Original Research

Post-COVID-19: effects on mental health and metabolic markers in type 2 diabetes

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Abstract

Background. This study aims to assess the impact of COVID-19 infection on both mental well-being and biological parameters of patients with type 2 diabetes, highlighting the potential long-term effects.

Methods. A longitudinal observational study was conducted on a total of 62 patients diagnosed with type 2 diabetes. We used two validated questionnaires: the WHO-5 Well-Being Index (WHO-5) and the Diabetes Distress Scale (DDS). Biological data were extracted from medical records. We had two-point evaluations, in 2023 and 2024. Patients were divided into three groups based on the year of COVID-19 diagnosis: 2020, 2021, 2022. Descriptive and inferential statistics were performed, with results presented as percentages and associations. The Wilcoxon signed-rank test, the Kruskal–Wali's test, and Spearman's rank correlation coefficient (ρ) were applied for non-normally distributed variables. Analyses were performed using Jamovi 3.2.28. A p value < 0.05 was considered statistically significant.

Results. There were 24 (38.7%) females, and 38 (61.3%) males. The mean age was 66.5 years. From the medical history, regarding COVID-19 severity, 7 (11.3%) of cases were classified as mild 29 (46.8%) as moderate, and 26 (41.9%) as severe. WHO-5 scores increased from a mean of 42.5 from 2023 to 51.2 in 2024, indicating improved psychological well-being over time. A significant reduction in diabetes-related emotional distress was observed ($p < 0.001$). Regimen-related distress scores showed a small but significant decrease from 2023 to 2024 ($p = 0.004$). A statistically significant correlation was observed between WHO-5 score (2023) and LDL cholesterol (2024) ($\rho = 0.629$, $p = 0.02$). Descriptive statistics showed that mean HDL cholesterol values vary with COVID-19 severity levels.

Conclusion. Psychological well-being showed an improvement over time. Emotional distress related to diabetes, including emotional burden and regimen-related distress decreased with time. Serum LDL- and HDL cholesterol levels may play a potential role in supporting psychological well-being. This study reinforces the importance of holistic approaches in managing post-COVID-19 effects, especially in patients with pre-existing metabolic disorders.

Keywords: diabetes mellitus type 2, COVID-19, psychological well-being, cholesterol HDL, cholesterol LDL

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Introduction

Recent data reported around 5,031 new COVID-19 cases worldwide [1]. All these cases are part of a pathology that brought new challenges in medicine. SAR-Cov-2 infection is now known for its short- and long-term complications [2]. Among special categories of patients that can be affected by SARS-Cov-2 infection are individuals with diabetes mellitus. The International Diabetes Federation (IDF) 2021 Atlas 10th edition reported that diabetes mellitus affects 537 million adults and this number is predicted to rise to 643 million by 2030 and 783 million by 2045 [3].

A two-year retrospective cohort analysis involving 1,284,437 patients revealed that the risk of developing cognitive deficits and psychotic disorders remained elevated in individuals with a history of COVID-19 compared to those who had experienced other respiratory infections [4]. A systematic review of 42 observational studies (2010-2022) assessed the prevalence of depression, anxiety, and insomnia in patients with type 2 diabetes before and during the COVID-19 pandemic. Depression rates ranged from 5.3% - 73.6% pre-pandemic and 5.6% - 30.4% during the pandemic. Anxiety prevalence was relatively stable (8.4% - 65.5% pre-pandemic; 8.4% during), while insomnia affected 9.6% - 48.2% of patient's pre-pandemic, with limited pandemic data (one study: 31.4%). Two studies directly comparing depression rates showed mixed results-one reported an increase, the other found no change [5]. Another systematic review and meta-analysis showed that the most common neuropsychiatric symptoms were sleep disturbance, with a pooled prevalence of 27.4%, followed by fatigue (24.4%), objective cognitive impairment (20.2%), anxiety (19.1%), and post-traumatic stress (15.7%) [6]. Chronic fatigue, musculoskeletal pain, and sleep disturbances are common systemic symptoms, with fatigue being the most frequently reported in meta-analyses [7].

