Acta Diabetologica (2022) 59:1265–1274
https://doi.org/10.1007/s00592-022-01927-7

ORIGINAL ARTICLE

Lifestyle pattern changes, eating disorders, and sleep quality in diabetes: how are the effects of 18 months of COVID-19 pandemic being felt?

Isadora Nunes Erthal[1] · Janine Alessi[3] · Julia Belato Teixeira[1] · Eduarda Herscovitz Jaeger[1] · Giovana Berger de Oliveira[1] · Gabriela D. L. G. Scherer[1] · Taíse Rosa de Carvalho[3] · Beatriz D. Schaan[2,4,5] · Gabriela H. Telo[1,3,6]

Received: 21 February 2022 / Accepted: 17 June 2022 / Published online: 13 July 2022

Abstract

Aims The pandemic resulted in a lifestyle crisis which may negatively affect patients with diabetes. Despite current knowledge, there is a lack of longitudinal studies evaluating this effect. To assess patients' perceptions about changes in lifestyle, and eating and sleeping patterns after 18 months of the COVID-19 pandemic, and to identify if aspects related to the pandemic (social distancing, COVID-19 infection, behavioral changes, and financial difficulties) are predictors of worsening in eating and sleeping parameters.

Methods This was a longitudinal study that followed patients with diabetes from April 2020 to July 2021 in Southern Brazil. Individuals with type 1 or type 2 diabetes, aged ≥ 18 years, were included. The outcome of this study was the assessment of daily habits during a 18-month period of the COVID-19 pandemic. Specific questionnaires were applied once participants were included in this study (3 months after the onset of the pandemic) and at the 18-month follow-up, which included the Eating Attitudes Test-26 (EAT-26), the Mini-Sleep Questionnaire (MSQ), and a specific questionnaire on diet, physical activity, and sleep pattern. Data were compared within and between groups (type 1 and type 2 diabetes), and multivariable models were used to identify subgroups of worse outcomes.

Results A total of 118 (78.6%) participants remained in the study at follow-up (mean age 54.6 ± 13.9 years, 41.3% male). In total, 33.9% of participants perceived weight gain during the pandemic, especially those with type 1 diabetes (43.1% vs 25.0% in type 2 diabetes, $P = 0.04$). About one in four participants reported emotional eating and changes in their eating habits for financial reasons. Regarding sleep patterns, more than half the participants reported taking naps during the day, out of which 30.5% of them perceived worse sleep quality, with no difference between type 1 and type 2 diabetes groups. There were no within-group differences in MSQ and EAT-26 scores. Among participants with type 2 diabetes, age ≥ 60 years (OR 27.6, 95%CI 2.2–345.7), diabetes duration ≥ 15 years (OR 28.9, 95%CI 1.4–597.9), and perceived emotional eating (OR 10.9, 95%CI 1.1–107.5) were associated with worsened food quality. Worse sleep quality during the pandemic was associated with age ≥ 60 years for both type 2 diabetes (OR 5.6, 95%CI 1.1–31.5) and type 1 diabetes (OR 5.5, 95%CI 1.0–29.9).

Conclusions Follow-up data from a cohort of patients with diabetes indicate that at the end of 18 months of social distancing, some lifestyle aspects worsened and some improved, showing that these patients responded differently to the adversities of this period. The evidence of clinical features associated with worsening in food and sleep quality provides new insights to prioritizing actions in crisis situations.

Keywords COVID-19 outbreak · Mental health · Living habits · Eating behavior · Sleep behavior · Longitudinal study

Introduction

If the COVID-19 pandemic has resulted in a current health and lifestyle crisis for most of the population [1], we wonder how it has affected patients with diabetes mellitus, for whom behavioral changes are critical to the control of the disease

Managed by Antonio Secchi.

Isadora Nunes Erthal, Janine Alessi and Julia Belato Teixeira have contributed equally to this work.

