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Report

Relationship Between Smartphone Addiction and Headaches in People with Chronic Headache

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To clarify the relationship between smartphone addiction and headaches, we conducted a questionnaire survey of women who were aware of having headaches. A questionnaire survey was conducted on the Internet of 600 women between the ages of 20 and 40 who had suffered from headaches in the past three months. The subjects were divided into a smartphone addiction group (n = 120) and a smartphone non-addiction group (n = 480). The addiction group had more complaints of photophobia and phonophobia, which are accompanying symptoms of headaches, and the impact of headache attacks on daily life was greater than the non-addiction group. There was no significant difference in sleep time between the groups, but the addiction group used their smartphones longer on average and felt more sleepy during the day. More respondents in the addiction group complained of decreased visual acuity, dry eyes, and blurred vision than the non-addiction group, suggesting that blue light from computers and smartphones affected their eyes. Moreover, the frequency of headaches, stiff shoulders, fatigue, sleeping disorders, hormonal imbalance, and dark circles and wrinkles around the eyes were higher in the addiction group compared to the non-addiction group. Although smartphone addiction has not been established as a disease, our findings suggest that it reduces sleep quality and worsens headaches.

Key words headache, migraine, smartphone addiction, sleep disorders

INTRODUCTION

Among chronic headaches, migraines disrupt daily life as they lead to recurrent moderate to severe headache attacks and are often accompanied by symptoms such as nausea, vomiting, photophobia, phonophobia, and osmophobia.¹⁾ Sleep disorders are known to be one of the risk factors for migraines becoming chronic.²⁾

Smartphones are used worldwide. However, excessive use of smartphones has various effects on the user's physical condition including causing sleep disorders. Blue light stimulation from the smartphone screen has been reported to suppress melatonin secretion and increase activity during the day, and may be interpreted as daytime at night, which affects the body's internal clock and suppresses the secretion of melatonin, making it difficult to fall asleep.³⁾ Sleep deprivation is known to be involved in the chronicity of not only migraines but also tension-type headaches.⁴⁾ In a survey of pharmacy students, we reported that students with migraine were more likely to be addicted to the Internet and have sleep deprivation than students with other types of headaches or without headaches.⁵⁾ Yamamoto *et al.* reported that neuroticism among personality traits affects sleepiness upon waking, falling asleep, maintaining sleep, and recovery from fatigue; moreover, the higher the neuroticism, the worse the feeling of sleep.⁶⁾ We reported that migraine patients have higher levels of neuroticism among personality traits than healthy adults.⁷⁾ On the

other hand, Cerutti *et al.* reported that internet addiction was not associated with headaches.⁸⁾ In this study, we conducted a questionnaire survey of women with headaches to clarify the relationship between smartphone addiction and headaches, focusing on personality traits and sleep quality.

METHODS

Questionnaire Study Using an internet research company (Cross Marketing Co., Ltd.), we conducted a survey targeting women in their 20s to 40s who had experienced headaches within the past three months. Request emails were sent to registered monitors (5,850 people), and 830 people responded. We enrolled 600 women in their 20s to 40s, and the number of women in each age group was set to 200. This study excluded people who did not have headaches, men, teenagers, and people over 50 years old. The response request email was sent on August 17, 2023, and the survey was discontinued on August 21, 2023, when the planned number of responses was reached. As a result, 600 samples were collected. The questionnaire was multiple-choice, and anonymous to protect the personal information of the respondents. In addition to basic attributes, the question items were "characteristics of headache", "smartphone usage status", "effects of smartphone use on physical condition", "sleep situation", and "personality traits". This survey was conducted after obtaining approval from the Human Subject Research Ethics Committee of Teikyo Heisei Univer-

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sity (approval number: 2023-033).