A retrospective longitudinal cohort study examining neuropsychiatric outcomes in post-COVID-19 patients demonstrated significant improvements in cognitive function and anxiety levels between 6 and 12 months after infection. However, the majority of patients continued to experience persistent functional disabilities, fatigue, and cognitive deficits even at one-year post-infection [8]. Regarding the potential long-term effects of COVID-19, according to the Consensus Study Report released by the National Academies of Sciences, Engineering, and Medicine (NASEM) in 2024, Long COVID is defined as a chronic condition that occurs after infection with SARS-CoV-2 and persists for at least three months [9]. 4% of children and 10-2% of adults developed Long-COVID, depending of the SARS-CoV-2 phenotype [10]. A systematic review and meta-analysis published last year, which included 41 studies and approximately 860,783 patients, identified key risk factors associated with post–COVID-19 condition (PCC). The analysis found that the presence of comorbidities and a history of hospitalization or ICU admission were significantly associated with an increased risk of developing PCC [11]. HbA1c level was identified as key factor associated with the development of post-COVID-19 syndrome (PCS). Elevated HbA1c was independently associated with PCS, regardless of oxygen therapy, glucocorticoid use, or the severity of acute COVID-19. Notably, HbA1c and mtDNA demonstrated a stronger association with PCS than other clinical variables, suggesting their potential utility as prognostic biomarkers in this vulnerable population [12]. A cross-sectional study conducted after the COVID-19 pandemic reported that HDL cholesterol may partially mediate the relationship between inflammatory markers (CRP, PC, PPN) and depressive symptoms [13]. Evidence from a meta-analysis and a case-control study indicates that serum LDL cholesterol is significantly reduced in patients diagnosed with depression [14,15]. Also, persistent depressive symptoms have been notably associated with low levels of serum HDL-Cholesterol [15]. Although direct studies on HDL cholesterol and depression are limited, a meta-analysis reported that individuals with suicidal tendencies had significantly lower levels of total cholesterol, HDL-C, LDL-C, and triglycerides. These findings support the hypothesis that altered lipid profiles, particularly low HDL-C, may be associated with severe affective symptoms [16].

This study investigated the impact of COVID-19 infection on psychological well-being and metabolic biomarkers in individuals with type 2 diabetes, emphasizing the potential long-term implications of the disease.

Methods

Study design and setting

We conducted a longitudinal observational study with repeated measures (2023, 2024), conducted in a single cohort of patients with type 2 diabetes, who had been previously hospitalized for COVID-19. In the present study, we explored the potential post-COVID-19 psychological and emotional disturbances and metabolic changes among individuals with type 2 diabetes. The analysis was conducted on HbA1c and lipid profile components, LDL and HDL cholesterol, as these biomarkers showed the highest consistency in documentation across both evaluation time points. Psychological well-being was assessed using the WHO-5 index, while diabetes-related distress was measured using the DDS, which evaluates emotional burden, treatment-related stress, and physician-related distress. Although these tools are not diagnostic instruments for post-COVID evaluation, persistently altered scores, measured at least 3 months after SARS-CoV-2 infection, may reflect the prolonged systemic impact of the virus. The findings may support the hypothesis that sustained emotional and psychological strain, particularly

in patients with diabetes or altered glycemic control, could be part of the broader clinical spectrum of post-acute COVID-19 syndrome.

