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The COVID-19 lockdown does not necessarily worsen diabetes control, in spite of lower physical activity — a systematic review

Abdulrhman Aldukhayel

Department of Family and Community Medicine, College of Medicine, Qassim University, Buraydah, Saudi Arabia

Abstract

Introduction: This review aimed to synthesize evidence on the impact of the COVID-19 lockdown on the glycaemic control, physical activity, and diet of diabetic patients.

Material and methods: Two electronic databases (PubMed and Scopus) were searched from January 2020 to February 2021. A total of 161 unique records were retrieved. Out of these, 25 articles met the eligibility criteria and were included in the final review. The quality of the studies was assessed by using the modified Newcastle-Ottawa Quality Assessment Scale for observational studies.

Results: Out of the 25 studies included in the review, 18 (72%) were cross sectional, 5 (20%) were retrospective analyses, and 2 (8%) were cohort studies. Thirteen studies included type I diabetics, 8 studies included type II diabetics, and 4 studies included both. In the quality assessment, 17 (68%) of the studies met the criteria of satisfactory quality. Overall glycaemic parameters were improved during the lockdown. Dietary patterns were affected during the lockdown, but the direction of change — either negative or positive — could not be inferred. However, physical activity patterns were found to be deteriorated during the lockdown.

Conclusion: The review found that lockdowns for curbing COVID-19 had no negative impact on glucose control, while there was a decline in the physical activity among diabetics. Furthermore, available studies are subject to various biases, which calls for robust studies in future with representative samples. There is also a need to promote physical activity and a healthy diet among diabetic patients, with follow-up through telemedicine during such confinement periods. **(Endokrynol Pol 2022; 73 (1): 131–148)**

Key words: *COVID-19; diabetes; physical activity; diet; glycaemia; control*

Introduction

The Corona virus disease 2019 (COVID-19) has affected all aspects of life directly and indirectly. Since its beginning, it has affected more than one billion people and caused nearly 3 million deaths globally [1]. In order to curb the rapid spread of disease, many measures were taken, which ranged from personal protection through masks to restriction of activities and complete lockdowns at national and sub-national levels [2]. These measures were aimed at reducing the transmission, but also resulted in economic hardship, especially for low income people, and difficult access to health care [3, 4].

The health care delivery system was also affected in more than one way, e.g. diversion of resources for acute care of COVID-19 cases, mobility of health care personnel, risk of infection at health care facilities, and the shutdown of normal care provision specially in outpatient clinics and non-acute care settings [5, 6].

Chronic diseases require long-term and continuous treatment in order to control the disease and prevent complications. The COVID-19 pandemic, however, disrupted this care, and patients with chronic diseases faced difficulties in obtaining medicine, follow-up, and monitoring of diseases status. Diabetes is a common chronic disease globally, with about 463 million people affected [7]. These diabetics need continuous care and must maintain a healthy lifestyle, such as diet and physical activity, in order to keep glucose levels within normal ranges. Failure to do so may result in another pandemic of complications, mortality, and increased burden on health systems [8].

Service delivery and access to care have been affected by COVID-19. Furthermore, lockdowns and movement restrictions might also have affected people's lifestyles. These factors may affect the glycaemic control among diabetic patients. However, studies from different parts of the world have shown varying results. Some have shown improvement in glucose levels, while others have reported deterioration amid COVID-19 lockdowns. It is therefore necessary to synthesize the evidence and see how lockdowns have affected the diabetics. This systematic review therefore aimed to assess the impact of COVID-19 lockdown on the glycaemic control, physical activity, and diet of diabetic patients.

Abdulrhman Aldukhayel, Department of Family and Community Medicine, College of Medicine, Qassim University, P.O. Box 6655, 52571 Buraydah, Saudi Arabia; e-mail: aaldukhayel@qumed.edu.sa

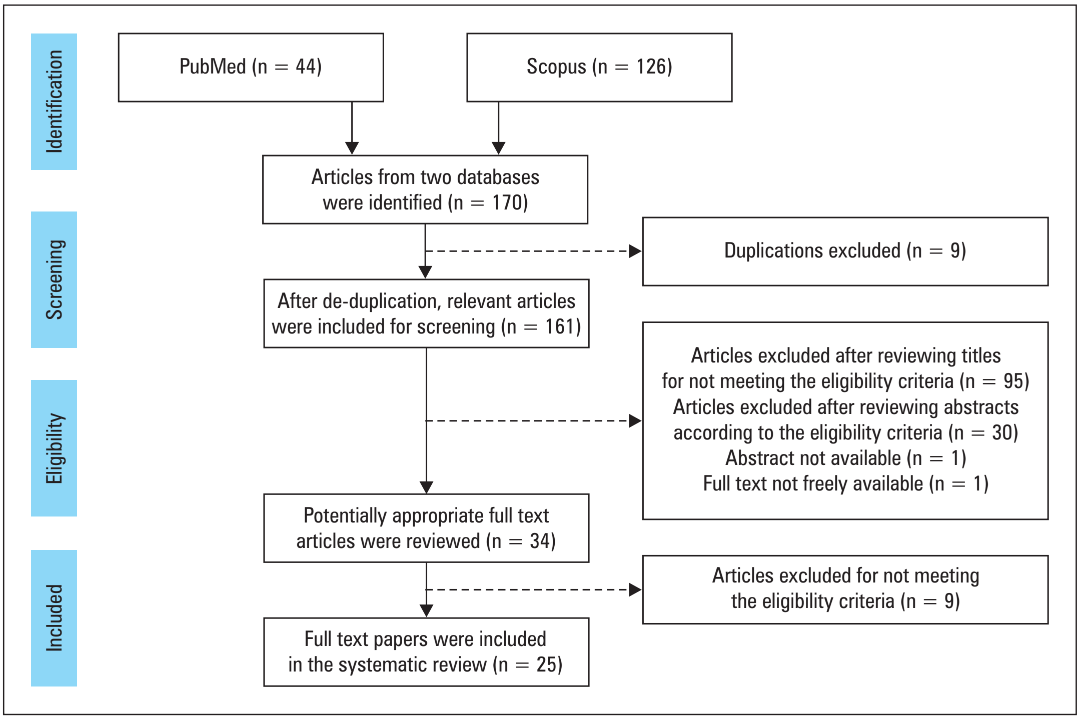

Figure 1. *Flow diagram showing identification and selection of studies in the review*

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Literature search

An electronic literature search was carried out systematically for the impact of COVID-19 lockdown on the glycaemic control, dietary habits, and physical activity of diabetic patients during the COVID-19 pandemic.

Eligibility criteria

We included studies involving target groups of diabetic patients, both type I and II, under treatment during the pandemic, with the outcomes demonstrating in at least one of them in study outcomes: change in glycaemic control, physical activity, and dietary pattern. The studies comprised comparative cross sectional, case-control, cohort studies, quasi-experimental and before and after (pre-post), and randomized controlled trials. All published literature across all countries in the English language was included, and the duration of the review was from January 2020 to February 2021.

Studies were excluded if they targeted adolescents, diabetes during pregnancy, studies in other languages, without an abstract, no full texts available, not free of cost, and those that did not mention the COVID-19 lockdown duration. Case studies, symposium proceedings, editorials, commentaries, and opinions were also excluded.

