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Initial Impact of the COVID-19 Outbreak on ADHD Symptoms Among University Students in Japan

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Objectives: The coronavirus disease 2019 pandemic and its associated societal responses are anticipated to have wide-ranging effects on youth development and mental health. Depression, anxiety, and attention deficit hyperactivity disorder (ADHD) are the three most common mental health problems among university students. Many factors that can threaten mental health during the outbreak affect these three conditions, as well as sleep conditions, in undergraduate students. Thus, determining how these abrupt changes in students' circumstances impact their mental health is very important from a public health perspective.
Methods: We investigated the usual conditions and changes in ADHD symptoms during the outbreak, in relation to depressive and sleep-related symptoms among undergraduate students. A total of 252 students, primarily juniors, completed the online survey.
Results: The results showed that 12% of the students exceeded the cut-off score of the ADHD questionnaire before the pandemic. Approximately 6%−21% of the university students, especially those with ADHD traits, rated their ADHD behaviors as worse during the outbreak than that before the outbreak.
Conclusion: Female students and undergraduates with ADHD traits are more susceptible to experiencing further deterioration of ADHD (inattention) symptoms during the pandemic. In cases where it is difficult to intervene with ADHD symptoms, approaching circadian rhythm or depression will be of considerable clinical use.

Keywords: ADHD; Depression; Sleep; Students; COVID-19; Pandemic.

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INTRODUCTION

The novel coronavirus disease 2019 (COVID-19) pandemic quickly spread across the globe from Wuhan, China, in late 2019 [1]. Prior to the declaration of the COVID-19 outbreak as a pandemic by the World Health Organization on March 11, 2020, the Japanese government "requested" local governments to shut down elementary, junior, and senior high schools across the country on February 27, 2020. Other educational facilities, such as colleges and universities, soon followed suit.

On April 7, the government declared a state of emergency in Japan and "requested" that the entire nation stay at home except when leaving to perform essential tasks. The government rescinded the state of emergency on May 26. Colleges and universities in Japan largely switched from in-person teaching to remote learning thereafter, and students were not allowed to enter campuses without legitimate reasons from the beginning of the first semester, which began in April.

The COVID-19 pandemic and its associated societal response are anticipated to have wide-ranging effects on youth development and mental health [2]. There are numerous factors supporting this prediction. Fear of illness causes individuals to become anxious and experience depressive symptoms. Social distancing interventions force people to restrict direct human contact, and most activities, such as extracurricular activities, socialization with peers, exercise, and physical activities are also restricted, resulting in a state of isolation. Staying home for a long period is likely to lead to a sedentary lifestyle and reduced exposure to sunlight, which is imperative for a consistent sleep routine [3]. A sedentary lifestyle also increases the time spent gaming on the Internet [4], which directly affects sleep onset and exposes students to blue light for a prolonged time. Students may struggle to establish a new structure and routine to adapt to a new way of life. This is a particularly difficult task for students living alone. Converse-

ly, students living with their families who need to stay home almost 24/7 might face difficulties if they are not on good terms with their parents.

Depression, anxiety, and attention deficit hyperactivity disorder (ADHD) are the three most common mental health problems among university students [5]. All the above-mentioned factors that can threaten mental health among undergraduates affect these three conditions and the sleep conditions of the students. Sleep, depression, and ADHD symptoms are intertwined with one another and often create a vicious cycle. Thus, determining how these abrupt changes in students' circumstances impact their mental health is very important from a public health perspective. To date, research into the effect of the COVID-19 pandemic on ADHD is scarce. One study from China revealed that children's ADHD traits during the COVID-19 outbreak significantly worsened compared to their normal state [6]. Similarly, the first nationally representative study using repeated contemporaneous measures showed that children and adolescents in Germany experienced significantly lower quality of life (QoL) and more mental health problems, especially hyperactivity and peer problems during the pandemic, although only selected items from ADHD symptoms were asked in these studies [7]. Additionally, our anecdotal report revealed the opportune need for special support for individuals with ADHD [8]. In this cross-sectional study, which included questions about past states, we investigated changes in ADHD symptoms in relation to depressive and sleep-related symptoms among undergraduate students during the pandemic.

