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Research Article

Changes in the Step Counts of University Students Living in Hokkaido during the COVID-19 Pandemic

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Background. Coronavirus disease (COVID-19) countermeasures, such as lockdowns, have been reported to reduce people's physical activity levels. *Purpose*. To determine changes in the step counts among university students before and after the COVID-19 pandemic and identify the risk factors for decreased step counts. *Materials and Methods*. An online questionnaire was sent by e-mail to 1,851 students enrolled in a university in Hokkaido, Japan; of these, 127 participated. The questionnaire items were average monthly step counts from October 2019 to March 2022, type of residence, part-time job, club activities, personal demographics, height, and weight. The average step counts in October/November 2019 (before the pandemic) were used as the baseline, and changes in step counts were studied at five time points (every 6 months): April/May 2020 (first state of emergency declared), October/November 2020 (period of contained infection), April/May 2021 (second state of emergency declared), and October/November 2021 (period of contained infection). We also examined changes in the number of steps due to different lifestyle factors and factors that contributed to decreased step counts during the study period. *Results*. Significantly lower step counts than those at baseline were observed in April/May 2020 and April/May 2021; however, there was no significant difference in October/November 2020 and October/November 2021 compared with baseline. In addition, significantly lower step counts were observed in April/May 2020 than in April/May 2021. The risk of decreased step counts was significantly associated with nonparticipation in club activities, even after adjustment for other variables. *Conclusion*. The step counts of university students decreased significantly during the declaration of a state of emergency and recovered to pre-pandemic levels after the declaration was lifted. Lifestyle status revealed differences in the number of steps taken before and after the pandemic. Nonparticipation in club activities was identified as a major risk factor for a decrease in step counts.

1. Introduction

Coronavirus disease (COVID-19) was confirmed in China at the end of December 2019 and spread worldwide, resulting in numerous infections and deaths in Japan, with countermeasures still underway. Restrictions on leaving the house during a state of emergency and semi-emergency measures have collectively been shown to negatively impact health by decreasing physical activity [1]. Reduced physical activity is known to be associated with increased mortality from chronic diseases and adverse psychological symptoms such as depression and anxiety [2].

COVID-19 has drastically changed the way college students take classes, with countermeasures to the pandemic resulting in online classes and seating assignments with a fixed distance between students and their neighbors being introduced. Online classes are designed to allow students to attend lectures from their homes, which may reduce the physical activity of commuting to and from school and college. Furthermore, the government's mandate restricting students from leaving the house unnecessarily is expected to reduce their activities outside of university as well.

A previous study of university students in Hiroshima Prefecture, Japan, measured the step counts taken from January to May 2020 and reported a significant decrease from 5,118 ± 2,291 steps in March, before the declaration of the state of emergency, to 3,281 ± 1,689 and 2,834 ± 1,676 steps in April and May, respectively, after the declaration [3]. In addition, a

comparison of the physical activity of college and graduate students living in Kochi Prefecture, Japan, between October 2019 and May 2020 showed that their total physical activity decreased significantly by 47.7%, high-intensity physical activity by 59.3%, and moderate-intensity physical activity by 42.1%; whereas sitting time increased significantly by 36.9% during the COVID-19 pandemic [4]. The same study also examined changes in physical activity at three time points in May, August, and November 2020 after the first emergency declaration was lifted and found that after a temporary decline in physical activity in May, physical activity increased in August and November [4]. Globally, physical activity is known to decrease during a lockdown, with a 31% decrease reported among young adults (18–35 years) [5]. A survey of college students in the USA also showed a significant decrease from approximately 10,300 steps/day the year before the pandemic to approximately 4,600 steps/day during the pandemic [6].