Information sources and search strategy

A systematic search was conducted from two international electronic databases, i.e. PubMed and Scopus, using a detailed search strategy. Medical subject heading (MeSH) terms were used where applicable for uniformity in search terms. The Boolean operators "AND" and "OR" were used. The search terms categorized under four categories and search strategy applied for this review are illustrated in Supplement 1.

Study selection

Full records were retrieved from the selected databases. After removing duplicates, unique records were available for screening. During screening, entries were removed based on title, and records were removed after screening the abstract. Further records were removed after a review of the full text or if the full text was not available. Final studies were included in the review. The procedure of study screening and selection are illustrated in Figure 1.

Data collection process

The reviewer screened the titles, abstracts, and full text of the selected studies according to the inclusion and exclusion criteria using an adapted and modified data-extraction form. The data-extraction form was developed on MS Excel using existing literature. The information extracted included the author, year of publication, study title, purpose of study, study setting, study design, study population, sampling technique, sample size, key outcome measures — change in glycaemic control and/or physical activity and/or dietary pattern, key study findings, study limitations, key study conclusion and recommendations, reviewers' comments, and quality appraisal of included studies. (Suppl. 2)

Quality assessment of included studies

All the relevant full texts of the included studies were examined for quality using the 'Newcastle-Ottawa-Quality Assessment Scale' adapted for cross-sectional and cohort studies. [9] This scale was used to assess the quality by examining potential sources of bias in the selection, comparability of participants, and the assessment of outcomes, awarding scores out of ten possible points. The higher score indicating the higher quality; scores (9-10) "very good", (7-8) "good", (5-6) "satisfactory", and (0-4) "unsatisfactory" quality.

Results

Study selection

A total of 170 records were retrieved from selected databases. After removing 9 duplicates, 161 unique records were available for screening. During screening, 95 entries were removed based on title and 31 records were removed after screening the abstract. A further nine records were removed after a review of the full text, while for one study the full text was not available. Finally, 25 studies were included in the review. The results of study screening and selection are illustrated in Figure 1.

Characteristics of included studies

Out of 25 study included in the review 18 (72%) were cross sectional, five (20%) studies were retrospective analysis [10-14] and two (8%) studies were cohort [15, 16] Only two studies [17, 18] employed simple random sampling while remaining used convenience sampling. In 13 studies the population was type I diabetics, 8 studies included type II diabetics, while 4 studies included type I and II diabetics. Sample sizes in the included studies ranged from 30 to 2510 participants, and 9 studies had sample sizes of less than 100 participants. Three studies recruited participants online, while the rest of the studies recruited participants or their data from health care facilities. The highest number of studies were from India (n = 8), followed by Italy (n = 7), and Spain (n = 4). Other countries included Saudi Arabia (n = 2), the Netherlands (1), Scotland (1), Turkey (1), and Brazil (1) (Tab. 1).

Quality of included studies

In the quality assessment, 8 studies (32%) were found to be unsatisfactory [16, 19-25] and 17 (68%) studies met the criteria of satisfactory quality using NOS quality assessment criteria. The major sources of bias were representativeness (n = 24), control of potential confounders (n = 24), and unpowered sample size (n = 21). (Supplement: Quality assessment). Ten (40%) of the studies did not objectively measure the outcomes.

Findings of included studies (Tab. 2, 3)

Glycaemic control

The findings and conclusions of individual studies are presented in Table 2. Mean glucose was reported in 14 studies, out of which, 5 reported an increase [18, 26–29], 7 reported a decrease [10, 12, 14, 30–33], and 3 studies reported no change [20, 21, 30] in mean blood glucose level during lockdown compared to pre-lockdown. The coefficient of variation (CV), which indicated glucose variability, was reported in eight studies, of which two reported a decrease [14, 20] while six reported no change [12, 21, 30–33]. Fasting blood sugar (FBS) levels were reported to increase in three studies [13, 15, 24], decrease in one study [17], while one study showed no change [23]. Post-prandial blood sugar (PPBS) was found to increase in three studies [13, 23, 24] and decrease in two studies [15, 17]. Glycosylated haemoglobin (HbA_{1c}) was reported in 12 studies, out of which 3 reported significant increase [13, 24, 27], 6 reported a decline [14–17, 32, 33], while 3 studies reported no change in the HbA_{1c} levels [20, 21, 34]. The Glucose Management Indicator (GMI) was reported in 5 studies. Out of these studies, one reported no significant change in GMI [11] while four reported a decrease in GMI [10, 12, 14, 31]. Glucose levels time in range (TIR) % was reported by 12 studies. The majority (9) of studies showed an increase in TIR [10, 12, 14, 16, 20, 30–33]. Only one reported a decrease [27] and two reported no significant change in TIR% [21, 30]. Overall glycaemic parameters were improved during the lockdown, as seen by larger number of studies showing a decline in mean glucose levels and HbA_{1c} levels. On the other hand, TIR% also increased in most of the studies, with corresponding changes in TAR and TBR percentages.

Out of 17 studies that met the criteria of satisfactory quality, 7 studies reported HbA_{1c} while 10 studies reported other indicators of glycaemia such as blood glucose, mean glucose, and glucose monitoring indicator. Five studies reported a decline in HbA_{1c} levels [14, 15, 17, 32, 33] while two studies reported no significant change in the HbA_{1c} levels [13, 34]. Among the studies reporting other measures of glycaemia, five studies reported a decline [10–12, 30, 31] and five reported an increase in glucose levels during lockdown [18, 26–29]. This indicates an overall improvement in the glycaemic control.

Changes in dietary pattern

Out of 25 included studies, 10 reported changes in the dietary patterns. Four studies reported a negative impact on diet [19, 24, 25, 29] during lockdown, while one study reported no change in the dietary patterns [10]. Five studies, however, just reported the change without indicating the direction of change [18, 20, 22, 23, 34]. Dietary patterns were affected by the COVID-19 lockdown. However, it is difficult to infer from available literature whether it was negatively affected or not.

Changes in physical activity pattern

Physical activity (PA) as an outcome was reported in 13 studies. One study [15] reported an increase in the PA levels while most (n = 11) studies reported decline in the PA levels during lockdown compared to pre-lockdown. [16, 17, 19, 20, 22, 24–29] One study only reported the change without indicating the direction of change [23]. Overall, PA patterns deteriorated during lockdown.

