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Association of Body Mass Index With Severity and Outcome of COVID-19

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ABSTRACT

Background: The COVID-19 pandemic, caused by SARS-CoV-2, has presented a global health challenge. Older people and patients with underlying conditions such as hypertension, diabetes, and obesity are more susceptible to severe disease outcomes. Obesity or high body mass (BMI) index is a significant risk factor for creating diabetes and plays a crucial role in the pathogenesis of COVID-19 infection. Obesity has been shown to increase vulnerability to infections, making it a significant risk factor for COVID-19. This study aims to investigate the relationship between BMI and COVID-19 severity and outcomes in patients with and without diabetes.

Materials and Methods: This case-control study was conducted on 400 patients with confirmed COVID-19 infection, referred to teaching hospitals in Sari City, Iran, during April and May 2019. The study population consisted of 192 diabetic patients (case group) and 208 non-diabetic individuals (control group), matched for age and sex. Participants' data, including demographics, medical history, laboratory findings, and disease progression details, were collected using a comprehensive questionnaire. According to CDC criteria, COVID-19 disease severity was defined as mild, moderate, and severe. The relationship between BMI and COVID-19 severity was compared between the diabetic and non-diabetic groups.

Results: This study was conducted on 192 diabetic and 208 non-diabetic COVID-19 patients with an average age of 62.85±0.88 and 53.21±1.18 years, respectively. The average BMI in the diabetic group was 28.68±0.4, whereas it was 26.94±0.31 (P=0.001) in the non-diabetic group. There was a statistically significant difference in the severity of COVID-19 infection between diabetic and non-diabetic patients (P=0.008). The results showed a statistically significant difference in disease severity based on BMI in the diabetic group (P=0.02). Significant differences were observed in the need for mechanical ventilation (P=0.000) and mortality in people with diabetes compared to non-diabetics. A significant association was observed between BMI and ICU admission in both diabetic (P=0.001) and non-diabetic (P=0.000) groups.

Conclusion: The study concluded that BMI may be a significant risk factor for severe COVID-19 outcomes, particularly among people with diabetes. This finding emphasizes the importance of BMI in disease prevention and control strategies, especially for populations with underlying conditions like diabetes.

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Introduction

The COVID-19 pandemic, caused by SARS-CoV-2, has been a global health problem characterized by a wide range of clinical presentations from moderately self-limiting influenza-like illness to complete pneumonia and acute respiratory distress syndrome (ARDS) and even death [1]. Older people and patients with underlying conditions such as hypertension, diabetes, and obesity are more vulnerable to severe diseases [2, 3]. COVID-19 infection and diabetes may provoke stress and increase the secretion of blood sugar-boosting hormones such as glucocorticoids and catechol amines, which cause high blood sugar and abnormal glucose turnover and complicate diabetes. Therefore, occasional management of blood glucose in diabetic patients with COVID-19 is essential [4].

Obesity, or high body mass index (BMI), is a significant risk factor for developing diabetes and plays a vital role in the pathogenesis of COVID-19 infection. The immune system, which is crucial in the pathogenesis of COVID-19, also plays an essential role in adipose tissue inflammation arising from obesity. This adipose tissue inflammation leads to metabolic dysfunction, manifesting as dyslipidemia, insulin resistance, type 2 diabetes, hypertension, and cardiovascular disease [5, 6].

Given the global prevalence of obesity, it is anticipated that a significant proportion of individuals who contract COVID-19 are obese or out of the normal BMI range [7]. Obesity has been shown to increase vulnerability to infections, making it a significant risk factor for COVID-19 [8]. Consequently, individuals with higher BMI are more likely to develop COVID-19 infection, with a higher likelihood of severe disease manifestations [9].

On the other hand, SARS-CoV-2 enters the host cells through the angiotensin-converting enzyme 2 (ACE2) receptor [8]. This interaction is a critical component of the virus's life cycle and significantly impacts the development of COVID-19. Tissue expression of ACE2 varies in the kidneys, heart, and lungs of healthy individuals and patients with COVID-19 infection [9]. The expression level of ACE2 in adipose tissue is significantly higher than in lung tissue, which is the primary tissue affected by COVID-19. Therefore, obese individuals have more cells expressing ACE2 [10]. Furthermore, adipose tissue is a significant source of pro-inflammatory markers and cytokines. Elevated serum levels of C-reactive protein (CRP) and interleukin 6 (IL-6) in obese patients indicate the presence of an inflammatory microenvironment, which may contribute to their increased susceptibility to severe outcomes [11].