Extended author information available on the last page of the article

and its long-term implications. This concern is particularly alarming in Brazil, which was the first country in South America to register a confirmed case of COVID-19 in February 2020. Since then, Brazil has shown a fast-ascending tendency in the number of cases across the country [2], and the adoption of public health measures to control the high transmissibility of SARS-CoV-2 [3]. The lifestyle changes that occurred are directly related to strategies to contain the dissemination of the virus. The required social distancing and quarantine have resulted in an increase in time spent at home, leading to significant changes in the quality of eating habits [4], physical activity time [5], and sleep quality [6]. These changes, on the other hand, seem to have an important impact upon patients with chronic diseases [7], especially diabetes mellitus [8]. Regarding food quality, accessibility, and availability, aspects closely associated with isolation and in-house permanence are related to worsened dietary practices. Ali Jafri et al. have described in their study that one fifth of patients with chronic diseases reported facing some struggle to acquire adequate food, being this challenge even more difficult for those with chronic diseases, older people, and children [9]. Inadequate eating habits, in turn, are well-documented in their association with poor outcomes in patients with diabetes, especially glycemic control [10, 11].

The necessary reinforcement of lockdown measures also had an impact of limiting physical activity, increasing sedentary time, stress, and glycemic variability [5]. Studies show that regular leisure-time physical activities can help persons with diabetes to achieve ideal glycemic control and lower glycated hemoglobin (HbA1c) levels, decrease body mass index (BMI), and control blood pressure [12], outcomes which could have been affected in this period. Moreover, more active people show better sleep quality and quantity [13], which could also have important outcomes during the pandemic. Regarding sleeping quality, it is known that both insufficient (less than 4.5 to 6 h per night) and increased (8 h or more) sleep are associated with increased HbA1c values [14], situations that have been both present in the pandemic. Moreover, some studies reported the influence of poor sleep quality on glycemic control, including type 1 and type 2 diabetes [14, 15], which may also have occurred during the pandemic.

Notwithstanding the knowledge on the different possible ways the pandemic may have affected both the general and the high-risk population, no longitudinal studies have been conducted to assess how health behaviors in patients with diabetes changed during the pandemic. This group of patients is of particular concern considering the impact that the pandemic has had in the first few months on individuals living with diabetes [16]. Although the pandemic seems to affect in a similar way patients with type 2 and type 1 diabetes in the short term, the response of them to mitigation strategies still seems to be different [17, 18], drawing attention to the peculiarities of each group that may also be affected differently during the pandemic. Moreover, understanding this situation could help us to assist the demands of these patients and understand how to avoid these conditions in a possible future event. This study is part of a larger project that sought to follow patients with diabetes during the COVID-19 pandemic and to assess its impact on different psychosocial domains [19]. In this manuscript, we aimed to assess the screening for eating and sleep disorders by validated questionnaires at the beginning of the COVID-19 pandemic and 18 months later. Secondly, we performed a subjective evaluation through a structured inquiry on social aspects and changes that occurred during the pandemic (cross-sectional evaluation after 18 months of the pandemic) and self-reported scores (at the beginning of the pandemic and after 18 months) for diet, physical activity, and sleep habits throughout this period in Brazil. We hypothesized that lifestyle habits would worsen during the follow-up year.

Methods

Study design

This was a longitudinal study that followed a group of patients with diabetes mellitus from April 2020 to July 2021, during the COVID-19 pandemic in Brazil. Selection of participants was performed via databases of two public hospitals that provided outpatient endocrinological and internal medicine care. During April 2020, right in the first months of the pandemic in Brazil, phone calls were made to invite potential eligible subjects to participate in this study and to assess baseline data. A follow-up evaluation was performed 15 months later, around 18 months since the onset of the pandemic in Brazil. This cohort report was described according to Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [20].

Participants

Participants with type 1 or type 2 diabetes, aged 18 years or older, who had their HbA1c levels evaluated from January to March 2020, and with an up-to-date telephone number in the databases were included. Exclusion criteria were: patients' limitations to answering the questionnaires via telephone calls, such as severe hearing or cognitive impairments; malfunction of their own phones; lack of interest; and cases in which patients were hospitalized at the time of selection.

Study procedures

Demographic characteristics

A review of the electronic medical records was performed to collect demographic characteristics, clinical data, and

laboratory tests from medical appointments. Aspects related to age, presence of diabetes complications, and antihyperglycemic agent use were evaluated. Ethnicity was registered based on self-identification. For weight description, the last weight measurement recorded in the medical records of the participants' healthcare institution was used.

The presence of retinopathy was considered based on the last available fundoscopy or retinography, or previous need for retinopathy treatment attributed to diabetes. Diabetic kidney disease was considered in case of microalbuminuria in two urinary samples or in the presence of a history of low glomerular filtration rate (< 60 mL) in medical records. Neuropathy was considered based on the description of errors in the 1-g monofilament test or the description of changes in sensitivity or neuropathic pain attributed to diabetes (also described in medical records). Macrovascular complications were described individually, via documentation of episodes of acute myocardial infarction, stroke, and peripheral arterial disease.

