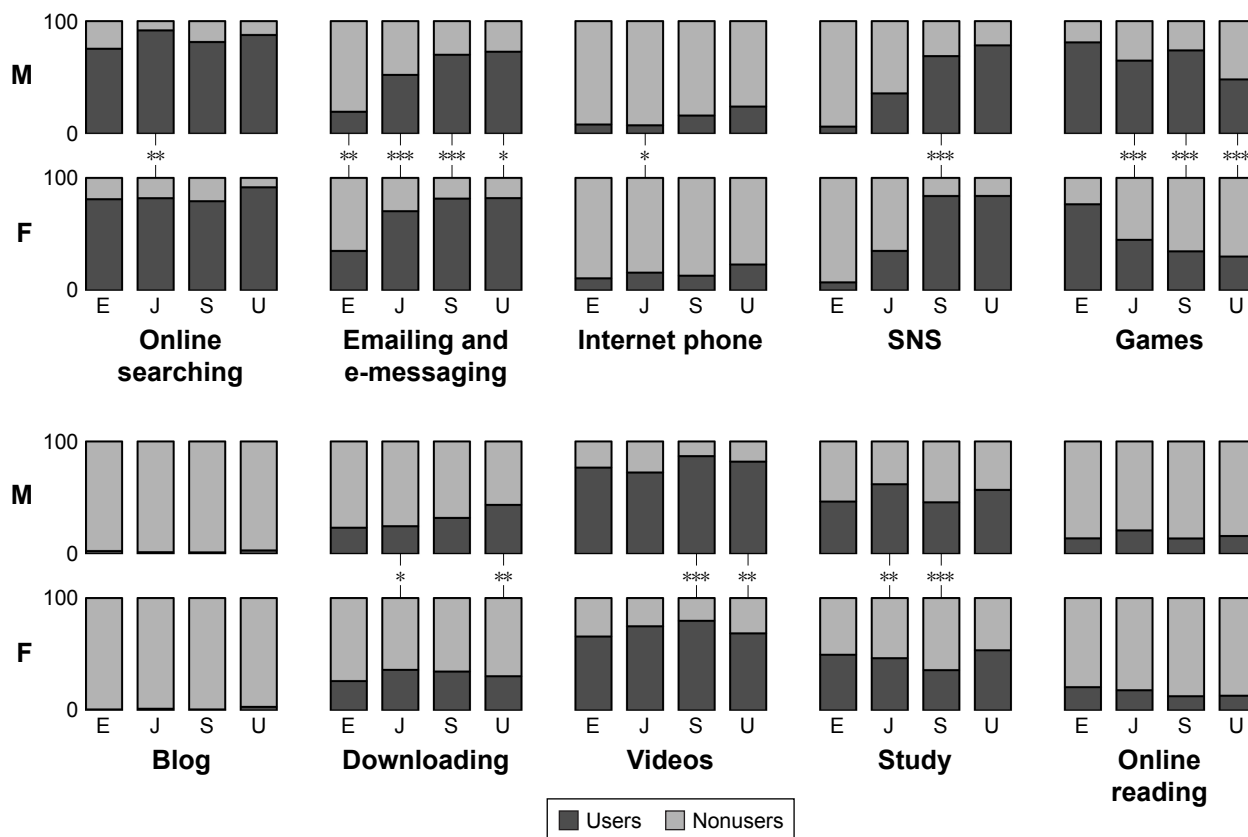
Figure 2 Ratio of participants involved in ten online activities stratified by educational stages and sex: ratio of users (dark gray) and nonusers (light gray) are shown with bars.
Notes: The top and bottom rows in each panel correspond to M and F. Four bars in the top and bottom rows of each panel correspond to E, J, S, and U, from left to right. Results of χ^2 test between males and females within each educational stage are indicated as follows: ***$P < 0.001$; **$P < 0.01$; *$P < 0.05$.
Abbreviations: E, elementary; F, female; J, junior high school; M, male; S, senior high school; U, university.

Emailing/e-messaging, longer holiday Internet usage, shorter Sleep duration, and younger age of Internet first exposure. Study predicted lower IAT total scores.