The intricate relationship between obesity, diabetes, and COVID-19 highlights addressing these comorbidities in the management of COVID-19 patients, particularly those with severe disease outcomes. This study aims to investigate the relationship between BMI and COVID-19 severity and outcomes in patients with and without diabetes. First, we compared clinical symptoms, laboratory findings, and COVID-19 severity between diabetic patients and non-diabetic controls. Next, we compared both groups' serum levels of inflammatory markers, specifically CRP and erythrocyte sedimentation rate (ESR). Additionally, the study assessed differences in BMI between the two groups. Finally, we explored the relationship between the severity and outcomes of COVID-19 infection and BMI.

Materials and Methods

This case-control study was conducted on 400 patients with COVID-19 who were referred to the teaching hospitals of Mazandaran University of Medical Sciences, Sari City, Iran, during April and May 2019. All COVID-19 patients were confirmed to have the disease based on clinical signs, imaging, laboratory, and molecular findings (the positive result of real-time polymerase chain reaction (RT-PCR) test on viral nucleic acid). The case group comprised 192 diabetic patients, and the control group consisted of 208 non-diabetic individuals who were age- and sex-matched to the case group. Diabetes status was confirmed by patients' medical histories and laboratory findings. Additionally, patients without a prior history of diabetes were considered diabetic if their fasting blood glucose level at admission exceeded 126 mg/dL or if their post-prandial blood glucose level was >200 mg/dL.

After obtaining informed consent from all participants, a comprehensive questionnaire was used to collect data on various parameters, including age, sex, height, weight, history of other chronic diseases, medications, imaging findings, laboratory test results, and details of the disease progression. The inclusion criteria were as follows: Individuals aged 18 or older have a clinically and laboratory-confirmed COVID-19 infection and provide informed consent to participate. Conversely, the exclusion criteria included lack of informed consent, presence of advanced underlying lung, kidney, or liver diseases, and pregnancy or lactation. The exclusion criteria were individuals with advanced lung, kidney, or liver diseases because these conditions can significantly affect COVID-19 outcomes, complicating the assessment of BMI's impact on disease severity. For instance, advanced lung disease may impair respiratory function, twisting results. Similarly,

the physiological changes during pregnancy and lactation can alter immune responses and disease outcomes, further confounding the relationship between BMI and COVID-19 severity.

According to the Centers for Disease Control and Prevention (CDC) criteria, the severity of the disease of COVID-19 was defined as mild, moderate, and severe [12]. Mild type accompanies symptoms such as dry cough, lethargy, and body pain without shortness of breath with or without loss of sense of smell and taste and normal lung CT scan. The moderate type in addition to the previous symptoms has fever above 38 ˚C, chills, shortness of breath along with activity, but oxygen saturation (SpO_2) greater than or equal to 94%, also gastrointestinal symptoms such as nausea, vomiting, and diarrhea may be seen in this category. In the severe form, the patient has symptoms of widespread viral pneumonia or develops complications such as ARDS, the respiratory rate is more than 30 times per minute, the lung involvement is more than 50%, and SpO_2 is less than 94%.

The BMI was calculated using the Equation 1:

1. $BMI=(Weight\ in\ Kg)/(Height\ in\ m)^2$

The relationship between BMI and severity of COVID-19 was compared between diabetic and non-diabetic individuals.

Statistical analysis

Data analysis was performed using SPSS software, version 20. The normal distribution of data was assessed using the Kolmogorov-Smirnov test. The chi-square test was used to compare qualitative variables, and the student t-test was used to compare quantitative differences. Data were expressed as Mean±SEM, and $P<0.05$ was considered significant.

