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ORIGINAL ARTICLE

The effect of COVID-19 pandemic on the lifestyle and glycemic control in patients with type 1 diabetes: a retrospective cohort study

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Abstract

Background To investigate the acute effects of coronavirus disease (COVID-19) on lifestyle and metabolic parameters in patients with type 1 diabetes (T1D).

Methods This retrospective cohort study included 34 patients who were admitted to our hospital from April 16 to May 1, 2020. Data on stress levels, sleep duration, exercise, total diet, snacks, and prepared food intake were obtained from the questionnaires. Changes in the values of hemoglobin A1c (HbA1c) and body weight from 3 months before the administration of the questionnaire to the time the study questionnaire was administered (pandemic year), and those from 15 months before to 12 months before the administration of the questionnaire (pre-pandemic year) were evaluated.

Results Increased stress levels and decreased exercise volumes were observed in approximately 60% and 50% of participants during the COVID-19 pandemic, respectively. Decreased sleep duration was associated with changes in the body weight for 3 months during pandemic year ($r = -0.40$, $p = 0.043$). Furthermore, compared with changes in HbA1c for 3 months during pre-pandemic year, changes in HbA1c during the pandemic year were worse (0.12% [0.33] % during pandemic year vs. −0.09 [0.39] % during pre-pandemic year, $p = 0.027$).

Conclusions Many patients experienced stress and exercised less due to the COVID-19 pandemic. Glycemic control in patients with T1D was worse than that in the previous year. Since the pandemic is currently ongoing, more attention should be paid to stress and lifestyle factor management in patients with T1D.

Keywords COVID-19 · Infection · Stress · Lifestyle · Type 1 diabetes

Background

Coronaviruses (CoVs) are one of the most common causes of respiratory infections in humans [1]. Human CoV infections are not severe. However, two major CoV outbreaks have occurred in the past, namely the severe acute respiratory syndrome coronavirus (SARS-CoV) outbreak in 2002–2003 and the Middle East respiratory syndrome coronavirus (MERS-CoV) outbreak in 2012 [2–4]. Recently, a novel coronavirus designated as SARS-CoV-2 was recognized as the pathogen causing COVID-19 in Wuhan, China in December 2019 [5]. On March 11, 2020, the World Health Organization declared COVID-19 a pandemic [6].

European countries have significantly curbed public life to halt the spread of COVID-19 outbreak. A state of emergency with request-based measures to encourage people to remain at home and businesses to limit operations was declared on April 7, 2020 in Japan. Therefore, Japanese people are adopting more restrictive behaviors. Infectious disease outbreaks, including COVID-19, are associated with increased stress levels in the general population [7]. Previous studies have shown that disasters are associated with higher levels of stress and worse glycemic control in patients with T1D [8, 9].

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Patients with diabetes mellitus are more likely to be infected with COVID-19 and have a higher risk of death [10, 11]. Although patients with diabetes mellitus should be careful to avoid becoming infected with COVID-19, it is possible that forcing them to restrict their daily lives lead to poor glucose control. However, little is known about the effect of the COVID-19 pandemic on glycemic control in patients with T1D [12, 13]. Therefore, this retrospective cohort study investigated the effects of the COVID-19 pandemic on the glycemic control and changes in stress levels and lifestyle in patients with T1D.

Methods

Study patients

We are performing an ongoing survey with the opt-out option among patients with diabetes mellitus to clarify their natural history. This study was approved by the ethics committee of the Kyoto Prefectural University of Medicine (KPUM) (ERB-C-1297). In this retrospective cohort study, a questionnaire was administered to patients with T1D who visited the Department of Endocrinology and Metabolism of the KPUM from April 16 to May 1, 2020. Patients with missing data were excluded from the study.

