



# How the large-scale blackout following the 2018 Hokkaido Eastern Iburi earthquake impacted adolescents' sleep patterns

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## Abstract

A blackout on the island of Hokkaido occurred following a massive earthquake on September 6, 2018. This study analyzed the sleep pattern data of junior high school students on the night of the blackout in comparison to a normal night. Data were collected from 52 junior high school students from a school away from the earthquake's epicenter but within the blackout area. Although the students normally slept less than 8 h per night, they slept for nine and a half hours during the blackout night. The duration during the blackout corresponded to the ideal sleep duration recommended by the NSF and AASM.

**Keywords** Blackout · Adolescents · Sleep duration · Earthquake

## Introduction

On September 6th, 2018, at 3:07 am, the 2018  $M_j$  6.7 Hokkaido Eastern Iburi earthquake (Iburi earthquake) occurred. The seismic epicenter of the earthquake was near the eastern boundary of the Ishikari Lowlands fault zone. The earthquake resulted in the failure of the largest thermal electric power plant in Hokkaido, the Tomato-Atsuma Station, located near the seismic epicenter. The failure of the power plant (Tomato-Atsuma Station) and the hydroelectric power plants led to a blackout at 3:25 a.m. across the entire Hokkaido region, an area comprising 2,950,000 homes [1].

We retrospectively obtained self-reported data of adolescents' sleep duration on the night of the blackout. Kiritappu Junior High School is in the Hamanaka-cho township located on the Eastern edge of the Hokkaido island.

The town hall of Hamanaka-cho, in the center of the township, is 257.98 km (160.30 miles) from the epicenter of the earthquake (42.691 N, 142.007E). In this area, the seismic intensity was relatively low (JMA seismic intensity level 2). This level of seismic activity experienced equates to hanging objects, such as lamps, swinging slightly and some people awakening from sleep [2]. Since the earthquake occurred in the early hours of the morning and seismic activity was relatively low, the majority of people were likely to have been unaware of the presence of seismic activity. Earthquakes are very frequent in Japan, as those of a level above 2 have occurred there over 800 times; therefore, Japanese people are relatively accustomed to earthquakes compared with people in other countries that rarely experience earthquakes.

The actual impact of the earthquake in the town was minor; however, the cessation of the electrical supply occurred across most of the Hokkaido island area and lasted several days. The electrical power restoration time varied across areas, and power was only fully operational again on September 8th [3]. For the students monitored during this study, sleep patterns were not widely affected by the earthquake itself but may have been influenced by the loss of artificial light during the night of the blackout. The presence of artificial light before bedtime has been shown to have an impact on circadian phases [4], sometimes delaying bedtime. The earthquake and associated blackout represented a rare opportunity to investigate adolescents in a field study setting, particularly in terms of the concomitant effects of the blackout, specifically, loss of artificial lighting.

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## Participants and methods

We administered a questionnaire to students at Kiritappu Junior High School concerning bedtime and wake times about one month after the earthquake. The questionnaire dealt with normal nights and mornings as well as the night of the blackout and the following morning. Students were informed that participation was voluntary and not compulsory. Of the 59 students, 52 (26 female and 26 male students, mean age of 13.7 years old) consented to participate in the survey. The minimum and maximum ages of Japanese junior high school students are 1–15 years old (3 grades). The questionnaire consisted of items regarding the students' normal bedtime and wake time. The same questions were posed concerning the night of the blackout and the following morning (i.e., bedtime on September 6th and wake time on the morning of September 7th, 2018, the night of the blackout). As the color temperature used in the home affects residents' circadian rhythm [5], the questionnaire also contained items regarding the color of light in the living area of students' homes: white and bright, orange and relatively dim, or other.

## Results

The mean bedtime and wake time were 22:45 and 06:36, respectively. Average sleep duration was 7 h 52 min. On the night of the blackout, these time variables were 21:23

for bedtime and 6:53 for wake time. Average sleep time extended to 9 h and 30 min (Fig. 1).

