



# The association of smartphone use and depression in Japanese adolescents

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## ABSTRACT

The aim of this study is to assess the association between smartphone usage and depression in each gender of senior high school students. A cross-sectional study with self-administered questionnaires for 295 high school students, aged 15–19 was conducted in Japan. Depression was assessed using the Center for Epidemiologic Studies Depression Scale (CES-D). Female adolescents used smartphones more hours a day than males. Students who used the smartphones for three hours a day accounted for 44.3% of female students and 22.5% of male students. Female students spent longer hours on online chat, social networking sites (SNS), and Internet browsing. The longer hours they spent for online chat (Odds ratio (OR): 1.74; 95% confidence interval (CI): 1.18–2.56), and SNS (OR: 1.41, 95% CI: 1.04–1.92) were associated with depression. On the other hand, male students spent more hours playing games than female students, and their smartphone use was not correlated with depression. There were gender differences in smartphone usage: female students spent more time on social contacts, whereas males were more likely to use them for entertainment. Therefore, if female students overuse online communication, they may be at a higher risk for depression.

## 1. Introduction

Young people, particularly adolescents, use mobile phones the most (De-Sola Gutierrez et al., 2016; The Ministry of Internal Affairs and Communications, 2017). According to the Cabinet Office of the Government of Japan (2017), 97.1% of senior high school students had mobile phones in 2017 and among them 66.7% were junior high school students and 55.5% were elementary school students. Most mobile phone users now have a smartphone, the most advanced version, which provides a variety of functions such as phone, camera, multimedia player, Internet browser, and a navigation system. Moreover, it facilitates access to social networks, online chat, videos, and games.

Excessive use of the smartphone is known to be associated with health problems. It is reported that using the smartphone for a long duration is related to headaches (Cho et al., 2016) and poor sleep conditions (Hysing et al., 2015; Mak et al., 2014). Our previous study was also found that excessively long hours of smartphone usage was associated with insomnia (Tamura et al., 2017). Other studies have shown that the use of smartphone in bed at night negatively impacts sleep outcome (Exelmans et al., 2016; Fossum et al., 2014; Munezawa et al., 2011). In the meantime, some reports have indicated the relationship between excessive smartphone use and depression (Ikeda et al., 2014; Thomee et al., 2011). However, there are disagreements

about which type of Internet activity is associated with depression. Some studies report that Internet use for non-communication purposes or playing games was associated with depression (Lee and Jeong, 2014; Selfhout et al., 2009). On the other hand, our previous study showed that long hours of smartphone use for social networking sites (SNS) or online chat were related to depression (Tamura et al., 2017).

Smartphone usage differs according to gender (Chen et al., 2017; De-Sola Gutierrez et al., 2016; Roberts et al., 2014). Females were more inclined to use a smartphone as a tool of communication (e.g., social networking sites (SNS) and instant messenger), while males were more likely to use it as a source of entertainment (e.g., games, videos, and music) (Chen et al., 2017; Roberts et al., 2014). As per our knowledge, there are two studies, which have investigated gender differences in smartphone usage and depression. (Ikeda and Nakamura, 2014; Thomee et al., 2012). However, the results were not consistent. A study has shown that a relationship between hours of smartphone usage and depressed mood is more predominant in males compared to females (Ikeda and Nakamura, 2014), whereas another study has reported such a relationship both in males and females (Thomee et al., 2012).

Hence, we investigated gender differences, which might affect the association between the smartphone usage and depression. In addition, earlier studies regarding smartphone have mostly investigated college students and adults, but not senior high school students who use a

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smartphone the most. So, the aim of this study was to examine the associations between smartphone usage and depression in each gender among Japanese senior high school students.