Among the 17 studies that were of satisfactory quality, 6 reported physical activity. Out of these, only one

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Table 1. *Characteristics of included studies (n = 25)*

Author (Year)	Objectives	Place	Study setting	Study design	Study population	Sampling technique	Sample size
Alshareef et al. (2020) [19]	To explore the influence of the COVID-19 lockdown on diabetes patients in Jeddah, Saudi Arabia, in terms of medication adherence, lifestyle, and quality of life	Jeddah, Saudi Arabia	Single specialized polyclinic	Cross-sectional	Type 2 diabetics, Saudi	Convenience	394
Anjana et al. (2020) [17]	To evaluate the effects of a prolonged lockdown on adoption of newer technologies (including telemedicine services) and changes in glycaemic control in patients with T2DM attending private tertiary care diabetes centres in India	Eight states of India	Specialized diabetic centres	Cross-sectional	Type 2 diabetics, ≥ 18 years	Simple random from EMR	2510
Aragona et al. (2020) [10]	To evaluate the effect the lockdown imposed during COVID-19 outbreak on the glycaemic control of people with T1DM using CGM or FGM	Undefined, Italy	Undefined	Retrospective analysis of web-based data of patients	Type 1 diabetics	Convenience	63
Assaloni et al. (2020) [26]	To explore the PA level in Italian people with T1DM before and after the national quarantine introduced to contrast COVID-19 disease and describe variation in glycaemia values	Italy	Online	Cross-sectional	Type 1 diabetic, ≥ 18 years, $HbA_{1c} \leq 10\%$, Italian speaking	Convenience	154
Barchetta et al. (2020) [27]	To investigate the effects of the COVID-19 lockdown on glycaemic control in T1DM subjects To explore determinants of changes of glucose variability	Rome, Italy	Diabetes outpatient clinics in a university	Cross-sectional	Type 1 diabetics	Convenience	50
Barone et al. (2020) [28]	To investigate challenges encountered by people living with DM in Brazil during the COVID-19 pandemic	Brazil	Online	Cross-sectional	Adult diabetic patients	Convenience	1701
Bonora et al. (2020) [30]	To examined glycaemic control during the first week of lockdown against the spread of SARS-CoV-2 in people with T1DM using FGM in Italy in comparison to the pre-lockdown period	Padova, Italy	Diabetes outpatient clinics in a university	Cross-sectional	Type 1 diabetics	Convenience	33
Capaldo et al. (2020) [20]	To evaluate the impact of lockdown on glucose control among Italian adults with T1DM	Naples, Italy	Diabetes outpatient clinics in a university	Cross-sectional	Type 1 diabetics	Convenience	207
Cotovad-Bellas et al. (2020) [21]	To analyse the effects of lockdown on glycaemic control on ambulatory glucose metrics in T1DM, in a real-world setting	Galicia, Spain	Endocrinology and nutrition unit of university hospital	Cross-sectional	Type 1 diabetics	Convenience	44
Dalmazi et al. (2020) [31]	To investigate TIR and the glucose variability as measured by CGM and factors contributing to glycaemic control in children and adults with T1DM during lockdown	Bolonga, Italy	Endocrinology and diabetes unit of a polyclinic	Cross-sectional	Type 1 diabetics	Consecutive	76 (adults)
Dover et al. (2021) [32]	To compare the glycaemic variables in those with T1DM using FGM, both before and approximately 7 weeks after lockdown To explore the clinical and demographic factors associated with decline in glycaemic control across this period	Edinburg, Scotland	Diabetes clinics of two hospitals	Cross-sectional	Type 1 diabetics	Convenience	572
Fernandez et al. (2020) [33]	To assess the impact that lockdown policies during the COVID-19 pandemic on glycaemic control in people with T1DM using FGM	Basque, Spain	Endocrinology and nutrition department of general hospital	Cross-sectional	Type 1 diabetics	Convenience	307

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Table 1. *Characteristics of included studies (n = 25)*

Author (Year)	Objectives	Place	Study setting	Study design	Study population	Sampling technique	Sample size
Ghosh et al. (2020) [22]	To test the hypothesis that that prolonged staying at home during COVID-19 lockdown can lead to disruption in diet and lifestyle in patients with T2DM	New Delhi, India	Diabetes centre	Cross-sectional	Type 2 diabetics	Convenience	150
Khader et al. (2020) [29]	To evaluate the impact of COVID-19 pandemic on medical treatment, routine care services, and challenges faced by people living with DM in India	India	Online	Cross-sectional	Diabetics	Convenience	1510
Khare et al. (2020) [23]	To study the effect of lockdown on glycaemic control in diabetic patients and possible factors responsible for this	Central, India	Endocrinology department of a tertiary care hospital	Cross-sectional	Type 2 diabetics	Convenience	143
Khare et al. (2021) [24]	To study the change in HbA_{1c} levels due to lock down in patients with DM	Central, India	Endocrinology department of a tertiary care hospital	Cross-sectional	Type 2 diabetics	Convenience	307
Longo et al. (2020) [11]	To evaluate the metrics of glycaemic control in people with T1DM using HCL system during the COVID-19 lockdown	Naples, Italy	Diabetes unit of the university hospital	Retrospective analysis of people with T1DM followed at diabetes unit	Type 1 diabetics	Not specified	30
Magliah et al. (2020) [25]	To investigate the impact of the COVID-19 lockdown on psychological status, self-management behaviours, and diabetes care maintenance among Saudi adults with T1DM using insulin pump therapy	Jeddah, Saudi Arabia	Insulin pump clinic at King Abdulaziz Medical City-Jeddah	Cross-sectional	Type 1 diabetics, ≥ 18 years	Convenience	65
Mesa et al. (2020) [12]	To evaluate impact of lockdown due to COVID-19 on glucose profile of patients with T1DM prone to hypoglycaemia using standalone continuous glucose monitoring	Barcelona, Spain	Diabetes Unit, Endocrinology and Nutrition Department at Hospital Clinic of Barcelona	Observational, retrospective study based on electronic medical records and databases of T1D patients	Type 1 diabetics	Not specified	92
Olickal et al. (2020) [18]	To study the impact of COVID-19 pandemic and national lockdown in patients with diabetes availing care at a tertiary care centre in southern India	Puducherry, Southern India	Diabetes clinic of a tertiary care centre in Puducherry	Cross sectional	Patients with diabetes	Simple random technique	350
Onmez et al. (2020) [13]	To investigate how the blood sugar levels, weight, diet, and exercise patterns of T2DM patients were affected by the lockdown	Turkey	The Düzce University Medical Faculty Internal Diseases and Diabetology Clinic, Turkey	retrospective, observational study	Type 2 diabetics	Convenience (not specified)	101
Pla et al. (2020) [14]	To study the impact of social and work confinement on glycaemic control in a cohort of patients with T1DM who use CGMs	Madrid, Spain	Virtual consultation/online	Retrospective study	Type 1 diabetics	Not specified	50
Rastogi et al. (2020) [15]	To study the effect of lockdown on physical activity and glycaemic control in people with pre-existing T2DM	Chandigarh, India	Diabetes clinic at Pgimer, Chandigarh	Prospective study	Type 2 diabetics	Convenience	422
Ruissen et al. (2020) [16]	To study how the lockdown has a differential impact on people with T2DM and T1DM and whether the presence of additional risk factors for severe outcomes of COVID-19 in these people plays a role	Netherlands	Diabetes outpatient clinic of the Leiden University Medical Centre	Observational cohort study	Type 1 and type 2 diabetics	Not specified	435
Sankar et al. (2020) [34]	To attempt and analyse the actual effect of lockdown on glycaemic control, lifestyle and psychosocial aspects in this population	Kerala, Southern India	Outpatient diabetes clinic of MGM Muthoot Hospitals, Pathanamthitta	cross-sectional	Type 2 diabetics	Convenience	110

T1DM — type 1 diabetes mellitus; T2DM — type 2 diabetes mellitus; CGM — continuous glucose monitoring; FGM — flash glucose monitoring; TIR — time in range; HbA_{1c} — glycated haemoglobin; HCL — the hybrid closed loop

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Table 2. *Findings, conclusions, recommendations and quality of included studies*