METHODS

A total of 252 students, primarily sophomores belonging to the faculty of literature, economics, law, and technology, completed this survey in early August 2020. The mean age was 19.89 (standard deviation=1.99) years, and there were 93 males and 156 females (3 not reported). This study was approved by the ethics committee of Ryukoku University (2020-01). Written, informed consent was obtained from all the students.

The following information was collected for this study: 1) ADHD symptoms in their normal (pre-COVID) state (obtained by retrospective report), as measured by the Adult ADHD Self-Report Scale−Japanese Version (ASRS-J) [9,10]; 2) depressive symptoms in their normal state (retrospective report), as evaluated by the new mood inventory, which probes the eight representative symptoms of depression by 5-point Likert scales [11] (since depression and anxiety are highly correlated, only depressive symptoms were evaluated in order to lessen the burden on the participants) [12]; 3) degree of change in circadian rhythm and sleep duration during the pandemic, as evaluated on 7-point Likert scales (1=no change, 7=major change; and 0=3-hour sleep deprivation, 1=2-hour sleep deprivation, 2=1-hour sleep deprivation, 3=no change, 4=1-hour increase in sleep, 5=2-hour increase in sleep, 6=3-hour increase in sleep, respectively); and 4) general QoL during the pandemic, as evaluated on a 10-point Likert scale (0=worst, 10=best).

For 1) and 2), following a precedent method adopted in the only existing study from China that investigated ADHD symptom change during the early stage of the pandemic, the participants were asked to rate their relevant symptoms during the outbreak compared with their normal state on a scale of 1 to 4 (1=improved, 2=not different, 3=a little worse, and 4=much worse) [6]. The mean changes in total ADHD symptoms, inattention, and hyperactivity-impulsivity were calculated as the sum of changes in 18, 9, and 9 ADHD symptoms per 18, 9, and 9, respectively (ranging from 1 to 4). The degree of change for the mean change in total ADHD symptoms, inattention, and hyperactivity-impulsivity was judged by criteria, such as 1−1.75, improved; 1.75−2.5, not different; 2.5−3.25, a little worse; and 3.25−4, much worse. The mean change in depressive symptoms was calculated and categorized.

To investigate whether there were significant changes in depression, ADHD, sleep, and QoL during the COVID-19 outbreak, students' responses were analyzed using a one-sample t-test. Pearson's correlation coefficients between depression, ADHD, circadian rhythm, sleep duration, and QoL were calculated using a correlation analysis. Furthermore, students were divided into two groups, the ADHD-trait and non-ADHD groups, according to the cut-off score of the ASRS-J set in the validation study of ASRS-J [10]. Then, a chi-square test was administered to determine if any significant difference existed in the rate of the degree of change in ADHD symptoms between the ADHD and non-ADHD groups. In case any significant difference existed through the administration of the chi-square test, a residual analysis was performed to detect which cells contributed to the significance. Residual analysis was used to calculate adjusted residuals. A figure exceeding ±1.96 for a certain cell shows that the figure in the relevant cell is significantly higher or lower than the expected figure. Additionally, to investigate gender differences in ADHD symptom changes, a t-test was performed. Significance levels were set to 0.05 for all analyses. This study was conducted as part of the diversity of coronavirus pandemic reactions.

RESULTS

The mean scores on each questionnaire assessing the changes in depression; ADHD total, inattention, and hyperactivity-impulsivity of ADHD; circadian rhythm; sleep duration; and QoL during the pandemic were 2.35 (0.64), 2.12 (0.25), 2.15

(0.32), 2.09 (0.25), 2.70 (1.23), 3.97 (1.67), and 4.82 (2.58), respectively (the scores indicating "no change" were 2, 2, 2, 2, 1, 3, and 5, respectively), and the t-scores (p-value) for one-sample t-test were 8.64 (p<0.001), 6.78 (p<0.001), 6.66 (p<0.001), 5.17 (p<0.001), 3.83 (p<0.001), 9.25 (p<0.001), and 1.12 (p=0.26), respectively (Table 1). The changes in each ADHD symptom and the results of the one-sample t-test are shown in Table 2. The correlations between the scores for depression, total ADHD, sleep, and QoL are shown in Table 3.