Cross-sectional assessment of social aspects and subjective perceptions related to changes that occurred during the pandemic

The maintenance of social distancing, when recommended in Brazil, was checked via specific questions about participants' reports for most of the period. To assess whether the patient followed any distancing measures, the evaluators used the question "How was your adherence to social distancing measures during the last year of the pandemic?" and then the evaluators presented three answer options for the patient to choose where he fits in best. The proposed alternatives were: 1—Total social isolation: you don't do not leave the house for anything (someone else goes to the market, pharmacy, and basic things); 2—Partial social isolation: you leave home to perform basic activities, such as going to the market and pharmacy; 3—No isolation: you maintain activities normally, such as work, outings, and social gatherings. Additionally, participants were also asked about the presence of COVID-19 infection, job loss, and financial difficulties during the pandemic.

Moreover, for the assessment of changes in lifestyle and habits which occurred during the first 18 months of the pandemic, we performed a cross-sectional evaluation via a telephone survey. Assessment of patients' perceptions on their dietary and physical aspects at the follow-up was carried out with specific questions in different domains. For the perception of weight change, patients were asked about weight gain, weight loss, or weight maintenance during the follow-up. For the perception about food quality choices, sleep quality, and amount of sleep hours, patients received three response options: worsened, improved, or maintained. For the other parameters (job loss during the pandemic, perception of emotional eating, change in eating habits for financial reasons, increased consumption of processed food, napping during the day, and caffeine consumption), positive or negative responses were asked.

Prospective assessment for grading the impact of the pandemic on diet, physical activity, and glycemic control

In order to objectify patients' perceptions regarding changes that occurred during the COVID-19 pandemic, an inquiry was performed asking about self-reported scores for eating habits, physical activity, and glycemic control. Participants were evaluated at two moments: in the first 3 months of the pandemic, and after 18 months of the pandemic. In each of these assessments, participants were asked to score, from 0 to 10, which grade they considered appropriate for the quality of their eating habits, physical activity habits, and glycemic control. These parameters were compared for "before and after" changes.

Prospective assessment of eating and sleeping disorders according to validated questionnaires

Specific questionnaires were used for the evaluation of eating disorders and sleeping disorders at baseline (3 months after the onset of the pandemic in Brazil) and at the follow-up (after 18 months of pandemic).

To evaluate eating disorders, the Portuguese version validated for the Brazilian population of the Eating Attitudes Test-26 (EAT-26) was used. It is a screening tool in which participants answer 26 questions about their eating behavior [21]. A total score of 21 or more was considered positive screening for eating disorders [21].

For the sleep disorder assessment, the Brazilian Portuguese version of the Mini-Sleep Questionnaire (MSQ-BR) was used. MSQ-BR consists of 10 questions that measure the subjective frequency of sleep difficulty; answers to which may have a score ranging from 1 (never) to 7 (always) [22]. Total score classifies sleep difficulties into good sleep quality, mild sleep difficulties, moderate sleep difficulties, and severe sleep difficulties. A total of 31 points was considered as a sleep disorder, and the higher the score, the worse the sleep quality [22]. See Supplementary Fig. 1 to access details of the study procedures.

Sample size calculation

To estimate sample size, we considered data from an Italian cross-sectional study that assessed whether nutritional and consumer habits of patients with diabetes have been affected during the quarantine period. This research found that 35.8% of adult with diabetes declared to eat less healthy

food during the COVID-19 lockdown [23]. Considering another study performed in pre-pandemic circumstances, which found that around 11% of patients with type 2 diabetes consider their diet as "unhealthy" [24], a sample size of 118 participants would be necessary for an analysis with 85% power and alpha 0.05.

Statistical analysis

Mean ± standard deviation (SD), median and interquartile ranges (IQR), and percentages were used to assess participants' baseline characteristics and perceptions regarding the changes that occurred during the pandemic. Results were stratified based on type of diabetes. These groups were compared via the Chi-square (χ^2) test for categorical variables and the Student's *t* test or Mann–Whitney *U* test for continuous variables.