Author (Year)	Findings	Limitations	Key conclusions	Recommendations	Reviewer's comments	Quality grade
Alshareef et al. (2020)	Commitment to; (always) Specific diet (16 *vs.* 14.7) PA (35 *vs.* 20.1)	Self-reporting bias	Compliance reduced significantly	Health care workers should develop monitoring system medication compliance and encourage diabetics to adhere to healthy behaviours Telemedicine should be used to main glycaemia and prevent complications Further research to establish national estimates	No validated tool for assessment of diet and PA. No statistical comparison of pre and post behaviours. Authors mentioned same questionnaire administered after lockdown. This is not clear because methods do not reflect pre and post data collection	Unsatisfactory
Anjana et al. (2020)	Pre- and post-lock down: BG monitoring (15.5% *vs.* 51.3%)*** FBS (177 ± 75 *vs.* 126 ± 45)*** RBS (283 ± 102 *vs.* 191 ± 75)*** HbA_{1c} (8.2 ± 1.9 *vs.* 7.7 ± 1.7)*** No change in dietary pattern of 88% participants PA decreased in 23.9% while increased in 13.5%	Telephonic interview may have introduced bias, proportion of those who measured BG was small, inclusion of upper middle and higher socioeconomic status	No major adverse effect on metabolic control	Further studies on larger sample and longer follow-up are required		Satisfactory
Aragona et al. (2020)	MG (165 ± 29 *vs.* 158 ± 31)* GMI (56 ± 8 *vs.* 53 ± 8)** TIR (58 ± 15 *vs.* 62 ± 16)* TAR (38 ± 18 *vs.* 32 ± 17)** TBR (5 ± 6 *vs.* 6 ± 6) PA, not reported Body weight (75.0 ± 14.4 *vs.* 76.0 ± 14.8)*	Single centre Small sample Subjects has well controlled BG at the start Well educated participants	T1DM showed improvement in glycaemic control T1DM patients with good knowledge of diabetes care and who used CGM (or FGM) can effectively manage their glycaemic control during crises	Intensified education for patients with DM to help them deal with critical situations	PA although mentioned in the objective; however, no results related to this are presented	Satisfactory
Assaloni et al. (2020)	PA (on GSS) (38.6 ± 1.7 *vs.* 25 ± 1.7)*** Glucose level (142.1 ± 25.4 *vs.* 150.8 ± 29.4)*** Sub-sample with AT (n = 100); PA (minutes of exercise) (66 ± 42 *vs.* 38 ± 31)*** Glucose levels (139.4 ± 22 *vs.* 147.8 ± 26.8)*** Number of steps (12,606 ± 5026 *vs.* 4760 ± 3145)***	Voluntary bias (people were active) Self-reporting bias Accuracy of smart watch may be questionable	PA levels declined and glucose levels increased due to quarantine	Exercise guidelines for T1DM should be developed Aerobic exercise with monitoring of heart rate should be performed Circuit or resistance exercise should be preferred to weight exercise		Satisfactory

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Table 2. *Findings, conclusions, recommendations and quality of included studies*

Author (Year)	Findings	Limitations	Key conclusions	Recommendations	Reviewer's comments	Quality grade
Barchetta et al. (2020)	PA (> 3.5 hours/week) (52% *vs.* 40%) (no statistical comparison) Mean glucose (154 ± 15 *vs.* 165 ± 25)* Estimated HbA_{1c} (7.3 *vs.* 7.5)* TIR% (75% *vs.* 69)*** TBR% (6% *vs.* 10%)* TAR% (19% *vs.* 20%) Moderate hypoglycaemic events increased (5 *vs.* 7)** Severe hypoglycaemic events increased (0.5 *vs.* 1)**	Not mentioned	COVID-19 negatively affected glycaemic control	None mentioned	Small sample, self-reported PA duration	Satisfactory
Barone et al. (2020)	BG deteriorated (60%) Number of meals increased in 22.34% while reduced in 18.34% Food intake increased in 30% while decreased in 22.28% PA increased in 7% while decreased in 59.50% TV time increased in 48.86% while decreased in 12.58% Internet time increased in 53.49% while decreased in 9.35%	Selection bias (younger, more educated, those with Internet access, geographical over representation of Sao Paulo) because of online nature of survey Self-reported outcomes Choices within each question and aggregation in analysis	Diabetics were adversely affected by COVID-19 pandemic Control measures were insufficient which led to unhealthy and unsafe behaviours among diabetics	Authorities need to expand the implementation measures and develop partnerships with other private organizations to cover more diabetics and prevent infection and complications Public and private health care should continue care provision for diabetics and people with other chronic diseases Monitoring and provision of health at primary care level Increase use of telemedicine Provision of medicines for longer duration Lab exam sampling at the doorstep or at designated facilities with strict infection control measures	No statistical tests were applied	Satisfactory

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Table 2. *Findings, conclusions, recommendations and quality of included studies*

Author (Year)	Findings	Limitations	Key conclusions	Recommendations	Reviewer's comments	Quality grade
Bonora et al. (2020)	Among those who stopped working (n = 20) Average glucose ± SD: (171.8 ± 35.4 *vs.* 161.0 ± 40.3)* CV (34.3 ± 6.5 *vs.* 33.0 ± 7.9) TIR (58.1 ± 3.7 *vs.* 65.2 ± 4.2)* TBR (3.1 ± 0.6 *vs.* 3.2 ± 0.9) TAR (38.7 ± 3.9 *vs.* 31.6 ± 4.4)* Among those who continued working (n = 13) Average glucose ± SD: (158.1 ± 17.5 *vs.* 151.2 ± 15.3) CV (34.0 ± 5.6 *vs.* 35.2 ± 6.6) TIR (65.6 ± 13.8 *vs.* 68.3 ± 14.1) TBR (3.1 ± 3.7 *vs.* 3.9 ± 4.2) TAR (31.3 ± 13.0 *vs.* 27.7 ± 12.7)	Other factors which affect glucose levels such as insulin dose, diet and snacks were not evaluated Study included those who regularly monitor BG and had controlled levels	T1D who stayed at home had improvements in their glucose levels	Further investigations are required to assess the long-term effects of lockdown and factors that affect glucose levels under such circumstances		Satisfactory
Capaldo et al. (2020)	MG (172.8 ± 36 *vs.* 171.34.2) eHbA$_{1c}$ (7.7 ± 1.2 *vs.* 7.6 ± 1.1) TIR (55.6 ± 17.6 *vs.* 58.2 ± 18.1)** TAR moderate (26.8 ± 11.2 *vs.* 26.3 ± 11.2), severe (14.7 ± 15.3 *vs.* 13.2 ± 13.7) TBR moderate (2.95 ± 3.05 *vs.* 2.71 ± 3.08), severe (1.42 ± 2.39 *vs.* 0.58 ± 1.17)*** CV (35.9 ± 7.0 *vs.* 34.7 ± 6.3)** PA reduced*** Food amount changed*** Regularity of meals changed*** Number of snacks changed***	Data on lifestyle was subjective and qualitative Lack of control group to attribute changes to lockdown	Glucose control improved among T1D during lockdown.	Lifestyle changes in T1D should not only focus on diet and PA but also regular and less stressful life	No values for pre-lockdown lifestyle behaviours mentioned to draw conclusion about direction of change	Unsatisfactory
Cotovad-Bellas et al. (2020)	MG (165 ± 33 *vs.* 161 ± 40) eHbA$_{1c}$ (7.2 ± 0.8 *vs.* 7.1 ± 0.9) TIR (58.0 ± 18.1 *vs.* 60.6 ± 20.0) TAR moderate (23.3 ± 9.4 *vs.* 21.4 ± 9.8), severe (13.2 ± 12.7 *vs.* 12.4 ± 14.8) TBR moderate (4.0 ± 3.6 *vs.* 4.9 ± 6.3), severe (1.6 ± 3.3 *vs.* 1.0 ± 2.1) GV CV%: 37.5 ± 7.4 *vs.* 36.8 ± 7.1)	Not mentioned	Glucose control was not affected by the lockdown	FGM is a useful tool in a real world setting for PLWD for self-control during this pandemic	Different definition of severe hypoglycaemia compared to other	Unsatisfactory

