Changes in Objectively Measured Lifestyle Factors During the COVID-19 Pandemic in Community-Dwelling Older Adults

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Abstract

Background: In this manuscript, we aimed at investigating whether objectively measured lifestyle factors, including walking steps, sedentary time, amount of unforced physical activity, level of slight and energetic physical activity, conversation time, and sleep parameters altered before and during the COVID-19 pandemic among community-dwelling older adults.

Methods: Data were obtained from a prospective cohort study conducted from 2015 to 2019 and a subsequent dementia prevention study undertaken in September 2020. Community-dwelling adults aged ≥65 years wore wearable sensors before and during the pandemic.

Results: A total of 56 adults were enrolled in this study. The mean age was 74.2±3.9 years, and 58.9% (n=33) of the participants were female. The moderate and vigorous physical activity time significantly decreased and sedentary time significantly increased during the pandemic.

Conclusions: This is the first study to demonstrate differences in objectively assessed lifestyle factors before and during the COVID-19 pandemic among community-dwelling older adults. The findings show that the pandemic has adversely affected physical activity among older adults living on their own in Japan.

Background

The coronavirus disease 2019 (COVID-19) pandemic is threatening the health of human populations globally. Following the emergence of COVID-19 in late 2019, countries experienced first, second, third, and now fourth waves of the disease. As of May 24, 2021, reportedly, there have been over 160 million cases of the disease and over 3 million deaths worldwide [1]. The COVID-19 pandemic has forced governments to impose strict confinement rules on their citizens. In Japan, more than 700,000 cases of COVID-19 have been confirmed, including approximately 100,000 deaths [2]. The government declared a state of emergency as the first wave hit, which was not legally binding but prompted many people to wear face masks, practice social distancing, and refrain from going out. The declaration, released on April 16, 2020, applied to the entire country and was in place for more than a month. People restricted their daily activities to prevent spreading COVID-19 while the advice was in place. These control measures potentially resulted in physical inactivity and social isolation leading to increased levels of psychological stress [3]. Several studies have examined changes in lifestyle factors among young adults that occurred during the period of confinement. The results showed that the COVID-19 restrictions had adverse effects on physical activity and sleep in younger adults [4, 5]. However, few studies have demonstrated whether the COVID-19 pandemic affected the lifestyles of older adults living lonely in the community. Physical inactivity, sleep disturbances, and social isolation are major problems in elderly adults with an increasing life prospect [6–9] and are associated with reduced wellbeing and an increased risk of mental impairment, major preexisting conditions, and death in older adults [10–15]. Thus, comparing lifestyle factors before and during the pandemic is important in understanding its indirect adverse impacts on physical health among older adults. Previously, to examine the risks and protection associated with lifestyle factors in relation to dementia, we conducted a prospective cohort study that measured lifestyle factors objectively in lonely older adults using wearable sensors from August 2015 to March 2019 [16]. Moreover, a subsequent dementia prevention study provided us with an opportunity to measure lifestyle factors objectively in a subgroup of these participants during the pandemic. These non-invasive and cost effective wearable sensors were used to assess the total daily effort and sleep objectively without recall bias, particularly in older adults. Herein, we aimed at evaluating the changes that occurred in objectively measured lifestyle factors before and during the COVID-19 pandemic in community-living older adults.

Methods

Study design and participants

A total of 56 participants (33 females, mean age 74.2 ± 3.9 years, years of education 11.7 ± 2.0 years) were enrolled among a population of lonely older adults living in the community of Usuki, Oita Prefecture, Japan. In the present study, the inclusion criteria, meet by all participants, were as follows: 1) aged 65 and over, 2) lived in Usuki, 3) physically and psychologically healthy, 4) no dementia, and 5) had an independent function in the activities of daily living. All subjects were instructed to wear wristbands (Silmee™ W20, TDK Corporation Tokyo, Japan) throughout the day, except when showering, for a week during September 2020. These subjects had previously participated in a prospective cohort study with a continuous follow-up that analyzed the association between objectively quantified lifestyle factors and mental function from August 2015 to March 2019. During that cohort study, we assessed lifestyle factors using the wearable sensors every 3 months for 3 years and calculated an average annual data [16]. Overall, the average annual data for 2016 and 2018 and the average weekly data for 2020 were collected for analysis.