## 2. Materials and methods

### 2.1. Design and sample

This cross-sectional study was conducted using self-reported questionnaires. Data was collected from the students of one public senior high school in Gifu Prefecture, Japan, between June and July 2014. This school was a Prefectural public school offering several courses of study, such as general courses, business courses, information processing courses, animal husbandry courses, and agricultural courses. This school had 346 students (1st year, 120 students; 2nd year, 117 students; 3rd year, 109 students). The 1st to 3rd year of high school in Japan is equivalent to the 10th to 12th grades in the United States. Anonymous questionnaires were distributed to all 346 students after their class teachers had explained the nature of this survey, and were returned in a sealed envelope to ensure the confidentiality of their information. Of the 346 students, 332 (96.0%) agreed to participate in this study. After excluding 37 questionnaires with incomplete information on smartphone usage or depression, 295 (88.9%) were analyzed. The Research and Ethics Committee of the School of Medicine, in the Graduate School of Nagoya University approved this study.

### 2.2. Measurements

#### 2.2.1. Personal data and lifestyle

Information collected included basic personal data and lifestyle, sex, age, school grade, school club activities, and hours spent sleeping, eating breakfast, and talking to family.

#### 2.2.2. Smartphone use

Information collected about smartphone usage included smartphone ownership such as smartphone, conventional phone, or none and daily smartphone usage such as e-mails, SNS, online chat, Internet browsing, gaming, and videos. The possible responses for the total hours of smartphone usage per day were as follows: none, < 1 h, 1 to < 2 h, 2 to < 3 h, 3 to < 4 h, 4 to < 5 h,  $\geq$  5 h; while those for the respective purpose of usage, such as e-mails, social networking sites (SNS) (e.g., Facebook, Twitter, or Instagram), online chat (e.g., Line, Skype, or Kakao Talk), Internet browsing, playing games, and viewing videos were as follows: none, < 30 min, 30 to < 60 min, 60 to < 120 min,  $\geq$  120 min.

#### 2.2.3. Depression measurements

The extent of depression was evaluated using the Japanese version of the Center for Epidemiological Studies-Depression (CES-D) scale (Shima et al., 1985). The CES-D is a 20-item self-report scale that measures depressive symptoms of general populations (Radloff, 1977). Its reliability and validity have been demonstrated (Radloff, 1977; Shima et al., 1985), and the value of Cronbach's  $\alpha$  was 0.83 in this study. Each item is rated on a 4-point Likert scale ranging from 0 (Rarely or never) to 3 (most of the time or always). All respondents were asked to reflect on how they felt during the week prior to testing. The scores range from 0 to 60, and a score of 16 or greater is used to define clinically meaningful depressive symptoms (Radloff, 1977). As a result, in this study, the cut-off value of 16 points was used to identify depression.

#### 2.2.4. Social support measurements

Social support was evaluated using the Japanese brief version of the Multidimensional Scale of Perceived Social Support (MSPSS) (Iwasa et al., 2007). The MSPSS is a 7-item self-report scale that measures perceived social support from family, friends, and a significant

other (Iwasa et al., 2007; Zimet et al., 1990). Each item is rated on a 7-point Likert scale, and the total score is calculated by averaging the scores for all items. The scores range from 1 to 7 and a higher score indicates more social support. The Cronbach's  $\alpha$  was 0.93 in this study.

### 2.3. Statistical analysis

The differences between gender and smartphone usage, depression, and other survey items, were statistically tested using the Mann-Whitney U and chi-square tests. Within each gender group, associations between smartphone usage and depression were examined using the multiple logistic regression analyses. The dependent variable was depression (0 = no problem: CES-D score < 16, and 1 = depression: CES-D score  $\geq$  16). In the logistic regression, the variables of hours of smartphone use per day and hours spent on e-mail, SNS, online chat, Internet browsing, playing games, and viewing videos were each included as predictors. An odds ratio (OR) was calculated from the logistic regression, adjusting for age and factors associated with the dependent variable. Goodness of fit between the observed and predicted outcomes of the logistic model was assessed based on the Hosmer-Lemeshow test. Additionally,  $p$ -values < 0.05 were considered statistically significant. All statistical analyses were performed using SPSS 20.0 J for Windows.

## 3. Results

The 295 student participants consisted of 173 males (58.6%) and 122 females (41.4%) with a mean (standard deviation: SD) age of 16.2 (0.9) years (range: 15 to 19).