Participants

The study group included participants previously hospitalized for COVID-19 with a known diagnosis of type 2 diabetes mellitus prior to their COVID-19 hospitalization, as well as patients who were newly diagnosed with diabetes in the post-COVID-19 period. After discharge, they were referred for diabetes monitoring and glycemic control at the Diabetes, Nutrition, and Metabolic Diseases Outpatient Clinic of the County Emergency Clinical Hospital in Cluj-Napoca. There, the patients with glycemic modifications following COVID-19 were evaluated and received their diagnosis of type 2 diabetes. The study group consisted of both male and female participants, with a higher number of men. Of the participants, 39 patients did not present post-diabetes complications, while the remaining patients had at least one diabetes-related complication, with diabetic polyneuropathy being the most frequently reported. Regarding treatment, more than half of the participants were receiving oral antidiabetic drugs (OADs) at the time of evaluation. Additionally, 36 patients were newly diagnosed with type 2 diabetes following their COVID-19 infection. In terms of comorbidities, the most prevalent were: obesity, arterial hypertension, dyslipidemia, hypothyroidism, and chronic kidney disease. The inclusion criteria were adult patients diagnosed with type 2 diabetes who had a confirmed history of prior COVID-19 infection. To reduce potential study risks and possible confounding variables that could affect the outcome of interest, we excluded patients with cognitive impairment and patients who declined participation in the research. Patients with cognitive impairment were excluded to ensure the accuracy and reliability of questionnaires responses, as these individuals may have difficulty understanding the questions or providing informed answers.

Data sources and measurement

1. Laboratory tests

In order to explore possible associations between metabolic alterations following COVID-19, biological data like, fasting blood glucose, HbA1c (%), lipid profile, serum creatinine, and hepatic profile were recorded from clinical evaluations at the time of each assessment (2023 and 2024). Laboratory values were extracted from patients' medical records, based on laboratory analyses performed during routine clinical visits. Due to missing or incomplete data for some laboratory variables, the correlation analysis was limited to HbA1c and lipid profile components, LDL and HDL cholesterol. These parameters showed the highest consistency in recording across both time points.

2. Psychosocial evaluation

Were also administered two validated instruments to assess psychological outcomes: the WHO-5, a widely used and psychometrically sound tool for evaluating subjective psychological well-being [17], and DDS, validated in Romanian diabetic populations [18], which measures diabetes-related emotional distress. The questionnaires used in this study is from existing sources [17,18]. The WHO-5, developed by the World Health Organization (WHO), consists of 5 items measuring positive mood, vitality, and life satisfaction over the past two weeks. Each item is rated from 0 to 5, with lower scores (<13/25) indicating low well-being and possible depressive symptoms. The DDS evaluates the emotional burden of living with diabetes through 17 items rated from 1 (no distress) to 6 (high distress). This questionnaire covers domains such as treatment burden, physician interaction, and interpersonal stress. Scores ≥3 suggest clinically relevant distress. It reflects patient experiences over the previous month. To assess the impact of post-COVID-19 factors on psychological well-being and diabetes-related distress, established thresholds were used to interpret questionnaire scores and perform correlation analyses. A score of ≤ 50 was used as the cut-off to indicate reduced psychological well-being [17]. For the DDS, a score of ≥ 2 was considered indicative of clinically relevant distress, in line with previously validated criteria [19].

Patients were divided into three groups, 2020, 2021 and 2022, depending on the year of infection, allowing assessment at 1 to 4 years after the acute phase. Two post-COVID-19 telephonic evaluations were performed in 2023 and 2024. A total of 62 questionnaires were administered at each evaluation point (2023 and 2024), with all patients responding via telephone interviews. The 2024 evaluation included patients with the longest periods since their COVID-19 infection. Telephone assessments were chosen due to logistical constraints, to increase accessibility, particularly for patients who had limited mobility or were reluctant to return for in-person visits. These two years were selected to capture medium and long term outcomes by extending the evaluation interval.

3. Data recording and management

All data were anonymized and no identifying information was included in the analysis database. Questionnaires and laboratory data were entered into a secure digital database (Microsoft Excel). Access to the database was restricted to the research team. Regular quality checks were conducted to ensure accuracy and completeness.