Changes in depression, total ADHD, inattention, and hyperactivity-impulsivity according to the classification criteria are shown in Table 4.

Thirty students (11.90%) exceeded the ASRS-J cut-off score. There was a significant difference in the change of (total) ADHD symptoms between the ADHD-trait (2.30±0.27) and the non-ADHD groups (2.10±0.24) during the outbreak (t=4.23, p<0.001). As for the degree of ADHD symptom change, the ADHD-trait and the non-ADHD groups showed changes of 0% and 3% (improved), 80% and 91% (not different), and 20% and 6% (a little worse) during the pandemic (Table 5). Chi-square analysis for this cross-tabulation reached a significant level (p=0.012), and further residual analyses revealed that the "no difference" and "a little worse" ASRS-J response in the control group were 2.0 and -2.9, respectively. However, they were -2.0 and 2.9 in the ADHD-trait group. These findings indicate that the ADHD-trait group had a significantly

Table 1. Reported change amount in comparison to normal state

	Score*	SD	t	Effect size (Cohen's d)
Depression	2.35	0.64	8.64**	0.55
ADHD total	2.12	0.25	6.78**	0.48
Inattention	2.15	0.32	6.66**	0.47
Hyperactivity-impulsivity	2.09	0.25	5.17**	0.36
Circadian rhythm	2.70	1.23	3.83**	0.24
Sleep duration	3.97	1.67	9.25**	0.58
QoL	4.82	2.58	1.12	0.16

The changes for depression and ADHD were calculated by the sum of symptom scores per 8 and 18, respectively. One sample t-test was administered to investigate if there is a significant change between the two points, i.e., before and during the pandemic. *scores indicating "no difference from the pre-COVID state" for seven variables were 2, 2, 2, 2, 1, 3, and 5, respectively (see the Methods for more details); **p<0.001. ADHD, attention deficit hyperactivity disorder; QoL, quality of life; SD, standard deviation

Table 2. Reported change for each ADHD symptom in comparison to normal state

	Score	SD	t	Cohen's d
1. Careless mistakes	2.09	0.48	3.47*	0.23
2. Fidgeting	2.27	0.59	7.17**	0.46
3. Difficulty keeping attention	2.31	0.64	7.64**	0.48
4. Leaves seat	2.10	0.40	3.92**	0.25
5. Does not listen	2.07	0.47	2.31*	0.15
6. Feels restless	2.24	0.55	6.89**	0.43
7. Does not follow through	2.13	0.48	4.20**	0.27
8. Difficulty relaxing	2.06	0.64	1.38	0.09
9. Difficulty organizing	2.10	0.58	2.62*	0.17
10. On the go	2.13	0.57	3.57**	0.23
11. Avoids effort	2.37	0.76	7.72**	0.49
12. Talks excessively	2.01	0.42	0.30	0.02
13. Loses things	2.02	0.45	0.70	0.04
14. Rules conversation one-sidedly	1.99	0.37	0.52	0.03
15. Easily distracted	2.25	0.57	6.80**	0.43
16. Difficulty waiting turn	2.00	0.22	0.00	0.00
17. Forgetful	2.06	0.47	2.04*	0.13
18. Interrupts others	2.01	0.26	0.73	0.04

One sample t-test was administered to investigate if there is a significant change between the two points, i.e., before and during the pandemic. The score indicating "no difference" for each 18 variable was 2. The score of each item ranges from 1 to 4. *p<0.05; **p<0.001. ADHD, attention deficit hyperactivity disorder; SD, standard deviation

Table 3. Correlations between changes from normal state in relevant variables

	ADHD	Circadian rhythm	Sleep duration	QoL
Depression	0.43*	0.17*	-0.04†	-0.44*
ADHD	-	0.28*	-0.08†	-0.32*
Circadian rhythm	-	-	-0.04†	-0.21*
Sleep duration	-	-	-	0.11†