Therefore, while a decrease in physical activity at the time of the first emergency declaration and subsequent recovery is apparent in Japan, reports on the second emergency declaration and subsequent changes in physical activity have been minimal. Some studies have investigated physical activity after the lockdown; however, either the activity before the COVID-19 pandemic is unknown [7], or the questionnaire used to evaluate changes in physical activity before and after the COVID-19 outbreak did not use objective measures and was not sufficient [8]. The number of people with COVID-19 has changed over time, and there is a possibility that the disease will continue to spread. Therefore, it is necessary to investigate the actual living conditions of college students during an infectious disease epidemic. Moreover, the COVID-19 control measures taken vary among regions. Hence, it is necessary to evaluate the policy and outcomes in each region to determine the extent to which government messages, both national and prefectural, reached young people and controlled their behavior. Therefore, in this study, we aimed to identify changes in the step counts of university students before and after the COVID-19 pandemic, determine whether the decreased step counts post-pandemic had subsided compared with before the COVID-19 outbreak, and identify risk factors related to decreased step counts.

2. Materials and Methods

2.1. Participants. The study included 1,851 students (591 males, 31.9%) enrolled at the Hokkaido Bunkyo University as of April 2022. This private university is located in Eniwa City, Hokkaido, with a population of approximately 70,000, and has a capacity of 2,200 students in two faculties. Many students also attend the university from the neighboring city of Sapporo, which has 1.95 million residents. Using the university's e-mail address for contacting students, an e-mail-formatted questionnaire was sent to all students. The participants were students from one university, and their identity was confirmed from the e-mail address they registered with at the time they responded to the questionnaire. Responses from other addresses were excluded. The survey period was from April 15 to May 9, 2022, and 188 students responded and consented to participate in the survey. The participant selection process is shown in Figure 1. The final number of people analyzed with complete data was 127 students (38 males, 86 females, and 3 individuals of unknown sex). Informed consent was obtained from all participants after explaining the questionnaire, and this study was approved by the ethics committee of Hokkaido Bunkyo University (approval number: 03019; Eniwa, Japan). The sample size was calculated using G* Power software (ver. 3.1.9.7), assuming that the main outcome, step counts, was measured a priori at five time points, and repeated measures analysis of variance was performed. Setting α at 0.05 and achieving a power of 0.80 and effect size of 0.10, the calculated sample size was 121. The study initially had 188 respondents; however, some were excluded due to missing data, resulting in a final sample size of 127.

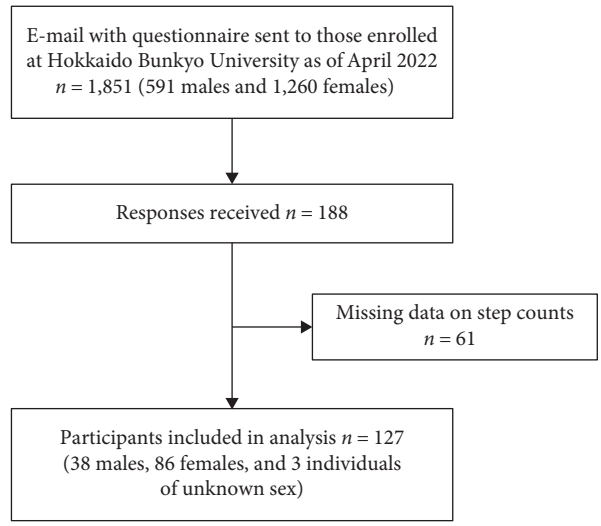

Figure 1: Flowchart of participant selection.

2.2. Methods. This is a retrospective cohort study investigating the situation after October 2019 as of April 2022. A questionnaire was created in Japanese using Google Forms, utilizing the questionnaire creation tools and management software provided by Google (Google LLC.), and a link to the questionnaire was included in the e-mail sent to the students to record responses. Questionnaire items were a combination of those used in previous studies and included personal demographics (age and gender) [9], height, weight, grade [9], and average monthly step counts from October 2019 to March 2022 (defined as physical activity) [3], the type of residence as of October 2021 (family home, living alone, dormitory, or other) [9], whether the respondent was holding a part-time job [10], and whether the respondent participated in club activities [10]. The respondents were asked to view their past step count records, taken using a pedometer application on their smartphones, and fill out the questionnaire form. The average monthly step counts were required to be stated based on the application "Health Care" (Apple Inc.) for iOS device users and "Google Fit" (Google LLC.) for Android device users [10, 11]. Those who did not use a pedometer app or had no data from October 2019 due to a phone model change or other reasons were excluded from

Table 1: Participants' characteristics.