Statistical analysis

Statistical analysis was performed using non-parametric tests, given that the quantitative variables did not follow a normal distribution**.** The Wilcoxon signed-rank test was applied to compare paired quantitative data. The Kruskal–Walli's test was used to compare independent samples across the three groups when the assumption of normality was not met. Spearman's rank correlation coefficient (ρ) was employed to assess associations

between two continuous, non-normally distributed variables. Descriptive statistics were presented as medians and interquartile ranges (IQR) for non-normally distributed variables. For visualization we used descriptive statistics plots displaying mean ± 95% confidence intervals (CI) and median values for each group or time point. Scatter plots were generated to illustrate the relationship between continuous variables (types of cholesterol, HbA1c (%), WHO-5 scores and DDS), particularly in the correlation analysis. Analyses were performed using Jamovi 3.2.28. A p-value < 0.05 was considered statistically significant.

Ethical consideration

This study has the approval No. 101/3 May 2022 of the Ethics Committee of Iuliu Haţieganu University of Medicine and Pharmacy Cluj-Napoca. Written informed consent was obtained from each participant in the study before the clinical parameters were extracted, including laboratory results, and before questionnaires were administered. Following ethical research guidelines, patients who declined participation were excluded to respect their autonomy and voluntary consent.

Results

Sample description

The study included a total of 62 diabetic patients previously hospitalized for COVID-19. The mean age of the study population was 66.5 years (standard deviation: 15.2 years). The interquartile range (IQR) was 15 years, with the first quartile (Q1) at 61 years and the third quartile (Q3) at 76 years. Of the total participants, 24 (38.7%) were female, and 38 (61.3%) were male. 62 (86.1%) had a diagnosis of type 2 diabetes. Regarding COVID-19 severity, 7 (11.3%) of cases were classified as mild, 29 (46.8%) as moderate, 26 (41.9 %) as severe. In terms of living environment, 48 patients (77.4%) resided in urban areas, while 14 (22.6%) were from rural areas (Table I).

Psychosocial assessment using the WHO-5 well-being index

The WHO-5 scores demonstrated a marked improvement between the two evaluation points, 2023 (WHO-5 score 1) and 2024 (WHO-5 score 2). The mean score increased from approximately 42.9 (95% CI: ~39–46) WHO-5 score 1(2023) to 52.2 (95% CI: ~48–55) for WHO-5 score 2 (2024). Similarly, the median score rose from 44 to 52. The difference between the two time points was statistically significant (Wilcoxon W = 9.00, $p < 0.001$), indicating improved psychological well-being over time (Table II).

Table I. Characteristics of the study population (N = 62).

	Variable	Total - n (%)	p-value
Gender	Female	24 (38.7)	>0.05
	Male	38 (61.3)	
COVID-19 Severity	Mild	7 (11.3)	
	Moderate	29 (46.8)	
	Severe	26 (41.9)	
Living area	Rural	14 (22.6)	
	Urban	48 (77.4)	

N = total number of participants; n = number of participants in each subgroup; p < 0.05 was considered statistically significant; chi-square

Descriptive statistics, for WHO-5 well-being 1 (2023) scores by year of COVID-19 diagnosis, showed slightly lower mean (M) values in patients diagnosed in 2022 (M = 38.4) compared to those diagnosed in 2020 (M = 44.1) and 2021 (M = 43.7) The WHO-5 well-being 2 (2024) scores showed similar mean scores across the three groups: 52.7 for 2020, 51.9 for 2021, and 50.2 for 2022. The widest confidence intervals were observed in 2022, particularly for WHO-5 Score 2 (Figure 1).

