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Impact of COVID-19 lockdown on glucemic control in children and adolescents with type 1 diabetes mellitus☆

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KEYWORDS
Type 1 diabetes;
Pediatric age;
Continuous glucose monitoring;
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COVID-19;
Lockdown;
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Abstract
Background and aims: To face the rapid spread of SARS-CoV2 coronavirus pandemic, home lockdown in Spain was decreed on 15th March 2020. The main objective of this study is to evaluate the impact of this constraint on glycemic control in children and adolescents with type 1 diabetes mellitus (T1D).
Patients and methods: Observational, retrospective study in children and adolescents with T1D users of interstitial glucose monitoring systems. The following information corresponding to the last 2 weeks of lockdown was collected for subsequent comparison with data of 2 weeks prior to quarantine: daily insulin needs, mean interstitial glucose, estimated HbA1c, coefficient of variation (CV), time in range (70–180 mg/dl), hypoglycemia (<70 and <54 mg/dl) and hyperglycemia (>180 and> 250 mg/dl), sensor use and number of blood glucose measurements. Data about meal routines, physical exercise, need for adjustments in therapy, acute complications and lockdown of caregivers were assessed via a survey.
Results: 80 patients were studied (mean age 12.61 ± 3.32 years, mean time of evolution of the disease 5.85 ± 3.92 years), 66.2% treated with an insulin pump, users of following glucose monitoring systems: Guardian 3 (65%), FreeStyle Libre (18.8%) and Dexcom G6 (16.2%). Time in range in the cohort increased significantly during confinement (72.1 ± 10.5 vs 74.8 ± 10.5%; $P = 0.011$) with lower time in hypoglycemia both <70 mg/dl (4.6 ± 3.2 vs 3.2 ± 2.7%; $P < 0.001$) and <54 mg/dl (1.2 ± 1.6 vs 0.7 ± 1.2%; $P < 0.001$) and hyperglycemia >250 mg/dl (4.6 ± 3.9 vs 3.7 ± 3.7%; $P = 0.038$). CV also decreased (35.8 ± 6.3 vs 33.1 ± 6.1%; $P < 0.001$). Patients treated with multiple doses of insulin and poorer baseline glycemic control experienced greatest improvement. Daily insulin requirements remained stable. Regular practice of physical exercise and caregivers' confinement did not have a significant impact.

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Conclusions: Glycemic control in children and adolescents with T1D improved during quarantine, particularly in those with worse baseline control.

PALABRAS CLAVE
Diabetes tipo 1;
Edad pediátrica;
Monitorización continua de glucosa;
Monitorización flash de glucosa;
Covid-19;
Confinamiento;
Control glucémico

Repercusión del confinamiento por COVID-19 sobre el control glucémico en niños y adolescentes con diabetes mellitus tipo 1