Discussion

This cross-sectional study based on a self-reported questionnaire investigated the relationships between IA severity and clinicodemographic factors targeting students ranging from elementary schools to universities. This study revealed that (a) the prevalence of IA was 25.6%, 37.3%, 52.7%, and 60% among students in elementary, junior high and senior high schools, and universities, respectively, that (b) use of SNS and Emailing/e-messaging increased with age among both sexes, while Internet gaming generally decreased with age, (c) that Internet usage on both weekdays and holidays increased with age, and that (d) Internet use for SNS and games, severity of psychological distress, Internet use for Emailing/e-messaging, longer holiday Internet usage, shorter sleep duration, and younger age of the first Internet exposure predicted higher IAT total scores in this order, while using Internet for study predicted lower IAT scores.

The results showed that various online activities, prolonged use of Internet, and mental distress are all at least partly independently related to severity of behavioral problems. Involvement of both social services such as SNS and e-messaging, and games was reported in past studies.[22,32] On the other hand, the present study showed that studying online is negatively linked to IA. Use of the activities positively linked to IA might reflect need in social relationships. Not only SNS and Emailing/e-messaging, but also Internet gaming can reflect needs for social acceptance.[33–35] Tokunaga reported in his meta-analysis that loneliness and depression were independently correlated to Internet habit.[18] Thus, need in social relationship might be an important driving force in the mechanism of IA. This idea is further corroborated by the present result that educational purposes predicted lower IA severity. Previous studies showed that Internet usage for educational purposes was not related to IA.[36,37]

These results give us some insight into the mechanisms of IA. The above findings might indicate that psychological urge to socialize rather than achieving concrete purposes plays an important role in IA. Predisposition toward IA may

Table 3 Percentage of students participating in various online activities among different educational stages

Educational stage	Sex	Number of participants	Age (mean ± SD)	Online search (%)	Emailing/e-messaging (%)	Internet phone (%)	SNS (%)	Games (%)	Blog (%)	Downloading (%)	Videos (%)	Study (%)	Online reading (%)
Elementary school	M	159	10.761±0.9	75.0	19.5	8.2	6.3	81.1	2.5	23.3	76.7	46.5	13.8
	F	111	10.838±0.8	81.0	35.1	10.8	7.2	76.6	0.9	26.1	65.8	49.5	20.7
Junior high school	M	134	13.746±0.9	92.0	52.2	7.5	35.8	64.9	1.5	24.6	72.4	61.9	20.9
	F	916	13.524±0.9	82.0	70.4	15.8	35.2	45.0	1.5	36.1	74.9	46.5	18.0
Senior high school	M	750	16.719±0.9	81.0	70.1	16.1	68.9	74.0	1.3	32.0	86.9	45.9	13.7
	F	647	16.618±1	79.0	81.6	13.1	83.9	34.8	0.9	34.6	79.8	35.9	12.7
University	M	195	19.862±1.4	88.0	72.8	24.1	78.5	48.2	3.1	43.6	82.1	56.9	15.9
	F	312	19.644±1.5	92.0	82.1	23.1	84.0	30.1	3.2	30.4	68.6	53.5	13.1
Total		3,224	15.644±2.8	83.0	69.4	15.7	57.8	52.1	1.6	33.3	78.2	46.3	15.4

Abbreviations: F, female; M, male; SNS, social networking services.

be facilitated when such urge is met with psychological and cognitive risk factors, such as depression, social anxiety, and maladaptive coping style.[8,38,39] Personal distress under tense interpersonal settings is demonstrated to be linked to Internet and smartphone use disorder.[40] High prevalence of social anxiety and social phobia among individuals with IA was reported.[41,42] Unsuccessful social relationships may encourage one to revert to virtual relationships online, but only resulting in poorer well-being. Kraut et al reported that using the Internet predicted better outcomes for extraverts but worse outcomes for introverts.[43] On the other hand, neuropsychological and neuroimaging studies suggest that IA is linked to functional changes in brain areas such as the prefrontal cortex, possibly related to cognitive risk factors including maladaptive coping styles.[10,38] These factors may work together to lead an individual toward overuse of specific services on the Internet, such as SNS and online games, and consequently to IA in some cases. Interestingly, using the Internet for study was found to be negatively correlated to IA severity. Using the Internet for study might have reflected overall well-being or successful adaptation of the students.