Measurement To select people with migraine, we used the modified ID migraine screener Japanese version,⁵⁾ which included five items: headache exacerbation during daily activities, nausea, photophobia, osmophobia, and phonophobia, covering the previous 3 months. Based on a previous study by Lipton *et al.*,⁹⁾ we assessed headache exacerbation during daily activities, nausea, photophobia, osmophobia and phonophobia using the following criteria: “yes” was assigned to a response of “less than half the time” or “half the time or more”. Migraine was evaluated according to the International Classification of Headache Disorders, Third Edition (ICHD-3).¹⁰⁾ Participants who answered yes to at least two of five questions were considered to have migraines. Those who did not meet the criteria of migraine were considered to have other headaches. Moreover, people with migraines who answered yes to the question about aura symptoms (visual symptom) were considered to have migraine with aura.

Daytime sleepiness was measured using the Japanese version of the Epworth sleepiness scale (ESS).¹¹⁾ An ESS score of 11 or greater was defined as abnormal daytime sleepiness.

The Smartphone Addiction Scale–Short Version is a 10-item scale designed to evaluate smartphone addiction.¹²⁾ The items of the scale are scored from 1 to 6, giving a possible total score range for the scale of 10–60, with higher scores indicating a higher risk of addiction. The cutoff point was determined as 33 for women.

We measured personality traits using the Japanese version of the Ten-Item Personality Inventory (TIPI-J). The TIPI-J is a measure of the Big-Five personality dimensions: extraversion, agreeableness conscientiousness, neuroticism, and openness to experience.¹³⁾ Each item was scored from 1 to 7 points, and the scores were summed. The TIPI-J has been validated and tested for reliability in Japan.¹⁴⁾

Statistical Analysis Data are expressed as mean \pm standard deviation (SD) or number of respondents (%). In this study, all the subjects were classified into smartphone addiction and non-addiction groups. Statistical analysis was performed using Student's t-test for continuous variables and χ^2 test for categorical variables. In addition, some data on respondents' backgrounds were compared between the migraine group and other headache groups. $P < 0.05$ was considered significant. The statistical software used was Excel Statistics ver. 3.21 (Social Information Service).

RESULTS

Respondent Background We enrolled 120 women in the smartphone addiction group and 480 in the smartphone non-addiction group (Table 1). Compared to the non-addiction group, the addiction group was younger ($p < 0.001$) and more often had headaches that interfered with their daily life ($p = 0.005$, Table 1). Although there was no difference in sleep duration between the two groups, there were more people in the addiction group who had poor sleep quality (defined as an ESS score of 11 or higher) ($p < 0.001$, Table 1). There was no difference in the average time spent using personal computers (PCs) between the two groups, but the time spent using smartphones was significantly longer in the addiction group ($p < 0.001$, Table 1). Regarding personality traits, the addiction group had significantly lower scores for extraversion, agreeableness, and conscientiousness, and significantly higher scores

for neuroticism than the non-addiction group (Table 1).

Of the 238 people with migraine, 56 were in the smartphone addiction group and 182 were in the smartphone non-addiction group (Table 2). Compared to the non-addiction group, significantly more people in the addiction group had poor sleep quality ($p = 0.018$) and spent significantly longer time using smartphones ($p < 0.001$, Table 2). Regarding personality traits, the addiction group had significantly lower scores for extraversion and agreeableness than the non-addiction group (Table 2).

Effects of Blue Light on Physical Condition We assessed the effects of blue light from PCs and smartphones on the respondents' eyes. We found that more people in the addiction group complained of decreased visual acuity, dry eyes, and blurred vision than the non-addiction group (Table 3). We assessed the effects of blue light from PCs and smartphones on factors other than the eyes. We found increases in headaches, stiff shoulders, fatigue, sleeping disorders, hormonal imbalance, and dark circles and wrinkles around the eyes in the addiction group (Table 3). Furthermore, more people in the non-addiction group answered that blue light has no effect on their eyes or anything other than their eyes than in the addiction group (Table 3).