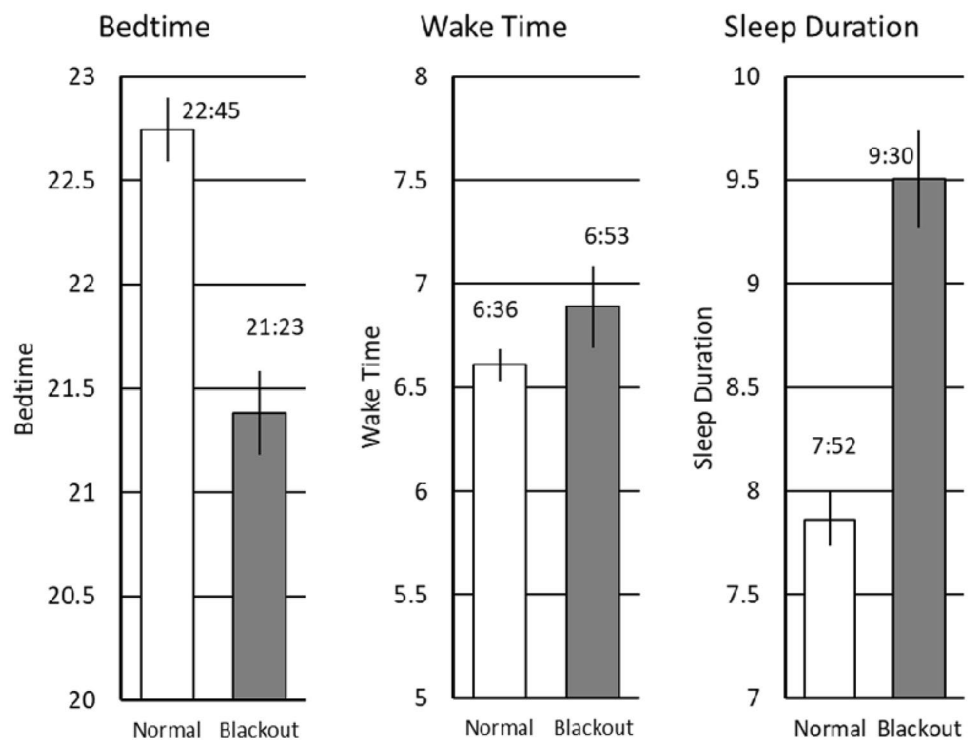
The students' average bedtime was significantly earlier on the night of the blackout [ $t(51) = 6.460$ ,  $p < 0.001$ ,  $d = 1.06$ ], and sleep duration was approximately 1.5 h longer [ $t(51) = 6.313$ ,  $p < 0.001$ ,  $d = 1.20$ ]; however, the wake time was not significantly different after the blackout in comparison to a normal day [ $t(51) = 1.417$ ,  $p = 0.130$ ,  $d = 0.26$ ].

The time of sunset on September 6th, 2018 and the time of sunrise on September 7th, 2018 in Hamanaka-cho township were 17:47 p.m. and 4:50 a.m., respectively. Kiritappu Junior High School temporarily closed on September 6th and 7th, although school teachers and staff were on duty at the school.

## Discussion

The mean normal bedtime and wake time were 22:45 and 6:36, respectively. Mean normal sleep duration was 7 h 52 min. Comparatively, the normal sleep pattern times for Japanese students in the general population of a similar age as those in our sample (calculated from 2015 report nationwide survey results by the Ministry of Education, Culture, Sports, Science and Technology) are 23:17 for bedtime and 6:41 for wake time, giving a mean duration of 7 h 24 min [6]. In comparison to the results of a nationwide survey in Japan, the students of Kiritappu Junior High School went to sleep approximately 30 min earlier; thus, their sleep duration

**Fig. 1** Bedtime, awakening time, and sleep duration of junior high school students on normal days and on the night of the blackout. Error bars represent standard errors



was approximately 30 min longer since their wake time was consistent. Japanese students went to sleep later than those in other countries and tended to sleep for at least half an hour less than those of a similar age (12–15 years) (USA: bedtime: 22:00; wake time: 6:33; sleep duration: 8:33 [7]; Australia: bedtime: 21:49; wake time: 6:59; sleep duration: 9:10 [8]). During the blackout, the time at which the students went to sleep was considerably earlier than normal, and the duration thus extended by approximately one and a half hours. Thus, the average sleep duration on the night of the blackout was 9 h and 30 min, which corresponds to the recommended sleep duration specified by the National Sleep Foundation [9] (NSF) (9–11 h for 6–13-year olds and 8–10 h for 14–17-year olds) and American Academy of Sleep Medicine [10] (AASM) (8–10 h for 13–18-year olds).

In Japan, people are currently using lighting with relatively high color temperatures and illuminance levels in their homes, particularly in comparison to Western countries [5]. Higuchi et al. (2016) [5], reported significant positive correlations between color temperatures in the home and participants' dim light melatonin onset (DLMO). This indicates that the higher the color temperature, the greater the delay in the onset of circadian rhythms. As light also has alerting effects, the changes in the students' sleep patterns may be due to these effects [11]. In our survey, 45 of the 52 students chose the item "white and bright" to describe their lighting at home. The comparative advance in bedtime on the night of the blackout may have potentially been caused by a reduction in artificial lighting. This may have also been partly due to a concomitant absence of available social networking services; however, these effects were not as significant since the networks of one leading phone carrier (NTT Docomo) were still available on the night of the blackout.

Several limitations were inherent in this study. First, the number of students surveyed was relatively small. Second, although the effects of the failure of social networking services were not considered a significant factor, it is not possible to eliminate the possibility of some form of impact (e.g., refraining from using one's smartphone for fear of running down its battery). Third, although the seismic intensity was relatively low, there remains a possibility that psychological factors such as anxiety may have some effect on their sleep. Further research in this area would be required to draw firmer conclusions.

## Conclusions

A major factor delaying the bedtime of Japanese adolescents could be the brightly illuminated rooms in Japanese homes. It might be preferable for Japanese homes to incorporate dimmer lighting options to promote better sleep schedules for adolescents.

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## Compliance with ethical standards

**Conflicts of interest** The authors have no conflicts of interest to declare.

**Ethical approval** As the data had to be obtained immediately after the earthquake, we did not have time to apply to the ethical review board; however, all procedures performed in the study involving human participants were in accordance with the ethical standards of the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

**Informed consent** Informed consent was obtained from all participants included in the study.

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