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Research article

Correlation of Body Mass Index with Glycemic Control in Type II Diabetes Patients Experiencing Respiratory Infection

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Abstract: Deficient glycemic control among patients with type 2 diabetes mellitus (T2DM) represents a major public health concern. This study aimed to determine the relationship between body mass index (BMI) and glycemic control (HbA1c) in T2DM patients who experienced COVID-19 infection in the rural population of Central Punjab. An observational cross-sectional study was conducted among male and female patients aged 35 years and above attending the outpatient clinic at the Rural Health Center, Awan Dhai Wala, Lahore, from 1 October 2021 to 31 March 2022. BMI and HbA1c levels were analyzed using the Pearson correlation coefficient (r). A total of 300 patients were included, with a mean age of 49.76 ± 8.81 years (median: 51; range: 35–65). The mean BMI was 24.37 ± 4.11 (median: 24; range: 17.5–36). A statistically significant difference (p = 0.001) was observed between mean BMI in patients with good glycemic control (21.81 ± 3.15) and those with poor glycemic control (25.22 ± 4.05). BMI category stratification also showed a significant association with glycemic control (p = 0.001). The Pearson correlation coefficient demonstrated a moderate positive correlation between BMI and HbA1c (r = 0.40), indicating that higher BMI is associated with poorer glycemic control. Overall, the findings suggest that elevated BMI contributes to inadequate glycemic control in T2DM patients previously infected with COVID-19 in rural Central Punjab.

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Introduction

A novel coronavirus responsible for severe respiratory tract infections, Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2), emerged in Wuhan, China, in late 2019 (Anis et al., 2021). The disease caused by this virus was subsequently named Coronavirus Disease 2019 (COVID-19). Within months, SARS-CoV-2 spread globally, leading to an unprecedented pandemic. Pakistan was among the countries significantly affected, experiencing multiple waves of COVID-19 outbreaks that placed substantial strain on the healthcare system and public health infrastructure (Ahmed et al., 2020; Zeshan et al., 2021).

COVID-19 primarily targets the respiratory system, ranging from mild upper respiratory tract symptoms to severe viral pneumonia and acute respiratory distress syndrome (ARDS) (Naveed et al., 2022; Yusof et al., 2021). Studies have shown that the severity and mortality of COVID-19 are

markedly higher among older adults and individuals with pre-existing medical conditions, including diabetes mellitus, hypertension, cardiovascular diseases, chronic lung diseases, obesity, renal disorders, and other infectious diseases (Ahmed et al., 2022; Sohail et al., 2023). These comorbidities compromise immune responses, thereby increasing susceptibility to severe complications. In addition to respiratory failure, COVID-19 can induce systemic involvement such as coagulopathy, cytokine storm, and multiorgan dysfunction, emphasizing its complexity as a respiratory and multisystem infectious disease (Ali et al., 2021; Rizvi et al., 2022).

Diabetic Mellitus is a chronic metabolic disorder that is characterized by the elevated level of glucose in blood (hyperglycemia) and caused by the impaired secretion or action of a hormone called insulin (Chen et al., 2012). The inadequate secretion of insulin from beta cells of pancreases or resistance of target tissues to insulin such as skeletal tissues, adipose tissues and etc. leads to the metabolic abnormalities. Diabetic Mellitus is categorized as one of the most prevalent and common disorder around the world, which is surging at a very high rate. It has been predicted that the number of diabetic patients will be increasing to 639 million by 2045 from 451 million in 2017. In developing 7 countries, like Pakistan this disease is growing very rapidly (Williams et al., 2020). According to the survey conducted in Pakistan, the percentage of type 2 diabetic patient in Pakistan is 11%. The prevalence of T2DM in males and females is 11.20% and 9.19% respectively (Aamir et al., 2019).

The obesity has the direct relation with the diabetes (Bae et al., 2016). The correlation of diabetes and obesity can be determined by the calculation of body mass index and measurement of level of in blood by HbA1c test (Babikr et al., 2016). Hb1ac is the hemoglobin molecule that is formed when the glucose molecule combined with the beta chain of hemoglobin (Chandalia and Tripathy, 2012). The synthesis of Hb1ac molecule is a normal physiological function but its quantity increases by the increase level of glucose in blood (Jaberi et al., 2019). This can be used as marker for the diagnosis of diabetes. The increased level of Hb1ac in blood shows the diabetic condition in an individual. According to the literature review, the BMI has the positive correlation with the T2DM (Hussain et al., 2017).