Addiction in online games is most widely studied among various forms of IA.[21,22,32] We also found in the present study that a wide range of children and adolescents in Japan have some kind of problems in online gaming. Several past studies reported higher rates of Internet gaming among males than females, which was reflected in higher prevalence of IA in males.[22,44] We also found higher rate of Internet game users in males, but this sex-related difference was not reflected in the IA prevalence or severity. This may be attributable to higher rate of SNS users among females than males, which compensated the effect of the lower rate of Internet game users in females. SNS and gaming were reported to work in a similar fashion that can augment IA symptoms,[45] which abolish the differential inclination according to gender.

The present study also demonstrated that both shorter sleep and a greater degree of psychological distress measured by K6 scale were associated with increase in IA severity. Sleep disorders and psychological distress such as depression were reported to be psychiatric comorbidities of IA.[46] Some studies hypothesized that sleep problems and depression may be consequences of IA.[47] Bhandari et al concluded that IA mediated 16.5% of the indirect effect of sleep quality on depressive symptoms, while sleep quality mediated 30.9% of the indirect effect of IA on depressive symptoms.[48] Chen et al reported that in their analysis with a time-lagged model, dyssomnias predicted IA.[49] Relationship between IA and psychological distress, sleep problems, and IA may be

Table 4 Differences in continuous variables among different educational stages

Educational stage	Sex	Internet first exposure (age in years)	Weekday Internet usage (minutes)	Holiday Internet usage (minutes)	Sleep duration (minutes)	Family members	K6 scale total scores	IAT total scores
E	M	7.5±1.9	90.5±89.2	134.2±138.9	471.3±72.4	3.14±1.1*	4.409±4.9	35.3±12.2*
	F	7.8±1.8	99.9±118.5	125.9±130.9	483.1±70.7	3.39±1.1	4.153±4.5	38.7±12.4
J	M	9.9±2.3	141.3±71.0***	183.4±121.9	419.6±47.9**	3.95±0.7***	4.075±4.7	38.7±12.4
	F	9.8±2.2	111.1±86.3	170.9±132.6	404.5±57.0	3.41±1.0	3.711±4.7	37.8±14.1
S	M	11.0±2.2	184.3±106.4	260.7±159.0**	387.1±50.2***	4.11±1.0	4.828±5.0	42.2±13.2
	F	10.9±2.1	186.8±116.0	294.9±184.9	376.4±52.9	4.1±1.1	4.961±5.2	42.6±13.7
U	M	10.7±2.8*	243.1±160.5	272.3±160.4	389.5±65.2**	2.61±1.8**	6.385±6.1	43.6±14.1
	F	10.2±2.8	228.6±135.4	270.2±147.3	372.5±58.7	3.06±1.6	6.994±5.6	45.4±13.2
Total		10.2±2.5	162.5±118.5	229.6±163.5	397.5±62.6	3.64±1.3	4.766±5.2	40.6±13.9

Notes: Means and SDs of Internet first exposure in years, holidays, and weekdays Internet usage time in minutes, sleep duration in minutes, family members, and K6 total scores among different educational stages. Results of Mann–Whitney's U-test between males and females within each educational stage are indicated as follows: ***$P<0.001$; **$P<0.01$; *$P<0.05$.
Abbreviations: F, female; IAT, Internet addiction test; J, junior high school; M, male; E, elementary school; S, senior high school; U, University.

reciprocal. Causal relationships among these conditions are likely to be complicated, and need to be studied further with longitudinal design, for example.

Emailing/e-messaging was positively associated with IA severity. This is also in line with the majority of the previous studies,[32,50,51] while one study demonstrated a negative relationship between them.[22] A longitudinal study including 663 students from the Netherlands aged 12–15 years concluded that using chat rooms and instant messengers was positively correlated to the onset of IA and depression 6 months later.[37] As Emailing/e-messaging can be considered as online social interaction media, it is reasonable that

Emailing/e-messaging has an effect on SNS severity in the same direction as SNS.