	Total ($n = 127$)	Male ($n = 38$)	Female ($n = 86$)	
Age (years)	19.6 ± 1.6	19.8 ± 1.9	19.4 ± 1.4	—
Height (cm)	162.6 ± 8.1	171.3 ± 6.1	158.5 ± 5.4	**
Weight (kg)	56.9 ± 11.9	66.2 ± 13.1	52.0 ± 7.3	**
BMI (kg/m^2)	21.4 ± 3.4	22.5 ± 4.1	20.7 ± 2.7	**
Residential status (n, %)	—	—	—	—
Living alone	35 (27.6)	10 (26.3)	25 (29.1)	—
With others (including in a dormitory)	92 (72.4)	28 (73.7)	61 (70.9)	—
Part-time job (n, %)	—	—	—	—
Employed	92 (72.4)	30 (78.9)	61 (70.9)	—
None	35 (27.6)	8 (21.1)	25 (29.1)	—
Club activities (n, %)	—	—	—	—
Participated	21 (16.5)	8 (21.1)	13 (15.1)	—
None	106 (83.5)	30 (78.9)	73 (84.9)	—

Data are presented as means ± standard deviations **: $p < 0.01$: significant differences between males and females. BMI, body mass index.

the analysis. The average step counts in October and November 2019 (October/November 2019) (before the COVID-19 pandemic) were used as the baseline, and the change in physical activity was investigated at five time points (every 6 months subsequently): namely, April and May 2020 (April/May 2020), October and November 2020 (October/November 2020), April and May 2021 (April/May 2021), and October and November 2021 (October/November 2021). Notably, April/May 2020 and April/May 2021 were periods when a state of emergency was declared.

The method of analysis was based on the Kolmogorov–Smirnov test for normality for all data, with a significance level of 5%. Differences in change over time from October 2019 to November 2021 were tested using the Friedman and multiple comparison tests by Bonferroni correction. In addition, the respondents were divided into two groups based on sex, residential status (living alone or other), whether they held part-time jobs, and whether they participated in club activities (the latter both being dichotomous variables). Mann–Whitney tests were performed at each time point to examine intergroup differences. Logistic regression analysis was performed with change in step counts in October/November 2019 through October/November 2021 (no decrease = 0, decreased = 1) as the dependent variable and other factors as the independent variables. The odds ratio (OR) and 95% confidence intervals (95% CIs) for a decrease in step counts were calculated from three models adjusted for age, sex, step counts for October/November 2019, residential status, part-time job, and club activities. All data were analyzed using SPSS version 25.0 (IBM Japan, Ltd., Tokyo, Japan). All reported p values are two-tailed, and a p-value of less than 0.05 was considered statistically significant.

3. Results and Discussion

3.1. Results. Table 1 shows the participants' characteristics.

The Kolmogorov–Smirnov test was performed for each time point and showed no normality for step counts other than October/November 2020. Changes in the average step counts at each time point are shown in Table 2.

Comparing the baseline with each time point, a significant decrease in step counts was observed in April/May 2020 and April/May 2021 ($p < 0.001$); however, no significant difference in step counts was observed in October/November 2020 and October/November 2021. Furthermore, the step counts were significantly lower in April/May 2020 than in April/May 2021 ($p < 0.01$).

Comparing step counts according to sex, the step counts in the male group were significantly lower in April/May 2020 than at baseline ($p < 0.001$). There was no significant difference in the step counts between baseline and October/November 2020 and October/November 2021; however, there was a significant difference in step counts between October/November 2020 and October/November 2021 ($p < 0.005$). The step counts in the female group were significantly lower in April/May 2020 and April/May 2021 than at baseline (both $p < 0.001$). There was no significant difference in the step counts between baseline and October/November 2020 and October/November 2021; however, there was a significant difference in step counts between April/May 2021 and October/November 2021 ($p < 0.001$). Comparing step counts between the male and female groups at each time point, there were no significant differences between the groups.