Data collection and measurements

Type 1 diabetes was diagnosed according to the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus [14]. Multiple daily injection (MDI) insulin therapy and continuous subcutaneous insulin infusion (CSII) were evaluated using medical records. According to the self-administered questionnaire, patients were classified as non-, past-, or current smokers; patients who regularly played any type of sport more than once a week before the COVID-19 pandemic were defined as regular exercisers. Diabetic nephropathy was defined according to a report by the Joint Committee on Diabetic Nephropathy [15]. Criteria for diabetic neuropathy suggested by the Diagnostic Neuropathy Study Group were used [16]. Retinopathies were classified as no diabetic retinopathy (NDR), simple diabetic retinopathy (SDR), and proliferative diabetic retinopathy (PDR) (which included pre-proliferative retinopathy). From medical records, we obtained the values of hemoglobin A1c (HbA1c) and body weight 4 points; the time the study questionnaire was administered (0 M), and 3, 12 and 15 months before the administration of the questionnaire (shown as − 3 M, − 12 M, − 15 M, respectively). To determine the effect of COVID-19 pandemic on the lifestyle and glycemic control in the patients, we evaluated the changes in the values from − 3 M to 0 M (pandemic year) comparing with those from − 15 M to − 12 M (pre-pandemic year).

Questionnaire

The questionnaire consisted of six short questions related to stress and lifestyle factors (Supplemental Table). A visual analog scale (VAS; 0 = considerably reduced, 5 = no change, and 10 = considerably increased) was used for all questions; patients were asked to score how their stress levels, sleep time, exercise intensity levels, total diet, snack, and prepared food intake changed due to the COVID-19 pandemic. Based on the patients' VAS scores, we further classified them as meeting or not meeting the following categories: increased stress levels (VAS ≥ 6), shortened sleep time (VAS ≤ 4), decreased exercise volumes (VAS ≤ 4), increased food intake (VAS ≥ 6), increased snack consumption (VAS ≥ 6), and increased prepared food intake (VAS ≥ 6).

Statistical analysis

Version 13.2 of the JMP software (SAS Institute Inc., Cary, NC) was used for statistical analyses; p values < 0.05 were considered statistically significant. The mean or frequency of the potential confounding variables were calculated. Continuous and categorical variables are presented as means (± standard deviations) and absolute numbers, respectively. Spearman's correlation coefficient was used to investigate the correlations of the stress or lifestyles factors and changes in the values of HbA1c and body weight for 3 months during pandemic year. Paired t test was used to evaluate the differences between the changes in the values for 3 months during pandemic year and those during pre-pandemic year.

Results

Among 35 patients with type 1 diabetes who were scheduled to visit our department, one patient received telemedicine. Therefore, 34 patients were included in this study (Fig. 1).

Clinical characteristics of the study patients are summarized in Table 1. Mean age and duration of diabetes in the study patients were 59.1 ± 16.0. years and 14.5 ± 16.0. years, respectively; 31 patients were treated with MDI and 3 patients were treated with CSII. Increased stress levels and decreased exercise volumes were observed in 59.3% (19/32) and 50% (16/32) of the participants, respectively, during the COVID-19 pandemic.

The correlations of the stress or lifestyles factors and changes in the values of HbA1c and body weight for 3 months during pandemic year are shown in Table 2. There was an association between sleep duration and changes in body weight ($r = -0.40$, $p = 0.043$).

