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Original Article

Effect of encouraging greater physical activity on number of steps and psychological well-being of university freshmen during the first COVID-19-related emergency in Japan

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Abstract
Problem Statement: In early 2020, novel coronavirus began spreading around the world. Japan entered its first state of emergency in April that year, and people were asked to avoid going out unless necessary. University students were unable to attend university, let alone participate in other activities. This may have caused a reduction in physical activity and affected mental health. Encouraging physical activity is a well-known effective way to maintain and improve one's psychological well-being. Thus, encouraging even a little amount of physical activity under the circumstances could benefit the psychological well-being of university students. **Purpose:** This study investigated whether the number of steps, psychological well-being, and sleep of university freshmen change following physical activity encouragement during the first novel coronavirus state of emergency in Japan. **Methods:** For 2 weeks from the middle of April in 2020, 161 university freshmen were asked to count their steps daily. In the first week (before intervention), they were told to behave normally. The next week (after intervention), they were told to add at least 10 min/day of walking level or more intense exercise to their activity in the previous week. They also completed questionnaires about number of steps before and after the intervention, their psychological well-being, and sleep. **Results:** Although number of steps increased after the intervention, no significant changes after the intervention were observed for psychological well-being and sleep. In addition, we divided subjects into groups based on the change in number of steps after the intervention (decreased, increased by 1 to 999 steps, increased by ≥1,000 steps) and conducted group comparisons. An interaction was observed with happiness, which was significantly increased among students whose step count increased by ≥1,000 steps from pre (7.0±2.3) to post (7.6±2.1) intervention. **Conclusions:** Encouraging physical activity during the state of emergency may have positive effects, especially on emotions like happiness.
Key Words*:* **COVID-19 pandemic, university students, happiness, 10 minutes**

Introduction

In Japan, the first state of emergency was declared on April 7, 2020, owing to the rapid spread of novel coronavirus (COVID-19), causing many schools to temporarily close. This moment marked the beginning of a change in university life, such as classes starting later and transitioning to online-remote classes instead of in person. The transition to remote classes meant that many students had to continue their studies at home. In addition, by declaring a state of emergency, the government requested that citizens voluntarily refrain from leaving home for non-essential purposes. Thus, students had to voluntarily stop all group activities since they could not go outside, let alone travel to school. Consequently, it was predicted that many students would become secluded in their homes, as activities were limited for all university students except those with part-time jobs. Limiting how often students can go outside means depriving them of the opportunity for physical activity. This was expected, especially as many university students live alone and are forced to reside in small living spaces, which can be emotionally taxing.

A recent study suggested that exercise frequencies of regular exercisers decreased when exercise facilities closed during the COVID-19 pandemic (Raiola & Di Domenico, 2021). In the basic policy of Japan's anti-COVID-19 measures, the government indicated that activities such as outdoor exercise and walking—which are essential for maintaining quality of life—are examples of activities excluded from the list of restricted activities. However, it is likely that people who do not normally exercise would not go outside; instead, they would prefer to spend longer hours inside. It is clear that physical activity would decrease under these circumstances. During this period, many university students, especially freshmen, were living alone for the first time. For the reason, they could not meet with friends because they were not allowed to physically travel to their university, and are

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confined to their homes in an unfamiliar place, greatly affecting their psychological well-being (Horita et al., 2022; Son et al., 2020).

Encouraging physical activity is a well-known effective way to maintain and improve one's psychological well-being (Byrne & Byrne, 1993; Paluska & Schwenk, 2000; Scully et al., 1998). Studies on university students have also reported an improvement in psychological well-being after an intervention encouraging exercise over the course some months (Gondoh et al., 2009). In addition, a recent European study targeting students aged 15 to 17 years suggested that encouraging physical exercise using internet coaching can help maintain students' psychological well-being during the COVID-19 lockdown (Piestrzyński et al., 2021). We believe that encouraging even a little amount of physical activity under the circumstances could benefit the psychological well-being of university students.

We aimed to investigate whether there would be an observable change in the number of steps using a remote approach in encouraging physical activity during voluntary isolation, and if that change would have a relationship with the psychological well-being and sleep status of university freshmen believed to have been greatly affected psychologically by Japan's first declaration of a state of emergency.