Resumen
Introducción y objetivos: Con objeto de hacer frente a la rápida propagación de la pandemia por coronavirus SARS-CoV2, España decretó el confinamiento domiciliario de la población el 15 de marzo de 2020. El objetivo principal de este estudio es evaluar la repercusión de dicha medida sobre el control glucémico en niños y adolescentes con diabetes mellitus tipo 1 (DM1).
Pacientes y métodos: Estudio observacional, retrospectivo, en niños y adolescentes con DM1 usuarios de sistemas de monitorización de glucosa intersticial. Se recogió la siguiente información correspondiente a las 2 últimas semanas de cuarentena, previas al inicio del desconfinamiento, para su posterior comparación con los datos de 2 semanas previas al confinamiento: necesidades diarias de insulina, glucosa intersticial media, HbA1c estimada, coeficiente de variación (CV), tiempo en rango (70−180 mg/dl), hipoglucemia (<70 y <54 mg/dl) e hiperglucemia (>180 y >250 mg/dl), uso del sensor y número de glucemias capilares. Mediante encuesta se obtuvo información acerca de rutinas de ingesta, ejercicio físico, necesidad de ajustes en la terapia, complicaciones agudas surgidas y acompañamiento de los pacientes por sus cuidadores durante el confinamiento.
Resultados: Se incluyeron 80 pacientes (edad media 12,61 ± 3,32 años, tiempo medio de evolución de la enfermedad 5,85 ± 3,92 años), 66,2% tratados con bomba de insulina, usuarios de los siguientes sistemas de monitorización: Guardian 3 (65%), FreeStyle Libre (18,8%) y Dexcom G6 (16,2%). El tiempo en rango en la cohorte se incrementó de forma significativa durante el confinamiento (72,1 ± 10,5 vs 74,8 ± 10,5%; p = 0,011) a expensas de una disminución del tiempo en hipoglucemia tanto <70 mg/dl (4,6 ± 3,2 vs 3,2 ± 2,7%; p < 0,001) como <54 mg/dl (1,2 ± 1,6 vs 0,7 ± 1,2%; p < 0,001) y de hiperglucemia >250 mg/dl (4,6 ± 3,9 vs 3,7 ± 3,7%; p = 0,038), reduciéndose también el CV (35,8 ± 6,3 vs 33,1 ± 6,1%; p < 0,001). Los pacientes tratados con múltiples dosis de insulina y con peor control glucémico basal fueron los que experimentaron mayor mejoría. Las necesidades diarias de insulina permanecieron estables. La práctica regular de ejercicio físico y el confinamiento parental no tuvieron una repercusión significativa.
Conclusiones: El confinamiento se asoció a una mejoría del control glucémico en niños y adolescentes con DM1, especialmente en aquellos con peor control basal.

Introduction

In response to the growing number of cases of coronavirus disease 2019 (COVID-19), after the World Health Organization (WHO) had already characterised the disease as a pandemic,[1] the Spanish government, in an extraordinary session, declared the state of alarm, in which the chief measure was the imposition of a nationwide lockdown that came into effect at 00:00 on March 15, 2020. This measure was one of the emergency measures taken to reduce transmission, and forced every inhabitant to remained confined in their usual place of residence with the exception of various specific situations, such as shopping for food or medicine, commuting to work or attending an emergency. Physical exercise outside the home was not allowed. The state of alarm came to an end on June 21, and was preceded by a progressive de-escalation of confinement measures that started on April 26 with allowing children aged less than 14 years to leave the home to walk, play and exercise for one hour a day during restricted hours.

Type 1 diabetes (T1D) is one of the most frequent chronic diseases in the paediatric population. Management is based on insulin therapy, nutrition, physical exercise and self-management. Adjustments to insulin therapy are mainly based on measurements of capillary blood glucose levels and/or continuous monitoring of interstitial glucose levels with a sensor. The child and/or the caregivers must know how to modify the insulin regimen taking into account the effects of nutritional intake and exercise, changing the dosage when levels of glucose are outside the target range for several consecutive days. Achieving adequate glycaemic control is a very complex process and poses an ongoing challenge as it requires taking into account numerous aspects of everyday life.[2,3]

Since there had been no precedent, the actual impact of the measures adopted during the state of alarm in patients with T1D has not been assessed in the past. Nevertheless, given the drastic change in the daily routine of the patients, the decrease in physical activity, the increased risk of consuming an imbalanced diet, the stress associated with confinement and the difficulty of accessing health care services, their potential negative impact on glycaemic control was a reasonable concern.[4–6] The main aim of our study was to assess the impact of home confinement on glycaemic control and daily routines in children and adolescents with T1D.

Patients and methods

Study design

We conducted a retrospective, observational and analytical study in patients with T1D followed up in a child and adolescent diabetes unit. The study was approved by the clinical research ethics committee and the management of the medical division of the hospital.

Participants

The study included patients with T1D that used continuous interstitial glucose monitoring (CGM) or flash interstitial glucose monitoring (FGM) systems. The families of all patients that fulfilled this criterion were informed of the study through a phone call and documents delivered by electronic mail (study methodology, informed consent form and questionnaire) in the days that followed the start of the de-escalation of confinement measures for children aged less than 14 years (April 26). The exclusion criteria were absence of previous monitoring and presence of intercurrent conditions unrelated to confinement that could interfere with the results. Families that agreed to participate submitted the informed consent forms signed by parents and, if applicable, patients aged 12 years or older by electronic mail.