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Table 2. *Findings, conclusions, recommendations and quality of included studies*

Author (Year)	Findings	Limitations	Key conclusions	Recommendations	Reviewer's comments	Quality grade
Dalmazi et al. (2020)	Median (IQR) BG [159 (137–189) *vs.* 154 (133–168)]*** Glucose management indicator: [7.3 (6.8–7.9)] *vs.* [7.2 (6.7–7.5)]** CV [36.6 (33.1–41.8)] *vs.* [36.3 (33.4–42.3)] TIR [57.7 (43.5–67.3)] *vs.* [61.3 (53.7–68.3]*** TAR moderate [26.5 (19.3–31.7)] *vs.* [25.1 (19–29.4)]**, severe [11.1 (4.5–19) *vs.* 7.8 (4.4–13)]** TBR moderate [2.5 (1.1–5.4) *vs.* 3 (1.2–5.7)]*, severe [0.4 (0.1–1.7) *vs.* 0.5 (0.1–1.6)] High BG index [8.3 (5.4–12.2) *vs.* 7.2 (4.–9.5)]** Low BG index [0.8 (0.4–1.7) *vs.* 0.8 (0.4–1.7)]*	Selected group of T1DM, using CGM Well controlled glycaemia at baseline No data on diet Different mechanisms of CGM devices included in the study; automatic versus patient induced	There was improvement in glycaemic control among adult T1D patients	None mentioned		Satisfactory
Dover et al. (2021)	Median (IQR) BG: 9.6 (8.5-10.9) *vs.* 9.3 (8.1-10.4)*** Glucose Standard deviation: 3.63 (3.0-4.2) *vs.* (3.5(2.8-4.0)*** CV %: 37 (33 to 42) *vs.* (37 (33 to 42) Number of low glucose events/14 days: 7 (3 to 12) *vs.* (7 (3 to 14)** Duration of low glucose events (min): 90 (60 to 120) *vs.* 92 (65 to 127) TBR: 3 (1 to 6) *vs.* 3 (1 to 7)** TIR: 53 (41 to 64) *vs.* 56 (45 to 68)*** TAR: 42 (29 to 56) *vs.* 39 (25 to 51)*** eHbA1c%: 7.7 (7.0 to 8.5) *vs.* 7.5 (6.7 to 8.2)*** Predictors of TIR fell by ≥5%: Socio-economic deprivation adjusted OR 0.41 (95% CI: 0.25–0.67) Predictors of TBR increased by ≥5%: % in range at baseline adjusted OR 1.02 (95% CI: 1.01–1.04)	Selected population with < 75% BG monitoring (proactive users) FGM users are younger Over representation of continuous subcutaneous insulin infusion users Some of statistically significant differences may not be clinically significant	Type 1 diabetics did not experience deterioration of glycaemia during COVID-19 lockdown Association of socio-economic deprivation with poor glucose control is important and needs attention.	people with socio-economic deprivation need support during challenging situations		Satisfactory
Fernandez et al. (2020)	Mean BG: 166.9 ± 29.4 *vs.* 158.0 ± 29.0*** Estimated HbA_{1c} (%): 7.4 ± 1.0 *vs.* 7.1 ± 1.0*** TIR (%): 57.8 ± 15.8 *vs.* 62.5 ± 16.1*** TBR: (Moderate 4.9 ± 4.0 *vs.* 5.5 ± 4.4**, severe 0.8 ± 1.4 *vs.* 0.9 ± 1.5) TAR (Moderate 37.3 ± 16.9 *vs.* 32.0 ± 17.1***, Severe 13.0 ± 11.3 *vs.* 10.3 ± 10.6***) CV%: 38.3 ± 6.6 *vs.* 37.7 ± 6.7	Relatively younger participants FGM users have better glycaemic control at baseline No data on changes in meals, physical activity, and insulin doses, as well as changes in working routine	During lockdown, there was improvement in the glycaemic control among T1D FGM users	More time for self-management may help improve glycaemia in short term		Satisfactory

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REVIEW

Table 2. *Findings, conclusions, recommendations and quality of included studies*

Author (Year)	Findings	Limitations	Key conclusions	Recommendations	Reviewer's comments	Quality grade
Ghosh et al. (2020)	Quantity of food: Decreased in 44% Meal timings: Delayed 31%, early 13% Quality of diet: More carbohydrates 21%, more fruits and vegetables 9% Consumption of sugar: Increased 7% Consumption of fruits: Increased 20%, decreased 17% Exercise duration: Decreased 42%, increased 25% Weight: Reduced 33%, increased 19% Self-monitoring of BG: Decreased 23%	Population belonged to single metropolitan city, may not be generalizable to smaller towns Self-reported outcomes may subject to bias	Some lifestyle behaviours improved such as taking care of diet and exercise, adding more fruits and having home cooked meals Carbohydrate consumption and snacking increased with decreased duration of physical activity and reduced SMBG	None mentioned	No statistical comparison	Unsatisfactory
Khader et al. (2020)	BG levels: increased 78%, decreased 7% PA: decreased 69%, increased 6% Food intake: increased 47%, decreased 14% Follow up for DM: decreased	Over representation of diabetics from Southern India Self-reported responses, may subject to reporting bias Online survey excluded those without internet connection	COVID-19 has caused severe disruption of glycaemic control, physical activity, food intake and access to care among diabetic patients in India This may lead to further complications which may lead to health crises more severe than pandemic itself	Teleconsultation and use of digital devices should be promoted Sedentary behaviour should be minimized Ensure home delivery of medicines for people with diabetes and NCDs	No statistical comparison	Satisfactory
Khare et al. (2020)	Mean fasting BG: Overall: 115.9 ± 8.09 *vs.* 119.4 ±11.67 Male: 115.7 ± 6.81 *vs.* 118.3 ± 12.43 Female: 116.4 ± 5.76 *vs.* 121.2 ± 11.76 Mean post prandial BG Overall: 124.9 ± 10.49 *vs.* 159.0 ± 16.38* Male: 121.4 ± 7.12 *vs.* 157.7 ± 18.23** Female: 131.1 ± 8.37 *vs.* 161.3 ± 18.45* Change in diet: type 39.9%, timing 60.1%, frequency 60.1%, amount 68.5% Change in PA: type 80.42, timing 72.7%, duration 60.8%	Small sample size Single-centre study Reliability of glucometers used by participants cannot be established	Glycaemic control was deranged during lock-down Diet and PA patters were also affected	Patient centric multidisciplinary approach is required Stress, diet, exercise and medication compliance should be addressed		Unsatisfactory
Khare et al. (2021)	FBS: 124.9 *vs.* 131.8* PLBS: 141.1 *vs.* 163.1** HbA_{1c}: 7.92 *vs.* 8.43* Diet: quantity 30.3% increase, quality 23.2 unhealthy PA: duration 43.6% decreased	Sampling bias because participants were recruited from a single centre Some participants (n = 143) were under regular monitoring	Glycaemic control was deranged during lockdown	Multi-disciplinary approach is required for diabetic patients to prevent complications		Unsatisfactory