Material & methods

Participants and procedure

On April 17, 2020, we asked all freshmen students (43 males and 118 females) in a particular faculty at the university to participate by email. They were asked to count their steps for 2 weeks and to then complete a questionnaire. We excluded participants with insufficient data, such as missing or incorrect responses to the survey (56 participants). We analyzed the data of 105 participants. In order to compare our data to those from before the COVID-19 pandemic as reference, we used a survey data based on university freshmen from the same university and department, conducted in April 2019 with 159 students. We conducted this study in compliance with the Declaration of Helsinki. We informed the participants that their cooperation was voluntary, and that failure to respond to the questionnaire would not put them at a disadvantage. We then explained the study's purpose, how we would protect their personal information, and how their data would be used. We created the item "consent to participate in the study" on the response form. Upon confirmation, we examined reponses from those participants who provided consent. The Ethics Committee of the Graduate School of Human and Social Sciences at Fukuoka Prefectural University approved this study (approval number: 22-07).

Measure

Before the survey, we confirmed that all participants had smartphones. We then requested that each individual use a smartphone app to count their number of steps daily for 2 weeks, from April 18 to May 1, 2020, during the first state of emergency. We asked the participants to try to keep their phones with them as much as possible, including when they were at home, but excluding when they went to bed or took a bath. We also asked that they report when they forget to count their steps. The participants were instructed to enter their daily number of steps into a Google Form once a week (for week 1: April 25–27; for week 2: May 2–4).

For the first week (April 18–24: before the intervention) the participants were told to behave normally and were not given any special instructions. For the second week (April 25–May 1: after the intervention), the participants were told to add at least 10 minutes per day of walking or more intense exercise to their activity compared to the previous week.

When the study was explained to them, they were told that exercise, walking, and other forms of physical activity for health purposes would not be a problem under the state of emergency. Each individual was presented with the "Active Guide" (Ministry of Health, Labour and Welfare [MHLW], 2013) presented by MHLW as reference material on physical activity, and they were encouraged to refer to it.

We followed previous research designs to handle the data on the number of steps by first setting the cutoff value (upper and lower limits), then determining that calculating the mean value was appropriate in order to minimize the influence of outliers (Matsushita et al., 2014). A report by MHLW led us to exclude step counts under 100 and over 50,000 before conducting the analysis (MHLW, 2020), and we used the mean value from each week.

We conducted a questionnaire survey on psychological well-being and sleep in addition to the counting of steps. For psychological well-being, we used questionnaires of the Center for Epidemiologic Studies Depression Scale (CES-D) (Radloff, 1977; Shima et al., 1985), subjective happiness, and subjective health status as indexes. The CES-D evaluates a person's degree of depression; it is a 20-item measure with 4-point scale (0–3 points) responses. Scores range from 0 to 60 and low scores indicate low/no depression. As for the questionnaire on subjective happiness and subjective health status, the participants' answers were scored on an 11-point scale (0–10). For the question, "How happy do you feel right now?" the answer, "I don't feel happy" was given 0 points while "I feel happy" was given 10 points. For the question, "How healthy do you feel right now?" the answer, "I am not healthy" was given 0 points while "I am healthy" was given 10 points. We performed a survey on sleep duration and subjective sleep sufficiency. For sleep duration, the participants were asked to provide their average sleep duration for the week. For subjective sleep sufficiency, the participants were asked, "Are you getting enough rest when you sleep?" and each answer was scored on an 11-point scale (0–10) for each type of answer. The answer "I am not resting" was given 0 points while the answer "I am well rested" was given 10 points.

We administered the questionnaire survey twice using the Google Form according to the inputted step counts and compared our findings to the results from the 2019 survey, which was conducted during the same period before the COVID-19 pandemic with university freshmen from the same university and department.

Statistical analysis

We performed a paired t-test on the comparison of before and after encouraging physical activity and conducted an unpaired t-test on the comparison of the 2020 and 2019 surveys. To compare the psychological well-being and the transition of the sleep according to the increase in the number of steps due to the intervention, we carried out a two-factor analysis of variance (ANOVA; between groups × before and after the intervention); if there was an interaction, we conducted a multiple comparison test using the Bonferroni correction. As the additional 10 minutes of physical activity corresponded to ≥1,000 when converted to the number of steps (Tudor-Locke et al., 2005), we divided the increase in the number of steps into three groups: "decreased," "increase of 1–999 steps," and "increase of ≥1,000 steps." The data were presented as mean ± standard deviation. The level of statistical significance was set at a P-value of <0.05.