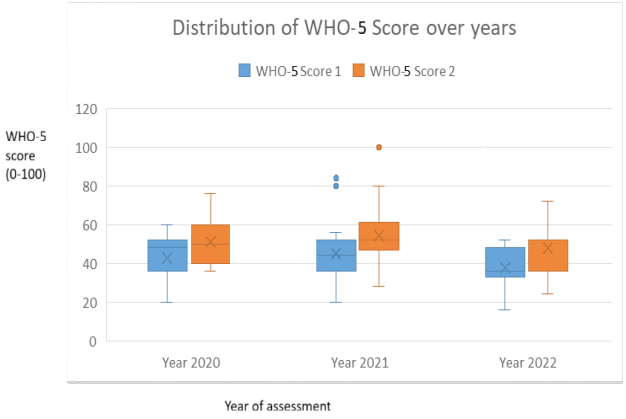

Figure 1. WHO-5 scores by year of COVID-19 diagnosis (2020-2022). WHO-5 score = World Health Organization Wellbeing Index Score; score 1 = first evaluation (2023); score 2 = second evaluation (2024).

Table II. Comparison of WHO-5 scores at Two Time Points in patients with type 2 diabetes (N = 62).

	N	Mean (95 % CI)	Median	SD	SE	p - value
WHO-5 score 1	62	42.9 (39.3 – 46.5)	44	14.2	1.82	<0.01
WHO-5 score 2	62	52.2 (48.5 – 55.9)	52	14.7	1.88	

N = total number of participants; WHO-5 = World Health Organization Wellbeing Index Score; score 1 = first evaluation (2023); score 2 = second evaluation (2024); SD = Standard Deviation; SE = Standard Error; CI = Confidence Interval; p < 0.05 was considered statistically significant; Wilcoxon test

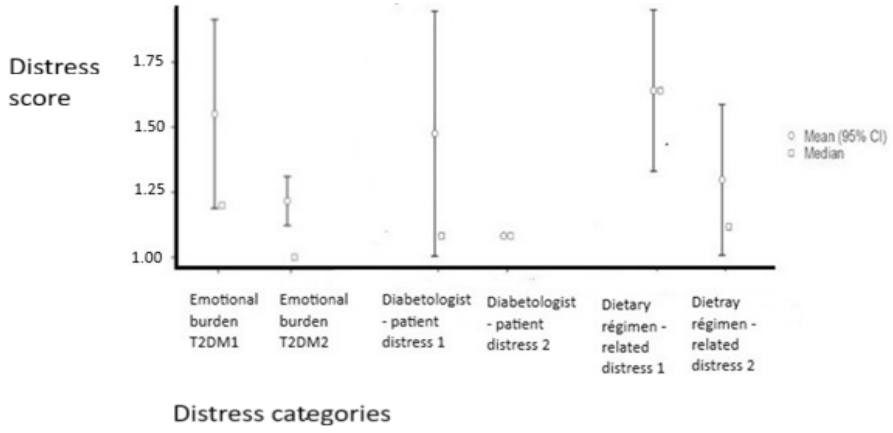

Figure 2. Comparison of DDS scores (Median, Mean, 95% CI) across distress categories between 2023 and 2024. CI = confidence interval; T2DM = type 2 diabetes mellitus; 1 = first evaluation (2023); 2 = second evaluation (2024).

Psychosocial assessment using the Diabetes Distress Scale (DDS)

The DDS was used to assess diabetes-related distress in all three patient groups during both post-COVID-19 evaluations. Was assessed: emotional burden regarding living with diabetes, diabetologist - related distress, regimen - related distress, and interpersonal distress, associated with social and relational stress caused by diabetes (Figure 2).

Emotional burden

A reduction in both the median score and its variability was observed between the first and second evaluations (Median: 1.20 vs. 1.00; SD: 1.446 vs. 0.375). The Wilcoxon signed-rank test indicated a statistically significant reduction in emotional distress score between the two assessments: W= 397, p<0.001. This decrease suggests a reduction in diabetes-related emotional distress over time among the evaluated patients.