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Table 2. *Findings, conclusions, recommendations and quality of included studies*

Author (Year)	Findings	Limitations	Key conclusions	Recommendations	Reviewer's comments	Quality grade
Longo et al. (2020)	Median (IQR). GMI (%) [7 (6.8–7.3) *vs.* 7 (6.8, 7.2)] Mean glucose: 155 (149, 164) *vs.* 154.5 (150, 164)** SD: 54.5 (50, 62) *vs.* 50.5 (47, 58)*** CV (%): 34.1 (32, 36) *vs.* 33.1 (30.7, 36.7)* TIR (%): 68.5 (65, 74) *vs.* 73 (69, 75)* TAR moderate (%): 23 (19,24) *vs.* 21 (19, 24), Severe % 6 (3, 8) *vs.* 5 (3, 9)** TBR% moderate: 1 (0,2) *vs.* 1 (0, 2), Severe: 0 (0,1) *vs.* 0 (0, 1)	Small sample size Participants included were with fair glycaemic control so could not evaluate the results on people with worst glycaemic control	Adults with type 1 diabetes using Hybrid closed-loop (HCL) (also known as automated insulin delivery system or artificial pancreas) showed a significant improvement of most of the metrics of glucose control over the lockdown phase due to SARS-Cov-2 pandemic	The use of artificial pancreas allowed patients to effectively manage diabetes, despite the change in lifestyle habits imposed by the quarantine		Satisfactory
Magliah et al. (2020)	Compared to pre-lockdown; 35.4% reported increased weight and 29.2% decreased weight 67.7% reported decrease in physical activity 41.5% reported decreased in ability to follow health diet 40% reported increase in experiencing hyperglycaemia symptoms 27.7% reported experience in hypoglycaemia symptoms	Small sample size, recall bias	During COVID-19 lockdown, a few patients were able to increase their adherence to a healthy diet and physical exercise, but majority patients reported a decrease in healthy diet and physical exercise behaviours	The role of healthcare workers in promoting self-management behaviours of patients with T1DM using insulin pump therapy should be emphasized Telemedicine is a useful alternative to in-person routine appointments during a lockdown	Self-reported findings of change in weight, physical activity, symptoms of hyper and hypoglycaemia can weaken the	Unsatisfactory
Mesa et al. (2020)	Mean ± SD sensor glucose concentration (mg/dL) (160.8 ± 30.7 *vs.* 153.5 ± 27.0)*** GMI (%) (7.2 ± 0.8 *vs.* 7.0 ± 0.8)** CV (%) (37.9 ± 7.5 *vs.* 38.0 ± 6.8) TIR (%) (59.3 ± 16.2 *vs.* 62.6 ± 15.2)** TAR (%) (moderate: 34.4 ± 18.0 *vs.* 30.7 ± 16.9**, severe: 11.1 ± 10.6 *vs.* 9.2 ± 9.7** TBR (moderate: 6.3 ± 4.8 *vs.* 6.4 ± 5.8, severe: 1.9 ± 2.6 *vs.* 1.8 ± 3.1) Sensor use (%) (95.7 ± 8.3 *vs.* 95.1 ± 7.2) Number of scans per day (12.4 ± 6.2 *vs.* 12.5 ± 6.6)	Retrospective observational study so no causation can be inferred, changes in daily life and diabetes management was not analysed, two short periods of assessment so positive findings may sustain for longer run was not sure, single-centre/diabetic unit study so no representative sample	In restrictive lockdown, glycaemic control was managed successfully by population with T1DM prone to hypoglycaemia using CGM. The strict daily routine at home explain the improvement in the time in glycaemic target without increasing the time hypoglycaemia	Not mentioned	Small sample size, no statistical calculation of sample size	Satisfactory

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Table 2. *Findings, conclusions, recommendations and quality of included studies*

Author (Year)	Findings	Limitations	Key conclusions	Recommendations	Reviewer's comments	Quality grade
Olickal et al. (2020)	46% of the PWDs tested for diabetes control status among these, 81% reported unsatisfactory glycaemic control during lockdown Decline in fruits consumption for > 2 days per week among PWDs in both rural (16.3% *vs.* 10.3%) and urban (10.7% *vs.* 6.7%) areas Significant increase in vegetable consumption for 7 days a week in rural area (64% *vs.* 71.3%) and insignificant increase in urban area (69.3% *vs.* 76%)	Glycaemic control was assessed using fasting and post prandial BG values HbA_{1c} could have provided better estimates	Majority of the PWDs did not consult any physician during lockdown period and most of them had a poor glycaemic control	A urgent action plan is needed to improve awareness among PWDs regarding availability of telemedicine services and strengthening the provision of diabetes care at primary care centres	No values of diabetes control for pre-lockdown duration mentioned to infer about the direction of change	Satisfactory
Onmez et al. (2020)	HbA_{1c} (%) (7.67 ± 1.76 *vs.* 8.11 ± 2.48) FBS [157.9 (83–645) *vs.* 163.2 (84–550)] Postprandial glucose (228.8 ± 72.9 *vs.* 260.3 ± 90.8)	Findings are compared for two different time points so difficult to establish a causal relationship, detailed factors affecting patients' glycaemic values, such as lifestyle changes, dietary compliance, the stress factor, and access to medications were not studied, study period was short, patient number was low, a single diabetes centre, the results may not be representative	The increases, although statistically insignificant, in fasting glucose, postprandial glucose, HbA_{1c}, and weight in the COVID-19 lockdown are noteworthy	none mentioned	objective of diet assessment is mentioned but self-reported dieting is reported only during lockdown	Satisfactory
Pla et al. (2020)	Mean glucose (160.26 ± 22.55 *vs.* 150 ± 20.96)*** $eHbA_{1c}$ (%) (7.21 ± 0.78 *vs.* 6.83 ± 0.71)*** GMI (%) (7.16 ± 0.57 *vs.* 6.88 ± 0.49)*** CV (%) (40.74 ± 6.66 *vs.* 36.43 ± 6.09)*** TIR (%) (57.46 ± 11.85 *vs.* 65.76 ± 12.09)*** TBR (%): (7.48 ± 5.23 *vs.* 6.28 ± 5.26) Hypoglycaemic events, number (range): 13 (7–19) *vs.* 9 (6–17) Total time < 70 mg/dL (min), number (range): [100.5 (79–118) *vs.* 101 (79–133)]	Non-validated questionnaires were used, small sample size	There was an improvement found in glycaemic control in patients with T1DM using CGMs during COVID-19 lockdown	To implement a virtual consultation model that could coexist with the traditional on-site one, which will also change the relationship pattern between patients with diabetes and health professionals		Satisfactory

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Table 2. *Findings, conclusions, recommendations and quality of included studies*