Results

There were 105 participants. Their mean number of steps per day was 2,115 ± 1,498 before the intervention and 2,612 ± 2,070 after the intervention. Instructing the students to add at least 10 minutes per day of walking or more intense exercise to their activity resulted in a significant increase of 497 ± 573 steps per day (Table 1). Although the mean CES-D score, which we used as an indicator of psychological well-being, showed a decrease from 12.9 ± 8.1 points before to 12.4 ± 8.8 points after the intervention; the change was not significant. There was no significant change before or after the intervention in subjective happiness, subjective health status, average sleep duration, or subjective sleep sufficiency (Table 1). When comparing the outcomes of the five items on the questionnaire survey to the one conducted in 2019, subjective health status and subjective sleep sufficiency before the intervention were significantly better and the average sleep duration at 2020 survey was significantly longer by around 0.9 hours than 2019 survey (Table 1).

Table 1. Data comparisons between the 2019 and 2020 surveys (before and during the COVID-19 pandemic) and changes after the 2020 intervention encouraging physical activity

	2019 survey (n=159)	2020 survey (n=105)		2019 vs. 2020 Pre	Pre vs. Post (2020 survey)
		Pre-test	Post-test		
	Mean ± SD	Mean ± SD	Mean ± SD	*P*	*P*
Male (%)	38 (23.9)	24 (22.9)		—	—
Number of steps (steps/day)	no data	2,115 ± 1,498	2,612 ± 2,070	—	**0.007**
CES-D (points)	11.8 ± 8.2	12.9 ± 8.1	12.4 ± 8.8	0.290	0.233
Subjective happiness (points)	7.3 ± 1.8	7.2 ± 2.0	7.0 ± 2.1	0.601	0.776
Subjective health status (points)	6.2 ± 2.1	7.3 ± 2.1	7.3 ± 2.0	< **0.001**	0.420
Sleep duration (hours/day)	6.4 ± 0.8	7.3 ± 1.1	7.4 ± 1.1	< **0.001**	0.436
Subjective sleep sufficiency (points)	6.5 ± 2.2	7.9 ± 2.1	7.8 ± 2.1	< **0.001**	0.513

CES-D=Center for Epidemiologic Studies Depression Scale

In contrast, there were unusually large individual differences in the number of steps both before and after the intervention. Before the intervention, there was a minimum of 152 steps per day and a maximum of 6,609 steps per day. After the intervention, there was a minimum of 191 steps per day and a maximum of 13,708 steps per day. The results also highlighted that, for some students, their number of steps decreased after the intervention. We therefore obtained the following number of individuals per group: decreased, n=40; increase of 1–999 steps, n=33; and increase of ≥1,000 steps, n=32.

We then investigated whether there was an observable difference in each group (Table 2). While the findings suggest an interaction in subjective happiness (P=0.012) and a significant elevation in the "increase of ≥1,000 steps" group (P=0.042) from 7.0 ± 2.3 points to 7.6 ± 2.1 points, there was a decline from 7.2 ± 1.9 points to 6.7 ± 2.0 points (P=0.055) in the "decreased" group. While this is not a significant difference, it does indicate a falling trend. There was no interaction or substantial change with the CES-D score, subjective health status, sleep duration, or subjective sleep sufficiency.

Table 2. Comparisons between changes in the number of steps based on the intervention encouraging physical activity

	Changes of steps per day	n	Pre-test	Post-test	Group-differences at pre-test	Time effect	Intaraction	Time effect in each group
			Mean ± SD	Mean ± SD	*P*	*P*	*P*	*P* †
CES-D (points)	Decreased	40	13.7 ± 8.7	13.6 ± 9.3				
	Increased ≤999	33	13.3 ± 7.7	12.6 ± 8.9	0.542	0.210	0.722	
	Increased ≥ 1,000	32	11.6 ± 7.6	10.6 ± 8.0				
Subjective happiness (points)	Decreased	40	7.2 ± 1.9	6.7 ± 2.0				0.055
	Increased ≤999	33	7.3 ± 2.0	6.9 ± 2.0	0.858	0.533	**0.012**	0.169
	Increased ≥ 1,000	32	7.0 ± 2.3	7.6 ± 2.1				**0.042**
Subjective health status (points)	Decreased	40	7.5 ± 1.8	7.3 ± 1.8				
	Increased ≤999	33	7.2 ± 2.5	7.3 ± 2.2	0.741	0.696	0.611	
	Increased ≥ 1,000	32	7.1 ± 2.2	7.3 ± 1.9				
Sleep duration (hours/day)	Decreased	40	7.4 ± 1.0	7.5 ± 1.1				
	Increased ≤999	33	7.4 ± 1.1	7.2 ± 1.1	0.630	0.455	0.193	
	Increased ≥ 1,000	32	7.1 ± 1.2	7.4 ± 1.2				
Subjective sleep sufficiensy (points)	Decreased	40	7.8 ± 2.1	7.8 ± 2.2				
	Increased ≤999	33	7.9 ± 2.2	7.5 ± 2.2	0.749	0.502	0.374	
	Increased ≥ 1,000	32	8.2 ± 2.0	8.3 ± 2.0				