The Kolmogorov–Smirnov test was used to evaluate data normality, and once an asymmetry was found, the results were shown as total scores in the median ± interquartile range (IQR). Differences between groups were assessed via the Mann–Whitney *U* test, whereas within-group variations, via the Wilcoxon signed-rank test. Finally, a logistic regression was used to assess predictors of worsened food and sleep quality during the COVID-19 pandemic. Specific assessments, corrected for age, duration of diabetes, gender, body mass index, COVID-19 infection, emotional eating, and weight gain were performed. Age, type 2 diabetes, and emotional eating were specifically chosen to multivariable analysis for predictors of worsened food during the pandemic because of its relation with difficulty of acquiring appropriate food, as pointed in the introduction section. For that analysis, emotional eating was considered as a dichotomous variable. The results were shown as odds ratios (OR) and their respective 95% confidence interval (95%CI).

Ethical aspects

Informed consent was provided by participants via audio recordings or text messages (electronic register). This study was developed in accordance with the Helsinki Declaration (2004) and approved by the National Research Ethics Committee (No. 4.903.365).

Results

A total of 150 participants were enrolled at the beginning of the study in April 2020. Out of these, 92 had type 2 diabetes and 58, type 1 diabetes. At follow-up—18 months after the onset of the pandemic in Brazil—118 participants remained in the study. The computed losses were due to: participants not answering their phone or invalid phone numbers (15), refusing to remain in the study (8), death (6), cognitive impairment (2) and hospitalization (1). When stratified according to the type of diabetes, the participants who withdrew were comparable to the included ones in terms of age, gender, duration of diabetes, and body mass index (BMI) (Supplementary Fig. 2).

Baseline characteristics of participants

At baseline ($N = 150$), participants had a mean age of 54.6 ± 13.9 years old, out of which 41.3% were male; 85.9%, white; and 67.4%, unemployed or retired. Type 2 and type 1 diabetes groups differed concerning age, diabetes duration, and BMI. Patients with type 2 diabetes were older (61.4 ± 9.1 years-old vs. 43.8 ± 13.6 years-old, $P < 0.001$), with a shorter diabetes duration (18.4 ± 9.3 years vs. 25.2 ± 11.5, $P < 0.001$), and a higher BMI (31.7 ± 6.2 vs. 25.3 ± 4.3, $P < 0.001$) than those with type 1 diabetes. Regarding comorbidities and medication use, hypertension, heart failure, coronary artery disease, and stroke, as well as all medications assessed, these variables differed between groups and were more prevalent in type 2 diabetes group. These characteristics are detailed in Table 1.

Cross-sectional assessment of social aspects and subjective perceptions related to changes that occurred during the pandemic

After the 18-month follow-up, we found that 91.5% of participants had followed any distancing measure, 16.1% had had COVID-19 infection, and 13.6% had lost their jobs during the pandemic (Table 2). These characteristics were similar between groups. Concerning dietary and physical aspects, one third of the patients perceived weight gain, a perception more prevalent in the type 1 diabetes group (43.1% vs. 25.0% in type 2 patients, $P = 0.04$), and a quarter of the patients perceived emotional eating, an aspect that was observed equally in both groups. In total, 21.2%, 20.0%, and 24.6% of participants perceived food quality worsening, increased consumption of processed foods, and changes in eating habits for financial reasons, respectively, with no differences between groups. Regarding sleep-related aspects, 22.0% perceived an increased number of sleep hours and 30.5%, worsened sleep quality, 51.7% had napping habits during the day, 60.2%, regular caffeine consumption, and a quarter of the participants had difficulty initiating sleep, maintaining it or both.

Grading the impact of the pandemic on diet, physical activity and glycemic control

We found no differences between and within groups regarding variations in eating habits, physical activity,