Comparing step counts according to the participant's residential status, the other group did not differ from the overall trend; however, the step counts in the living alone group were significantly lower in April/May 2020 and April/May 2021 than at baseline ($p < 0.001$ and $p < 0.005$, respectively). There was no significant difference in the step counts between baseline and October/November 2020 and October/November 2021; however, there was a significant difference in step counts between October/November 2020 and October/November 2021 ($p < 0.001$). Comparing step counts between the group living alone and the other group at each time point, there were

Table 2: Change in step counts over time.

	a: Oct–Nov 2019 (baseline)	b: Apr–May 2020 (emergency 1)	c: Oct–Nov 2020 (contained infection 1)	d: Apr–May 2021 (emergency 2)	e: Oct–Nov 2021 (contained infection 2)	Multiple comparisons
Overall	5,687.2 ± 2,437.2 5,493 (3,904–7,120)	2,955.5 ± 2,015.7 2,499 (1,559–3,561)	5,364.1 ± 2,356.8 5,199 (3,727–6,644)	4,545.1 ± 1,940.7 4,176 (3,150–5,732)	5,842.1 ± 2,248.4 5,547 (4,145–7,000)	a > b, a > d, b < c, b < d, b < e, c > d, d < e: **
Sex						
Male	5,425.5 ± 2,763.9 5,087 (3,628–6,291)	3,244.3 ± 2,436.2 2,703 (1,464–4,174)	5,503.4 ± 2,242.1 5,229 (3,848–6,614)	4,362.1 ± 2,059.3 4,037 (2,596–5,767)	5,723.4 ± 2,327.6 5,233 (4,489–6,522)	a > b, b < c, b < e, d < e: **, c > d: *
Female	5,748.8 ± 2,284.8 5,545 (3,959–7,129)	2,761.8 ± 1,663.5 2,407 (1,555–3,515)	5,264.0 ± 2,381.5 5,166 (3,628–6,578)	4,547.2 ± 1,833.0 4,178 (3,229–5,688)	5,755.6 ± 2,134.5 5,574 (3948–7013)	a > b, a > d, b < c, b < d, b < e, d < e: **
Residential status						
Living alone	4,625.8 ± 1,958.9 4,683 (3,192–6,032)	2,513.3 ± 1,333.0 2,499 (1,496–3,356)	4,358.8 ± 2,481.3 4,138 (2,673–5,565)	3,766.6 ± 1,504.3 3,656 (2,744–4,683)	5,378.2 ± 1,548.6 5,389 (4,526–6,467)	a > b, b < c, b < e, c < e, d < e: **, a > d: *
With others (including dormitory)	6,091.0 ± 2,488.5 5,932 (4,107–7,409)††	3,123.7 ± 2,204.1 2,516 (1,589–3,746)	5,746.5 ± 2,203.2 5,563 (4,091–7,300)††	4,841.2 ± 2,011.8 4,307 (3,589–6,000)††	6,018.6 ± 2,447.4 5,810 (3,977–7,298)	a > b, a > d, b < c, b < d, b < e, d < e: **, c > d: *
Part-time job						
Employed	5,696.1 ± 2,544.2 5,471 (3,902–7,005)	2,946.1 ± 2,003.1 2,381 (1,650–3,553)	5,490.2 ± 2,449.9 5,255 (3,738–7,157)	4,541.4 ± 1,896.6 4,182 (3,154–5,715)	5,982.5 ± 2,268.6 5,794 (4,486–7,149)	a > b, a > d, b < c, b < d, b < e, c > d, d < e: **
None	5,663.9 ± 2,165.2 5,500 (3,904–7,120)	2,980.0 ± 2,077.6 2,535 (1,431–3,561)	5,032.5 ± 2,089.1 5,050 (3,486–5,895)	4,554.8 ± 2,080.8 4,067 (3,117–5,873)	5,473.2 ± 2,183.3 5,389 (3,750–6,452)†	a > b, b < c, b < d, b < e: **
Club activities						
Participated	5,762.4 ± 1,957.7 5,621 (4,243–6,682)	2,850.6 ± 2,497.6 2,312 (1,511–3,361)	6,163.9 ± 2,935.5 6,125 (3,834–7,095)	4,395.2 ± 1,633.0 3,847 (3,305–5,292)	6,643.7 ± 2,169.9 6,467 (5,078–7,643)	a > b, b < c, b < e, d < e: **
None	5,672.4 ± 2,529.2 5,471 (3,826–7,127)	2,976.2 ± 1,919.6 2,569 (1,592–3,588)	5,205.6 ± 2,207.0 5,166 (3,604–6,543)	4,574.8 ± 2,001.5 4,200 (3,139–5,804)	5,683.3 ± 2,239.6 5,502 (3,920–6,838)	a > b, a > d, b < c, b < d, b < e, d < e: **, c > d: *