Author (Year)	Findings	Limitations	Key conclusions	Recommendations	Reviewer's comments	Quality grade
Rastogi et al. (2020)	HbA_{1c} (%) [7.8 (6.9–9.4) *vs.* 7.4 (6.5–8.7)]** FBS [135.0 (112.0–175.0) *vs.* 150.0 (120.0–180.0)]** Postprandial blood glucose (mg/dL) [(200 (152–252.0) *vs.* 158.0 (140.0–200.0)]*** GPAQ score (MetS) [140 (0.0–1260) *vs.* 840 (0.0–1680)]*	Biases due to respondents who were self-motivated, long duration DM and under regular follow-up and aware of lifestyle and glycaemic goal. GPAQ was conducted on telephone; glucometer and weighing scale might not reliable. The dietary change, macronutrient composition, and calorie intake were not recorded. Cannot be generalized to those with shorter duration of diabetes or with limited healthcare teleconsultation access	Lockdown period may not be associated with worsening of glycaemic control in people with long-standing DM	Limiting sedentary time and increasing indoor activities help in achieving better glycaemic control during COVID-19 lockdown Awareness of glycaemic goals, access to self-monitoring of BG, and ability to cope with restrictions of lockdown by rigorously following lifestyle recommendations and engagement in some form of physical activity are beneficial		Satisfactory
Ruissen et al. (2020)	HbA_{1c} T1DM (7.68% ± 1.2 *vs.* 7.52% ± 1.1)*** T2DM no change. TIR (60.5% *vs.* 63.4%)*** TAR (34.6% *vs.* 32.1%)**. The 40.9% of the participants reported weight gain and 45.7% reported less exercise than before	Self-reported weight change, well controlled diabetics were recruited	Lockdown measures resulted in increased weight gain and less exercise in both people with relatively well-controlled T1DM and T2DM, however this did not negatively impact glycaemic control	diabetes care profession should be discussing diabetes self-management and well-being during consultations	self-reported findings for weight gain and exercise. Assessment of additional risk factors BMI, cardiovascular disease, blood pressure and blood pressure lowering agent mentioned in objective to assess association with HbA_{1c}, but findings were not report in statistical terms.	Unsatisfactory
Sankar et al. (2020)	Mean HbA_{1c} (8.2 ± 1.3% *vs.* 8.12 ± 1.6%) Mean body weight (71.5 ± 14.8 kg *vs.* 71.8 ± 13.6 kg). 80.9% reported increased consumption of vegetables 42.7% reported increased consumption of fruits no values for pre-lockdown	Single-centre, small sample, subjective responses, results are from a limited semi urban geographic area, well aware respondents, not generalizable	Lockdown did not cause a major change in the overall glycaemic control	Measures to promote healthy lifestyle practices must be implemented for better T2DM management The increased utilization of technology for communication may pave the way towards increased acceptance of remote telehealth services in the future	Self-reported findings for vegetables and fruits consumption and no results reported for pre lockdown	Satisfactory

MG — mean glucose; CV — coefficient of variation; BG — blood glucose; FBS — fasting blood sugar; PPBS — post prandial blood sugar; GMI — glucose management indicator; TIR — time in range; TAR — time above range; TBR — time below range; PA — physical activity; TAR moderate — 181–250 mg/dL, severe — > 250 mg/dL; TBR moderate — 54–69 mg/dL, severe — < 54 mg/dL; *p ≤ 0.05; **p ≤ 0.01; ***p ≤ 0.001; GV (glycaemic variability)

Table 3. *Summary of changes in the various para meters included in the review*

Author	MG	CV%	FBS	PPBS	HbA_{1c}	GMI	TIR	TAR		TBR		Diet	PA
								Moderate	Severe	Moderate	Severe		
Alshareef et al. (2020)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	P	D
Anjana et al. (2020)	NR	NR	D	D	D	NR	NR	NR	NR	NR	NR	NC	D
Aragona et al. (2020)	D	NR	NR	NR	NR	D	I	D		NC		NR	NR
Assaloni et al. (2020)	I	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	D
Barchetta et al. (2020)	I	NR	NR	NR	I	NR	D	I		NC		NR	D
Barone et al. (2020)	I	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	D
Bonora et al. (2020)	D	NC	NR	NR	NR	NR	I	D		NC		NR	NR
	NC	NC	NR	NR	NR	NR	NC	NC		NC		NR	NR
Capaldo et al. (2020)	NC	D	NR	NR	NC	NR	I	NC	NC	NC	D	C	D
Cotovad-Bellas et al. (2020)	NC	NC	NR	NR	NC	NR	NC	NC	NC	NC	NC	NR	NR
Dalmazi et al. (2020)	D	NC	NR	NR	NR	D	I	D	D	I	NC	NR	NR
Dover et al. (2021)	D	NC	NR	NR	D	NR	I	D		I		NR	NR
Fernandez et al. (2020)	D	NC	NR	NR	D	NR	I	D	D	I	NC	NR	NR
Ghosh et al. (2020)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	C	D
Khader et al. (2020)	I	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	P	D
Khare et al. (2020)	NR	NR	NC	I	NR	NR	NR	NR	NR	NR	NR	C	C
Khare et al. (2021)	NR	NR	I	I	I	NR	NR	NR	NR	NR	NR	P	D
Longo et al. (2020)	NR	NR	NR	NR	NR	I	NR	NR	NR	NR	NR	NR	NR
Magliah et al. (2020)	NR	NR	NR	NR	NR	NR	NR	I	NR	I	NR	P	D
Mesa et al. (2020)	D	NC	NR	NR	NR	D	I	D	D	NC	NC	NR	NR
Olickal et al. (2020)	I	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	C	NR
Onmez et al. (2020)	NR	NR	I	I	I	NR	NR	NR	NR	NR	NR	NR	NR
Pla et al. (2020)	D	D	NR	NR	D	D	I	NR	NR	NC	NC	NR	NR
Rastogi et al. (2020)	NR	NR	I	D	D	NR	NR	NR	NR	NR	NR	NR	I
Ruissen et al. (2020)	NR	NR	NR	NR	D	NR	I	D	NR	NR	NR	NR	D
Sankar et al. (2020)	NR	NR	NR	NR	NC	NR	NR	NR	NR	NR	NR	C	NR

MG — mean glucose; CV — coefficient of variation; FBS — fasting blood sugar; PPBS — post prandial blood sugar; GMI — glucose management indicator; TIR — time in range; TAR — time above range; TBR — time below range; PA — physical activity; TAR moderate — 181–250 mg/dL; severe — > 250 mg/dL);
TBR moderate — 54–69 mg/dL, severe — < 54 mg/dL; NR — not reported; NC — no change; I — increased; D — decreased; C — changed; P — poor

[15] reported an increase in the physical activity, while five reported a decline in physical activity [17, 26–29].

Association between glycaemic control and changes in diet and physical activity

A total of eight studies reported blood glucose measurements and dietary changes. Three studies reported increase in blood glucose levels along with poor diet. [24, 25, 29] One study reported increase in the blood glucose and changes in diet without specification of the direction.[18] Three studies reported no change in glycaemia during change in the diet [20, 23, 34]. One study reported decline in the blood glucose with no change in the diet [17].