Table 1 Baseline characteristics of study participants

	Total ($n=150$)	Type 2 diabetes ($n=92$)	Type 1 diabetes ($n=58$)	P value
Age (years)	54.6 ± 13.9	61.4 ± 9.1	43.8 ± 13.6	< 0.001
Gender (male)	41.3%	38.0%	46.6%	0.30
Race/ethnicity (white)	85.9%	84.9%	87.9%	0.65
Higher income*	41.3%	46.5%	32.7%	0.11
Unemployed or retired	67.4%	66.3%	69.2%	0.72
Diabetes duration (years)	21.2 ± 10.8	18.4 ± 9.3	25.2 ± 11.5	< 0.001
HbA1c (%)	8.7 ± 1.6	8.8 ± 1.7	8.7 ± 1.5	0.73
(mmol/mol)	72.0 ± 17.5	73.0 ± 18.6	72.0 ± 16.4	
Diabetes microvascular complications	64.4%	70.0%	58.6%	0.20
Insulin use	89.3%	82.6%	100.0%	–
Metformin use		78.5%		–
BMI (Kg/m^2)	29.1 ± 6.3	31.7 ± 6.2	25.3 ± 4.3	< 0.001
Systemic arterial hypertension	60.7%	82.6%	25.9%	< 0.001
Heart failure	10.7%	15.4%	3.4%	0.02
Coronary artery disease	19.3%	27.2%	6.9%	< 0.01
Stroke	6.7%	9.8%	1.7%	0.05
ACE use	45.0%	53.8%	31.0%	< 0.01
ARB inhibitor use	22.1%	28.6%	12.1%	0.02
Statin use	65.8%	82.4%	39.7%	< 0.001
ASA use	38.3%	52.7%	15.5%	< 0.001

Data are shown as mean ± standard deviation or %

$\alpha \leq 0.05$ indicates a significant difference

HbA1c hemoglobin A1c, *ACE* angiotensin-converting enzyme, *ARB* angiotensin II receptor blocker, *ASA* acetylsalicylic acid, *BMI* body mass index

*Family monthly income higher than the equivalent to $ 539.19 (USD)

and perceived glycemic control between baseline and the 18-month follow-up (Table 3).

Prospective assessment of eating and sleeping disorders

We performed comparisons between and within groups for type 1 and type 2 diabetes, according to baseline scores (3 months after the onset of the pandemic) and follow-up scores (18 months after the onset of the pandemic) (Table 3).

Baseline (3 months)

Regarding eating disorders (EAT-26 questionnaire), patients with type 2 diabetes showed more frequent positive screening for eating disorders at baseline (85.0% in type 2 diabetes vs. 69.0% in type 1 diabetes, $P=0.04$). For the MSQ questionnaire, both groups showed a high prevalence of positive screening for sleep disorders, with no difference between groups at baseline (66.7% in type 2 diabetes vs. 75.9% in type 1 diabetes, $P=0.27$). There was no difference in total scores between groups for both eating and sleeping disorders evaluations (Table 3).

Follow-up (18 months)

Regarding eating disorders (EAT-26 questionnaire), patients with type 2 diabetes showed more frequent positive screening for eating disorders at follow-up (83.3% in type 2 diabetes vs. 67.2% in type 1 diabetes, $P=0.04$). Variation on EAT 26 scores was similar in both groups [median − 1.0 (IQR − 6.8 to + 6.0) in type 2 diabetes vs. median + 1.0 (IQR − 8.5 to + 5.0) in type 1 diabetes, $P=0.76$]. There was no difference in within-group comparisons regarding total questionnaire scores.

With respect to results from the MSQ questionnaire, both groups showed a high prevalence of positive screening for sleep disorders after 18 months of the pandemic, with no differences between them (66.7% in type 2 diabetes vs. 58.6% in type 1 diabetes, $P=0.37$). The median variation on total score was + 1.5 (IQR − 13.0 to + 7.8) in type 2 diabetes vs. − 3.0 (IQR − 13.0 to + 10.0) in type 1 diabetes, $P=0.52$.

Table 2 18-month follow-up pandemic-related characteristics reported by the participants

	Total (118) (%)	Type 2 diabetes ($n=66$) (%)	Type 1 diabetes ($n=52$) (%)	*P* value
Social distancing aspects				
-Any social distancing measure	91.5	91.7	91.4	0.99
-No social distancing measure	8.5	8.3	8.6	
Had COVID-19 infection*	16.1	13.3	19.0	0.55
Lost their job during the pandemic	13.6	13.3	13.3	0.94
Dietary and physical aspects				
Perceived weight change				
-Gained weight	33.9	25.0	43.1	0.04
-Lost weight	31.4	30.0	32.8	
Maintained weight	34.7	45.0	24.1	
Perceived emotional eating	25.6	27.1	24.1	0.71
Perceived food quality				
-Worst quality	21.2	21.7	20.7	0.51
-Improved quality	28.0	23.3	32.8	
-Maintained quality	50.8	55.0	46.6	
Changed food habits for financial reasons	24.6	20.0	29.3	0.24
Increased consumption of processed food	20.0	21.2	19.0	0.78
Sleep-related aspects				
Perceived amount of sleep hours				
-Increased	22.0	25.0	19.0	0.51
-Decreased	17.8	20.0	15.5	
Maintained	60.2	55.0	65.5	
Perceived quality of sleep				
-Worst quality	30.5	30.0	31.0	0.60
-Improved quality	13.6	16.7	10.2	
= Maintained quality	55.9	53.3	58.6	
Napping during the day	51.7	50.0	53.4	0.71
Regular caffeine consumption	60.2	58.3	62.1	0.68
Difficulty sleeping				
-Initiating sleep	22.0	20.0	24.2	
-Staying asleep	20.4	18.3	22.4	0.83
-None	62.7	66.7	58.6	