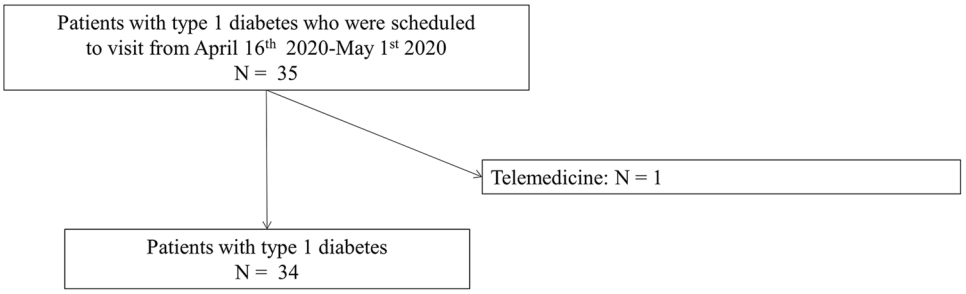

Fig. 1 Inclusion and exclusion flow

Table 1 Clinical characteristics of the study participants

N	34
Age (year)	59.1 (16.0)
Sex (men/women)	11/23
Duration of diabetes (year)	14.5 (8.0)
Smoking (non-/past-/current smoker)	25/3/6
Exercise habit (no/ yes)	20/14
Nephropathy stage (1/2/3/4/5)	22/8/1/1/1
Neuropathy (no/yes)	24/9
Retinopathy (NDR/SDR/PDR)	24/2/7
Treatment (MDI/CSII)	31/3
Questionnaires ($n=32$)	
Feel stress	6.7 (2.1)
Increasing of stress (no/yes)	13/ 19
Sleep time	4.4 (1.4)
Shorten sleep time (no/ yes)	23/9
Exercise	3.5 (2.2)
Decreasing of exercise (no/yes)	16/16
Total diet intake	5.1 (1.4)
Increasing of total diet intake (no/ yes)	26/6
Snack consumption	5.0 (1.9)
Increasing of snack consumption (no/ yes)	22/10
Prepared food intake	5.2 (1.2)
Increasing of prepared food intake (no/yes)	26/6

NDR non-diabetic retinopathy, *SDR* simple diabetic retinopathy, *PDR* proliferative diabetic retinopathy, *MDI* multiple daily injections, *CSII* continuous subcutaneous insulin infusion

All items of the change of stress and lifestyles factors were evaluated by used visual analog scale. 0 = considerably reduced, 5 = no change, 10 = considerably increased

Data are presented as the means (± standard deviations) and absolute numbers

Furthermore, compared with changes in HbA1c for 3 months during pre-pandemic year, changes in HbA1c during the pandemic year were worse (0.12% [0.33] % during pandemic year vs. − 0.09 [0.39] % during pre-pandemic year, $p=0.027$) (Table 3 and Fig. 2).

Table 2 Correlations of the stress or lifestyles factors and changes in the values of HbA1c and body weight for 3 months during pandemic year

	Change in HbA1c		Change in body weight	
	r	*p*	*r*	*p*
Stress	− 0.09	0.626	− 0.08	0.699
Sleep time	− 0.001	0.995	− 0.40	0.043
Exercise	− 0.05	0.780	0.11	0.607
Total diet intake	0.03	0.884	− 0.13	0.535
Snack consumption	− 0.11	0.564	− 0.11	0.578
Prepared food intake	− 0.25	0.169	0.31	0.125

Spearman's correlation coefficient was performed to investigate the correlations. Changes in the values of HbA1c and body weight from 3 months before the administration of the questionnaire to the time the study questionnaire was administered (pandemic year) was evaluated

Discussion

This study investigated the acute effects of the COVID-19 pandemic on the lifestyle of patients with T1D. Based on our findings, patients with T1D reported increased stress levels and decreased exercise volumes during the COVID-19 pandemic. Furthermore, compared with changes in HbA1c for 3 months during pre-pandemic year, changes in HbA1c during the pandemic year were worse in patients with T1D.

Recent studies have revealed that the COVID-19 pandemic is associated with increased stress levels in the general population [7]. External stress may lead to reduced physical activity [17, 18]. Stress can also affect metabolic parameters in patients with diabetes mellitus [19]. In fact, stress and lifestyle changes during the COVID-19 pandemic are associated with worse glycemic control and body weight in patients with type 2 diabetes (T2D) [20]. In addition, previous studies have shown that earthquakes are associated with increased stress and worse glycemic control in patients with T1D [8, 9]. Conversely, there was no association between external stress or reduced

Table 3 Differences between the changes in the values for 3 months during pandemic year and those during pre-pandemic year