Methods

We collected the following information from health records: age, duration of diabetes, treatment used, modality of CGM/FGM used and number of follow-up appointments carried out through telemedicine from the start of the lockdown. We also obtained the following information for the 2-week period that preceded the start of home confinement: daily insulin requirements (overall and distribution into basal/bolus), percentage of glycated haemoglobin (HbA_{1c}) estimated by the software of the CGM/FGM system (or glucose management indicator), mean interstitial glucose level, coefficient of variation (CV), percentages of time spent in the blood glucose target range (70–180 mg/dL) (time in range), in the hypoglycaemic range (<70 and <54 mg/dL) and in the hyperglycaemic range (>180 and >250 mg/dL) based on the International Consensus,[7] time of active monitoring (or number of scans per day in the case of FGM), number of capillary blood glucose measurements and daily intake.

We collected data on the same variables for the 2 weeks preceding April 26 (start of de-escalation of confinement measures). To do so, patients downloaded data from their devices (sensors, monitors and insulin pumps) at home. The reports used in data collection were generated directly by researchers through the hospital accounts linked to patient accounts. Participants managed with multiple daily insulin injection (MDI) reported in a telephone survey their current insulin requirements, number of capillary glucose measurements and daily intake; in the case of patients managed with continuous subcutaneous insulin infusion (CSII), downloading the pump data allowed to obtain this information directly.

We developed a questionnaire that included open- and close-ended questions, which was sent to families by email and submitted back to the researchers by the same means once it had been filled out by the parents and, depending on their level of maturity, the patients. Through this questionnaire, we obtained information about dietary habits, schedules and physical activity during the confinement, need for adjustment of insulin dosage, the emergence of acute complications, support received by patients from their caregivers and development of symptoms compatible with COVID-19 (defined as fever, cough or breathing difficulty).

Outside the framework of this study, the diabetes care team had sent every family an email in the early days of the lockdown with the intent of promoting calm and a feeling of being supported, and including a series of recommendations regarding healthy nutrition, keeping a regular routine, exercising at home, general measures to prevent infection by coronavirus and how to act if symptoms were to develop, and informing of the availability of the diabetes care team through telemedicine services. In addition, the team maintained the routine visits of patients with T1D, although these were held remotely through eHealth resources until approximately 1 month after the start of the de-escalation of the confinement.

Statistical analysis

We performed the statistical analysis of the data with the software SPSS version 24 for Windows (IBM SPSS Statistics; Armonk, NY, USA). We compared related continuous data with the Student *t* test for paired samples if the data fit a normal distribution, and otherwise with Wilcoxon test. To compare independent continuous data, we used the Student *t* test for independent samples if the data fit a normal distribution, and otherwise the Mann–Whitney *U* test. We defined statistical significance as a *P*-value of less than 0.05 for all of the tests.

Results

Of the 122 patients followed up by the child and adolescent diabetes unit at the time of the study, 87 used CGM/FGM systems. We excluded 2 patients: 1 that received the diagnosis of T1D 48 h before the start of the lockdown and 1 undergoing treatment for cancer. In the end, a total of 80 patients (45 male and 35 female) agreed to participate. The mean age was 12.61 ± 3.32 years (range, 2.98–18.05 years),

Table 1 Comparison of CGM/FGM parameters before and during the confinement in the total sample.