Longer time spent online was found to predict both higher IA severity and higher levels of psychological distress.[2,15] This seems to be natural, because prolonged use of Internet inevitably results in reduced amount of time available for other activities, including spending time with friends and family. This accordingly leads to increased loneliness and depression, and accordingly leads to IA.[43] Eight out of 20 questions of IAT are related to time. The proposed criteria of Internet gaming disorder in DSM-5 include ten items related to time spent on gaming, along with one item related

Table 5 Relationship between IAT total score and possibly involved factors surveyed with the questionnaire

Independent variable	B	SE B	95% CI		β	VIF	P-value
Intercept	36.191	2.381	31.098	41.121	–	–	<0.001***
Sex	0.070	0.431	−0.810	0.912	0.002	1.171	0.874
Emailing/e-messaging	0.982	0.448	0.078	1.823	0.033	1.136	0.027*
SNS	2.426	0.463	1.523	3.341	0.086	1.392	<0.001***
Games	1.910	0.418	1.070	2.750	0.069	1.161	<0.001***
Study	−1.126	0.397	−1.882	−0.349	−0.041	1.046	0.005**
Age	0.084	0.092	−0.102	0.274	0.017	1.698	0.387
Number of family members	−0.267	0.157	−0.577	0.029	−0.024	1.040	0.080
Internet first exposure	−0.188	0.084	−0.363	−0.027	−0.033	1.119	0.024*
Weekday Internet usage	0.005	0.003	−0.001	0.011	0.043	2.602	0.094
Holiday Internet usage	0.022	0.002	0.018	0.026	0.257	2.474	<0.001***
Sleep duration	−0.019	0.003	−0.026	−0.012	−0.085	1.217	<0.001***
K6 total score	1.061	0.039	0.963	1.160	0.394	1.074	<0.001***

Notes: Multiple regression analysis. *$P<0.05$, **$P<0.01$, and ***$P<0.001$.
Abbreviations: β, standardized coefficient; B, coefficient; IAT, Internet addiction test; SE, standard error; SNS, social networking services; VIF, variance inflation factor.

to tolerance.[3] A longer time spent online likely reflects a poorer control on Internet overuse, which could be seen as one characteristic of IA rather than a cause of IA. Tokunaga et al conducted a meta-analysis of 100 studies and the results supported a model conceptualizing IA as a case of deficient self-regulation in which psychosocial problems foster IA and, indirectly, time spent using specific Internet-based technologies.[52]

However, in our analysis, holiday usage but not weekday usage of the Internet predicted higher IA severity. It seems possible that inclination to spend more time on Internet on holidays rather than doing other things is a risk factor, or alternatively indicative of psychological distress or underlying social maladaptation, which increases the risk of IA. It is also possible that excessive use of Internet impairs functioning in other areas of life, which may in turn result in more inclination for Internet usage. Longitudinal research investigating individual's change in pattern of Internet use, personal achievement, social relationship, mental state, and problems related to Internet use is needed to reveal causal relationship among these factors.

This study revealed that people who started using Internet at younger ages showed higher IA severity, which is in line with previous studies that demonstrated that starting using the Internet at younger age was associated with higher IA prevalence.[2,53] This finding, together with others, suggests that controlling how young children use the Internet can be beneficial in preventing IA.

Using Internet for study predicted lower IA severity. Students with higher academic performance were reported to have lower IA prevalence,[54–56] and a longitudinal study reported that self reported engagement in school activities is a protective factor against IA.[57] Studying online may reflect higher academic performance of the students who try to confine Internet use for study.

Strikingly, age and sex were not suggested to be significant predictors of IA severity. This finding appears to converge with previous studies' finding that IA is unrelated to neither age nor sex,[45,58,59] whereas other studies noted that school grade was a positive predictive factor for IA prevalence.[11,12,22] In the present study we found that IA prevalence increased with educational stage, but the effect of age on IAT total score was not significant when the effect of other factors was partialed out. These findings seem to suggest that age may indirectly affect IA severity via other factors including online activities and psychological distress, although the relationship between age and these factors may vary reflecting the characteristic of the population.

The present study found relatively high prevalence of problematic Internet usage. A study in Korea reported that 28.6% of junior high school students were problematic users,[60] while studies in China reported prevalence rates ranging from 10.8% to 21.2%.[12,61] Although such variability in prevalence may partly reflect true difference between countries, it seems that the variability is largely due to difference in methods as discussed by Kuss and Lopez-Fernandez.[62] They stated that comparisons of current studies are impeded because they significantly differ in the cutoff points used to identify problematic Internet users.