Data are presented as means ± standard deviations and medians (interquartile ranges). Multiple comparison test by Bonferroni correction *: $p < 0.005 = 0.05/10$, **: $p < 0.001 = 0.01/10$. Difference between groups †: $p < 0.05$, ††: $p < 0.01$.

Table 3: Odds ratios and 95% confidence intervals for the risk of decreased step counts between October–November 2019 and October–November 2021.

	Residential status		Part-time job		Club activities	
	Living alone	With others	Employed	None	Participated	None
No decrease in step counts/decreased step counts	24/11	44/48	51/41	17/18	16/5	52/54
OR 1 (95% CI)	1	2.61 (1.11–6.09)*	1	1.29 (0.58–2.86)	1	3.35 (1.12–10.03)*
OR 2 (95% CI)	1	1.54 (0.61–3.92)	1	1.31 (0.55–3.14)	1	4.08 (1.21–13.83)*
OR 3 (95% CI)	1	1.58 (0.61–4.10)	1	1.32 (0.54–3.22)	1	4.06 (1.20–13.74)*

OR 1 = adjusted for age and sex. OR 2 = adjusted for age, sex, and step counts for October–November 2019. OR 3 = adjusted for age, sex, step counts for October–November 2019, residential status, part-time job, and club activities, *$p < 0.05$.

significant differences between both groups at the baseline and in October/November 2020 and April/May 2021 (both $p < 0.01$).

Comparisons were made based on whether the participants held a part-time job. In the part-time job group, the overall trend was unchanged, whereas, in the nonworking group, there was a significant decrease in step counts in April/May 2020 compared with the baseline ($p < 0.001$). There was no significant difference in step counts when the baseline was compared with October/November 2020 and October/November 2021. When the part-time job group was compared with the nonworking group at each time point, a significant difference was observed between the groups only in April/May 2021 ($p < 0.05$).

Comparisons were made between the groups with and without club activities. The nonclub group did not differ from the overall trend; however, the club group showed a significant decrease in step counts in April/May 2020 than at baseline. There was no significant difference in step counts between baseline and October/November 2020 or October/November 2021. The club activity group was compared with the non-club group at each time point, and no significant differences were found between the groups.

The results of the logistic regression analyses are presented in Table 3. The group was divided into two: those with decreased step counts from October/November 2019 to October/November 2021 and those with increased step counts. Compared with the increased group, the decreased group showed a significant association with living with others (OR: 2.61; 95% CI: 1.11–6.09; $p < 0.05$) after adjusting for age and sex. However, after additionally adjusting for step counts for October/November 2019, the risk of residence status became insignificant. The decreased group was significantly associated with not participating in club activities on adjusting for age and sex (OR: 3.35; 95% CI: 1.12–10.03; $p < 0.05$) and on additional adjustment for step counts for October/November 2019 (OR: 4.08; 95% CI: 1.21–13.83; $p < 0.05$). Moreover, a similar association was found by adding residence status and part-time job status as adjustment variables (OR: 4.06; 95% CI: 1.20–13.74; $p < 0.05$).

4. Discussion

The step count in October/November 2019, which was before the COVID-19 pandemic, was considered the baseline, and subsequent step counts were obtained every 6 months until October/November 2021. The present study's results showed significantly lower step counts than the baseline in April/May 2020 and April/May 2021; however, there was no significant difference in step counts between the baseline and October/November 2020 and October/November 2021. Therefore, our results showed that the step counts decreased due to the emergency declaration, which restricted going out; however, the step counts improved compared with the pre-COVID-19 epidemic level when the emergency declaration was lifted, and the restriction was relaxed. Moreover, these results did not differ significantly between male and female students.