n = 80	Pre-confinement	Confinement	*P*
Mean glucose, monitoring (mg/dL)	145.4 ± 12.9	145.4 ± 13.8	NS
Estimated HbA_{1c} (%)	6.69 ± 0.44	6.67 ± 0.44	NS
Coefficient of variation (%)	35.8 ± 6.3	33.1 ± 6.1	<.001
Time in range 70–180 mg/dL (%)	72.1 ± 10.5	74.8 ± 10.5	.011
Time > 180 mg/dL (%)	23.5 ± 9.8	22.0 ± 10.0	NS
Time > 250 mg/dL (%)	4.6 ± 3.9	3.7 ± 3.7	.038
Time < 70 mg/dL (%)	4.6 ± 3.2	3.2 ± 2.7	<.001
Time < 54 mg/dL (%)	1.2 ± 1.6	0.7 ± 1.2	<.001
Use of monitoring system (%)	90.2 ± 10.7	89.6 ± 12.5	NS

Data expressed as mean ± standard deviation.
NS: not significant.

with a mean duration of diabetes of 5.85 ± 3.92 years (range, 0.8–15.64 years). When it came to treatment, 66.2% of the patients were managed with CSII and 33.8% with MDI. The pump models used for CSII were the Medtronic® MiniMed 640G (n = 46), the Medtronic® MiniMed 670G (n = 6) and the Roche® Accu-Chek Aviva Insight (n = 1). The interstitial glucose monitoring systems used were the Medtronic® Guardian 3 in 65% of cases, the Abbott® FreeStyle Libre in 18.8% and the Novalab® Dexcom G6 in 16.2%. Of the 80 patients recruited, 75 provided information through a questionnaire regarding their routines during the confinement. None of the patients experienced symptoms compatible with COVID-19.

Glycaemic control

In the total sample, the percentage of time in range (70–180 mg/dL) increased significantly during the confinement, mainly on account of a reduction in the time below range (for both <70 and <54 mg/dL) and in the hyperglycaemic range with levels above 250 mg/dL. We did not find significant differences in the mean concentration of HbA_{1c} estimated before and at the end of the confinement. We also found no differences in the mean interstitial glucose levels, although there were differences in the CV, which decreased significantly during the lockdown (Table 1).

When we analysed these variables based on the treatment modality, we found that patients managed with CSII started out with better glycaemic control before the lockdown (decreased HbA1c, mean interstitial glucose and CV, increased time in range and decreased time in hyperglycaemic range, defined as either >180 or >250 mg/dL) compared to patients treated with MDI. However, during the confinement, only the patients managed with MDI experienced a significant increase in the time in range (on account of a decrease in the time below range with levels >250 mg/dL) and a significant decrease in the CV. On their part, patients managed with CSII exhibited a significant decrease in the time in the hypoglycaemic range (both for levels <70 and <54 mg/dL) and the CV during the confinement, with no significant differences in the rest of the parameters (Table 2).

In the small subgroup of patients (n = 6) who used the Medtronic® MiniMed 670G system (a hybrid system with automated delivery of basal insulin), the mild improvements in the estimated HbA_{1c} and the time in range were not statistically significant despite a greater time spent under CGM (93.2 ± 5.3% vs 95.2 ± 3.8%; *P* = 0.039). However, the rate of automated basal insulin delivery (automatically adjusted) did not increase significantly.

When we compared patients that started out with adequate glycaemic control before the confinement in terms of the estimated HbA_{1c} (<7%) with those that had not met that target, we found that patients with higher HbA_{1c} levels exhibited greater improvement. Thus, while in the group with an estimated HbA_{1c} of less than 7% at baseline the CV and percentage of time spent below target decreased significantly, in the group with baseline HbA1c of 7% or greater there was a significant increase in the time in range and a decrease in the time spent in the hyperglycaemic range, the estimated level of HbA_{1c} and the CV (Table 3). The findings were similar when it came to the time in range, as patients that started with a percentage of less than 70% before the confinement exhibited the greatest improvement (increase in time in range, decrease in time spent below or above the target range and decreased CV), while patients that started out with percentages of 70% or greater in the target range exhibited a more modest improvement (decrease in CV and in the time spent in the hypoglycaemic range) (Table 4).