Data are shown as mean ± standard deviation or %

$\alpha \leq 0.05$ indicates a significant difference

*COVID-19 infection confirmed by polymerase chain reaction test (PCR) or clinical judgement (without PCR)

Assessment of predictors of worsened food and sleep quality

Overall, two multivariable models were designed to evaluate the impact of different factors on the worsening of food and sleep quality at the 18-month follow-up (see supplementary appendix). In the first multivariable model, worsening of food quality (self-reported perception) was evaluated according to age ≥ 60 years, duration of diabetes > 15 years, female gender, BMI > 30, a positive test for COVID-19 infection, and emotional eating. In type 2 diabetes, age ≥ 60 years (OR 27.6, 95%CI 2.2–345.7; $P=0.01$), duration of diabetes > 15 years (OR 28.9, 95%CI 1.4–597.9; $P=0.03$), and perceived emotional eating (OR 10.9, 95%CI 1.1–107.5; $P=0.04$) were positively associated with the perception of worsened food quality choices. We found no associations for type 1 diabetes.

In the second multivariable model, worsened sleep quality (self-reported perception) was evaluated according to age ≥ 60 years, duration of diabetes > 15 years, female gender, BMI > 30, a positive test for COVID-19 infection, napping during the day, and perceived weight gain. In both type 2 and type 1 diabetes, age ≥ 60 years showed a positive association with the perception of worsened sleep quality

Table 3 Comparison of questionnaire and self-reported scores at baseline and after 18 months of the pandemic reported by the participants

	Type 2 diabetes ($n=66$)	Type 1 diabetes ($n=52$)	P value
Eating disorders (EAT 26 score)			
Baseline	28.0 (22.0–33.0)	26.0 (18.0–31.3)	0.23
One-year follow-up	28.5 (20.3–32.0)	24.0 (18.0–31.3)	0.17
Variation	− 1.0 (− 6.8 to + 6.0)	+ 1.0 (− 8.5 to + 5.0)	0.76
Within-group differences for total scores (P value)	0.99	0.62	
Positive screening for eating disorders (%)			
Baseline	85.0%	69.0%	0.04
One-year follow-up	83.3%	67.2%	0.04
Within-group differences for screening (P value)	1.00	1.00	
Sleep disorders (MSQ score)			
Baseline	37.0 (27.0–45.0)	36.0 (29.8–43.3)	0.83
One-year follow-up	37.5 (26.0–43.0)	33.5 (24.8–41.0)	0.27
Variation	+ 1.5 (− 13.0 to + 7.8)	− 3.0 (− 13.0 to + 10.0)	0.52
Within-group differences for total scores (P value)	0.54	0.17	
Positive screening for sleep disorders (%)			
Baseline	66.7%	75.9%	0.27
One-year follow-up	66.7%	58.6%	0.37
Within-group differences for screening (P value)	1.00	0.09	
Eating habits (self-reported score)[a]			
Baseline	7.5 (6.0–8.0)	7.0 (5.5–8.0)	0.64
One-year follow-up	8.0 (5.3–9.0)	7.0 (5.0–8.0)	0.20
Variation	0.0 (− 1.0 to + 1.0)	0.0 (− 1.0 to + 2.0)	0.94
Within-group differences for total scores (P value)	0.95	0.81	
Physical activity (self-reported score)[a]			
Baseline	6.5 (3.0–8.3)	5.0 (3.0–8.0)	0.67
One-year follow-up	5.0 (1.3–8.0)	5.0 (0.0–7.3)	0.42
Variation	0.0 (− 2.0 to + 1.0)	− 1.0 (− 3.0 to + 1.0)	0.89
Within-group differences for total scores (P value)	0.06	0.09	
Glycemic control (self-reported score)[a]			
Baseline	8.0 (6.3–9.0)	8.0 (5.0–9.0)	0.47
One-year follow-up	7.0 (7.0–9.0)	7.5 (6.0–8.0)	0.59
Variation	0.0 (− 1.0 to + 1.0)	0.0 (− 2.0 to + 2.0)	0.65
Within-group differences for total scores (P value)	0.19	0.91	