A previous study examined differences in physical activity between October 2019 and May 2020 among college and graduate students living in Kochi Prefecture, Japan. The results showed that total, high-intensity, and moderate physical activities decreased, whereas sedentary time increased. Furthermore, when changes in physical activity were examined at three time points in May, August, and November 2020, a temporary decrease in total and high-intensity physical activities and a subsequent increase were reported in May [4]. In an online survey of 1,600 older adults in Japan, compared with the pre-pandemic period, there was a 33.3% decrease in total physical activity in April 2020 (during the first wave), 28.3% decrease in August 2020 (during the second wave), and 40.0% decrease in January 2021 (during the third wave) [12]. The first and third waves overlapped with the period when the state of emergency was declared in the research area, indicating that physical activity also declined during the second declaration of emergency. Consistent with these studies, our results also showed that physical activity decreased during the second declaration of a state of emergency and improved to baseline physical activity levels after the state of emergency was lifted. A study in China examined physical activity before (December 2019), during (January 2020), and after (April 2020) lockdown with the International Physical Activity Questionnaire-long form and showed that physical activity during lockdown decreased in moderate to vigorous physical activity and improved after lockdown. However, it was still significantly lower than the corresponding level before lockdown [13]. Further studies on physical activity after the COVID-19 pandemic are still needed.

Mobility data from mobile devices and area-level data studied in the United States reported a greater decrease in utilitarian walking than in recreational walking before and after the lockdown [14]. The decrease in step counts among

college students in the present study is predictably due to a decrease in the step counts for utilitarian walking to and from the university due to the restricted commuting to the university and online lectures.

The step counts in April/May 2020 were significantly lower than those in April/May 2021. During the first declaration of emergency [15], the participants' university was closed, and online lectures were conducted. Use of facilities and stores, including movie theaters and department stores, was restricted or halted, and people were asked to refrain from going out except when necessary to maintain their daily lives. Elementary, junior high, and high schools across Japan were temporarily closed, and the National High School Athletic Meet and the National Junior High School Athletic Meet were canceled. During the second declaration of the state of emergency [16], online lectures were conducted for university courses, and face-to-face lectures were held only for very few practical training courses. There were restrictions on the use of public facilities; however, no temporary school closures were required, and the athletic clubs' conventions and other events were held without spectators. Accordingly, club activities for official competitions were allowed. Hence, the first emergency declaration was considered more restrictive nationwide, and university students were more conscious of the need for self-restraint. This might have led to a significant difference in physical activity levels between April/May 2020 and April/May 2021 in the present study.

Comparing step counts according to the type of residence, the living alone group had significantly fewer step counts than the other group at baseline. As most participants in the living alone group lived in the university's neighborhood, they had a shorter commute to the campus than the other group, which may have contributed to their lower step counts. The trend of lower step counts from the baseline to the declaration of the state of emergency was the same for the living alone and the other group. In a survey of 4,376 participants in the United States, 45% of all participants had a decrease in physical activity time of more than or equal to 5 min/week before and after the COVID-19 pandemic, and the decrease in physical activity was associated with higher pre-pandemic physical activity levels, living alone, lower household income, and COVID-19-associated lower income [17]. Living alone is a risk factor for lower physical activity. Because the present study was limited to college students, and the participants were not the same as those in the previous study, the two groups were likely not to show differences in trends. Furthermore, because the living alone group was associated with lower step counts at baseline and participants living alone are also the most likely to experience a decline in mental health during pandemic-related stay-at-home restrictions [18], it is suggested that interventions to maintain physical activity and supportive measures to encourage connections with others are needed for those who live alone in the future.

Comparing step counts according to part-time job employment, participants who worked part-time had significantly higher step counts than those who did not in October/November 2021. At the other time points, there was no difference between the two groups. The college students who worked part-time were significantly affected by the closure of restaurants, reduction of business hours, and suspension of part-time employment due to COVID-19 preventive measures. The significant difference in step counts observed in October/November 2021 is likely due to employment being in the recovery phase [19] from the decrease in job offers due to the COVID-19 pandemic.

No significant differences were found between the two groups when comparing step counts according to club activities. The low percentage of participants (16.5%) engaged in club activities in the present study did not result in a statistically significant difference.