Values are presented as Pearson correlation coefficients. *p<0.01; †not significant. ADHD, attention deficit hyperactivity disorder; QoL, quality of life

Table 4. Changes in depression and ADHD symptoms

	Depression (n=247)	ADHD (n=241)	Inattention (n=247)	Hyperactivity -impulsivity (n=244)
Improved	22 (9)	6 (2)	6 (2)	8 (3)
Not different	136 (55)	217 (90)	208 (84)	223 (91)
A little worse	64 (26)	18 (8)	32 (13)	13 (5)
Very much worse	25 (10)	0 (0)	1 (1)	0 (0)

Values are presented as number (%). The mean changes in total ADHD symptoms, inattention, and hyperactivity-impulsivity were calculated by the sum of changes in 18, 9, and 9 ADHD symptoms per 18, 9, and 9, respectively (ranging from 1 to 4). The degree of change for the mean change in the total ADHD symptoms, inattention, and hyperactivity-impulsivity was judged by the criterion such as 1−1.75, improved; 1.75−2.5, not different; 2.5−3.25, a little worse; and 3.25−4, much worse. A mean change in depression symptoms was likewise calculated and categorized. ADHD, attention deficit hyperactivity disorder; SD, standard deviation

Table 5. Changes in ADHD symptoms by ADHD-trait during the outbreak

	ADHD-trait (n=30)	Non-ADHD (n=222)
Improved	0 (0)	7 (3)
Not different	24 (80)	202 (91)
A little worse	6 (20)	13 (6)

Values are presented as number (%). The mean changes in total ADHD symptoms, inattention, and hyperactivity-impulsivity were calculated by the sum of changes in 18, 9, and 9 ADHD symptoms per 18, 9, and 9, respectively (ranging from 1 to 4). The degree of change for the mean change in the total ADHD symptoms, inattention, and hyperactivity-impulsivity was judged by the criterion such as 1−1.75, improved; 1.75−2.5, not different; 2.5−3.25, a little worse; and 3.25−4, much worse. ADHD, attention deficit hyperactivity disorder

Table 6. Gender differences in ADHD symptoms before and during the pandemic

	Male	Female	p
Age	20.01 (1.55)	19.81 (2.23)	0.45
Baseline-total	27.86 (8.35)	26.56 (7.03)	0.20
Baseline-IA	15.60 (5.03)	15.39 (4.08)	0.72
Baseline-HI	12.21 (4.28)	11.20 (3.54)	0.06
Change during the pandemic-total	37.47 (4.15)	38.58 (4.47)	0.06
Change during the pandemic-IA	18.77 (2.49)	19.67 (2.93)	0.01
Change during the pandemic-HI	18.69 (2.05)	18.79 (2.19)	0.71

Values are presented mean (standard deviation). ADHD, attention deficit hyperactivity disorder; IA, inattention; HI, hyperactivity-impulsivity

higher ratio of "a little worse" response and a lower ratio of "no difference" response than the control group.

There is no significant difference in age, the ASRS total score, the ASRS inattention score, or the ASRS hyperactivity-impulsivity score before the pandemic between male and female students (20.01 [1.55] vs. 19.81 [2.23], p=0.45; 27.86 [8.35] vs. 26.56 [7.03], p=0.20; 15.60 [5.03] vs. 15.39 [4.08], p=0.72; 12.21 [4.28] vs. 11.20 [3.54], p=0.06). Female students showed significantly greater change in the ADHD inattention score than their male counterparts during the pandemic (19.67 [2.93] vs. 18.77 [2.49], p=0.01), but not in the ADHD total score or the ADHD hyperactivity-impulsivity score (38.58 [4.47] vs. 37.47 [4.15], p=0.06; 18.79 [2.19] vs. 18.69 [2.05], p= 0.71) (Table 6).