Results

This study was conducted on 192 diabetic patients (case) and 208 non-diabetic patients (control) with COVID-19. The average age in the case group was 62.85±0.88 years, significantly different from the control group's average age of 53.21±1.18 years (P=0.000). The gender distribution also showed significant differences between the two groups. In the case group, 80(41.7%) were men, and 112(58.3%) were women. In contrast, the control group comprised 121 men (58.2%) and 87 women (41.8%). This difference in gender distribution was statistically significant (P=0.001). The BMI in the case group was 28.68±0.40 kg/m^2, whereas in the control group, it was 26.94±0.31 kg/m^2, a statistically significant difference (P=0.001).

The results showed no significant differences between the two groups in terms of the prevalence of underlying diseases such as liver diseases (P=0.14), lung diseases (P=0.72), cerebrovascular diseases (P=0.15), and malignancy (P=0.09). However, significant differences were observed in the education level (P=0.002), smoking (P=0.002), and the presence of comorbidities, including blood pressure (P=0.000), cardiovascular diseases (P=0.000), and kidney disease (P=0.002).

Comparing clinical symptoms and laboratory findings in two groups

Clinical symptoms of COVID-19 in the case and control groups were assessed using the chi-square test. No significant differences were observed in COVID-19 symptoms, including fever, chills, cough, rhinorrhea, dyspnea, headache, diarrhea, sore throat, dizziness, and myalgia between the two groups, except the feeling of fatigue. The average number of patients who experienced fatigue in the case group was 74(56.5%), while it was 57(43.5%) in the control group, and the difference was statistically significant (P=0.02).

Laboratory findings in patients with COVID-19 were evaluated in two study groups. Given that the two study groups consisted of diabetic and non-diabetic patients, we anticipated a significant difference between the two groups in the random blood sugar (BS) and fasting blood sugar (FBS) levels. The present study evaluated random and FBS levels in the diabetic and non-diabetic COVID-19 patient groups at three time points: Upon initial hospitalization (BS-1 and FBS-1), 3 days after hospitalization (BS-2 and FBS-2), and at the time of discharge (BS-3 and FBS-3). The laboratory findings revealed a statistically significant correlation between BS-1 and BS-2 and FBS-1 and FBS-2 levels in diabetic and non-diabetic groups (Table 1). The analysis showed statistically significant differences between the diabetic and non-diabetic groups in the average serum sodium (P=0.000) and albumin (P=0.04) levels.

Comparing serum levels of inflammatory markers (CRP, ESR) in two groups

The average level of inflammatory markers in all patients with COVID-19 is shown in Table 2.

Table 1. Laboratory findings in patients with COVID-19 in two study groups

Laboratory Findings	COVID-19 Patients		P
	Diabetes	Non-diabetes	
FBS-1 (mg/dL)	193.42±13.45	120.93±4.8	0.000*
FBS-2 (mg/dL)	174.16±14.61	132.43±9.22	0.02*
FBS-3 (mg/dL)	169.83±35.67	131.5±23.66	0.45
BS-1 (mg/dL)	219.44±8.44	116.05±3.31	0.000*
BS-2 (mg/dL)	187.15±15.31	136.71±8.26	0.015*
BS-3 (mg/dL)	143.2±13.24	152.5±25.41	0.76
WBC (x10^9/L)	9723.6±676.8	8427.07±343.06	0.08
PLT (µL)	232340.22±9890.58	233655.29±7169.48	0.47
Hb (g/dL)	11.11±0.16	11.65±0.18	0.02
Ca (mg/dL)	8.48±0.14	8.43±0.08	0.76
P (mg/dL)	3.7±0.09	3.62±0.07	0.53
Cr (mg/dL)	1.73±0.11	1.58±0.14	0.43
Na (mmol/L)	134.98±0.27	136.77±0.3	0.000*
K (mmol/L)	4.29±0.04	4.19±0.03	0.08
Mg (mg/dL)	2.06±0.38	2.06±0.46	0.99
CPK (U/L)	197.26±22.52	304.66±54.14	0.06
LDH (U/L)	610.92±20.3	772.86±83.96	0.06
ALT (U/L)	31.95±2.42	38.68±2.89	0.07
AST (U/L)	40.37±2.62	50.69±5.13	0.075
ALP (U/L)	250.98±19.14	258.78±18.03	0.77
ALB (g/dL)	3.77±0.06	3.6±0.05	0.04*
Ferritin (ng/mL)	506.25±64.13	626.77±123.2	0.35