CES-D=Center for Epidemiologic Studies Depression Scale. †Adjusted by Bonferroni correction.

Discussion

We examined whether encouraging physical activity, such as walking or more intense exercise for at least 10 minutes longer per day during Japan's first declaration of a state of emergency with COVID-19 change the number of steps that university students took per day, and whether this change was related to their psychological well-being and sleep status. Ranges of 10,000 to 11,000 and 7,700 to 8,000 steps are the optimal number of steps per day needed for Japanese people to adhere to physical activity guidelines (Cao et al., 2014). A previous study that counted the number of steps using smartphones reported the average number of steps per day for a week as 9,253 ± 3,787 (Amagasa et al., 2019). As the average number of steps per day before the intervention was 2,115 ± 1,498, we noted that the number of steps of the participants in this study was abnormally low. It was not difficult to imagine that this was a result of most students voluntarily refraining from going outside for non-essential purposes, as the Japanese government had declared a state of emergency for the first time. In reality, most people exhibited a decrease in their number of steps during the COVID-19 pandemic (Hino & Asami, 2021; Tison et al., 2020; Yamada et al., 2021).

We aimed to increase the physical activity of university students by guiding them to do at least an additional 10 minutes per day of walking or more intense exercise . MHLW has developed the "Active Guide" (MHLW, 2013) to help encourage wellness. The guide promotes "increasing physical activity by over 10 minutes (plus 10)," and thus, we followed this guideline. The number of steps significantly increased after the intervention (2,612 ± 2,070 steps per day) compared to before the intervention (2,115 ± 1,498 steps per day), which implies that just encouraging students to do an additional 10 minutes of exercise contributes to an increase in the amount of physical activity. As 10 minutes of walking corresponds to approximately 1,000 steps (Tudor-Locke et al., 2005), we expected that the call for an additional 10 minutes would lead to that level of increase in the number of steps. However, the actual increase was only about 500 steps. One major reason for this could be because this study only "guided the students to do at least an additional 10 minutes per day of walking or more intense exercise " and that the actual activity was left up to the students themselves. Many students did dance, resistance training while watching a video, or a similar physical activity at home. We believe this was potentially not reflected in the results for the number of steps.

Although we conducted this investigation using CES-D scale as one indicator of psychological well-being, there was no significant difference between before the intervention (12.9 ± 8.1 points) and the 2019 survey (11.8 ± 8.2 points). In a study involving 19,850 Japanese people before the COVID-19 pandemic, the average CES-D score was 13.2 ± 8.1 points (Konno et al., 2010). As the level before the intervention was lower score when comparing it to the outcomes of that study, we can infer that the participants in our study did not show worse psychological well-being. We believe one reason we could not detect a negative impact on psychological well-being from the limitation of free movement under the state of emergency was because of the increase in sleep duration. Sleep duration in the 2019 survey, conducted before the COVID-19 pandemic, was 6.4 ± 0.8 hours, which is a largely similar value to the sleep duration of Japanese university students (males: 6.20 hours, females: 6.09 hours) reported in previous studies (Steptoe et al., 2006). However, sleep duration under the state of emergency (2020, before the intervention) was 7.3 ± 1.1 hours, which is around 1 hour longer compared to

before the COVID-19 pandemic. A study on university students in the US (Wright et al., 2020) similarly found that sleep duration increased by 30 minutes on weekdays and by 24 minutes on weekends and holidays during the stay-at-home order. Our study on Japanese university students affirms this. Further, subjective sleep sufficiency and subjective health status before the intervention were significantly higher compared to that in the 2019 survey, which denotes favorable outcomes.