Data obtained by the wearable sensors

For movement detection, we used a tri-axis accelerometer that can measure acceleration in three perpendicular axes. Accelerometers are based on the principle of differential capacitance, which results from the movement of the sensing element due to acceleration. Data were recorded continuously and analyzed every minute. We defined non-wearing time as the time when heart rate counts were zero. We analyzed the data for participants who had at least three days of valid accelerometer monitoring during the measurement period and at least three hours of valid accelerometer monitoring per day. We used our wearable sensors to assess various lifestyle parameters, including moving steps, metabolic equivalents of tasks (METs), total sleep time (TST), sleep effectiveness, wake time after sleep onset (WASO), number of awakenings, and conversation time. We summarized the measured values of these parameters into the sum of the sensor data collected on each day and their average values over the entire length period. Each parameter was represented as an average value per day. Before our study, we validated the accuracy of our measurements of hiking steps, talking time, and sleep time by comparing them with data from video observations of healthy elderly subjects.

Physical activity

We defined walking step as a movement in the frequency range of 2-3 Hz of acceleration detected by the sensor. The device computed the intensity of activities as METs using algorithms developed by the product designer. Sedentary behavior was defined as activities that involved ≤1.5 METs such as sitting, lying down, or watching television. Light physical activity (LPA) was defined as activities that involved 1.5–3.0 METs such as slow walking, laundry, cooking food, washing dishes, or vacuuming, whereas moderate and vigorous physical activities (MVPA) were defined as activities that involved ≥3 METs such as walking, jogging, or ascending and descending stairs.

Sleep

We evaluated sleep-wake parameters using the magnitude of acceleration and cumulative energy synthesized by a tri-axial accelerometer. The data were verified and corrected visually by a qualified technician. The bedtime was determined according to the number of activities logged by the wristband sensor. Sleep factors including TST, WASO, and sleep efficiency, and the awakening count were measured between 6:00 pm and 5:59 am (the following day). The time of sleep onset was defined as the time when the resting state began, with no movement for more than 20 minutes. We evaluated sleep fragmentation by using WASO, sleep effectiveness, and awakening counts. We defined nightly awakening as 5 to 90 minutes of continuous movement during a continuous sleep period. Sleep effectiveness was determined as the percentage of TST over bedtime. In this study, sleep diaries were not utilized but measured the total bedtime spent using TST and WASO.

Conversation time

This sensor was able to detect whether an adult or someone nearby had made utterances. Although we were not able to exclude the speech of someone nearby from the audio data, the contribution of the participant in the conversation itself was judged to be a valuable sign of social activity. The microphone on the wearable sensor cannot detect the substance of the chat, but it can collect data as sound every minute. We analyzed sound data to evaluate the time of the conversation. Our wearable sensor can detect the sound pressure level of utterances within a 2m radius of the device. The vibration level, considered as utterances at this distance, was 55-75 dBA. Furthermore, the incidence band corresponding to the human voice was extracted as a signal frame from the sound data within the vibration range. A chat was defined as a period of one min during which there were more than four sound frames.

Statistical analysis

The annual average data for 2016 and 2018 and the weekly average data for 2020 before and during the pandemic, respectively, were used for statistical analyses. A repeated-measures analysis of variance (rANOVA) was conducted to compare nine variables of lifestyle factors (walking steps, sedentary time, LPA, MVPA, chat time, TST, WASO, sleep effectiveness, and waking time count) before and during the pandemic. All statistical analyses were conducted using SPSS statistical software (version 25.0, IBM

Corporation, USA) and Prism (version 7.00, GraphPad), and all *p*-values of <0.05 were considered statistically significant.

Results

The demographic and clinical characteristics of all participants are summarized in Table 1. The mean age was 74.2±(3.9) years, and 41.1 % were male (n=23). The mean of education level was 11.7±2.0 years, and the mean of Mini-Mental State Examination score was 27.4±2.6 points. The temporal changes in the objectively measured lifestyle factors are shown in Table 2 and Figure 1, respectively. The amount of daily sedentary time increased (p = 0.028), the daily MVPA time significantly decreased (p = 0.042). No significant changes were noticed in daily walking steps, chat time, LPA time, or other sleep parameters.