Diabetologist - related distress

During the first evaluation, a median score of 1.00 was observed, with a standard deviation of 0.176. The second evaluation showed no variability, with a constant median of 1.00 (SD = 0.000). A Wilcoxon signed-rank test was conducted to compare scores between the two time points. Although a slight decrease in distress was observed, the difference did not reach statistical significance (Wilcoxon W = 10.0, p = 0.098).

Regimen - related distress

Dietary regimen - related distress was assessed at both time points (2023 and 2024) using the corresponding subscale of the DDS, and scores were compared using the Wilcoxon signed-rank test. At the first evaluation, the median score was 1.60 (SD = 0.472). At the second evaluation, a slight decrease was observed, with a median of 1.40 (SD = 0.441). These findings suggest a minor reduction over time. The results showed a statistically significant decrease in distress (W = 182, p = 0.004), suggesting an improvement in patients' ability to manage their dietary regimen over time.

Interpersonal distress

The scores for Interpersonal Distress were nearly identical across participants, indicating a high level of homogeneity within the sample (mean = 1,06, median = 1, SD = 0,28). Detecting statistically significant differences or meaningful associations was limited (Figure 3).

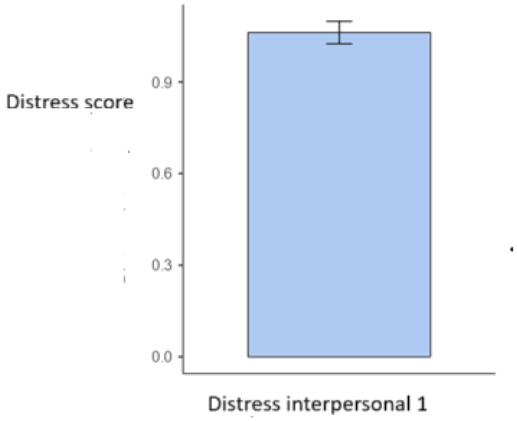

Figure 3. Interpersonal distress: DDS score. Distress interpersonal 1 = distress score first evaluation (2023).

Biomarkers and questionnaire correlations

A positive association was observed between HbA1c (%) and DDS score (range: 1–6) during the 2024 evaluation (ρ = 0.292, p = 0.09). However, this association did not reach statistical significance. No significant results were identified for the remaining variables (Figure 4).

Table III. Descriptive statistics of HDL cholesterol levels by COVID-19 severity.

	COVID19 form	N	Mean	SD	SE	p-value
HDLCol 3	moderate	18	44.3	7.92	1.87	0.026
	severe	12	47.4	11.66	3.37	
	mild	3	55.4	4.33	2.50	

HDL= high density lipoprotein cholesterol, first evaluation; N = number of participants in each group; SD = standard deviation; SE = standard error; $p < 0.05$ was considered statistically significant; Welch ANOVA test.

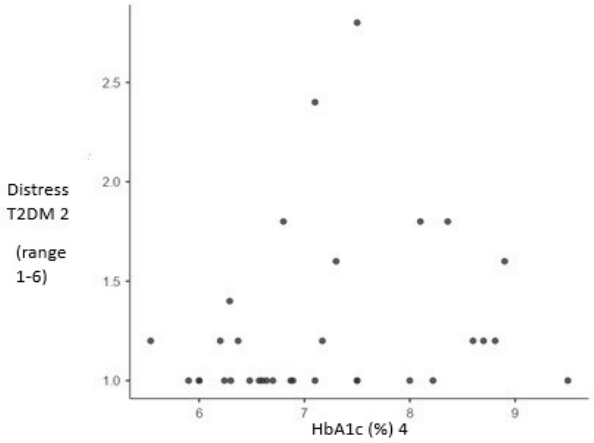

Figure 4. Correlation between HbA1c (%) levels and diabetes-related distress scale. Second evaluation (2024). HbA1c (%) 4 = glycate hemoglobin second evaluation (2024); Distress T2DM 2 = Diabetes Type 2 Distress Scale second evaluation.