	Pandemic year			Pre-pandemic year			*p* value
	− 3 M	0 M	Change in values	− 15 M	− 12 M	Change in values	
HbA1c ($n=28$)	7.7 (0.9)	7.8 (0.9)	0.12 (0.33)	7.5 (0.9)	7.4 (1.0)	− 0.09 (0.39)	0.027
Body weight ($n=19$)	60.0 (13,2)	60.2 (13.4)	0.16 (0.97)	58.9 (13.2)	59.4 (13.0)	0.47 (1.54)	0.421

Changes in the values of hemoglobin A1c (HbA1c) and body weight from 3 months before (− 3 M) the administration of the questionnaire to the time the study questionnaire was administered (0 M) (pandemic year), and those from 15 months before (− 15 M) to 12 months before (− 12 M) the administration of the questionnaire (pre-pandemic year) are shown. Paired *t* test was used to evaluate the differences between the changes in the values for 3 months during pandemic year and those during pre-pandemic year. Data are presented as the means (± standard deviations)

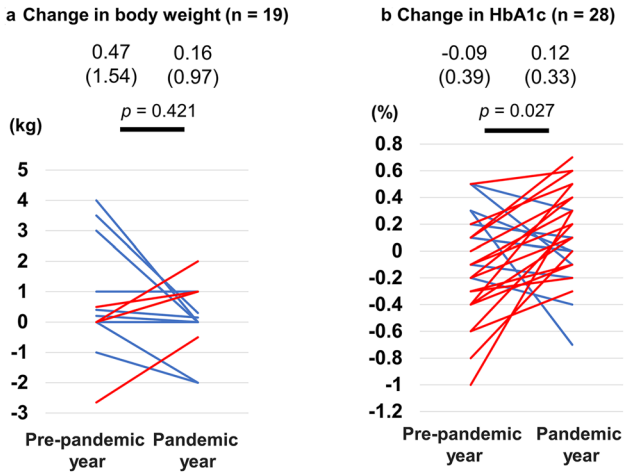

Fig. 2 Difference in change of body weight or HbA1c. Paired t tests were performed to evaluate the difference between change in the values of body weight or HbA1c from − 3 M to 0 M (pandemic year) and that from − 15 M to − 12 M (pre-pandemic year). **a** Difference in change of body weight. Red lines represent the case of increase the body weight due to COVID-19 pandemic. Blue lines represent the case of decrease the body weight due to COVID-19 pandemic. **b** Difference in change of HbA1c. Red lines represent the case of increase the HbA1c due to COVID-19 pandemic. Blue lines represent the case of decrease the HbA1c due to COVID-19 pandemic

physical activity and changes in Hb1c or body weight in this study. This may be due to the small number of participants. Therefore, further large-scale studies are required to clarify this association. The COVID-19 pandemic is ongoing, and there are concerns that impact on patients with diabetes mellitus will continue or worsen. High glucose levels have been reported to be associated with increased mortality during COVID-19 infection [10, 11]. Therefore, attention should be paid to glycemic control in patients with T1D.

In this study, body weight did not change due to the COVID-19 pandemic, which is the same as in previous studies [8, 9]. Contrariwise, there was an association between sleep duration and changes in body weight in patients with T1D. Short sleep duration has been reported to be associated with weight gain [21]. Therefore, it is necessary to pay attention to the deterioration of glycemic control with weight gain among patients with decreased sleep duration, although there was no association between sleep duration and glycemic control.

In this study, changes in glycemic control over 3 months in patients with T1D was worse than that in the previous year. A previous study has revealed that there are no negative effects of a lockdown due to the COVID-19 pandemic on glycemic control in people with T1D [12, 22–25]. These studies have suggested that the reason why lockdown due to COVID-19 pandemic does not adversely affect glycemic control in patients with T1D might be due to improved lifestyle with continuous glucose monitoring [24, 25]. These studies have also shown that the reason why there are no negative effects of a lockdown due to COVID-19 might be because many patients with T1D do not have to attend work due to lockdown. Thus, there is a possibility that many participants in this study were elderly; not having jobs only had negative aspects, such as reduced exercise volume and increased stress levels.