Data are shown as median and interquartile range

$\alpha \leq 0.05$ indicates a significant difference

EAT 26 Eating Attitudes Test, *MSQ* Mini-Sleep Questionnaire

[a]Participants were asked to give a score, from zero to 10, for the quality of the aspects presented at the beginning of the COVID-19 pandemic and one year after

(for type 2 diabetes, OR 5.6, 95%CI 1.1–31.5, $P=0.05$; for type 1 diabetes, OR 5.5, 95%CI 1.0–29.9, $P=0.04$).

Discussion

The health and lifestyle of patients with diabetes were affected in different ways during the COVID-19 pandemic. We found that one third of the patients perceived weight gain, a finding more commonly reported among patients with type 1 diabetes. Patients' perceptions about worse food quality, increased consumption of processed foods, perceived emotional eating and changes in eating habits for financial reasons were present in 20–25% of patients, although we detected no difference between type 1 and type 2 diabetes. The subjective impact on sleeping during this period was also relevant. Despite showing no difference between groups, patients perceived an increased amount of sleep (22%), worse sleep quality (30.5%), and some difficulty related to sleeping (25%). It is also noteworthy that a

significant number of participants noticed maintenance and even improvement in some lifestyle aspects, showing that these patients responded differently to the adversities of this period.

In our study, a cross-sectional assessment of patients' perceptions of changes in dietary and physical activity aspects showed different responses during the 18 months of follow-up: while almost a quarter of the participants showed worsening in these parameters, more than half of them reported maintenance or improvement in these aspects. First, despite having affected a smaller proportion of the participants, the worsening in life habits causes concern as it may reflect in poor glycemic control in these patients. Among patients with type 1 diabetes, for example, almost half of them noticed weight gain during the 18 months evaluated. Some of the factors that may explain this worsening may be attributed to the COVID-19 pandemic, according to previous studies. A multicentric survey found that common consequences of lockdown measures are related to decreased access to food variety and difficulty to buy food due to price raises [25]. Another study performed by Lucile Marty et al. [4] indicated that changes in daily routine contribute to lower dietary nutritional quality, expressed by the increased daily energy intake and unhealthy foods (processed meat, sugar-sweetened beverages, and alcohol), when comparing lockdown with the pre-pandemic period. However, it should be noted that the increased time at home resulting from social distancing measures may also have provided the opportunity for greater engagement in diabetes-related dietary care. Corroborating, our results show that a significant number of patients reported maintenance and even improvement in perceptions of eating habits, physical activity and general care during the 18 months of follow-up.

In the second part of our study, we assessed longitudinally the screening for eating and sleep disorders using validated questionnaires. For eating disorders, we found that patients with type 2 diabetes more often had positive screening at follow-up than patients with type 1 diabetes. Still, there was a high prevalence of eating disorders in both groups, which raises concern for dietary behaviors potentially deleterious to diabetes control [26, 27] Some studies performed in patients with diabetes also showed a high prevalence of eating disorders during the pandemic period, significantly higher in relation to the prevalence described in the pre-pandemic period [28–30]. For the screening of sleep disorders, there was a high prevalence of participants with diabetes who presented positive screening, without worsening or improvement in the 18-month follow-up period. Other studies also corroborate the relationship between the pandemic and the increase in sleep disorders: staying longer at home and having irregular sleep times are possible facts related to these high numbers [28]. Considering that the amount and the quality of sleep are factors associated with metabolic control and diabetes self-care [14, 31, 32], the high prevalence of positive screening for sleep disorders is concerning and demands effective measures.

Finally, we sought to identify predictors of patients at higher risk for worsening food quality and sleep quality during the COVID-19 pandemic. To our knowledge, this is the first study to perform this assessment within an 18-month period of the COVID-19 pandemic. We identified that for patients with type 2 diabetes, being aged 60 years or older, having a diagnosis of diabetes for more than 15 years, and perceiving an emotional influence on food choices was associated with a higher risk of worsening eating habits during the 18 months of follow-up of our study. These results are in line with studies carried out in pre-pandemic situations, which show that elderly people with a longer duration of diabetes are more vulnerable to difficulties in appropriately maintaining timing and content of diet [33, 34]. In addition, patients aged 60 years and older also had a greater chance of worsening sleep quality, both in type 1 and type 2 diabetes. Corroborating, some studies performed during the COVID-19 pandemic showed that older individuals were the most affected by common sleep disorders [35, 36]. These evidences justify addressing aspects related to food and sleep quality especially when caring for older adults diagnosed with diabetes.