Insulin requirements

Although 85.3% of participants reported having made changes to the insulin dosage during confinement, the daily insulin requirements did not change significantly, overall or in the basal to bolus ratio. However, when we analysed groups separately based on the treatment modality, we found that users of the integrated MiniMed® system, while maintaining similar daily insulin requirements, did exhibit a significant change in the distribution of insulin, with an increase in basal insulin requirements (41.3 ± 8.9 pre-confinement vs 43.5 ± 9.1% during confinement; *P* = .006) and a decrease in bolus delivery. In addition, in this group of patients we were able to analyse objective information on the number of portions entered in the pump bolus calculator and the number of delivered prandial boluses: patients consumed a similar number of portions, although the number of prandial boluses was significantly lower (4.9 ± 0.9 boluses a day pre-confinement vs 4.3 ± 0.9 during confinement; *P* = .001).

Table 2 Comparison of CGM/FGM parameters before and during the confinement in patients treated with multiple insulin injection (MDI) y con continuous subcutaneous insulin infusion (CSII).

	MDI (n = 27)			CSII (n = 53)		
	Pre-confinement	Confinement	*P*	Pre-confinement	Confinement	*P*
Mean glucose, monitoring (mg/dL)	150.3 ± 13.4	147.0 ± 16.0	NS	142.9 ± 12.0	144.5 ± 12.5	NS
Estimated HbA_{1c} (%)	6.87 ± 0.43	6.75 ± 0.49	NS	6.60 ± .42	6.64 ± .41	NS
Coefficient of variation (%)	38.3 ± 7.2	34.9 ± 6.9	<.001	34.5 ± 5.3	32.2 ± 5.5	.005
Time in range 70–180 mg/dL (%)	67.6 ± 11.6	70.1 ± 13.0	.018	74.5 ± 9.2	76.8 ± 8.5	NS
Time > 180 mg/dL (%)	27.5 ± 10.0	24.5 ± 12.3	NS	21.4 ± 9.1	2.8 ± 8.3	NS
Time > 250 mg/dL (%)	6.6 ± 4.4	4.9 ± 4.4	.011	3.6 ± 3.3	3.3 ± 3.4	NS
Time < 70 mg/dL (%)	5.5 ± 4.1	4.5 ± 3.8	NS	4.1 ± 2.5	2.4 ± 1.7	<.001
Time < 54 mg/dL (%)	1.6 ± 2.0	1.3 ± 1.8	NS	1.0 ± 1.2	.3 ± .5	<.001
Use of monitoring system (%)	95.7 ± 7.1	97.1 ± 4.7	NS	87.3 ± 11.2	85.7 ± 13.5	NS

Data expressed as mean ± standard deviation.
NS: not significant.

Table 3 Comparison of CGM/FGM parameters before and during the confinement in patients with a baseline estimated HbA_{1c} of < 7% versus ≥ 7%.

	HbA_{1c} < 7% (n = 62)			HbA_{1c} ≥ 7% (n = 18)		
	Pre-confinement	Confinement	*P*	Pre-confinement	Confinement	*P*
Mean glucose, monitoring (mg/dL)	140.0 ± 8.2	143.9 ± 14.0	.029	163.9 ± 8.2	15.5 ± 11.9	.001
Estimated HbA_{1c} (%)	6.52 ± 0.29	6.62 ± 0.44	NS	7.30 ± .28	6.86 ± .37	.002
Coefficient of variation (%)	35.2 ± 6.4	32.4 ± 6.4	<.001	37.8 ± 5.4	35.5 ± 4.3	.028
Time in range 70–180 mg/dL (%)	75.7 ± 8.8	76.1 ± 10.7	NS	6.0 ± 6.2	7.7 ± 8.9	.001
Time > 180 mg/dL (%)	19.7 ± 6.9	20.9 ± 10.1	NS	36.7 ± 6.3	26.0 ± 8.7	.003
Time > 250 mg/dL (%)	3.2 ± 2.8	3.4 ± 3.7	NS	9.5 ± 3.7	5.5 ± 3.9	.001
Time < 70 mg/dL (%)	4.8 ± 3.2	3.1 ± 2.9	<.001	3.7 ± 2.8	3.4 ± 2.1	NS
Time < 54 mg/dL (%)	1.2 ± 1.6	0.7 ± 1.3	.001	1.1 ± 1.5	.7 ± 1.0	NS
Use of monitoring system (%)	89.7 ± 10.6	89.4 ± 12.4	NS	91.9 ± 11.3	9.3 ± 12.9	NS

Data expressed as mean ± standard deviation.
NS: not significant.