Table 1
Clinical and demographical characteristics of participants

Characteristics	
Age, mean (SD), years	74.2 (3.9)
Sex	
Male, n (%)	23 (41.1%)
Female, n (%)	33 (58.9%)
Education level, mean (SD), years	11.7 (2.0)
MMSE, mean (SD)	27.4 (2.6)
Medical history	
Hypertension, n (%)	30 (53.6%)
Diabetes, n (%)	13 (23.2%)
Hyperchoresterolemia, n (%)	20 (35.7%)
MMSE, Mini-Mental State Examination	

Table 2
Temporal changes of objectively measured lifestyle factors

				Repeated measures ANOVA
Wearable sensor data	2016	2018	2020	*p* value
Walking steps, mean (SD), steps/day	5727.3 (2506.0)	5449.6 (2547.4)	4985.3 (3092.8)	0.066
Talking ratio, mean (SD), min/day	217.2 (77.8)	222.0 (70.0)	217.1 (78.5)	0.19
TST, mean (SD), min/day	403.1 (66.7)	406.9 (86.2)	400.8 (89.1)	0.67
WASO, mean (SD), min/day	16.4 (9.3)	16.9 (9.6)	17.0 (13.1)	0.44
Sleep efficiency, mean (SD), %/day	96.1 (2.2)	95.9 (2.5)	95.7 (3.4)	0.49
Awake time count, mean (SD), counts/day	0.44 (0.28)	0.43 (0.28)	0.45 (0.33)	0.51
Sedentary time, mean (SD), min/day	785.3 (69.7)	787.2 (72.2)	829.1 (87.4)	0.028
LPA, mean (SD), min/day	26.9 (18.3)	25.5 (15.1)	23.9 (14.4)	0.80
MVPA, mean (SD), min/day	29.4 (16)	26.5 (16)	24.8 (18.5)	0.043

LPA, light physical activity; MVPA, moderate-vigorous physical activity; TST, total sleep time; WASO, time awake after sleep

Discussion

We investigated the changes in lifestyle factors before and during the COVID-19 pandemic among lonely older adults using wearable sensors. Although multiple reports have assessed the changes in physical activity or sleep parameters individually during the pandemic among younger adults, to the best of our knowledge, this is the first study to investigate the changes in objectively measured lifestyle factors during the pandemic in older adults. Our results provide novel and interesting insights that will help in developing strategies to prevent the indirect health impacts of the pandemic on older adults. The sedentary time significantly increased, in contrast to daily MVPA time decreased. The present study has several strengths, including the objective measurement of various lifestyle factors among community-dwelling older adults and the comparison of those measurements obtained before and during the pandemic.

The truly interesting finding of the present study was that the extent of sedentary time was significantly greater during the pandemic than before the pandemic. Few studies have compared the intensity of exercise taken by people before and during the pandemic. One study showed that the time spent undertaking MVPA decreased during a semi-lockdown period compared with that measured before the pandemic in Chinese young adults [17]. Similarly, our results showed that the daily time spent undertaking MVPA decreased significantly during the pandemic compared with that measured before the pandemic; however, the time spent on MVPA had already decreased between 2016 and 2018. Thus, we were unable to determine whether the decreased amount of MVPA was caused by aging or the pandemic. Physical inactivity can result in increased risks of developing metabolic diseases [18], cardiovascular diseases [19], and immune dysfunctions [20]. For older adults, even short-term physical inactivity can result in muscle loss or frailty [3]. Muscle loss has a negative relationship with metabolic syndromes and cognitive function. The World Health Organization (WHO) has recommended regular physical activity during the pandemic for people of all ages to maintain their health and wellbeing [21]. Our results suggest that the pandemic indirectly had an adverse impact on physical activity among older adults and support the recommendations of the WHO. Moreover, our results indicated that there had been no changes in sleep parameters according to measurements taken before and during the pandemic among older adults. Previous studies that objectively measured sleep time using smartphones showed that sleep time significantly increased during the pandemic compared with that before the pandemic among young adults [4, 22, 23]. Possible explanations for this discrepancy may have been the differences in the ages of the participants or the severity of psychological stress during the pandemic. The psychological stress endured by Japanese people was milder than that by people from other countries because the lockdown in Japan was not as strict.