Furthermore, many T2DM patients have dyslipidemia, which is considered to play a substantial role in mediating the cardiovascular risk linked with diabetes. One group among the spectrum of diseases is cardiovascular disease (CVD), and atherosclerosis in DM is exacerbated by abnormal lipid metabolism (Bhanpuri et al., 2018). Comparatively to those who do not have DM, this considerably raises the risk of CVD. People with T2DM are more likely to have CVD, which is also the leading cause of death in this population (Pandey et al., 2020).

Globally, the primary causes of death are related to diabetes (Hussain et al., 2020; Wojciechowska et al., 2016). Diabetics' propensity to develop the illness is still unknown in patients, but it is apparent that patients are at higher risk of becoming infected once they are the potential for serious illness (Hussain et al., 2020). Additionally, it has also established that diabetic patients' overall survival, who develop COVID-19 infection are worse off than those who are not diabetic. patients (Wojciechowska et al., 2016). We investigated the data from diabetic patient's correlation with body mass index in SARS-CoV-2 infected patients who were reported at an outpatient clinic in the rural health center, Awan Dhai Wala, Lahore. Determining the link between BMI and glycemic control Hb1Ac in T2DM patients infected with COVID-19 among the rural population of Central Punjab is the purpose of this study.

Materials and Methods

The observational cross-sectional study design included all males and females above 35 years of age or older having COVID-19 infection with type 2 diabetes reported at an outpatient clinic in the rural health center, Awan Dhai Wala, Lahore from 1 October 2021 to 31 March 2022. The study was approved by the under ethical number 107/22/RHC AD Wala. A total of 300 patients reported in the

above-mentioned time frame were included in the study, after documenting the demographic data of the patients, a details clinical history and details of diabetes was obtained from the patients. Patients of both sexes who had been diagnosed with T2DM and were between the ages of 35 and 65 were eligible to take part in this study. According to medical records and clinical histories, patients who had not taken medications regularly for the previous three months were excluded. Patients with urinary tract infection, obstructive uropathy and on statins will be excluded. Patients who had history of previous hypoglycemic medications and those with abnormal liver function, retinopathy or neuropathy, nephropathy. Patients with serum creatinine >2 mg/dl, serum sodium <12 mmole/l or have liver cirrhosis along with ascetics as per investigations and clinical record. Patients taking any drug which affect glucose metabolism.

After all the required procedures and taking written informed consent, the patients were subjected for the investigations. The investigations HbA1c, lipid profile, waist hip ratio, waist circumference and fasting blood sugar were conducted. Total 5 mL of fasting blood was taken as a sample then it was centrifuged for separation of serum. By using a method of micro particle agglutination inhibition, the concentration of HbA1c was detected through immune turbidimetrically. All the data along with the demographical details was noted and entered in to the attached Performa. To remove bias, all HbA1c levels were assessed in the same lab (i.e hospital lab) using only drugs produced by the same pharmaceutical manufacturer. By excluding them, confounding variables were managed.

Statistical analysis

SPSS version 23 was used to gather and analyze the data. Numerical variables i-e age, height, weight, fasting glucose were presented by mean ± standard deviation. Categorical variable i-e gender, HbA1c, BMI levels (underweight, normal weight, overweight & obese), duration of diabetes (10 years) was presented as frequency and percentage. The post-stratification chi-square test was used, with a p-value of ≤0.05 being considered significant. Data was stratified for age, BMI, and gender. The correlation between BMI and HbA1c glycemic control was measured using the Pearson correlation coefficient (r). A p-value of less than 0.05 was regarded as significant.

Results

This study included three hundred patients, with a mean age and standard deviation of 49.76 ± 8.81 years and a median of 51 with a range of (35-65). In addition, majority of the patients were male 190 (63.3%). Furthermore, Mean and median body mass index was 24.37 ± 4.11 and 24 (17.5-36), respectively. Also, body mass index was categories as per World Health Organization criteria; underweight 35 (11.7), healthy weight 123 (41.0), over weight 102 (34.0) and obese 40 (13.3).