Table 4 Comparison of CGM/FGM parameters before and during the confinement in patients with a baseline time in range (70–180 mg/dL) > 70% vs ≤ 70%.

	Time in range > 70% (n = 42)			Time in range ≤ 70% (n = 38)		
	Pre-confinement	Confinement	*P*	Pre-confinement	Confinement	*P*
Mean glucose, monitoring (mg/dL)	136.6 ± 7.4	140.6 ± 13.8	.045	155.1 ± 1.6	15.4 ± 12.0	NS
Estimated HbA_{1c} (%)	6.39 ± 0.26	6.51 ± 0.43	NS	7.03 ± .34	6.86 ± .38	NS
Coefficient of variation (%)	32.5 ± 5.0	30.6 ± 5.8	.023	39.4 ± 5.5	35.9 ± 5.1	<.001
Time in range 70–180 mg/dL (%)	80.4 ± 6.1	79.8 ± 9.2	NS	63.1 ± 5.9	69.4 ± 9.2	.001
Time > 180 mg/dL (%)	16.3 ± 5.6	17.9 ± 9.2	NS	31.5 ± 6.8	26.6 ± 8.7	.032
Time > 250 mg/dL (%)	1.9 ± 1.5	2.2 ± 2.9	NS	7.6 ± 3.6	5.6 ± 3.8	.005
Time < 70 mg/dL (%)	3.6 ± 2.3	2.4 ± 2.6	.003	5.7 ± 3.6	4.0 ± 2.6	.001
Time < 54 mg/dL (%)	0.6 ± 0.8	0.4 ± 0.9	NS	1.9 ± 1.9	1.0 ± 1.4	.001
Use of monitoring system (%)	90.4 ± 11.5	89.9 ± 12.9	NS	89.9 ± 9.9	89.3 ± 12.2	NS

Data expressed as mean ± standard deviation.
NS: not significant.

Self-management

The monitoring time remained stable (90.3 ± 10.7 pre-confinement vs 89.6 ± 12.5% during confinement; $P = .05$), as did the number of scans per day in patients that used the FreeStyle Libre system (12.3 ± 4.5 pre-confinement vs 14.9 ± 6.7 during confinement; $P = .05$). On the other hand, the number of capillary glucose measurements per day decreased during the confinement (6.8 ± 1.8 vs 6.0 ± 1.5; $P = .001$).

Nutrition

A total of 30.7% of patients acknowledged that the frequency of dietary transgressions (fast food, processed foods, industrial baked goods, sweets...) had increased during the confinement. However, most of patients (89.3%) reported they had kept counting carbohydrates as usual, while the remaining patients acknowledged a decrease in carbohydrate counting during the confinement. Furthermore, 61.3% reported maintaining a similar meal schedule, while 32% reported their schedules had become more irregular.

Physical activity

Regular physical activity, defined as exercising at least 3 days a week, was reported by 46.3% of participants. Aerobic exercise and exercise based on workout plans were the types of physical activity reported most frequently, with a mean of 1.89 h a week of exercise reported by those that engaged regularly in it. Exercising was not associated with improved control in terms of the estimated HbA_{1c} or the time in range, nor to a higher frequency of hypoglycaemia, although the time in the hyperglycaemic range with levels of more than 250 mg/dL was significantly lower in patients that exercised regularly.

Caregiver confinement

Most patients (88%) were confined at home with at least one of their usual caregivers. In the remaining 12% of cases, the usual caregivers worked outside the home during the lockdown. We did not find significant differences in any of the variables used to assess glycaemic control between these two groups.