DISCUSSION

This is the first study to investigate changes in ADHD symptoms in relation to depression and sleep-related symptoms among university students during the outbreak in Japan. As expected, some undergraduates experienced greater mental health difficulties in the emergency state than in normal circumstances, although there were a wide variety of diverse reactions in response to the outbreak. Additionally, the residual analyses indicated that the ADHD-trait group had a higher risk of exacerbating ADHD symptoms during the pandemic.

It is natural for people to become anxious or depressed during emergencies, such as an epidemic [13]; however, this is a particular problem in students who are already in a vulnerable mental state, and such students may reach clinical levels of anxiety or depression. A large online survey of 44447 college students revealed that the prevalence of depressive symptoms during COVID-19 was 12.2% [14]. This study cannot estimate the prevalence of depression during the pandemic; however, one-third of the students who reported negative changes in mental health would be candidates for interventions.

Time spent in undergraduate studies is characterized by the specific period between adolescence and adulthood, when students are expected to be independent and engage in self-management, such as controlling their activities (academic, social, economic, and interpersonal), which demands executive function. Furthermore, academic activities in colleges or universities are less structured than during childhood [15]. During the emergent pandemic, such activities became even less structured. Thus, even students with typical development may experience difficulties in accomplishing tasks until they establish a new routine. Studies on children with ADHD in both China and France revealed that approximately one-third to one-half of children displayed worse ADHD symptoms [13,16]. Our study indicated that approximately 6% to 21% of students rated their ADHD behaviors (i.e., inattention or hyperactivity-impulsivity) as worse during the outbreak. This percentage is an unexpected number considering the abrupt change in their circumstances; however, this turmoil would continue to lead to deteriorations in the academic and daily lives of around 10% of students. The possibility that a certain proportion of students with ADHD traits experienced even tougher times adapting to new routines and getting things done during this fluctuating situation is an alarming but expected finding. This study confirmed that students with ADHD traits are more susceptible to further deterioration in their daily lives during the COVID-19 pandemic. Unexpectedly, this study indicated that female students showed significantly greater changes in ADHD inattention symptoms than their male counterparts did. The reason for this finding is unclear and requires further investigation. Regardless, these students are strong candidates for mental health interventions.

In terms of individual ADHD symptoms, eight out of nine inattentive symptoms changed significantly during the pandemic. In contrast, only four out of nine hyperactive-impulsive symptoms did. The only inattentive symptom that did

not reach statistical significance was "lose things." This result likely arose from decreased opportunities to go out during the self-lockdown period. Among the other eight inattentive symptoms, three symptoms, namely, "difficulty keeping attention," "avoids efforts," and "easily distracted," almost reached a medium effect size (i.e., d=0.5). These symptoms possibly resulted from numerous distractions at home (e.g., the presence of family members and video games) during self-lockdown, which encouraged people to stay at home. Among the four hyperactive-impulsive symptoms, two symptoms, namely "fidgeting" and "feels restless," almost reached a medium effect size. These symptoms might have resulted from restraint during the pandemic. In addition, these two symptoms potentially negatively affected inattention symptoms. Acute and/or chronic physical activity might mitigate ADHD symptoms and is beneficial for general health [17].

The prevalence of poor sleep quality among students was initially very high, particularly in Japan. In our study, students reported longer sleep duration and moderate or major changes in their circadian rhythms during the outbreak. These findings are consistent with those of a study on nursing students [18], which may reflect longer free time by saving time to commute to universities. Longer sleep duration may have a positive effect on students' mental health, considering the consistent lack of sleep in the normal state. However, disruption in circadian rhythm negatively affects students' mental health and academic performance in the long run.

Many studies have examined the relationship between ADHD and sleep problems (see Hvolby for review) [19]. Individuals with ADHD have a higher risk of suffering from sleep disruption by hyper-focusing on entertainment, such as video gaming [20]. Higuchi et al. [4] indicated that social restrictions during the COVID-19 pandemic negatively affected Internet use and gaming behavior among treatment seekers in Japan. Furthermore, ADHD is often comorbid with internalizing disorders, including depression and anxiety [6]. Thus, these three conditions may negatively affect one another, as confirmed in this study. In our study, ADHD, depression, and circadian rhythm were significantly and mildly to moderately correlated.