People with poor sleep conditions also have poor mental health (Kaneita et al., 2007). The increase in the number of hours spent in bed due to voluntarily staying at home during the COVID-19 pandemic is connected to ensuring adequate sleep duration and could possibly positively affect subjective sleep sufficiency and subjective health status. In recent years, schools have tested delaying the start of the school day to ensure a sufficient amount of time for students to sleep (Minges & Redeker, 2016). Although an increase in sleep duration was not the initial intention of remote classes, we believe this provides an opportunity to consider students' sleep issues.

As many studies have shown that encouragement of physical activity is good from a psychological standpoint (Byrne & Byrne, 1993; Paluska & Schwenk, 2000; Scully et al., 1998), we investigated if encouraging physical activity would improve psychological well-being. However, the analysis of all the participants did not indicate a significant change in any of the study items. This study only "instructed students to add at least 10 minutes per day of walking or more intense exercise to their activity." However, a previous study has reported that university students improved their psychological well-being by doing aerobic exercises at least once a week for 60 minutes per session for several months (Gondoh et al., 2009). Thus, we believe that the intensity and duration of adding at least 10 minutes per day of walking or more intense exercise to their activity for only a week, as done in this study, may be insufficient to improve the psychological well-being of the entire sample. In addition, we expected there would be a large disparity between people who actually increased their physical activity and people who did not as, in this study, the execution of physical activity was limited to non-enforceable and voluntary activities, unlike interventions in previous studies (Gondoh et al., 2009). In reality, when considering physical activity from the aspect of the number of steps, although there was a significant increase after the intervention, the average was limited to 2,612 ± 2,070 steps per day. This does not come close to the target number of steps (males: 9,000 steps per day, females: 8,500 steps per day) (Nishi & Okuda, 2012) for adults (20–60 years of age) indicated by MHLW, and the individual variability is extremely large, as shown by the standard deviation.

Thus, we separate the increase in the number of steps after the intervention when compared to before the intervention into 3 groups and then conducted an investigation. The results revealed an interaction in subjective happiness and indicated a significant improvement in the group "increase of ≥1,000 steps." Because 10 minutes of walking corresponds to 1,000 steps when converted (Tudor-Locke et al., 2005), the group with an "increase of ≥1,000 steps" corresponds to people who achieved daily physical activity of at least an additional 10 minutes, and suggests that the rise in this level of physical activity is necessary to increase the degree of happiness. As many factors can lead to someone feeling happy, it is quite possible that plus 10 minutes evoke positive emotions. In addition, although we did not observe any interactions in the CES-D, the score for the "increase of ≥1,000 steps" group after the intervention was 10.6 ± 8.0 points versus the 13.6 ± 9.3 points for the "decreased" group. Even when compared to the average CES-D score of 11.8 ± 8.2 points from the 2019 survey, we could expect that encouraging physical activity would effectively influence psychological well-being. Moreover, although we did not observe a significant interaction between subjective health status, sleep duration, or subjective sleep sufficiency, scores in the "increase of ≥1,000 steps" group tended to improve. Therefore, we consider physical activity as crucial, even in an environment where the government requests its citizens to voluntarily refrain from going outdoors, and that this encouragement positively acts on psychological aspects of individuals. The limitations of this study include the following: the measurement accuracy of each device was not consistent because the students used applications for the smartphones in their possession, and we could not assess physical activity that was not reflected in the number of steps. In addition, since we did not conduct a survey before the state of emergency, the details are unclear on whether psychological well-being changed after the state of emergency was declared.

Conclusions

The results of encouraging incoming university freshmen to do walking or more intense exercise for at least an additional 10 minutes during the first state of emergency for COVID-19 showed a significant increase of approximately 500 steps per day among all the participants. We also found a significant improvement in happiness for the group with an "increase of ≥1,000 steps." The results suggest that a remote approach to encourage physical activity can help maintain physical activity and psychological well-being among university students during the COVID-19 pandemic. This study is important in the sense that we uncovered the significance of proactively engaging in physical activity in the unique situation of having to voluntarily stay at home. Under these circumstances, where COVID-19 has not yet abated, it is likely that people might once again find themselves in an such a situation. This has deepened the importance of encouraging feasible physical activity in this unique context. In the future, it is vital to investigate in detail the duration, intensity, and types of physical activity.

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Conflicts of interest The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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