Eleven studies reported one or more of the glycaemic indicators and physical activity. Seven studies reported an increase in blood glucose along with reduction in physical activity or changes in diet.[15, 24-29] Three studies reported a decline in blood glucose levels despite a decline in physical activity levels.[16, 17, 20] The direction of changes could not be ascertained in one study [23].

Discussion

The included studies in this review showed mixed evidence of the impact of COVID-19 lockdown on diabetics. Overall, glycaemic indicators were improved during the pandemic lockdown; as mentioned by the majority of the studies included in this review, physical activity was decreased and dietary patterns were affected. Whereas, the findings from developing countries generally reported that the dietary pattern was affected [18, 22–24, 29, 34], as well as a decline in physical activity [17, 22–24, 29]. One study reported a decrease in HBA_{1c}, FBS, and PPBS along with the unexpected finding of decreased physical activity and no change in diet [17]. One study showed increases in all three parameters, i.e. HBA_{1c}, FBS, and PPBS, along with poor diet and decreased physical activity [24]. Similarly, one study showed an increase in mean glucose levels along with poor diet and decreased physical activity, although the study contained no reporting of other blood glucose parameters (HBA_{1c}, FBS, and PPBS) [29]. Another study showed an increase in PPBS, no change in FBS, no reporting of HBA_{1c} and mean glucose, and change in diet and physical activity without mentioning the direction of change [23]. One study reported no change in HBA_{1c} but reported a change in diet but without specifying its direction, while no reporting of FBS, PPBS, and mean glucose and physical activity was made [34]. However, one study showed a decrease in PPBS and HBA_{1c} but an increase in FBS and increase in physical activity, whereas, mean glucose and diet were not reported [15]. Henceforth, a variation of reporting a reliable measure, i.e. HBA_{1c} in some studies and reporting severely biased blood glucose parameters in others, of different assessment methods for diet and physical activity, and reporting of anyone outcome from diet and physical activity have led to inconclusive evidence for the determination of an association of HBA_{1c} or glucose with diet and physical activity from the included studies in our review.

Diabetes has been an established risk factor associated with an influenza-related mortality; hence, evidence from a Hong Kong study suggests that mortality rates among people with diabetes from pneumonia exceed mortality rates from cardiovascular disease and cancer [35, 36]. For that very reason, keeping a compliant lifestyle among diabetic patients during pandemic lockdown must be an unarguably important agenda to deter from avoidable complications that may arise from uncontrolled diabetes [37, 38].

The current review gathered evidence of increased levels of mean glucose, fasting blood sugar, and HbA_{1c} [13, 15, 18, 24, 26–29]. Overall, the majority of included studies showed well-controlled glucose management indictors and glycaemic parameters. This indicates that patients with diabetes were proactive in maintaining their blood glucose levels during lockdown. Emerging adaptation of online consultation technology could be a way to make patients compliant with their diabetes control measures [39]. However, the accessibility to telemedicine is limited and questionable, and needs to be explored by further research. Another explanation for this improved glycaemia could be the reduced access to fast food due to lockdown and restricted movement.

Physical activity is an important tool to assist in diabetes control; however, evidence shows a reduction in physical activity and prolonged sitting time due to home confinement during the COVID-19 lockdown, which might have a worse metabolic impact on diabetes patients [40, 41]. In our review, comparable findings consisting of a decrease in physical activity were gathered from almost all included studies in the review, which indicates an alarming situation. A meta-analysis suggested that prolonged sitting time and sedentary behaviour were associated with increased risk for diabetes and all-cause mortality [42]. Hence, a dire need for physical activity has been realized lately, and suggestions have been proposed to decrease sedentary behaviour, reduce daily sitting time, and reduce the duration of lying through home-based physical activity programs that are a doable, useful, safe, and effective strategy for diabetes management due to home confinement during the COVID-19 lockdown [43].

The dietary pattern among diabetic patients has been affected due to lockdown, as reported in the majority of studies included in this review. This disturbed pattern might not be a positive sign because diet and healthy eating behaviour are crucial for the control of diabetes, and adverse metabolic impact due to unhealthy food consumption and distorted meal patterns during home confinement may have important clinical implications [41]. Comparable findings of unhealthy eating patterns and food consumption have been observed across several settings where lockdowns were implemented [40].

Overall, only three studies showed poor diet [24, 25, 29], and one reported changes in the diet without specification of the direction [18] along with an increase in blood glucose levels. Moreover, seven studies reported increase in blood glucose along with reduction in physical activity or changes in the diet [15, 24–29]. Three studies reported a decline in blood glucose levels despite a decline in physical activity levels [16, 17, 20]. Therefore, the variation in the included studies' findings to conclude an association between HBA_{1c} or blood glucose, diet and physical activity could be due to methodological bottlenecks, limitations in outcome assessment in non-unanimous and unstandardized form, and majorly the confounders that are not addressed. All these limitations imply inconclusive evidence, and the gaps in the current research call for further exploratory research to identify whether a non-compliant diet or a lower level of exercise, or some other confounding factors, affect the blood glucose levels.

The present review with a comprehensive search has remarkably synthesized important up-to-date and quantitative evidence regarding lifestyle habits among diabetics during the COVID-19 lockdown period, to understand and advocate a comprehensive strategy for them in managing a healthy life pattern. This current synthesis of studies also has the advantage of including the maximum outcome as possible because diabetes is a multi-factorial process.

About two-thirds (68%) of the studies included in the review had satisfactory quality, which enhances the reliability of the findings included and accurate interpretation of the outcomes. However, this review, despite including a majority of satisfactory quality studies, might be restricted somehow to analysing the impact of the COVID-19 lockdown on daily lifestyle habits of diabetics due to potential sources of bias in the included studies. Firstly, the sampling was based on convenience, without power calculations, which severely affect the representativeness of samples. Secondly, non-validated tools were used for the assessment of physical activity and diet, which are subject to reporting bias. Thirdly, various parameters were used either in combination or alone to assess the glycaemic levels. Out of 17 studies meeting the criteria of good quality, only 7 reported HbA_{1c}, which is a more reliable parameter, while other parameters that can be affected by short-term changes in diet were used in most of the studies. The outcome of medication adherence was not mentioned in studies, which is an important outcome variable; however, the deficiency was covered as objective assessment of glucose parameters were reported, and these could be a predictor for medication adherence. Additionally, the scoring assigned to exposure (COVID-19 lockdown) was consistently same as "two" throughout all included studies in-lieu for quality assessment because studies were conducted in lockdown-affected settings. As a result of methodological limitations of included studies meeting the inclusion criteria, robust studies with representative samples and objective assessments are needed to comprehensively explore the impact of COVID-19 lockdown on lifestyle and healthy behaviour among diabetic patents.

Conclusion

The review concludes that lockdown and home confinement due to COVID-19 do not negatively affect the glycaemic control among diabetic patients. There was a decline in the physical activity; however, the evidence was weak about the impact on diet. The current body of evidence is of low quality in terms of the studies' methodological robustness. It is therefore strongly recommended that future studies use robust and objective measurement to avoid biases in the studies and generate strong evidence to draw conclusions and make recommendations for the care of diabetic patients. Nonetheless, there is need to promote indoor physical activity and proper diet, ensure regular supply of anti-diabetic medications, and more importantly regular follow-up with teleconsultation to maintain good glycaemic control among diabetic patients.

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Conflict of interest

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