Regarding migraine sufferers, many respondents in the addiction group complained of decreased visual acuity due to the effects of blue light from PCs and smartphones on their eyes (Table 4). Moreover, headaches, stiff shoulders, fatigue, dizziness, sleeping disorders, and hormonal imbalance were more common in the addiction group than in the non-addiction group (Table 4). Furthermore, more people in the non-addiction group than in the addiction group answered that blue light has no effect on their eyes or factors other than their eyes (Table 4).

DISCUSSION

Background of Respondents In our study, in the migraine group ($n = 238$), migraine with aura accounted for 25.6% (data not shown), which is similar to previous studies conducted in Japan.^{1,15)} Both headaches and accompanying symptoms are reported to affect the quality of life of migraine patients.¹⁾ We confirmed that the migraine group had a higher degree of disability in daily life than the other headache group (data not shown). Although people with migraine may be included in the other headache group if physicians do not conduct interviews or diagnoses,¹⁶⁾ in the present study, people with migraine had the characteristics of general migraine patients. The addiction group tended to have more migraines than the non-addiction group; moreover, there were more people in the addiction group who had photophobia, phonophobia, and headaches that seriously interfered with their daily lives; however, no significant differences were found when the migraine groups were divided into addiction and non-addiction groups. However, the present study limited the age of the subjects to those in their 20s to 40s, the age at which migraines often occur, and was conducted over the Internet; thus, there may have been bias.

Relationship among Smartphone Addiction, Sleep Duration, Sleepiness Scale, and Personality Traits On the ESS, a total score of 11 or more is considered pathological hypersomnia, and treatment is required for sleep apnea syndrome (SAS).¹¹⁾ In the present study, in both the overall analysis and the analysis of the migraine group, there was no difference in sleep time between the addiction and non-addiction

Table 1. Respondent Backgrounds

	Addiction		Non-addiction		p-value	
	n = 120	%	n = 480	%		
Age	Mean ± S.D.					
		32.7 ± 8.2	35.9 ± 8.0		<0.001 *	
Headache exacerbation during daily activities						
	Never	32	26.7	178	37.1	0.073
	Rarely	36	30.0	109	22.7	
	Less than half the time	39	32.5	127	26.5	
	Half the time or more	13	10.8	66	13.8	
Nausea						
	Never	47	39.2	235	49.0	0.056
	Rarely	31	25.8	126	26.3	
	Less than half the time	30	25.0	96	20.0	
	Half the time or more	12	10.0	23	4.8	
Photophobia						
	Never	45	37.5	240	50.0	0.040 *
	Rarely	34	28.3	113	23.5	
	Less than half the time	25	20.8	92	19.2	
	Half the time or more	16	13.3	35	7.3	
Osmophobia						
	Never	64	53.3	312	65.0	0.059
	Rarely	22	18.3	77	16.0	
	Less than half the time	26	21.7	62	12.9	
	Half the time or more	8	6.7	29	6.0	
Phonophobia						
	Never	31	25.8	205	42.7	0.008 *
	Rarely	39	32.5	112	23.3	
	Less than half the time	35	29.2	116	24.2	
	Half the time or more	15	12.5	47	9.8	
Type of headache						
	Migraine	56	46.7	182	37.9	0.080
	Other headache	64	53.3	298	62.1	
Influence of headaches on daily life						
	Always stay in bed	3	2.5	7	1.5	0.005 *
	Sometimes stay in bed	47	39.2	129	26.9	
	Considerable hindrance (excluding stay in bed)	29	24.2	89	18.5	
	Somewhat affected (excluding stay in bed)	34	28.3	196	40.8	
	No influence	7	5.8	59	12.3	
Average sleeping time						
	Weekdays (hours, mean ± S.D.)	6.4 ± 1.3		6.4 ± 1.2		0.969
	Weekend (hours, mean ± S.D.)	7.2 ± 1.5		7.2 ± 1.5		0.927
Epworth Sleepiness Scale						
	Score (mean score ± S.D.)	12.6 ± 4.8		10.7 ± 5.1		<0.001 *
	11 points or more (strong sleepiness during the day)	85	70.8	241	50.2	<0.001 *
Average smartphone usage time						
	Weekdays (hours, mean ± S.D.)	5.1 ± 2.6		3.6 ± 2.2		<0.001 *
	Weekend (hours, mean ± S.D.)	6.2 ± 3.1		4.6 ± 2.6		<0.001 *
Average usage time of personal computer						
	Weekdays (hours, mean ± S.D.)	2.4 ± 2.9		2.7 ± 3.3		0.457
	Weekend (hours, mean ± S.D.)	1.3 ± 2.1		1.4 ± 2.4		0.967
Smartphone Addiction Scale						
	Score (mean score ± S.D.)	37.9 ± 5.2		22.1 ± 6.7		<0.001 *
	33 points or more	120	100.0	0	0.0	(-)
Personality traits						
	Extraversion (mean score ± S.D.)	2.9 ± 1.3		3.3 ± 1.4		0.001 *
	Agreeableness (mean score ± S.D.)	4.3 ± 1.3		4.8 ± 1.2		<0.001 *
	Conscientiousness (mean score ± S.D.)	3.2 ± 1.4		3.7 ± 1.3		0.002 *
	Neuroticism (mean score ± S.D.)	5.2 ± 1.2		4.7 ± 1.3		<0.001 *
	Openness (mean score ± S.D.)	3.3 ± 1.2		3.3 ± 1.2		0.650