Table 1 shows the usage of Smartphone on each day and the lifestyle, social support, and depression is shown based on gender. Female adolescents had more daily hours of overall smartphone usage than males ( $p < 0.001$ ); users who used the smartphone for three hours a day accounted for 44.3% of female students and 22.5% of males. Females spent more time on SNS ( $p < 0.001$ ), online chat ( $p < 0.001$ ), and Internet browsing ( $p = 0.024$ ). On the other hand, males spent more time playing games ( $p < 0.001$ ). Females were more likely to have depression ( $p = 0.004$ ), participate in cultural club activities ( $p < 0.001$ ), and spend more time talking to family ( $p < 0.001$ ).

Table 2 shows the association between depression and smartphone usage for each gender group. Among females, more time spent on online chat and Internet searching via a smartphone were associated with depression ( $p = 0.022$ ,  $p = 0.035$ , respectively). Moreover, more time spent on SNS tended to be associated with depression ( $p = 0.054$ ). In addition, more daily hours of overall smartphone usage were associated with depression ( $p = 0.049$ ). On the other hand, among males, more time spent playing games via a smartphone tended to be associated with depression ( $p = 0.072$ ).

Table 3 shows the associations between smartphone usage and depression yielded by multiple logistic regression analyses that were adjusted for age and factors associated with depression. Among females, more time spent on SNS and online chat via a smartphone was associated with depression (OR: 1.41, 95% CI: 1.04–1.92, OR: 1.74; 95% CI: 1.18–2.56, respectively) after adjusting for age, talking to family, social support, and hours spent sleeping. Meanwhile, among males, smartphone usage was not significantly correlated with depression. Goodness of fit indicated the appropriateness of the logistic regression model to predict depression (Hosmer-Lemeshow test's  $p$  range of 0.183–0.918).

## 4. Discussion

The present study showed gender differences in smartphone usage. Female adolescents used smartphones for more duration per day than males. They spent more time on SNS, online chats, and Internet browsing, while males spent more time on playing games. These findings are consistent with previous studies indicating gender differences

**Table 1**

The relationship between gender and smartphone use, depression, social support, and lifestyle.

	Males Mean	SD	Females Mean	SD	<i>p</i>
Age	16.3	1.0	16.1	0.9	0.347
CES-D	14.9	7.7	18.1	9.2	0.004
Social support	5.4	1.1	5.6	1.2	0.076
	<i>n</i>	%	<i>n</i>	%	<i>p</i>
Own a smartphone	157	90.8	117	95.9	0.134
smartphone	12	6.9	5	4.1	
conventional phone	4	2.3	0	0.0	
Total hours of smartphone use (hours/day)					
none	7	4.0	1	0.8	< 0.001
< 1 h	25	14.5	7	5.7	
1 to < 2 h	55	31.8	27	22.1	
2 to < 3 h	47	27.2	33	27.0	
3 to < 4 h	18	10.4	20	16.4	
4 to < 5 h	13	7.5	11	9.0	
≥ 5 h	8	4.6	23	18.9	
E-mail (minutes/day)					
none	75	43.6	69	57.0	0.346
< 30 min	58	33.7	27	22.3	
30 to < 60 min	22	12.8	11	9.1	
60 to < 120 min	9	5.2	7	5.8	
≥ 120 min	8	4.7	7	5.8	
SNS (minutes/day)					
none	77	44.5	37	30.6	< 0.001
< 30 min	50	28.9	22	18.2	
30 to < 60 min	27	15.6	21	17.4	
60 to < 120 min	11	6.4	29	24.0	
≥ 120 min	8	4.6	12	9.9	
Online chat (minutes/day)					
none	12	6.9	6	4.9	< 0.001
< 30 min	55	31.8	22	18.0	
30 to < 60 min	47	27.2	20	16.4	
60 to < 120 min	34	19.7	34	27.9	
≥ 120 min	25	14.5	40	32.8	
Internet search (minutes/day)					
none	19	11.0	14	11.5	0.024
< 30 min	95	55.2	53	43.4	
30 to < 60 min	48	27.9	35	28.7	
60 to < 120 min	6	3.5	14	11.5	
≥ 120 min	4	2.3	6	4.9	
Playing games (minutes/day)					
none	19	11.0	34	27.9	< 0.001
< 30 min	42	24.3	33	27.0	
30 to < 60 min	65	37.6	33	27.0	
60 to < 120 min	33	19.1	16	13.1	
≥ 120 min	14	8.1	6	4.9	
Viewing of videos (minutes/day)					
none	24	13.9	16	13.1	0.200
< 30 min	57	32.9	40	32.8	
30 to < 60 min	55	31.8	26	21.3	
60 to < 120 min	18	10.4	20	16.4	
≥ 120 min	19	11.0	20	16.4	
Depression					
no problem	119	68.8	63	51.6	0.004
depression	54	31.2	59	48.4	
Participation in school club activities					
sports club	104	60.1	19	15.7	< 0.001
culture club	35	20.2	75	62.0	
none	34	19.7	27	22.3	
Hours spent sleeping					
< 5 h	19	11.1	10	8.3	0.667
5 to < 6 h	44	25.7	39	32.2	
6 to < 7 h	66	38.6	47	38.8	
≥ 7 h	42	24.6	25	20.7	
Eating breakfast					
eat daily	146	84.9	97	79.5	0.297
occasionally do not eat	26	15.1	25	20.5	
Talking to family					
talk daily	146	84.4	110	90.2	0.205
occasionally do not talk	27	15.6	12	9.8	
Minutes spent talking to family					
< 15 min	35	20.2	13	10.7	< 0.001