Moreover, mean and median hemoglobin A1c (HbA1c) was 9.02 ± 1.89 and 8.87 (6.13-14.54) and also categorized as good glycemic control 75 (25.0) and poor glycemic control 225 (75.0). Furthermore, mean of circumference of waist (cm), circumference of hip (cm) and waist hip circumference ratio (cm) were 82.88 ± 12.41, 92.0 ± 10.71 and 0.91 ± 0.13, respectively. Additionally, mean of lipid profile of the patients segregated as serum cholesterol, serum low density lipoprotein (LDL), serum triglycerides, and serum HDL. In addition, the mean serum cholesterol, serum LDL, serum triglycerides, and serum HDL were 181.0 ± 7.70, 145.50 ± 21.56, 195.75 ± 18.10, and 39.51 ± 5.76, respectively. Moreover, duration of diagnosis of diabetes mellitus categorized as <10 years 110 (36.7%) and ≥10 (years) 190 (63.3%) as shown in **Table 1**.

Table 1. Demographic and clinical characteristics of overall patients (years).

Variables	Categories	N (%)
Age (years)	Mean ± SD*	49.76 ± 8.81
Sex	Male	190 (63.3)
	Female	110 (36.7)
Body mass index (kg/m2)	Mean ± SD*	24.37 ± 4.11
Body mass index categories (kg/m2)	Under weight: ≤18.5	35 (11.7)
	Healthy weight: 18.5-24.9	123 (41.0)
	Over weight: 25.0-29.9	102 (34.0)
	Obese: 30.0-34.9	40 (13.3)
Hemoglobin A1c (HbA1c)	Mean ± SD*	9.02 ± 1.89
HbA1c categories	Good glycemic control	75 (25.0)
	Poor glycemic control	225 (75.0)
Waist circumference (cm)	Mean ± SD*	82.88 ± 12.41
Hip circumference (cm)		92.0 ± 10.71
Waist hip circumference ratio		0.91 ± 0.13
Serum cholesterol		181.0 ± 7.70
Serum triglycerides		195.75 ± 18.10
Serum low density lipoprotein		145.50 ± 21.56
Serum high density lipoprotein		39.51 ± 5.76
Duration of diabetes mellitus (years)	<10 (years)	110 (36.7)
	≥10 (years)	190 (63.3)

*Standard deviation.

Additionally, the mean difference of serum LDL (p-value 0.001) and serum HDL (p-value 0.001) versus good and poor glycemic control. Mean difference of serum LDL versus good glycemic control 133.71 ± 21.33 and poor glycemic control 149.43 ± 20.20 and mean difference of serum HDL versus good glycemic control 35.36 ± 1.40 and poor glycemic control 40.89 ± 6.0, respectively. The duration of diabetes mellitus versus poor and good glycemic control. **Figure 1** the bifurcation of BMI versus poor and good glycemic control (HbA1c).

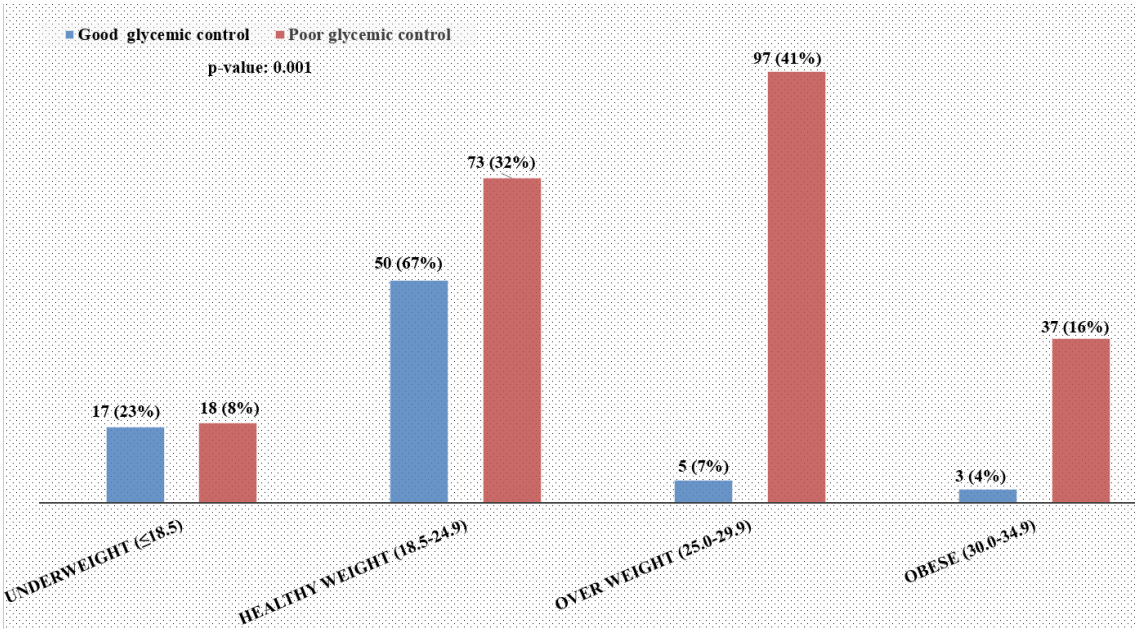

Figure 1. Bifurcation of body mass index versus good and poor glycemic control (HbA1c).