A moderate direct correlation was observed between the WHO-5 score 1 (range: 0 – 100), and the LDL cholesterol (mg/dL) measured at the second evaluation in 2024 (Spearman's Rho = 0.629, p = 0.02) (Figure 5).

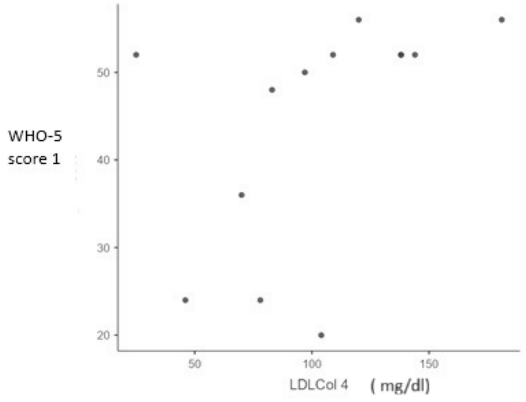

Figure 5. Correlation between LDLCol 4 second evaluation (2024) and WHO score 1 first evaluation (2023). LDLCol 4 = Low-Density Lipoprotein second evaluation (2024); WHO-5 score 1 = World Health Organization-5 Well-Being Index score first evaluation.

Descriptive statistics showed that mean HDL cholesterol (mg/dL) values variates with COVID-19 severity levels. Patients with mild COVID-19 had the highest HDL levels (M = 55.4, SD = 4.33), followed by those with severe forms (M = 47.4, SD = 11.66) and moderate forms (M = 44.3, SD = 7.92). Standard errors ranged from 1.87 to 3.37 across groups. A Welch's ANOVA revealed a statistically significant difference in HDL cholesterol levels between groups based on COVID-19 severity (p = 0.026) (Table III).

Discussion

This longitudinal observational study investigated post-COVID impact on mental well-being, diabetes-related emotional distress, and biological parameters in patients with type 2 diabetes. What sets this study apart is the extended follow-up period, 1 to 4 years after the initial infection, particularly in this vulnerable population: patients with type 2 diabetes. Our findings, measured at both evaluation points, revealed that patients reported lowered distress levels as measured by the DDS, alongside increased well-being scores based on the WHO-5 Index. Biologically, we observed minor but relevant changes in lipid profiles, and glycated hemoglobin, suggesting that long COVID-19 may have lingering metabolic and psychological effects in this vulnerable population. HDL cholesterol quantity and functionality is altered in COVID-19. Longitudinal data indicate higher risks of developing new-onset dyslipidemia after COVID19, especially lower HDLC levels in those with moderate to severe disease compared to mild cases or non-infected controls. Also, variations in HDL levels may reflect chronic inflammatory burden and HDL dysfunction, which in turn could contribute to long-term cardiovascular and psychological risks [20].

The WHO-5 scores demonstrated a marked improvement between the two evaluation points, 2023 (OMS1) and 2024 (OMS2) indicating improved psychological well-being over time. Individuals with diabetes are already exposed to various stressors due to the nature of the disease itself, which can significantly impact their quality of life [21]. A systematic review of 33 studies including 6,743 participants reported that most post-COVID-19 individuals experienced mild or no symptoms of long-term anxiety, depression, and PTSD, with sleep disturbances (mainly insomnia) being the most commonly reported issue [22]. In a prospective online survey, the findings revealed that COVID-19-

related persistent symptoms can improve over time, but neurological symptoms may persist longer than others [23]. A descriptive qualitative study assessed mental health, quality of life, and coping in people who had survived hospitalization with COVID-19. Survivors showed gradual improvement in physical and mental health. Most returned to their previous jobs within two years. However, many still experienced persistent symptoms [24]. These findings align with our WHO-5-based results, which indicate an overall improvement in self-reported well-being over time.