**Table 1 (continued)**

	Males Mean	SD	Females Mean	SD	<i>p</i>
15 to < 30 min	48	27.7	22	18.0	
30 to < 60 min	62	35.8	42	34.4	
≥ 60 min	28	16.2	45	36.9	

Data are expressed as mean (SD) and frequency (%). *P*-values yielded by Mann-Whitney U test and chi-square test.

in smartphone usage (Chen et al., 2017; De-Sola Gutierrez et al., 2016; Ikeda and Nakamura, 2014; Roberts et al., 2014). Thus, females are more likely to use smartphone for communicating with peers (Barker, 2009; Muscanell and Guadagno, 2012).

Additionally, this study showed that long hours spent on online chats or SNS using smartphone was related to depression among female students, while they were not present in males. SNS (e.g., Facebook, Twitter, and Instagram) and online chat (e.g., Line, Skype, and Kakao Talk) are popular Internet communication activities among adolescents (Durkee et al., 2012). It is reported that an excessive use of online communication is associated with depression (Thomee et al., 2007; van den Eijnden et al., 2008). A six-month longitudinal study indicated that excessive use of instant messenger was related to the development of depression among adolescents (van den Eijnden et al., 2008). Another one-year cohort study reported that chatting online and e-mailing was associated with depression in female college students (Thomee et al., 2007). According to the Consumer Affairs Agency of Japan (2017), by using SNS or online chat via smartphones, more than 50% of Japanese young people aged 15–25 had negative experiences such as being ignored and criticized. Another study reported that 55% of young adults had a past-year negative social media experience (for example, bullying or meanness, unwanted contact, misunderstandings, or the like), and that such negative experiences were associated with depressive symptoms (Rosenthal et al., 2016). It is, thus, suggested that excessive use of online communication can be a risk for depression. In the present study, females were more inclined to use the communication tools than males as earlier studies showed (Barker, 2009; Muscanell and Guadagno, 2012). It is, therefore, considered that an association between online communication use via smartphones and depression may be more clearly encountered in females than in males.

The present study did not show an association between smartphone use and depression among male students. A previous study indicated the association between the daily amount of online game playing and the severity of depression (Lee and Jeong, 2014). We found that males spent long hours playing games than females, but there was no association between playing games and depression among males. These results might have been caused by an examination of hour spent only via smartphones in this study. Males tend to spend long hours on online games via personal computers and video gaming consoles, compared to smartphones (Paik et al., 2017; The Cabinet Office, Government of Japan, 2017). Further studies are required that study the personal overuse of various electronic devices in adolescents.