Abbreviations: FBS: Fasting blood sugar; BS: Random blood sugar; WBC: White blood cell count; PLT: Platelet count; Hb: Hemoglobin; Ca: Calcium; P: Phosphorus; Cr: Creatinine; Na: Sodium; K: Potassium; Mg: Magnesium; CPK: Creatine phosphokinase; LDH: Lactate dehydrogenase: ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; ALP: Alkaline phosphatase; ALB: Albumin.

The present study measured ESR and CRP level at three time points: Upon initial hospitalization (ESR-1 and CRP-1), on the third day of hospitalization (ESR-2 and CRP-2), and at the time of discharge (ESR-3 and CRP-3). The results showed a statistically significant difference in ESR levels between the diabetic and non-diabetic groups on the first day of hospitalization (ESR-1) (P=0.005). However, no significant differences were observed in ESR levels between the two groups on the third day of hospitalization (ESR-2) and at the time of discharge (ESR-3) (P>0.05). Additionally, the analysis revealed a statistically significant difference in the average CRP level between the two groups on the third day of hospitalization (CRP-2) (P=0.02). In contrast, no significant differences were found in CRP levels between the diabetic and non-diabetic groups on the first day of

Table 2. The relationship between inflammatory markers in patients with COVID-19

Inflammatory Marker	Mean±SEM		P	Mean±SEM
	COVID-19 Patients With Diabetes	COVID-19 Patients Without Diabetes		COVID-19 Patients
ESR-1 (µg/mL)	51.57±2.6	41.64±2.09	0.005*	44.79±1.66
ESR-2 (µg/mL)	66±4.52	53.04±6.27	0.14	53.04±6.27
ESR-3 (µg/mL)	61±8.33	62.87±11.15	0.91	62±8.42
CRP-1 (mm)	43.24±4.1	41.52±3.26	0.75	42.3±2.6
CRP-2 (mm)	63.31±6.09	44.61±4.55	0.02*	49.63±3.82
CRP-3 (mm)	51.93±12.79	26.99±8.42	0.11	32.93±7.29

ESR: Erythrocyte sedimentation rate; CRP: C-reactive protein.

hospitalization (CRP-1) and at the time of discharge (CRP-3) (P>0.05).

Comparing BMI between two groups

The analysis revealed a statistically significant difference in BMI between the diabetic and non-diabetic groups. The mean BMI in the diabetic group was 28.68±0.40 kg/m^2, whereas in the non-diabetic group, it was 26.94±0.31 kg/m^2 (P=0.001).

Comparing severity of COVID-19 infection between two groups

Based on CDC criteria, patients with COVID-19 infection were categorized into three severity levels: Mild, moderate, and severe.

The results demonstrate that in the diabetic group, 67 patients (39.62%) exhibited mild disease, 61(57%) had moderate disease, and 64(52.5%) experienced severe form of disease. In contrast, the non-diabetic group showed a higher proportion of mild disease cases at 104(60.8%), with 46(43%) and 58(47.5%) of patients exhibiting moderate and severe form of disease, respectively. There was a statistically significant difference in the severity of COVID-19 infection between diabetic and non-diabetic patients (P=0.008). The findings suggest that the severe form of COVID-19 was more prevalent in the diabetic group compared to the non-diabetic group.

Relationship between the severity of COVID-19 infection and BMI

The relationship between BMI and disease severity was examined in the studied subjects using a chi-square statistical test. The participants were categorized into three BMI groups: less than 25 kg/m^2, between 25 and 29.9 kg/m^2, and 30 kg/m^2 or more. The statistical analysis revealed no significant association between BMI and the severity of COVID-19 disease across all patients (P=0.27).

The severity of COVID-19 disease was evaluated separately for diabetic and non-diabetic groups based on BMI classification. The results in Table 3 show a statistically significant difference in disease severity based on BMI in the diabetic group (P=0.02). Specifically, in the diabetic group, individuals with a BMI >30 were more likely to have severe disease (40%), while those with a BMI <25 were more likely to have mild disease (43.4%). In contrast, the non-diabetic group did not exhibit a statistically significant relationship between BMI and disease severity (P=0.15). These findings suggest that BMI has a significant impact on the severity of COVID-19 disease in diabetic individuals but not in non-diabetic individuals.