Among the conditions discussed, circadian rhythm is the most convenient and easiest to perform interventions. Healthy sleep practices include the following: a regular sleep/wake schedule, adequate opportunity for sleep, calming and structured bedtime routines, avoidance of caffeine, large amounts of liquids, naps, exercise, and alerting activities (e.g., use of electronic devices) soon before bedtime, sleeping only in bed and using the bed only for sleeping, and attention to environmental factors, such as bedroom furniture, lighting, and temperature [21]. Thus, implementing healthy sleep practices is the recommended first-line option for addressing problems during an outbreak, which may also enhance immune health.

There is a relatively strong relationship between depression and ADHD. Around four times as many participants reported deterioration in depression as in ADHD. Combining these findings, treating depression is another option for the intervention of students with both depression and ADHD symptoms, given that only practitioners specializing in developmental disorders can manage the mental crises of students with ADHD. However, starting ADHD medication during the outbreak is risky in this emergent situation [22].

This study had some limitations. First, partly due to potential selection bias, the relatively small number of participants, and the greater number of females in the sample, the results of our study may not be generalizable to all university students. The third one will potentially decrease the likelihood of identifying ADHD-trait cases because adult women usually develop many compensation mechanisms. Additionally, this study employed a cross-sectional design with retrospective questions for emergency situations. Moreover, the use of retrospective reports of symptoms increased the likelihood of bias. However, this method followed the one adopted in the only existing paper from China investigating ADHD symptom change during the pandemic, which makes it possible to ensure the international comparability of this study. Because this study was conducted a few months after the state of emergency declaration, students could maintain their vivid perception of their behavioral changes between pre- and mid-pandemic. Finally, the mild-to-moderate correlations between ADHD, depression, and sleep symptoms do not necessarily imply causation. The effects can be either directional, bi-directional, or due to a third variable. Additionally, the use of single informants increased the likelihood of spurious associations between variables. Despite these limitations, however, it is worth noting that this research was conducted within a few months after the first state of an emergency in Japan, when students had still retained a sense of change in their mental condition.

This study focuses on the negative aspects of mental health among university students. However, the fact that approximately up to 10% of students endorsed positive answers in depression or ADHD domain, and students sleep longer on average than usual during the outbreak, possibly because this emergent period gives students a respite from social jetlag, albeit only temporarily, is notable [23].

CONCLUSION

This is the first study to investigate changes in ADHD symptoms in relation to depression, sleep duration, circadi-

an rhythm, and QoL among university students during the COVID-19 outbreak in Japan. As expected, some university students experienced greater mental health difficulties in the emergency state than in normal circumstances, although there was a wide variety of diverse reactions in response to the outbreak. Additionally, depression, ADHD, sleep, and QoL have been shown to negatively affect one another. Our study also indicated that approximately 6% to 21% of students rated their ADHD behaviors (i.e., inattention or hyperactivity-impulsivity) as worse during the outbreak. The possibility that a certain proportion of students who originally had ADHD traits were experiencing even tougher times in adapting to new routines and getting things done during this fluctuating situation is an alarming but expected finding. They are strong candidates for mental health intervention. In cases where it is difficult to intervene with ADHD symptoms, approaching circadian rhythm or depression will be of clinical use.

Availability of Data and Material

The datasets generated or analyzed during the study are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

Author Contributions

Conceptualization: Toshinobu Takeda, Tatsuya Nomura. Data curation: Toshinobu Takeda, Reiko Akatsu. Formal analysis: Toshinobu Takeda, Yui Tsuji. Funding acquisition: Toshinobu Takeda, Tatsuya Nomura. Investigation: Toshinobu Takeda. Methodology: Toshinobu Takeda, Yui Tsuji. Project administration: Toshinobu Takeda. Resources: Toshinobu Takeda. Software: Toshinobu Takeda. Supervision: Tatsuya Nomura. Validation: Toshinobu Takeda. Visualization: Yui Tsuji. Writing—original draft: Toshinobu Takeda. Writing—review & editing: Toshinobu Takeda.

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