Research Article / Araştırma Makalesi

Association of Higher Body Mass Index and Diastolic Dysfunction in Patients Non-Hospitalized with COVID-19: A Post-COVID-19 Echocardiography Study

COVID-19 ile Hastaneye Yatırılmayan Hastalarda Yüksek Vücut Kitle İndeksi ve Diyastolik Disfonksiyon İlişkisi: Bir COVID-19 Sonrası Ekokardiyografi Çalışması

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Abstract

Background: The studies reported an association between body mass index (BMI) and diastolic function in metabolically healthy individuals. The relationship between the BMI and diastolic dysfunction (DD) of metabolically healthy who recovered from COVID-19 without hospitalization and who have effort dyspnea has not been adequately studied yet. This study aimed to characterize the association between BMI and diastolic function in an uncomplicated group with preserved ejection fraction.
Materials and Methods: The study included 50 (17 males and 33 females) patients and 50 (20 males and 30 females) healthy control subjects. A transthoracic echocardiogram was performed in all patients.
Results: There was no significant difference between the groups in terms of age (p=0.101), gender (p=0.534), and BMI (p=0.070). C-reactive protein (CRP) (p=0.005) and D-dimer (p=0.009) were significantly higher in the patient group. DD was significantly higher in the patient group (p<0.001). When controlling for the effect of age in the patient group, a significant negative correlation was found between BMI and E/e' ratio (r=0.428; p=0.001), while this significance was not detected in the control group (r=0.118; p=0.414). According to the linear regression analysis, BMI had a significant and positive predictive effect on the E/e' ratio (p=0.004). According to the logistic regression analysis, BMI was found to have a predictive effect on the diagnosis of DD (p=0.007).
Conclusions: Obesity has been associated with severe COVID-19 infection through impaired ventilation. In our study, it is understood that the deterioration in ventilation can continue, and diastolic dysfunction is more common in overweight patients who have had COVID-19.

Key Words: Body mass index, Diastolic function, Transthoracic echocardiography, COVID-19

ÖZ.

Amaç: Çalışmalar, metabolik olarak sağlıklı bireylerde vücut kitle indeksi (VKİ) ile diyastolik fonksiyon arasında bir ilişki olduğunu bildirmektedir. Metabolik olarak sağlıklı olup hastaneye yatırılmadan COVID-19'dan iyileşen ve sonrasında efor dispnesi gelişenlerin VKİ ile diyastolik disfonksiyon (DD) arasındaki ilişki henüz yeterince araştırılmamıştır. Bu çalışmada, ejeksiyon fraksiyonu korunmuş komplike olmayan bir grupta VKİ ile diyastolik fonksiyon arasındaki ilişkiyi karakterize etmeyi amaçladık.
Materyal ve Metod: Çalışmaya 50 (17 erkek ve 33 kadın) hasta ve 50 (20 erkek ve 30 kadın) sağlıklı kontrol deneği dahil edildi. Tüm hastalara transtorasik ekokardiyogram uygulandı.
Bulgular: Gruplar arasında yaş (p=0,101), cinsiyet (p=0,534) ve VKİ (p=0,070) açısından anlamlı fark yoktu. Hasta grubunda C-reaktif protein (CRP) (p=0,005) ve D-dimer (p=0,009) anlamlı olarak daha yüksekti. DD, hasta grubunda anlamlı olarak daha yüksekti (p<0,001). Hasta grubunda yaşın etkisi kontrol edildiğinde, VKİ ile E/e’ oranı arasında anlamlı negatif korelasyon bulunurken (r=0,428; p=0,001), kontrol grubunda bu anlamlılık tespit edilmedi (r=0,118; p=0,414). Lineer regresyon analizine göre VKİ'nin E/e' oranı üzerinde anlamlı ve pozitif bir prediktif etkisi vardı (p=0,004). Lojistik regresyon analizine göre VKİ'nin DD tanısını öngörücü etkisi olduğu bulundu (p=0,007).
Sonuç: Obezite ventilasyonda bozulma yoluyla şiddetli COVID-19 enfeksiyonu ile ilişkilendirilmiştir. Çalışmamızda COVID-19 geçirmiş overweight hastaların COVID-19 sonrasında da ventilasyondaki bozulmanın devam edebildiği ve diastolik disfonksiyonun daha sık görüldüğü anlaşılmaktadır.