*:p < 0.05, Addiction vs. Non-addiction

groups, but the addiction group spent more time using smartphones than the non-addiction group. The use of smartphones before bedtime may cause sleep disturbances. Since sleep disorders are a risk factor for the severity of migraine and tension-type headaches,⁴⁾ they may have been involved in the onset of headaches in the smartphone-addiction group. Our findings suggest that patients who are highly addicted to smartphones also have SAS. As SAS-related headaches have been reported,¹⁷⁾ patients with a score of 11 or higher on the ESS should be advised to see a doctor.

Addiction is a condition in which a person is unable to quit a particular substance or behavior even if they want to. Similar to nicotine dependence, smartphone addiction can also be considered a psychiatric disorder. In studies on nicotine dependence, smokers were less cooperative, less diligent, and more nervous than nonsmokers.¹⁸⁾ Moreover, previous studies reported that migraine patients^{7,19)} and depression patients¹⁹⁾ have higher neuroticism among personality traits than healthy individuals. Furthermore, psychiatric disorders are known to be aggravating factors for migraine.²⁰⁾ In this study, extraversion

Table 2. Respondent Backgrounds in Migraine Group

	Addiction		Non-addiction		p-value
	n = 56	%	n = 182	%	
Age	Mean ± S.D.				
		33.5 ± 8.3	35.2 ± 7.9		0.184
Headache exacerbation during daily activities					
Never	5	8.9	14	7.7	0.060
Rarely	13	23.2	22	12.1	
Less than half the time	30	53.6	93	51.1	
Half the time or more	8	14.3	53	29.1	
Nausea					
Never	9	16.1	35	19.2	0.245
Rarely	13	23.2	43	23.6	
Less than half the time	22	39.3	84	46.2	
Half the time or more	12	21.4	20	11.0	
Photophobia					
Never	7	12.5	35	19.2	0.328
Rarely	12	21.4	30	16.5	
Less than half the time	22	39.3	83	45.6	
Half the time or more	15	26.8	34	18.7	
Osmophobia					
Never	17	30.4	63	34.6	0.853
Rarely	9	16.1	31	17.0	
Less than half the time	22	39.3	60	33.0	
Half the time or more	8	14.3	28	15.4	
Phonophobia					
Never	2	3.6	16	8.8	0.466
Rarely	10	17.9	23	12.6	
Less than half the time	31	55.4	96	52.7	
Half the time or more	13	23.2	47	25.8	
Type of migraine					
MA	19	33.9	42	23.1	0.104
MO	37	66.1	140	76.9	
Influence of headaches on daily life					
Always stay in bed	3	5.4	4	2.2	0.409
Sometimes stay in bed	29	51.8	84	46.2	
Considerable hindrance (excluding stay in bed)	14	25.0	46	25.3	