When the risk of decreased step counts was analyzed by dividing the groups into those with or without decreased step counts from October/November 2019 to October/November 2021, after adjusting for age and sex, living with others was significantly associated. However, when the step counts at baseline were added as an adjustment variable, the risk of residential status was no longer significant. The living alone group originally had a lower step count at baseline than the living with others group, suggesting that they were more likely to increase. In a previous study, living alone was shown to be a factor for decreased physical activity during the COVID-19 pandemic, with a 3.67-fold risk of decrease compared with living with a family [20]. The decreased group was also significantly associated with not participating in club activities, even after adjusting for other variables. Previous studies have shown that adolescent participation in sports clubs is associated with recommended physical activity [21, 22]. In addition, using sports facilities and gyms for physical activity before COVID-19 was significantly associated with increased physical activity during the pandemic [20]. Participation in club activities (lack of interesting club activities) in Japan has been shown to be an independent factor in the temporary leaves and drop-outs observed among college students [23]. Club activities are not only a means to increase physical activity but also a place to spend time with friends. While many college students experienced anxiety during COVID-19, club activities may have contributed to a sense of satisfaction and decreased anxiety.

In the Hokkaido area, where the participants resided, a unique prefectural emergency declaration was issued on February 28, 2020 (Table 4, Figure 2). Because of the outbreak, a state of emergency was declared by the government on April 16, 2020. Various measures were taken depending on the infection situation, including a period of intensive measures, a semi-state of emergency, and measures to prevent a respreading period [24]. The present study's results suggest that the declaration of a state of emergency announced by the government was effective in restraining university students' behavior, but Hokkaido's unique infection control messages were less effective. Strong government enforcement was considered necessary to restrain university students' behavior.

In the future, it is necessary to consider measures to maintain and improve the physical activity level when activities are restricted due to infectious diseases such as COVID-19. In particular, it is important to improve awareness of physical activity among students living alone.

Table 4: COVID-19 policy in Hokkaido.

Date	Event and main policy	Number of persons testing positive per day in Hokkaido (monthly average)
January 28, 2020	The first confirmed infective case in Hokkaido	0.3
February 28, 2020	State of emergency declaration by Hokkaido (ends March 19)	2.4
April 8, 2020	Intensive measures period (ends April 15)	19.7
April 16, 2020	First government state of emergency declaration (ends May 31)	—
October 28, 2020	Intensive measure period (ends March 7, 2021)	33.2
March 8, 2021	Measures to prevent re-spread (ends May 7)	61.3
May 8, 2021	Semi-state of emergency by the government (ends May 15)	444.8
May 16, 2021	Second government state of emergency declaration (ends June 20)	—
June 21, 2021	Semi-state of emergency by the government (ends July 11)	112.4
August 2, 2021	Semi-state of emergency by the government (ends August 26)	399.5
August 27, 2021	Third government state of emergency declaration (ends September 30)	—
October 1, 2021	Measures to prevent respread	16.5

Created based on excerpts from the government website [25].