Relationship between the outcome of COVID-19 infection and BMI

The study examined the outcomes of COVID-19 disease, including the intensive care unit (ICU), the length of stay in the ICU, the need for mechanical ventilation, the incidence of ARDS, and the mortality rate due to COVID-19. The results showed that 156 patients (39%) were admitted to the ICU, 37(9.3%) required mechanical ventilation, and 47(11.8%) died due to the disease. The average duration of hospitalization in the ICU was 10.13±1.3 days.

Comparing the outcomes between diabetic and non-diabetic groups, the study found no significant differences in ICU admission (P=0.06) and length of hospitalization in the ICU (P=0.24). However, significant differences

Table 3. Relationship between the severity of COVID-19 infection and BMI

Severity	No. (%) All COVID-19 Patients BMI (kg/m²)			P	No. (%) COVID-19 Patients With Diabetes BMI (kg/m²)			P	No. (%) COVID-19 Patients Without Ddiabetes BMI (kg/m²)			P
	<25	25-29.9	≥30		<25	25-29.9	≥30		<25	25-29.9	≥30	
Mild	51(41.8)	73(43.5)	47(42.7)		23(43.4)	17(24.6)	27(38.6)		28(40.6)	56(56.6)	20(50)	
Moderate	35(28.7)	50(29.8)	22(20)	0.27	19(35.8)	27(39.1)	15(21.4)	0.02*	16(23.2)	23(23.2)	7(17.5)	0.15
Severe	36(29.5)	45(26.8)	41(37.3)		11(20.8)	25(36.2)	28(40)		25(36.2)	20(20.2)	13(32.5)	
Total	122(100)	168(100)	110(100)		53(100)	69(100)	70(100)		69(100)	99(100)	40(100)	

BMI: Body mass index.

*Statistical significance.

Table 4. Relationship between the outcomes of COVID-19 infection and BMI

COVID-19 Outcome	Yes/No	No. (%) COVID-19 Patients With Diabetes (n=192) BMI (kg/m²)			P	No. (%) COVID-19 Patients Without Diabetes (n=208) BMI (kg/m²)			P
		<25	25-29.9	≥30		<25	25-29.9	≥30	
ICU hospitalization	Yes	12(22.6)	18(26.1)	36(51.4)	0.001*	22(31.9)	60(60.6)	25(62.5)	0*
	No	41(77.4)	51(73.9)	34(48.6)		69(68.1)	99(39.4)	40(37.5)	
Ventilation	Yes	6(11.3)	10(14.5)	13(18.6)	0.53	4(5.8)	2(2)	2(5)	0.41
	No	47(88.7)	59(85.5)	57(81.4)		65(94.2)	97(98)	38(95)	
Death	Yes	6(11.3)	13(18. 8)	12(17.1)	0.51	9(13)	4(4)	3(7.5)	0.09
	No	47(88.7)	56(81.2)	58(82.9)		60(87.4)	95(96)	37(92.5)	

*Statistical significance.

were observed in the need for mechanical ventilation, 29(15.1%) in people with diabetes vs 8(3.8%) in non-diabetics (P=0.000) and mortality, 31(16.1%) in people with diabetes vs 16(7.7%) in non-diabetics (P=0.009) between the two groups. These findings suggest that diabetic patients were more likely to require mechanical ventilation and experience higher mortality rates compared to non-diabetic patients.

The study examined the relationship between BMI and disease outcome in diabetic and non-diabetic groups. As shown in Table 4, a significant association was observed between BMI and ICU admission in both diabetic (P=0.001) and non-diabetic (P=0.000) groups. However, no significant correlation was found between BMI and the need for mechanical ventilation or mortality in either group (P>0.05).

Discussion

This study was designed based on the hypothesis that elevated BMI can potentially exacerbate the severity of COVID-19 infection and adversely impact disease outcomes.