Additionally, **Table 2** showed bifurcation of demographic and clinical characteristics with respect of poor and good glycemic control. The mean difference of age (years) versus poor and good glycemic control. No statistical difference was observed (p-value 0.92) in mean age of good 49.67 ± 8.70 and poor glycemic control 49.79 ± 8.90. Also, there is statistically significant difference (p-value 0.04) was observed in sex versus good and poor glycemic control. Also, the mean difference of circumference of hip, circumference of waist, and waist hip circumference ratio versus good and poor glycemic control. There is only statistically significant (p-value 0.01) difference was observed in mean difference of hip circumference versus good and poor glycemic control. Moreover, the mean difference of serum cholesterol, LDL, serum triglycerides, and HDL versus poor and good glycemic control. There is a statistically significant (p-value 0.001) difference was observed in serum cholesterol versus good glycemic control 177.72 ± 8.10 and poor glycemic control 182.09 ± 7.22. Also, mean difference of serum triglycerides versus good glycemic control 183.52 ± 12.51 and poor glycemic control 199.83 ± 17.82 also showed statistically significant difference (p-value 0.001).

Table 2. Bifurcation of demographic and clinical characteristics with respect of good and poor glycemic control.

Variables	Categories	Good glycemic control 75 (25%)	Poor glycemic control 225 (75%)	p-value
Age (years)	Mean ± SD*	49.67 ± 8.70	49.79 ± 8.90	0.92
Sex	Male	55 (73.3)	135 (60.0)	0.04
	Female	20 (26.7)	90 (40.0)	
Waist circumference (cm)	Mean ± SD*	82.85 ± 9.39	82.90 ± 10.42	0.91
Hip circumference (cm)		91.60 ± 10.54	92.14 ± 11.70	0.01
Waist hip circumference ratio (WHR)		0.91 ± 0.13	0.89 ± 0.20	0.41
Serum cholesterol		177.72 ± 8.10	182.09 ± 7.22	0.001
Serum triglycerides		183.52 ± 12.51	199.83 ± 17.82	0.001
Serum low density lipoprotein		133.71 ± 21.33	149.43 ± 20.20	0.001
Serum high density lipoprotein		35.36 ± 1.40	40.89 ± 6.0	0.001
Duration of diabetes mellitus (years)	<10 (years)	26 (34.7)	84 (37.3)	0.68
	≥10 (years)	49 (65.3)	141 (62.7)	

*Standard deviation.

Table 3 showed the mean difference versus good and poor glycemic control, bifurcation of body mass index categories versus poor and good glycemic control and Pearson correlation coefficient of body mass index versus poor and good glycemic control (HbA1c). Furthermore, the is statistically significant (p-value 0.001) difference was observed in mean body mass index versus good glycemic control 21.81 ± 3.15 and poor glycemic control 25.22 ± 4.05. In addition, bifurcation of body mass index categories versus good and poor glycemic control also showed statistical significance (p-value 0.001). Additionally, Table 3 also revealed that with increase in BMI categories the number of patients having good glycemic control were decreased and having poor glycemic control the number of patients were increased with increase in BMI categories. There is also statistically significant (p-value 0.001) difference was observed. Pearson correlation coefficient of BMI versus HbA1c was (r = 0.40) that showed medium positive correlation.

Table 3. Mean difference, bifurcation and Pearson correlation of body mass index versus good and poor glycemic control (HbA1c).