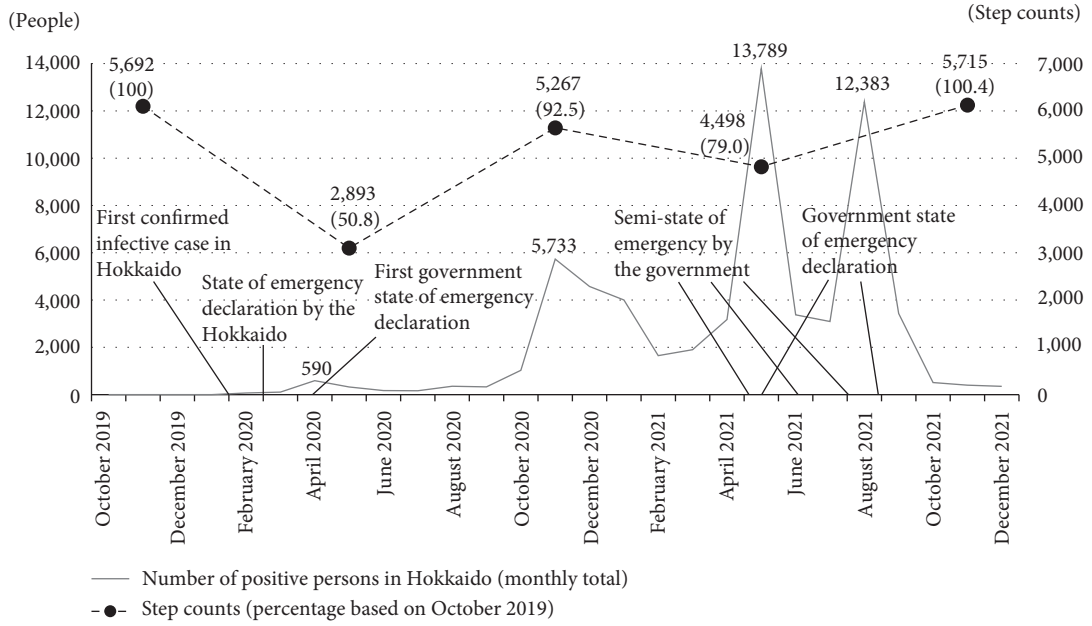

Figure 2: Number of people infected and step counts taken in Hokkaido.

This study had some limitations. First, step counts were obtained using a smartphone application, which does not measure the intensity of sports activity or activity when the device is not carried around, such as during a part-time job; therefore, activity may have been underestimated. Second, the questionnaire collection rate in this study was low (10.2%), the sample size was small, and the variability of the step count variable was large. The study design required participants to refer to step count data from a smartphone application and respond to the questionnaire on a smartphone or personal computer; however, this required effort for those who did not use a personal computer. Third, since the final analysis was limited to 127 participants due to the limited number of students who responded to the questionnaire with complete data (127/1,851), the study results may not accurately represent the population. However, a study of Japanese university students using smartphones to examine the step counts taken before and after the COVID-19 pandemic showed $4,988 \pm 2,345$ steps in January 2020, before the pandemic, and $2,834 \pm 1,676$ steps in May 2020, during the pandemic [3]. Furthermore, another study showed $5,201 \pm 2,226$ steps in December 2019 and $2,810 \pm 2,344$ steps in May 2020 [26]. Considering that the step count decreases during the winter months of December and January, a nearly similar trend is observed; hence, the findings in this study may be considered reasonable.

Although the proportion of males in this study was low (30%), it is likely that the response rate was similar to the overall percentage of males in the university, which was 591 out of 1,851 (31.9%). This study was conducted at a single university and is similar to a survey using a nonrandom sampling method. While the data cannot be said to be representative

of the approximately 80,000 university students in Hokkaido, the results may be representative of the characteristics of young people, including those in large urban areas.

To the best of our knowledge, this is the first study on COVID-19-related changes among university students living in Hokkaido, Japan. Although there have been many reports on COVID-19, the methods and timing of countermeasures differed between countries and regions. Therefore, a variety of findings are needed. This study is useful because it showed changes in step counts of university students over time.

5. Conclusions

This study investigated changes in step counts of university students living in Hokkaido, Japan, during the COVID-19 pandemic. We found that the step counts of university students decreased significantly during the declaration of a state of emergency and recovered after the declaration was lifted to levels akin to those before the COVID-19 pandemic. In addition, nonparticipation in club activities was found to be a significant risk factor for decreased step counts. This study was conducted with a limited sample size within one university in Hokkaido, Japan, and step counts were obtained from a smartphone; hence, activity was not measured when the participants were not carrying the device. However, it was possible to ascertain the step counts taken on a daily basis, such as commuting to school and leisure activities, and we were able to show temporal changes in the step counts taken before and after the COVID-19 pandemic among these university students. The changes in physical activity during the COVID-19 pandemic require further elucidation since the methods and timing of the countermeasures for COVID-19 differed among countries and regions. Therefore, it is necessary to evaluate policies and outcomes to determine the extent to which government messages (national and prefectural) reached young people and determined their behavior.

Data Availability

The data used to support the findings of this study have not been made available because the current ethical approval does not permit their deposition.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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