This study had several limitations. Firstly, the sample size was relatively small; participants were limited to a single center. In addition, this study only included patients who visited our department during the COVID-19 pandemic. Therefore, data of patients who did not visit were not included. There is a possibility that patients who did not visit our department experienced more stress or changes in lifestyle and, therefore, had poor glycemic control. Secondly, the questionnaire in this study was subjective and did not include a quantitative evaluation. However, during the pandemic, reduced contact time is essential to reduce the risk of disease transmission. Therefore, we only asked the patients a minimum number of questions for simplicity. Thirdly, we did not have data on self-monitoring of blood glucose and/or flash glucose monitoring. Fourthly, we did not have data on changes in the dosage of insulin, although patients with T1D are likely to change the dosage of insulin on their own. However, despite the possibility of self-titration, glycemic control worsened, compared to the previous year. Fifthly, examining whether patients with T1D experienced more stress than controls, including healthy adults and patients

with type 2 diabetes during the coronavirus pandemic is essential. Unfortunately, however, stress levels and lifestyle factors of healthy adults during the COVID-19 pandemic have not been examined. Conversely, compared with the data of patients with type 2 diabetes in our previous study [21], there were no differences between the questionnaire scores of patients with T1D and those with type 2 diabetes. Lastly, this study only included Japanese patients; therefore, whether our findings can be generalized to populations of other countries remains unclear.

Conclusion

In conclusion, many patients with T1DM have reported increased stress levels and changes in lifestyle factors (particularly reduced exercise) during the COVID-19 pandemic. Furthermore, glycemic control during pandemic year in patients with T1D was worse than that during pre-pandemic year. Given the ongoing pandemic, more attention should be paid to stress and lifestyle factor management in patients with T1D to prevent worsening of their glycemic control.

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Authors' contributions CM and YHo obtained and analyzed data and wrote manuscript. These authors equally contributed to this work. YHa planned, and designed the work, obtained, analyzed and interpreted data and contributed to discussion. TO analyzed and interpreted data and contributed to discussion. FT, RK, HN, SM, TS, NN, EU, MH, and MY obtained data and contributed to discussion. MF contributed to the conception of the work, obtained, and interpreted data and contributed to discussion. All authors checked the final version, and agree to be responsibility for the work to ensure that any questions related to the accuracy or completeness of any of the work are appropriately investigated and resolved. Corresponding author, Yoshitaka Hashimoto, takes full responsibility for the work and publish the manuscript.

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Availability of data and materials The datasets used and analyzed during the current study are available from the corresponding author on reasonable request. We affirmed that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as originally planned.

Declarations

Disclosure of potential conflicts of interest Michiaki Fukui received honoraria from Sanofi K.K., Novo Nordisk Pharma Ltd., Mitsubishi Tanabe Pharma Corporation., MSD K.K., Takeda Pharmaceutical Company Limited, ONO PHARMACEUTICAL CO., LTD., Taisho Pharmaceutical Co., Ltd., Nippon Boehringer Ingelheim Co. Ltd., AstraZeneca K.K., SANWA KAGAKU KENKYUSHO CO., LTD., Eli Lilly Japan K.K., and KOWA PHARMACEUTICAL COMPANY LTD. and subsidies or received donations from Nippon Boehringer Ingelheim Co., Ltd., Sumitomo Dainippon Pharma Co., Ltd., Mitsubishi Tanabe Pharma Corporation, DAIICHI SANKYO COMPANY, LIMITED, Astellas Pharma Inc., Kyowa Kirin Co., Ltd., Takeda Pharmaceutical Company Limited, Sanofi K.K., Novo Nordisk Pharma Ltd., MSD K.K., Eli Lilly Japan K.K., SANWA KAGAKU KENKYUSHO CO., LTD., and Abbott Japan LLC. and received endowed departments by commercial entities from ONO PHARMACEUTICAL CO., LTD. The other authors have nothing to disclose.

Research involving human participants and informed consent This study was approved by the ethics committee of Kyoto Prefectural University of Medicine (KPUM) (ERB-C-1297, 2018/10/11). This study was opt-out survey and opt-out survey was approved by the ethics committee.

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