The strengths of this study are as follows: this study was the first survey on elementary school students in Japan. We also comprehensively assessed IA severity and its predictive factors in the wide range of student population. Moreover, we used IA severity instead of IA prevalence to assess the involvement of various factors and found the three online activities closely linked to IA. It should be better to assess risk and protective effects of related factors with IA severity, rather than categorical distinction between normal Internet use and IA.

This study has several limitations. Assessment was based on self-reporting. Insight into participants' own behavior may have varied among individuals. As the survey was conducted in classrooms, we might have missed students with the highest level of IA who were absent from the class. Other limitation is that we surveyed participants' involvement in eight online activities, which were not exhaustive. We could not recruit the same number of students from each school. Also, junior high school participants were biased to females, which may have partly affected the results. We could not perform multiple regressions for each educational group separately because of the limited statistical power. In this research, as we did not collect data about the personality traits of the participants, we could not examine the association between IA and personality traits. Causal relationship between mental distress and depression, and IA needs to be investigated in longitudinal studies.

Conclusion

The present study was the first study to assess the relationship between IA and clinicodemographic factors across students of elementary, junior high and senior high schools, and universities. This study noted that IA severity had positive association with SNS use, online gaming, Emailing/e-messaging, and psychological distress.

IA is a new problem for our society, emerging from the rapid development of technology. IA can change its form

and magnitude over time by its nature. Types and usability of services available online are continuously increasing, some of which may be addictive to some individuals. To maximize the benefit of the Internet while minimizing its negative impact, it is important to continue studies on IA looking at various aspects of Internet usage and its relationships with personal achievement and mental health in various populations. We plan to use the results from this study and continue working with other colleagues in the field to improve the theoretical models for IA.

Acknowledgments

Author contributions

ElSalhy conceived of the presented idea. ElSalhy, Miyazaki, Nakajima, Nakayama, Mihara, Kitayuguchi, Higuchi, Muramatsu, and Mimura developed the theory and collected the data. Miyazaki and ElSalhy performed the statistical analyses. Noda and Nakajima verified the analytical methods. Mimura and Muramatsu encouraged for further statistical methods and supervised the findings of this work. Draft was mainly written by ElSalhy, Miyazaki, Noda, and Nakajima after all authors discussed the results. All authors contributed to data analysis, drafting and revising the article, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

Disclosure

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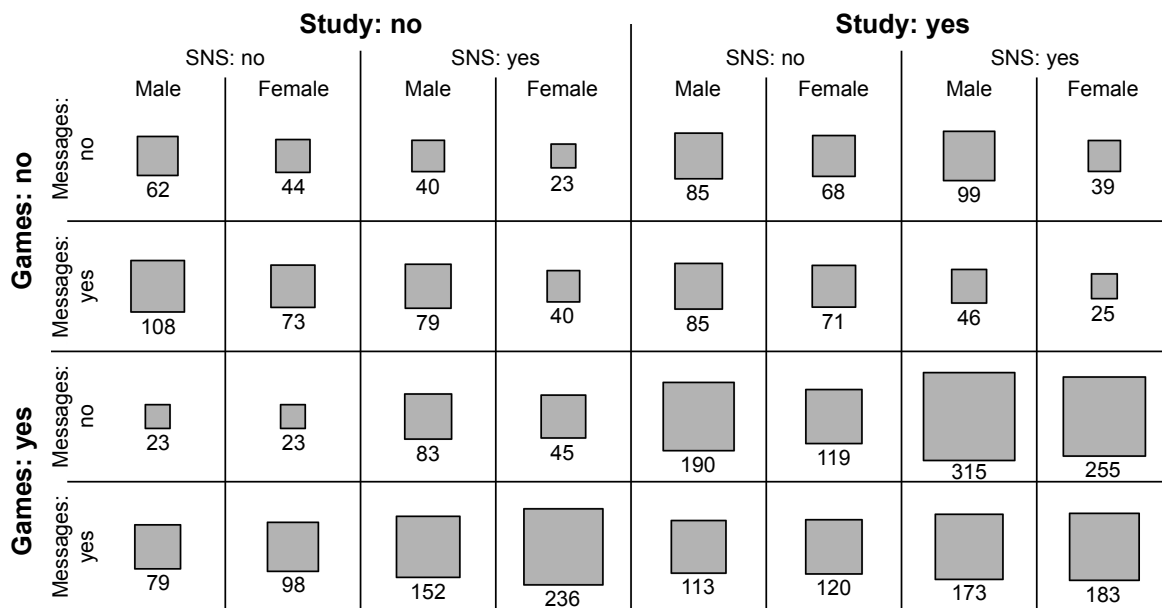
Supplementary materials

Figure S1 Number of participants stratified by engagement in Study, SNS, Games, and Emailing/e-messaging.
Abbreviation: SNS, social networking service.