Anahtar kelimeler: Vücut kitle indeksi, Diyastolik fonksiyon, Transtorasik ekokardiyografi, COVID-19

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Introduction

The exact relationship between body mass index (BMI) and the coronavirus disease 2019 (COVID-19) clinic has been studied many times over the past year (1). While the first studies focused more on obesity (2), subsequent studies revealed that higher BMI (3, 4), which does not meet the obesity criteria, also has a negative effect on COVID-19. Obesity might act as an independent risk factor for a poor disease progression of COVID-19 (5), and it is associated with various problems such as a decrease in total respiratory system compliance, respiratory muscle inefficiency, increased airway resistance and work of breathing, and ventilation-perfusion inequality in the respiratory system (6, 7). Simonnet et al. (8) demonstrated that the risk for invasive mechanical ventilation in patients diagnosed with COVID-19 was more than seven-fold higher for those with BMI>35 compared with BMI<25 kg/m2. From a cardiovascular perspective, obesity is causally related to diabetes mellitus, stroke, hypertension, renal disease, and heart failure (8). However, obesity or higher BMI can cause cardiopulmonary problems without causing these complications (9). On the other hand, studies show a graded association between higher BMI levels and higher risk of COVID-19 infections (3, 4).

The vast majority of the above information addresses the acute episodes of patients hospitalized for COVID-19 (10). It is known that many people infected with COVID-19 experience the disease without any or milder symptoms and the need for hospitalization (11). While some of this group of outpatients did not show any signs after recovery, it was reported that post-COVID-19 dyspnea occurred in some individuals (12). Studies have reported that these symptoms after COVID-19 may be associated with comorbid diagnoses (13). Unlike, people who do not have any comorbid diseases may experience symptoms in the post-COVID-19 period. Effort dyspnea is one of these symptoms recently encountered in cardiology outpatient clinics (12-14).

In this study, we aimed to compare the transthoracic echocardiogram (TTE) parameters of patients who were admitted to the cardiology outpatient clinic of a district state hospital with dyspnea and who had COVID-19 no more than three months ago with no or mild symptoms without hospitalization with healthy controls regarding with clinical and sociodemographic variables.

This study aimed to investigate diastolic dysfunction in people who have recently had COVID-19 and to compare it with the control group.

Materials and Methods

Study Design

In this cross-sectional study, we compared consecutive patients admitted to the cardiology outpatient clinic of a district state hospital with a control group. After being seen by the treating cardiologist, each patient's eligibility for the study was evaluated, and if they were eligible, they were invited to participate in the study. The patient group consisted of individuals with effort dyspnea. The patient group consists of patients who applied to the cardiology outpatient clinic for various reasons, who had a positive COVID-19 reverse transcriptase-polymerase chain reaction (RT-PCR) test, and were treated at home. The patient group received favipiravir treatment for COVID-19. The control group consisted of metabolically healthy subjects. All subjects underwent TTE within the admission day. Biochemical analysis was also performed on the same day. BMI was calculated by dividing weight in kilograms (kg) by height in meters squared (m^2). The approval of the local ethics committee was obtained, and all study participants provided written informed consent (University Ethics Committee, Protocol number: 2021/01-7).

Exclusion and Inclusion Criteria

Patients and controls were included if they were over 18 years of age. All subjects were considered metabolically healthy, defined as lack of known diabetes mellitus, hypertension, and hyperlipidemia. All patients had used favipiravir 50-60 days ago due to COVID-19 (first day 1600 mg twice daily; 2-5 days 600 mg twice a day) without the need for hospitalization. Those who tested positive for COVID-19 RT-PCR in the patient group before three months were excluded from the study. None of the subjects had a history of dyspnea. The subjects with ejection fraction (EF) under 50% and patients with extreme BMIs (<18.5 or >50) were excluded. The subjects with aortic stenosis and regurgitation, mitral stenosis and regurgitation, or atrial fibrillation were excluded. The control group consisted of metabolically healthy subjects who were judged to be free of any acute or chronic illness by history and physical examination, and they were recruited from hospital staff. There was no drug use in the patient group and control group.

Measurements

The modified Medical Research Council Dyspnea Scale (mMRC), which consists of five statements that describe almost the entire range of dyspnea from none (grade 0) to nearly complete incapacity (grade 4), was used in the evaluation of dyspnea (15).

The twelve lead electrocardiogram (ECG) recordings (50 mm/s, 10 mm/mV) were obtained in the supine position using a CardioFax S device (Nihon Kohden, Tokyo, Japan). Resting heart rate was measured using the ECG data, and QT intervals were manually calculated by a cardiologist using the ECG data. Calipers and magnifying glasses were used to reduce measurement errors. The QT interval was calculated as the time from the start of the QRS complex to the end of the T wave. According to Bazett's formula's heart rate, the measured values were corrected, and a corrected QT interval (QTc) was obtained.

Transthoracic echocardiographic evaluations were performed on all participants using a Vivid 5 Pro ECO device (General Electric, Horten, Norway). All comprehensive two-

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dimensional echocardiographic examinations were performed according to the American Society of Echocardiography (16). In the lateral decubitus position, the images of the parasternal long and short axis and four-chamber and two-chamber views from the apical window were obtained. The left ventricular (LV) EF was assessed using Simpson's method. Cardiologists interpreted images with ≥5 years of working experience.