Telemedicine appointments

We found that 77.5% of the patients had at least one scheduled telemedicine appointment during the lockdown. On the other hand, patients that did not have any follow-up appointments during this period had lower estimated HbA_{1c} values (6.47 ± 0.40 vs $6.74 \pm 0.43\%$; $P = .02$), a greater percentage of time in range (79.9 ± 7.1 vs $73.4 \pm 11.0\%$; $P = .02$) and a decrease time in the hyperglycaemic range with glucose levels greater than 180 mg/dL (16.9 ± 7.1 vs $23.5 \pm 10.2\%$; $P = .012$) during the confinement.

Acute complications

Patients did not develop severe episodes of hypoglycaemia or episodes of ketoacidosis during the confinement. There were 5 episodes of ketosis in patients managed with CSII secondary to pump obstruction.

Discussion

The lockdown imposed in the wake of the COVID-19 pandemic allowed us to analyse the impact of a sudden and radical change in lifestyle in children and adolescents with T1D in an unprecedented context. Our findings show that home confinement was not only not associated with a deterioration of glycaemic control, but that there was actually an overall improvement in glycaemic control. Patients with adequate control before the lockdown experienced a modest improvement during home confinement, and it was precisely patients with suboptimal control (either in terms of HbA_{1c} or the time in range) that exhibited the greatest improvement. In our opinion, patients with adequate control and their caregivers tend to exhibit greater motivation and adherence to treatment, and very likely continued to maintain a similar attitude during the confinement. On the other hand, we attribute the improvement in glycaemic control observed in patients that had exhibited poorer control at baseline to the opportunity to invest greater effort in diabetes care during home confinement.

In our sample, the group of patients managed with CSII exhibited better glycaemic control before the confinement compared to patients managed with MDI. Usually, this treatment modality is associated with a greater degree of motivation and skill in the management of disease by patients and caregivers. Our findings show that this group of patients, which exhibited a good baseline glycaemic control, generally maintained a similar level of control during the confinement, with a modest improvement in some variables. The results were similar in the subset of patients that used the hybrid 670G system, despite a longer daily time of CGM. In any case, the algorithm for automated basal insulin infusion seems to have adapted well to the needs imposed by the confinement.

Nearly one third of the patients reported decreased regularity in mealtimes and a similar percentage reported increased consumption of unhealthy foods. A more objective finding in patients managed with integrated systems that caught our attention was that the total number of portions entered in the bolus calculator of the pump remained constant, while the number of delivered prandial boluses was significantly lower during the confinement. This finding suggests that patients may have tended to skip snacks, like the snack typically consumed mid-morning during school hours, despite having increased their carbohydrate intake in the main meals.

Exercise is associated with beneficial effects in patients with T1D in a cardiovascular health, lipid levels, mental health or sleep quality. However, the correlation is not as exact when it comes to blood glucose levels largely due to the variations that can be attributed to physical activity.[8] In our study, glycaemic control during home confinement did not change in association with regular physical activity. In contrast, Tornese et al.[9] did find better glycaemic control in adolescents managed with the hybrid MiniMed 670G that exercised regularly during the confinement.

In March 2020, Europe became the epicentre of the pandemic, and most countries around Spain mandated varying degrees of confinement. The results of our study are consistent with those of other published works on the subject.

Several studies published in Spain and abroad in both the paediatric and the adult populations also found no deterioration of glycaemic control during confinement periods. A study conducted in Greece[10] that included 34 children managed with the integrated Medtronic® MiniMed 640G system, patients maintained glycaemic control in degrees similar to those exhibited before confinement. There were also no significant changes in insulin requirements (although there was an increasing trend in the percentage delivered as basal insulin during confinement) or carbohydrate intake, although patients reported substantial changes in their meal schedule. Another multicentre study conducted in Israel[11] that included 102 children and adolescents with T1D that used the Dexcom G5 CGM system found that glycaemic control remained relatively stable during confinement, without significant changes in the percentage of time spent in the target range. Yet another study, conducted in Italy[12] in 22 patients aged 3.5 to 10.5 years and managed with the Tandem Basal-IQ system, which features a predictive low-glucose suspend algorithm, found an improvement in the time spent in the target range, and the authors remarked on the positive effect of parental care during the confinement. The study did not find significant changes in daily insulin requirements, but there was an increase in the mean bolus dose and in the number of correction boluses.