Our study has some limitations. Among them, we highlight the fact that assessments were made by phone, which requires participants' time to answer phone calls. This may result in their mistrust in remotely providing information and might represent a challenge for seniors who often have hearing difficulties or difficulties using the telephone. The lack of validated questionnaires, as well as self-report questionnaires, also contributed to the limitations of this study, as subjective reports may either overestimate or underestimate the impacts caused by the pandemic, depending on participants' realities and experiences. Follow-up losses also contribute to our limitations. Notwithstanding, this information contributes to a better longitudinal understanding of how patients with diabetes reacted over the pandemic. It is also a limitation of the study that we did not have objective assessments of weight gain, metabolic profile and anthropometric variables at the follow-up. This is due to the design of the study, which was performed via telephonic calls, making these assessments impossible. Finally, we did not assess possible interventions from other studies performed during the pandemic and, if included, they could have an impact on our results.

The results of this study showed that as evidenced in previous studies with other groups during the COVID-19 pandemic, some patients with diabetes mellitus noticed worsened lifestyles, and dietary and sleeping patterns. It is possible that these changes have negatively affected

these patients' glycemic control and metabolic parameters, resulting in anxiety and worsening their quality of life. For other patients, lifestyle aspects remained the same or even improved during the follow-up, showing that these patients responded differently to the adversities of this period. Thus, this study fills a gap in the existing knowledge on how patients with diabetes perceive the effects of the pandemic, and which factors are associated with worsening in food and sleep quality. Furthermore, our findings provide interesting insights on how to elaborate different strategies to avoid the impact of similar crises in the future.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00592-022-01927-7.

Acknowledgements GHT has full access to all the data and takes responsibility for the integrity and accuracy of the data.

Author contributions JA, JBT, and INE were involved in conceptualization, methodology, data curation, and writing–original draft preparation. GOB, GDLGS, EHJ, and TRC were involved in methodology and writing–original draft preparation. BDS was involved in supervision and writing–reviewing and editing. GHT was involved in conceptualization, supervision, and writing–reviewing and editing.

Funding This work was conducted with support from the Research Incentive Fund (FIPE/HCPA), Graduate Program in Endocrinology Health Sciences at the Universidade Federal do Rio Grande do Sul, School of Medical Sciences at the Pontifícia Universidade Católica do Rio Grande do Sul, and Hospital São Lucas da Pontifícia Universidade Católica do Rio Grande do Sul. IATS This study was partially funded by the Coordination for the Improvement of Higher Education Personnel – Brasil (CAPES) – Finance Code 001.

Availability of data and materials The data collected for the study, including de-identified participant data, will be available for 1 year after the publication of this article upon justified request to the email address of the main researcher and with a signed data access agreement.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval and consent to participate This study was approved by the National Research Ethics Commission of Brazil (CONEP), No. 4.029.368. All participants agreed to provide informed consent forms, which were saved by voice recording and electronic registration.

Informed consent All authors have reviewed the final version of the manuscript and agree with the publication of the results presented.

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Authors and Affiliations

Isadora Nunes Erthal[1] · Janine Alessi[3] · Julia Belato Teixeira[1] · Eduarda Herscovitz Jaeger[1] · Giovana Berger de Oliveira[1] · Gabriela D. L. G. Scherer[1] · Taíse Rosa de Carvalho[3] · Beatriz D. Schaan[2,4,5] · Gabriela H. Telo[1,3,6]

✉ Isadora Nunes Erthal
isadoranerthal@gmail.com

[1] School of Medicine, Pontifícia Universidade Católica do Rio Grande do Sul, Avenida Ipiranga, 6681, Prédio 12, 2° andar, Porto Alegre, RS 90619900, Brazil

[2] Graduate Program in Endocrinology, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil

[3] Medicine and Health Sciences Graduate Program, Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre, Brazil

[4] School of Medicine, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil

[5] Endocrinology Division, Hospital de Clínicas de Porto Alegre, Porto Alegre, Brazil

[6] Internal Medicine Division, Hospital São Lucas – Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre, Brazil