Somewhat affected (excluding stay in bed)	8	14.3	44	24.2	
No influence	2	3.6	4	2.2	
Average sleeping time					
Weekdays (hours, mean ± S.D.)	6.5 ± 1.4		6.3 ± 1.3		0.555
Weekend (hours, mean ± S.D.)	7.1 ± 1.6		7.1 ± 1.6		0.902
Epworth Sleepiness Scale					
Score (mean score ± S.D.)	12.8 ± 4.8		11.2 ± 5.4		0.0497 *
11 points or more (strong sleepiness during the day)	39	69.6	94	51.6	0.018 *
Average smartphone usage time					
Weekdays (hours, mean ± S.D.)	5.3 ± 2.8		3.7 ± 1.3		<0.001 *
Weekend (hours, mean ± S.D.)	6.3 ± 2.9		4.7 ± 2.7		<0.001 *
Average usage time of personal computer					
Weekdays (hours, mean ± S.D.)	1.9 ± 2.4		2.7 ± 3.3		0.107
Weekend (hours, mean ± S.D.)	1.4 ± 2.1		1.6 ± 2.7		0.518
Smartphone Addiction Scale					
Score (mean score ± S.D.)	37.8 ± 5.7		22.2 ± 6.5		<0.001 *
33 points or more	56	100.0	0	0.0	(-)
Personality traits					
Extraversion (mean score ± S.D.)	2.8 ± 1.3		3.3 ± 1.4		0.021 *
Agreeableness (mean score ± S.D.)	4.3 ± 1.1		4.8 ± 1.3		0.018 *
Conscientiousness (mean score ± S.D.)	3.2 ± 1.4		3.6 ± 1.3		0.053
Neuroticism (mean score ± S.D.)	5.3 ± 1.2		4.9 ± 1.3		0.076
Openness (mean score ± S.D.)	3.5 ± 1.2		3.2 ± 1.3		0.255

*:p < 0.05, Addiction vs. Non-addiction

sion, agreeableness, and conscientiousness were lower in the addiction group than the non-addiction group, and neuroticism was higher in the addiction group. Similar trends were found for the migraine group, with significant differences in extraversion and agreeableness. Therefore, it is important to provide lifestyle guidance that takes into account personality characteristics for headache patients at risk of smartphone addiction.

Effects of Blue Light on Physical Condition Intrinsically photosensitive retinal ganglion cells (ipRGCs), which

are involved in photophobia in migraines, contain a visual substance called melanopsin that is sensitive to blue light (480 nm).²¹⁾ Blue light is known to be emitted by digital devices such as smartphones.³⁾ Blue light causes various symptoms in the eyes, which may cause headaches among people addicted to smartphones. Many people in the addiction group complained of headaches and also had various symptoms in their eyes. On the other hand, more people in the non-addiction group answered that blue light had no effect on their physical condition, indicating that smartphone addiction has various