The current study compared the BMI of diabetic and non-diabetic patients with COVID-19, examining its effect on disease severity and outcome. The results revealed that diabetic patients had significantly higher BMI values compared to non-diabetic patients. Furthermore, diabetic patients exhibited more severe symptoms of COVID-19 compared to non-diabetic patients. These findings suggest that higher BMI and the underlying disease of diabetes may play a significant role in the exacerbation of inflammation caused by COVID-19 infection.

Mongraw-Chaffin et al. in England (2023) examined 2663 patients with COVID-19 and obesity/diabetes (case group) compared to those without (control group). The results showed that obesity and diabetes were significantly linked to severe COVID-19 symptoms, longer illness duration, and hospitalization. The study suggests that these conditions may increase the risk of contracting and worsening COVID-19, emphasizing the need to consider them in patient management and treatment, especially for those with severe symptoms and prolonged hospitalization [1].

In another study in the United States of America, which was conducted on 7162 patients with COVID-19 in 2020, it was observed that 10.9% of the patients had diabetes, of which 24% were admitted to the hospital, and 32% to the ICU. This study also reported a significant association between diabetes and the risk of infection and the severity of COVID-19 [2].

These studies, which found significant associations between diabetes and increased risk of infection and severity of COVID-19, are consistent with our observations and can strengthen the results of our study. However, few studies have reported contradicting results. One such study, conducted by Tamura et al. (2021). They compared 188 diabetic patients with COVID-19 to 895 non-diabetic patients with COVID-19 and found no direct significant relationship between diabetes and the development or exacerbation of COVID-19 infection [4].

Our study revealed that BMI significantly impacts the severity of COVID-19 in all patients, with a notable correlation observed in the diabetic group. This finding is consistent with the majority of studies, which have consistently shown that individuals with underlying conditions such as diabetes and a high BMI, particularly above 30 kg/m^2, are more likely to contract COVID-19 and experience severe symptoms.

Several studies have investigated the relationship between BMI and the severity of COVID-19. A systematic review and meta-analysis confirmed that obesity is a significant risk factor for severe infection, independent of potential confounding factors [13]. In a study conducted by Alqahtani et al. (2022) in Saudi Arabia, researchers analyzed 950 patients with COVID-19 from three main hospitals. They found that patients with BMI ≥40 kg/m^2 were more likely to develop severe COVID-19 than those with normal weight [14].

Our findings align with previous research, indicating a significant association between high BMI and the severity of COVID-19. The mechanisms underlying this relationship are being actively investigated and researched. Several studies have proposed hypotheses about the relationship between BMI and COVID-19 severity, including uncoordinated immune responses, inadequate antibody responses, cytokine storm, increased viral shedding, and associations with comorbidities such as high blood pressure, cardiovascular diseases, diabetes mellitus, and vitamin D deficiency [15]. Additionally, another study suggests that the coronavirus receptor in fat cells may contribute to the greater severity of infection and longer hospitalization in individuals with higher BMI [16]. Consequently, these findings suggest that the effect of BMI on COVID-19 severity may be mediated by a combination of immunological, virological, and comorbidity-related factors.

Our study found a significant association between BMI and ICU hospitalization rates in diabetic and non-diabetic patient groups. This finding suggests that elevated BMI is a risk factor for severe COVID-19 outcomes, regardless of diabetes status. Most studies conducted are in line with our findings and confirm the results of our research. For instance, a survey by Al-Sabah et al. in Kuwait (2020) found that obese patients with COVID-19 (BMI >40 kg/m2) required ICU care more frequently than non-obese patients with COVID-19 [7]. This supports our conclusion that obesity is a significant risk factor for severe COVID-19 outcomes. Additionally, the CDC notes that the risks of hospitalization, ICU admission, need for invasive mechanical ventilation, and death increase with higher BMI, particularly among individuals under 65 years of age [17].

A study in New York [18] and a case-control study in [19] showed a significant risk of severe outcomes of COVID-19 in patients with a BMI of 30 kg/m^2 or higher. Additionally, a multivariate study of hospitalized patients in Kuwait showed that obese individuals, particularly those with BMI >40 kg/m^2, had a higher risk of needing ICU care [8]. While a few studies have found different results [9].