There were several limitations to the present study that should be considered. First, the television or radio noise might be detected during the conversation using the chosen detection method, which was based on vibrations and frequencies. Besides, the chat time may have comprised sleep during television broadcasting or radio hearing. However, a previous study showed that only 6.4% of the sleeping time was included in the daily chat. Second, a small number of participants were included in the present study. Therefore, larger sample sizes are warranted in future studies.

In summary, this study is the first to confirm the indirect and adverse effect of the COVID-19 pandemic on physical health among community-dwelling older adults. A decline in the number of daily MVPA time and a rise in sedentary time were observed during the pandemic compared with those before the pandemic. These results will contribute to our knowledge about the reduction of physical inactivity during the pandemic in older adults.

Declarations

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Author contributions: N.K. had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Concept and design: N.K., E.M.; acquisition, analysis, or interpretation of data: all authors; drafting of the manuscript: T.A., N.K.; critical revision of the manuscript for important intellectual content: all authors; statistical analysis: T.A.; obtained funding: E.M.; supervision: E.M.

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Competing interest

Dr. Kimura received a grant from the Japan Society for the Promotion of Science and received honoraria from Takeda Pharmaceutical, Janssen Pharmaceutical, Daiichi Sankyo, Eisai, Sumitomo Dainippon Pharma, FUJIFILM Toyama, Kyowa Kirin, Otsuka Pharmaceutical, and Tsumura outside the submitted work. No other disclosures were reported.

Ethics declarations

The study was conducted in accordance with the Helsinki declaration, and approved by the institutional review board of Oita University Hospital. All participants provided written informed consent before the study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used during the current study are available from the corresponding author upon reasonable request.

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Figures

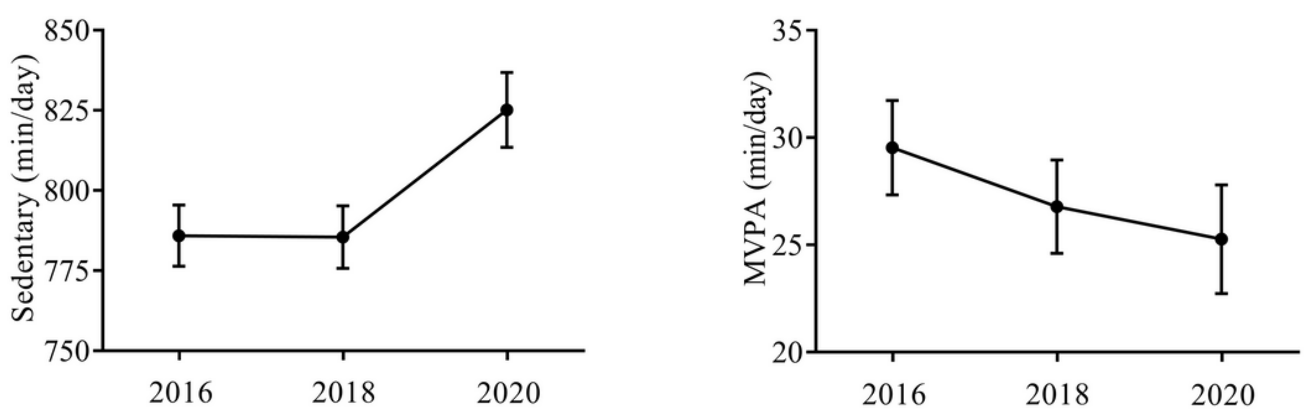

Figure 1

Temporal variations in the objectively measured MVPA and inactive time. The sedentary time significantly increased during the pandemic compared with that before the pandemic. The time spent undertaking MVPA time drastically diminished. ($p < 0.05$*). Abbreviations: MVPA, moderate-vigorous physical activity.