Table 3. Effects of Blue Light on Physical Condition

	Addiction		Non-addiction		p-value
	n = 120	%	n = 480	%	
What effect does blue light from using computers and smartphones have on your eyes? (Multiple answers possible)					
Eye strain	87	72.5	308	64.2	0.085
Decreased visual acuity	78	65.0	218	45.4	<0.001 *
Dry eyes	67	55.8	204	42.5	0.009 *
Blurred vision	52	43.3	136	28.3	0.002 *
Hyperemia	21	17.5	57	11.9	0.101
Others	1	0.8	2	0.4	(-)
No influence	8	6.7	90	18.8	0.001 *
What are the effects of blue light on things other than the eyes when using computers and smartphones? (Multiple answers possible)					
Headache	91	75.8	279	58.1	<0.001 *
Stiff shoulders	88	73.3	288	60.0	0.007 *
Fatigue	39	32.5	78	16.3	<0.001 *
Dizziness/vertigo	24	20.0	63	13.1	0.056
Sleeping disorder	49	40.8	111	23.1	<0.001 *
Hormone imbalance	30	25.0	59	12.3	<0.001 *
Increased dark circles and wrinkles around the eyes	29	24.2	75	15.6	0.027 *
Others	0	0.0	3	0.6	(-)
No influence	13	10.8	116	24.2	0.002 *
Are you currently taking measures against blue light?					
I am taking measures.	33	27.5	137	28.5	0.934
I am thinking of taking measures in the future.	57	47.5	219	45.6	
I do not want to take any measures.	30	25.0	124	25.8	

*:p < 0.05, Addiction vs. Non-addiction

Table 4. Effects of Blue Light on Physical Condition in Migraine Group

	Addiction		Non-addiction		p-value
	n = 56	%	n = 182	%	
What effect does blue light from using computers and smartphones have on your eyes? (Multiple answers possible)					
Eye strain	41	73.2	126	69.2	0.569
Decreased visual acuity	40	71.4	95	52.2	0.011 *
Dry eyes	36	64.3	92	50.5	0.071
Blurred vision	25	44.6	63	34.6	0.174
Hyperemia	9	16.1	31	17.0	0.866
Others	1	1.8	2	1.1	(-)
No influence	1	1.8	28	15.4	0.007 *
What are the effects of blue light on things other than the eyes when using computers and smartphones? (Multiple answers possible)					
Headache	48	85.7	124	68.1	0.010 *
Stiff shoulders	47	83.9	114	62.6	0.003 *
Fatigue	27	48.2	41	22.5	<0.001 *
Dizziness/vertigo	19	33.9	33	18.1	0.012 *
Sleeping disorder	28	50.0	54	29.7	0.005 *
Hormone imbalance	17	30.4	32	17.6	0.039 *
Increased dark circles and wrinkles around the eyes	12	21.4	37	20.3	0.859
Others	0	0.0	1	0.5	(-)
No influence	2	3.6	37	20.3	0.003 *
Are you currently taking measures against blue light?					
I am taking measures.	13	23.2	54	29.7	0.565
I am thinking of taking measures in the future.	30	53.6	84	46.2	
I do not want to take any measures.	13	23.2	44	24.2	

*:p < 0.05, Addiction vs. Non-addiction

effects. However, the effects of blue light are the subjective impressions of the respondents, it is not possible to conclude that it is the effect of blue light. Moreover, in addition to blue light, the posture while using a smartphone can cause muscle tension in the neck and shoulders, which can also lead to headaches.

When comparing people with migraine between the addiction and non-addiction groups, the group with smartphone-addiction had more patients with complaints of symptoms, such as headaches, caused by blue light; however, there were

no differences between the two groups in terms of eye symptoms other than decreased visual acuity. Since there was no difference in photophobia between the two groups, factors other than ipRGC activation by blue light may be involved in the onset of headaches in migraine patients. For example, excessive smartphone use may lead to psychological problems such as social isolation and increased stress. This can create chronic stress and anxiety, which can trigger migraines.

Conclusion Comorbidities associated with mental illness, such as depression, are known to worsen migraine.²⁰⁾

Gaming disorder refers to a person's preoccupation with gaming becoming a higher priority than other hobbies or activities of daily living. There is no medical term for smartphone addiction; however, it has similarities to gaming disorder, as it involves prioritizing smartphone use over other hobbies and daily activities. Although smartphone addiction has not been established as a disease, our findings suggest that smartphone addiction is a factor that worsens headaches.

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