In our study, BMI was found to have no significant effect on the need for mechanical ventilation and mortality among COVID-19 patients. Most studies have similar results to our findings, indicating no significant relationship between BMI and mortality due to COVID-19. For instance, a study by Omais et al. (2021) from the Eastern Mediterranean region reported a lower death rate compared to other regions, with a notable difference observed

between diabetic and non-diabetic patients. The researchers attributed the low death rate to the prevalence of a less virulent coronavirus strain in those areas [20].

In summary, while some studies have identified an association between obesity and COVID-19 outcomes, others have found no significant association or reported a weak association between BMI and mortality in COVID-19 patients. A better understanding of the relationship between BMI and outcomes of COVID-19 is needed to inform public health strategies and improve patient outcomes.

The limitation of the study was the potential impact of insulin use during the treatment of diabetic patients with COVID-19 on the outcomes of the disease. The use of insulin may create new challenges in the treatment of COVID-19, which could potentially lead to the aggravation of the disease and the development of metabolic diseases. This outcome could, in turn, affect the relationship between BMI and COVID-19 outcomes, making it difficult to establish a clear association between the two.

Conclusion

In this study, we found significant differences in disease severity, with people with diabetes showing higher severity and increased need for mechanical ventilation and mortality rates. Additionally, a significant association was observed between BMI and ICU admission in both groups.

The findings of this study indicate that BMI is likely a significant risk factor for the severity of COVID-19 infection and the rate of ICU hospitalization, particularly among diabetic individuals compared to non-diabetic patients. These results suggest that BMI should be considered a crucial factor in the development of disease prevention and control strategies, especially in populations with underlying conditions like diabetes.

Ethical Considerations

Compliance with ethical guidelines

The study was conducted according to the guidelines of the Declaration of Helsinki and was approved by the Ethics Committee of Mazandaran University of Medical Sciences, Sari, Iran (Code: IR.MAZUMS.REC.1399.7764).

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Authors contribution's

Supervision: Zahra Hosseini-khah and Ozra Akha; Data collection, and analysis: Negar Javadinasab and Narges Mirzaei Ilali; Writing the original draft: Negar Javadinasab and Zahra Hosseini-khah; Conceptualisation, study design, review, editing and final approval: All authors.

Conflict of interest

The authors declared no conflict of interest.

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References

[1] Mongraw-Chaffin M, Tjaden AH, Seals AL, Miller K, Ahmed N, Espeland MA, et al. Association of obesity and diabetes with sars-cov-2 infection and symptoms in the covid-19 community research partnership. J Clin Endocrinol Metab. 2022; dgac715. [PMID]

[2] CDC COVID-19 Response Team. Preliminary estimates of the prevalence of selected underlying health conditions among patients with coronavirus disease 2019-United States, February 12-March 28, 2020. MMWR Morb Mortal Wkly Rep. 2020; 69(13):382-6. [DOI:10.15585/mmwr.mm6913e2] [PMID]

[3] Stefan N, Birkenfeld AL, Schulze MB, Ludwig DS. Obesity and impaired metabolic health in patients with COVID-19. Nat Rev Endocrinol. 2020; 16(7):341-2. [DOI:10.1038/s41574-020-0364-6] [PMID]

[4] Tamura RE, Said SM, de Freitas LM, Rubio IGS. Outcome and death risk of diabetes patients with Covid-19 receiving pre-hospital and in-hospital metformin therapies. Diabetol Metab Syndr. 2021; 13(1):76. [DOI:10.1186/s13098-021-00695-8] [PMID]

[5] Meigs JB, Wilson PW, Fox CS, Vasan RS, Nathan DM, Sullivan LM, et al. Body mass index, metabolic syndrome, and risk of type 2 diabetes or cardiovascular disease. J Clin Endocrinol Metab. 2006; 91(8):2906-12. [DOI:10.1210/jc.2006-0594] [PMID]

[6] Powell-Wiley TM, Poirier P, Burke LE, Després JP, Gordon-Larsen P, Lavie CJ, et al. Obesity and cardiovascular disease: A scientific statement from the American Heart Association. Circulation. 2021; 143(21):e984-1010. [DOI:10.1161/CIR.0000000000000973] [PMID]