The present study has some limitations. The first is that the subjects were limited to participants in a single high school in central Japan. As a result, the findings largely cannot be generalized to other areas and countries. A second limitation is that the information on time of smartphone usage might not be very precise since the information was obtained using a self-administered questionnaire. Finally, this was a cross-sectional study. A causal relationship could not be shown. Nonetheless, this study showed that among female adolescents, the overuse of smartphones for SNS and online chat could be linked to depression. As a result, appropriate use of smartphones should be considered particularly for females overusing online communication.

**Table 2**

The associations between depression and smartphone use, sleep, social support, and talking with family among each gender.

	Male		Depression		<i>p</i>	Female		Depression		<i>p</i>
	No problem mean	<i>SD</i>	mean	<i>SD</i>		No problem mean	<i>SD</i>	mean	<i>SD</i>	
Age	16.3	1.0	16.2	1.0	0.826	16.1	0.9	16.2	0.8	0.332
Social support	5.7	1.0	4.7	1.0	< 0.001	6.0	1.1	5.2	1.1	< 0.001
	<i>n</i>	%	<i>n</i>	%	<i>p</i>	<i>n</i>	%	<i>n</i>	%	<i>p</i>
E-mail (minutes/day)										
none	55	46.2	20	37.7	0.398	36	58.1	33	55.9	0.963
< 30 min	38	31.9	20	37.7		13	21.0	14	23.7	
30 to < 60 min	14	11.8	8	15.1		4	6.5	7	11.9	
60 to < 120 min	6	5.0	3	5.7		5	8.1	2	3.4	
≥ 120 min	6	5.0	2	3.8		4	6.5	3	5.1	
SNS (minutes/day)										
none	51	42.9	26	48.1	0.951	24	38.1	13	22.4	0.054
< 30 min	38	31.9	12	22.2		10	15.9	12	20.7	
30 to < 60 min	19	16.0	8	14.8		11	17.5	10	17.2	
60 to < 120 min	6	5.0	5	9.3		15	23.8	14	24.1	
≥ 120 min	5	4.2	3	5.6		3	4.8	9	15.5	
Online chat (minutes/day)										
none	9	7.6	3	5.6	0.867	4	6.3	2	3.4	0.022
< 30 min	38	31.9	17	31.5		15	23.8	7	11.9	
30 to < 60 min	30	25.2	17	31.5		10	15.9	10	16.9	
60 to < 120 min	26	21.8	8	14.8		19	30.2	15	25.4	
≥ 120 min	16	13.4	9	16.7		15	23.8	25	42.4	
Internet search (minutes/day)										
none	15	12.7	4	7.4	0.150	9	14.3	5	8.5	0.035
< 30 min	66	55.9	29	53.7		31	49.2	22	37.3	
30 to < 60 min	33	28.0	15	27.8		16	25.4	19	32.2	
60 to < 120 min	2	1.7	4	7.4		5	7.9	9	15.3	
≥ 120 min	2	1.7	2	3.7		2	3.2	4	6.8	
Game (minutes/day)										
none	13	10.9	6	11.1	0.072	21	33.3	13	22.0	0.230
< 30 min	31	26.1	11	20.4		17	27.0	16	27.1	
30 to < 60 min	50	42.0	15	27.8		14	22.2	19	32.2	
60 to < 120 min	18	15.1	15	27.8		7	11.1	9	15.3	
≥ 120 min	7	5.9	7	13.0		4	6.3	2	3.4	
Video (minutes/day)										
none	18	15.1	6	11.1	0.411	8	12.7	8	13.6	0.337
< 30 min	39	32.8	18	33.3		24	38.1	16	27.1	
30 to < 60 min	39	32.8	16	29.6		13	20.6	13	22.0	
60 to < 120 min	11	9.2	7	13.0		9	14.3	11	18.6	
≥ 120 min	12	10.1	7	13.0		9	14.3	11	18.6	
Total hours of smartphone use (hours/day)										
< 1 h	22	18.5	10	18.5	0.993	5	7.9	3	5.1	0.049
1 to < 3 h	70	58.8	32	59.3		35	55.6	25	42.4	
3 to < 5 h	22	18.5	9	16.7		15	23.8	16	27.1	
≥ 5 h	5	4.2	3	5.6		8	12.7	15	25.4	
Hours spent sleeping										
< 5 h	13	11.0	6	11.3	0.102	5	7.9	5	8.6	0.056
5 to < 6 h	26	22.0	18	34.0		15	23.8	24	41.4	
6 to < 7 h	46	39.0	20	37.7		27	42.9	20	34.5	
≥ 7 h	33	28.0	9	17.0		16	25.4	9	15.5	
Talking with family										
talk daily	105	88.2	41	75.9	0.066	61	96.8	49	83.1	0.025
occasionally not talk	14	11.8	13	24.1		2	3.2	10	16.9	
Minutes spent talking with family										
< 15 min	22	18.5	13	24.1	0.586	1	1.6	12	20.3	0.006
15 to < 30 min	36	30.3	12	22.2		12	19.0	10	16.9	
30 to < 60 min	39	32.8	23	42.6		21	33.3	21	35.6	
≥ 60 min	22	18.5	6	11.1		29	46.0	16	27.1	