Variables	Good glycemic control 75 (25%)	Poor glycemic control 225 (75%)	p-value
Body mass index			
Mean ± SD*	21.81 ± 3.15	25.22 ± 4.05	0.001
Body mass index (categorical)			
Under weight: ≤18.5	17 (22.7)	18 (8.0)	0.001
Healthy weight: 18.5-24.9	50 (66.7)	73 (32.4)	
Over weight: 25.0-29.9	5 (6.7)	97 (43.1)	
Obese: 30.0-34.9	3 (4.0)	37 (16.4))	
Body mass index versus HbA1c Pearson correlation	r=0.40 (medium positive correlation)		0.001

Discussion

Glycemic control is crucial in the clinical management of diabetes and its related complications (Association, 2011). It has been recommended that people with T2DM who have poor glycemic control have decreased rates of neuropathic events and microvascular complications. 300 T2DM participants between ages of 35 & 65 were included in the current study. According to research, overweight participants' mean HbA1c readings were statistically considerably higher than normal ones. Furthermore, compared to 32% of people with a healthy weight BMI, 68% of overweight participants had poor glycemic control. BMI and glycemic control showed a statistically significant difference (HbA1c), according to Pearson correlation chi-square test (p-value 0.001), (p-value 0.001) bifurcation of body mass index groups vs good and bad glycemic control (HbA1c), and independent t-test (p-value 0.001). This is in line with several studies that also noted the important connection between BMI and glycemic control.

The greatest mean HbA1c levels were seen in overweight diabetic patients, according to Nguyen, Ninh T., et al. 2021 (Nguyen et al., 2011). Additionally, another was done by Bae, J. P., et al 2016, reported the relationship between obesity and glycemic control in T2DM patients also showed a relationship between obesity and HbA1c >7% (DeFronzo et al., 2015). Additionally, another study on the association between HbA1c and HDL-Cholesterol and BMI in T2DM patients reported and reached the same conclusion (Babikr et al., 2016). They discovered a strong correlation between poor glycemic control and body mass index. In their 2013 study, Kumar A et al. showed that weight loss in overweight T2DM patients can quickly reverse the state of insulin resistance and return blood sugar levels to normal. If weight loss is sustained, T2DM people who are successful in losing weight experience larger improvements in their lipid profile and glycemic control (Kumar, 2013).

The plausible explanation for the association between poor glycemic control and increased body mass index is that insulin resistance has gotten worse as a result of increased visceral adiposity and fat mass, which reduce insulin sensitivity and increase insulin resistance (Kamuhabwa and Charles, 2014). Adipokines such as resistin, retinol binding protein-4, and leptin are secreted into the circulation at higher rates due to adiposity. Insulin resistance is caused by resistin. The activation of the AMP-activated protein kinase enzyme generally causes adiponectin and leptin to promote insulin sensitivity. In turn, this protein kinase enzyme promotes the liver's and skeletal muscle's fatty acid oxidation. In the end, reduced adiponectin and elevated resist in reduce target tissues' sensitivity to insulin (Chandalia and Tripathy, 2012).

Diabetes mellitus is a multifactorial condition that has a wide range of lipid abnormalities. Compared to other lipid abnormalities, hypertriglyceridemia is more common in T2DM (Chandalia

and Tripathy, 2012; Ozder, 2014). This study reported the link between good and poor glycemic control versus LDL, serum cholesterol, triglycerides, and HDL. The mean values of serum cholesterol, LDL, triglycerides, and HDL versus good and poor glycemic control were statistically significantly higher in poor glycemic control as compare to good glycemic control. These results were similar with the published data as well (Naqvi et al., 2017).

According to Lebovitz, triglycerides have a lipotropic mechanism which inhibits the neural or gastric pathways that regulate glycemic control (Lebovitz et al., 2013). Studies have shown an association between dyslipidemia and glycemic control (Parhofer, 2015). According to a recent study, high triglycerides and HbA1c correlate positively. HbA1c can be utilized as a strong indicator of dyslipidemia and to lessen the disease's side effects on the micro and macro vessels (Hussain et al., 2017). A limitation of the present study was that it was a single center experience. Also, we need a large sample size study to evaluate and support overall status of diabetic patients infected with COVID-19 infection.

Conclusion

In conclusion, we reported comprehensive data of the correlation of diabetic patients with body mass index in COVID-19 infected patients from Pakistan. The results of the showed that the Hb1Acected with COVID-19 infection level of an individual increases with the increasing BMI. Most of the patients with T2DM have the BMI greater than 30 that showed the positive correlation between T2DM and BMI. With this study it is proved that the Obesity is directly related to the levels Hb1Ac in the type 2 diabetes infected patients belongs to the rural population of Central Punjab.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and ethical approval was obtained from the Human Research Ethics Committee, Rural Health Centre, Awan Dhai Wala, Lahore, Pakistan, with code HREC Code: 107/22/RHC AD Wala, approved on 25 August 2021.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patient(s) to publish this paper.

Data Availability Statement: More data related to this research could be obtained upon a reasonable request to the corresponding author.

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