The results in the adult population with T1D practically overlap. With a similar design to ours, a study conducted in Spain[13] in 307 adults found an increase in the time spent in the target range and a decrease in HbA_{1c} estimates comparing the 2 weeks that preceded the lockdown and the past 14 days after 8 weeks of confinement. As occurred in our study, the authors found a greater reduction in the estimated HbA_{1c} and an increase in the time spent in the target range in patients that had started out with higher levels of HbA_{1c}. Another study in Spain[14] that included 92 adults with a history of recurrent or inadvertent severe hypoglycaemic episodes found similar outcomes, with an improvement in the estimated HbA_{1c} and the time spent in the target range, although the time in hypoglycaemia remained unchanged. Several studies conducted in Italy in adults with T1D had similar findings. Bonora et al.[15] observed an improvement in glycaemic control in patients that stayed home in the first week of confinement, while glycaemic control remained stable in those who were essential workers and continued to work outside the home (although the baseline glycaemic control in this group had been better and most used CSII). Capaldo et al.[16] reported a significant increase in the time in range and a reduction in the time below range with levels of less than 54 mg/dL and in the CV in a cohort of 207 adults. The study by Maddaloni et al.[17] did not find significant changes in ambulatory glucose levels in the first 2 weeks of confinement, although patients with greater times spent in hypoglycaemia before the lockdown did exhibit a significant decrease in this parameter.

In contrast with the aforementioned studies, our findings differ from those of other studies conducted in different socioeconomic contexts. The study by Verma et al.,[18] conducted in India in 52 paediatric patients with T1D that did not use CGM/FGM data found that glycaemic control worsened during the confinement mainly due to shortages in insulin and glucose strips to measure capillary blood glucose levels. Similar problems with supply shortages were described in another study in children with T1D conducted in Jordan.[19]

One finding that may stand out in our study was that patients that had telemedicine appointments during the confinement exhibited poorer glycaemic control. It is worth noting that although routine appointments continued to be held at regular intervals, patients with poorer control are usually followed up more closely in our unit, independently of the epidemiological context. In this regard, the pandemic not only put our health care system to the test, but also has required adapting the traditional care delivery model to the new and changing circumstances. In this context, telemedicine is playing a crucial role.[20] Its use has been increasing in recent years and has experienced a substantial growth in the current health crisis. Telemedicine facilitates the interaction between patients and health care professionals, helps improve adherence to treatment, saves the patient time and travel, decreases costs and is positively perceived by users[21,22]; in addition, it guarantees the safety of both patients and providers in the current context. However, it is still necessary to regulate and standardise this modality of care delivery, and allocate specific and sufficient time to it in provider schedules. In any case, the progressive and unstoppable integration of emerging technologies in the treatment of diabetes is developing a particularly well-suited framework for the follow-up of patients through telemedicine,[23] as our findings illustrate.

The main limitations of our study are its design, which did not include a control group, the exclusion of patients not managed with CGM or FGM and the subjectivity of some of the variables collected through a questionnaire. Notwithstanding, we can assert that this sample of patients and caregivers had proven able to face an uncertain scenario successfully, achieving adequate management of the disease during confinement.

In conclusion, our study shows that glycaemic control in children and adolescents during the lockdown remained stable or improved modestly in patients that had previously exhibited adequate control, and that the improvement was particularly relevant in patients that had poorer control at the outset. In agreement with other published studies, the initial concern that glycaemic control could have deteriorated during the confinement not only was not confirmed, and we may even state that, if a similar situation were to present itself again, it would be possible to face it with less worry as concerns glycaemic control in children and adolescents with T1D. Furthermore, telemedicine has shown its considerable potential and is positioned as a modality of care delivery that should be promoted not only in the current epidemiological context, but even once it is over.

Conflicts of interest

The authors have no conflicts of interest to declare.

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