Data are expressed as mean (*SD*) and frequency (%).*P*-values yielded by Mann-Whitney U test and chi-square test.

## 5. Conclusion

Among senior high school students, the present study showed that females spent long duration on online chat, SNS, and Internet browsing via smartphones, whereas males spent more time playing games. Moreover, long hours spent using online chat or SNS were related to depression among females. Females, who tend to overuse online communication, may be at a higher risk for depression. Appropriate education on safe use is necessary to prevent the overuse of online communication using smartphones.

## Declarations of interest

The authors declare that they have no conflict of interest.

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**Table 3**

The associations between smartphone use and depression based on multiple logistic regression analyses for each gender.

	Model 1 OR (95% CI)	Model 2 <i>p</i>	Model 3 OR (95% CI)	<i>p</i>	OR (95% CI)	<i>p</i>
<b>Male</b>						
E-mail	1.09 (0.80–1.48)	0.581	1.03 (0.75–1.41)	0.849	1.20 (0.83–1.74)	0.333
SNS	1.08 (0.82–1.44)	0.584	1.06 (0.79–1.41)	0.718	1.23 (0.88–1.73)	0.228
Online Chat	1.00 (0.76–1.32)	0.995	0.99 (0.74–1.31)	0.915	1.17 (0.83–1.63)	0.369
Internet search	1.41 (0.94–2.11)	0.096	1.31 (0.86–1.98)	0.205	1.49 (0.92–2.40)	0.102
Game	1.26 (0.92–1.72)	0.146	1.21 (0.88–1.66)	0.244	1.19 (0.83–1.70)	0.352
Video	1.09 (0.82–1.45)	0.547	1.09 (0.82–1.46)	0.566	1.12 (0.81–1.55)	0.482
Smartphone use (Total)	1.03 (0.66–1.60)	0.909	0.99 (0.64–1.56)	0.978	1.09 (0.65–1.82)	0.737
<b>Female</b>						
E-mail	0.94 (0.69–1.28)	0.673	0.89 (0.65–1.23)	0.482	0.88 (0.62–1.25)	0.471
SNS	1.29 (0.99–1.68)	0.059	1.26 (0.96–1.64)	0.097	1.41 (1.04–1.92)	0.029
Online Chat	1.45 (1.07–1.98)	0.017	1.38 (1.01–1.90)	0.045	1.74 (1.18–2.56)	0.005
Internet search	1.46 (0.99–2.14)	0.055	1.35 (0.91–2.00)	0.136	1.35 (0.86–2.10)	0.192
Game	1.15 (0.84–1.57)	0.387	1.08 (0.79–1.49)	0.634	1.01 (0.71–1.44)	0.954
Video	1.13 (0.85–1.49)	0.401	1.07 (0.80–1.44)	0.636	1.15 (0.83–1.59)	0.402
Smartphone use (Total)	1.52 (1.00–2.33)	0.051	1.38 (0.89–2.15)	0.150	1.58 (0.95–2.63)	0.076

Data are expressed as odds ratio (OR) and 95% confidence interval (CI) of multiple logistic regression analysis.

Model 1: adjusted for age.

Model 2: adjusted for age and hours spent sleeping.

Model 3: adjusted for age, hours spent sleeping, minutes spent talking with family, and social support.

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