[7] Al-Sabah S, Al-Haddad M, Al-Youha S, Jamal M, Almazeedi S. COVID-19: Impact of obesity and diabetes on disease severity. Clin Obes. 2020; 10(6):e12414. [DOI:10.1111/cob.12414] [PMID]

[8] Gao M, Piernas C, Astbury NM, Hippisley-Cox J, O'Rahilly S, Aveyard P, et al. Associations between body-mass index and COVID-19 severity in 6·9 million people in England: A prospective, community-based, cohort study.Lancet Diabetes Endocrinol. 2021; 9(6):350-9. [DOI:10.1016/S2213-8587(21)00089-9] [PMID]

[9] Simonnet A, Chetboun M, Poissy J, Raverdy V, Noulette J, Duhamel A, et al. High prevalence of obesity in severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) requiring invasive mechanical ventilation. Obesity. 2020; 28(7):1195-9. [DOI:10.1002/oby.22831] [PMID]

[10] Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: Summary of a report of 72 314 cases from the Chinese Center for Disease Control and Prevention. JAMA. 2020; 323(13):1239-42. [DOI:10.1001/jama.2020.2648] [PMID]

[11] Niederseer D, Wernly B, Aigner E, Stickel F, Datz C. NAFLD and cardiovascular diseases: Epidemiological, mechanistic and therapeutic considerations.J Clin Med. 2021; 10(3):467. [DOI:10.3390/jcm10030467] [PMID]

[12] Centers for Disease Control and Prevention (CDC). Clinical Course: Progression, Management, and Treatment. Atlanta: CDC ; 2019. [Link]

[13] Singh R, Rathore SS, Khan H, Karale S, Chawla Y, Iqbal K, et al. Association of obesity with COVID-19 severity and mortality: An updated systemic review, meta-analysis, and meta-regression. Front Endocrinol (Lausanne). 2022; 13:780872. [DOI:10.3389/fendo.2022.780872] [PMID]

[14] Al-Qahtani AA. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2): Emergence, history, basic and clinical aspects. Saudi J Biol Sci. 2020; 27(10):2531-8. [DOI:10.1016/j.sjbs.2020.04.033] [PMID]

[15] Aghili SMM, Ebrahimpur M, Arjmand B, Shadman Z, Pejman Sani M, Qorbani M, et al. Obesity in COVID-19 era, implications for mechanisms, comorbidities, and prognosis: A review and meta-analysis. Int J Obes (Lond). 2021; 45(5):998-1016. [DOI:10.1038/s41366-021-00776-8] [PMID]

[16] Moezzi M, Ghanavati M, Heydarnezhad M, Farhadi E, Rafati Navaei AR. Relationship between bmi and disease severity in covid-19 patients. Anesth Pain Med. 2022; 12(4):e129880. [DOI:10.5812/aapm-129880] [PMID]

[17] Kompaniyets L, Goodman AB, Belay B, Freedman DS, Sucosky MS, Lange SJ, et al. Body mass index and risk for COVID-19-related hospitalization, intensive care unit admission, invasive mechanical ventilation, and death-United States, March-December 2020. MMWR Morb Mortal Wkly Rep. 2021; 70(10):355-61. [DOI:10.15585/mmwr.mm7010e4] [PMID]

[18] Arulanandam B, Beladi H, Chakrabarti A. Obesity and COVID-19 mortality are correlated.Sci Rep. 2023; 13(1):5895. [DOI:10.1038/s41598-023-33093-3] [PMID]

[19] Hafez W, Abdelshakor M, Kishk S, Gebril A, Gador M, Osman S, et al. Body mass index and clinical outcomes in adult COVID-19 patients of diverse ethnicities. Healthcare (Basel). 2022; 10(12):2575. [DOI:10.3390/healthcare10122575] [PMID]

[20] Omais S, Kharroubi S, Zaraket H. No association between the SARS-CoV-2 variants and mortality rates in the Eastern Mediterranean Region. Gene. 2021; 801:145843. [DOI:10.1016/j.gene.2021.145843] [PMID]

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