Table S1 Participated schools and students, and the ratio of participants who fully responded to the questionnaire

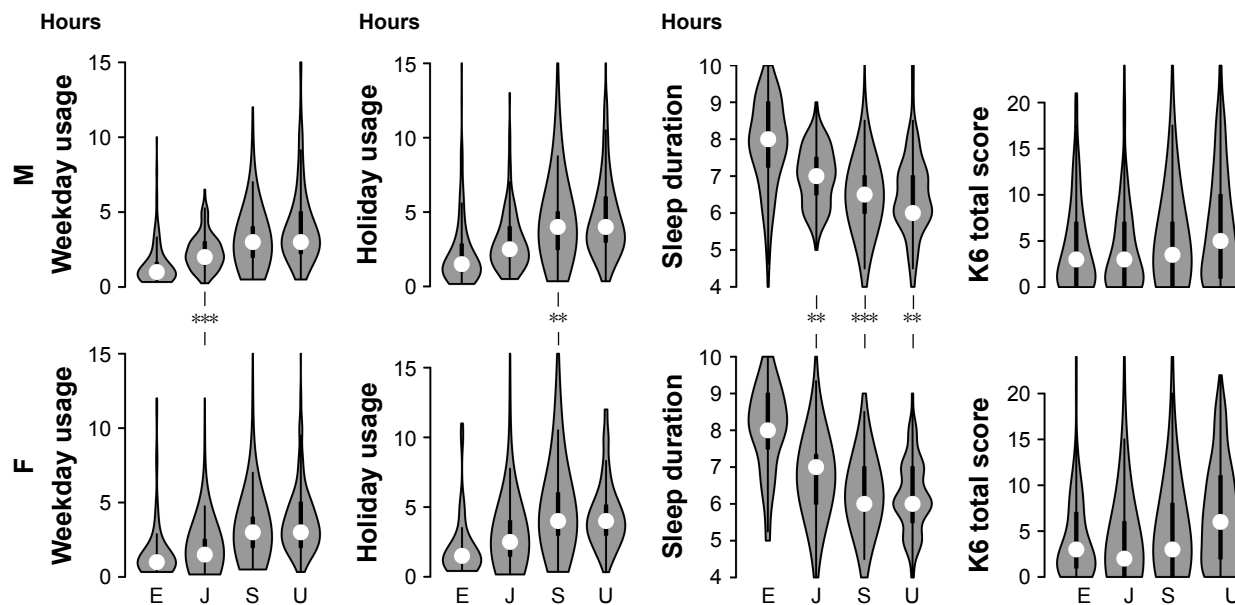| School	Total	Fully responded	
Elementary			
A	122	70	57.4%
B	121	81	66.9%
C	234	119	50.9%
Subtotal	477	270	56.6%
Junior high			
D	364	296	81.3%
E	341	284	83.3%
F	568	470	82.7%
Subtotal	1,273	1,050	82.5%
Senior high			
J	497	314	63.2%
H	341	290	85.0%
I	946	793	83.8%
Subtotal	1,784	1,397	78.3%
University			
J	36	29	80.6%
K	87	73	83.9%
L	78	64	82.1%
M	54	46	85.2%
N	330	295	89.4%
Subtotal	585	507	86.7%
Total	4,119	3,224	78.3%

Figure S2 Distribution of weekday and holiday Internet usage, sleep duration, and K6 total score of participants stratified by educational stages and sex: four violin plots in each panel correspond to elementary, junior high and senior high school, and university, from left to right.

Notes: The gray area showed smoothed distribution of each variable, where the horizontal width represented relative frequency. White discs indicate the medians, and the thick black vertical lines indicate 25–75 percentile intervals. Results of Mann–Whitney's U-test between males and females within each educational stage are indicated as follows: ***$P<0.001$; **$P<0.01$.

Abbreviations: E, elementary school; F, female; J, junior high school; M, male; S, senior high school; U, university.