Also, the absence of variability in diabetologist-related distress scores during evaluations may also reflect contextual factors. In 2023, participants were still relatively close to the COVID-19 pandemic period, which may have increased their perceived need for closer monitoring or maintaining a stronger connection with their diabetologist, given the heightened vulnerability of individuals with chronic conditions and the potential severity of COVID-19 in such populations. By 2024, greater adaptation and a return to routine care may have led to increased comfort and reduced distress, contributing to the uniformly low scores observed. Additionally, we observed a decrease in diabetes-related emotional distress over time among the evaluated patients, as well as an improvement in patients' ability to manage their dietary regimen. A cross-sectional study which assessed psychosocial and behavioral factors that are associated with distress in patients with diabetes found that lower diabetes distress scores were linked to more days on a healthy diet and increased physical activity. Conversely, younger age and higher BMI were significantly associated with higher DDS ($p < .05$) [25].

Moreover, our data suggest a tendency for higher HbA1c (%) levels to be associated with greater diabetes-related distress. A study examining psychosocial and quality of life correlates of glycemic control during intensive treatment of type 1 diabetes found that emotional distress may act as a negative predictor for glycemic outcomes, like HbA1c (%) values [26]. This suggests that while our current findings do not confirm a statistically significant relationship, the study results are consistent with existing literature and highlights the importance of considering psychological factors in diabetes management.

Regarding lipid profile, a moderate direct correlation was observed between the WHO-5 score and the LDL cholesterol value at the second evaluation. This statistically significant association suggests that individuals with higher psychological well-being scores tend to have higher LDL cholesterol values. However, this correlation does not imply causality, and further investigation is required to understand the underlying mechanisms of this relationship. In an observational study about blood lipids after COVID-19 infections, increased levels of LDL cholesterol, triglycerides, and total cholesterol, along with decreased HDL cholesterol were observed. The study related these findings to nutrition and infection or inflammation [27]. The significantly higher HDL cholesterol levels observed in patients who experienced mild COVID-19, compared to those with moderate forms, may indicate a less pronounced metabolic impact of the disease. These results suggest that milder COVID-19 may be associated with a more favorable lipid profile, particularly higher HDL levels, possibly reflecting reduced systemic stress or better recovery [28]. Our results align with evidence suggesting that milder COVID-19 may be associated with a more favorable lipid profile. On the other hand, HDL cholesterol levels did not correspond to the severity grades of COVID-19.

This study has several strengths, including the use of validated instruments (DDS, WHO-5), the integration of both biochemical and psychological indicators, and a relatively long evaluation period that enhanced the temporal depth of the analysis.

There are several limitations to this study. First, the incomplete availability of certain laboratory parameters across all participants, along with loss to follow-up that reduced the sample size, may introduce attrition bias and limit the generalizability of our findings regarding broader metabolic changes and the statistical power for subgroup analyses. The absence of a control group limits our ability to distinguish post-COVID-19 effects from general post-illness recovery trends. Additionally, confounding factors that were not controlled for could have influenced the observed outcomes. Lipid levels may have been influenced by external factors such as medication, dietary habits, physical activity, and other comorbidities, which were not controlled for in the analysis. Moreover, the observational nature of the study restricts the capacity to account for all variables impacting the results. These limitations highlight the need for further larger observational studies to confirm these findings. In addition, questionnaire-based data may be affected by recall bias, social desirability effects, and the potential for inaccurate or incomplete responses.

Conclusions

Post-COVID-19 infection can be associated with prolonged mental health effects, including a decline in psychological well-being and diabetes-related distress. However, these effects tend to diminish over time, suggesting a gradual process of psychological recovery. In parallel, persistent sequelae may contribute to long-term metabolic dysregulation, such as disturbances in glucose and lipid metabolism, which can extend well beyond the acute phase of the illness. These long-lasting physiological and biological changes point toward a chronic dimension of COVID-19, underscoring the need for integrated long-term follow-up and care strategies, especially for vulnerable populations such as patients with diabetes.

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