LV diastolic function was assessed with Doppler echocardiography following the American and European Societies of Echocardiography recommendations. The following variables were measured: peak transmitral flow velocity in early diastole (E), peak transmitral flow velocity in late diastole (A), E/A ratio, early diastolic mitral annular velocity (e'), E/e', septal e', lateral e', left atrium volume index, tricuspid regurgitation velocity. Diastolic dysfunction (DD) was diagnosed according to the TTE results and categorized into three grades based on the 2016 version of recommendations (Figure 1) (17).

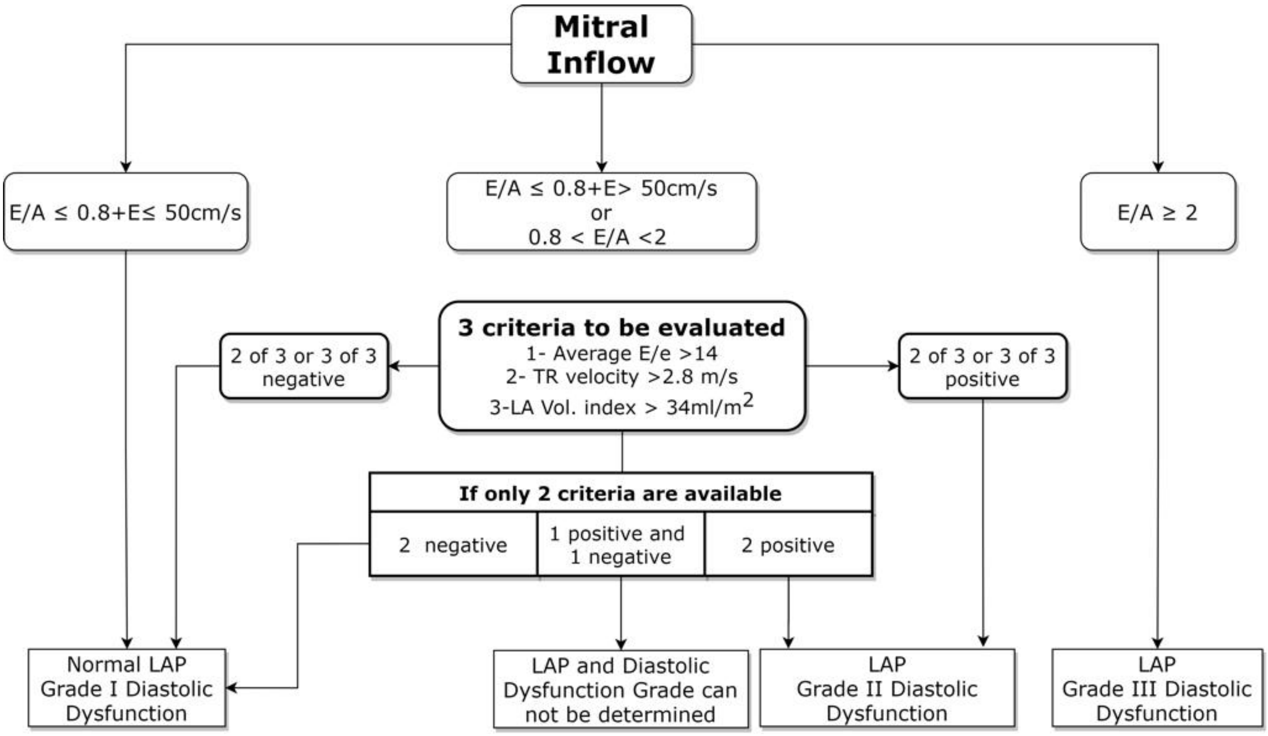

Figure 1. Diagnostic Criterias of Diastolic Dysfunction (LAP: Left atrial pressure, TR: Triscuspid Regurgitation)

Venous blood samples were obtained from the antecubital vein of both the patient and control group. The samples were centrifuged within 30 minutes, and on the same day, centrifugation was followed in the "CELL-DYN 3700 SL analyzer (Abbott Diagnostics, Chicago, U.S.A.)" device at the biochemistry laboratory the same hospital.

Statistical Analysis

Statistical analysis was performed using SPSS Mac Version 26.0 (Statistical Package for the Social Sciences Inc.). Descriptive statistics and continuous variables were given as mean ± standard deviation, and categorical variables were presented as frequency and percentage. The Chi-square test was used to analyze the categorical data. Normal distribution suitability was assessed using the Kolmogorov–Smirnov test. Independent-samples t-test was used to compare two groups to determine significant differences between groups. Pearson correlation analysis was performed in both groups. Binary logistic regression analysis was used in diastolic dysfunction prediction. Linear regression analysis was used in E/e' ratio prediction. A value of less than 0.05 (p-value) was considered statistically significant.

Results

TTE and ECG parameters were compared between the patient group and the control group. EF (p=0.073), E (p=0.717), A (p=0.475), E/A ratio (p=0.557), lateral e' (p=0.061), pulse (p=0.545), QT (p=0.228), and QTc (p=0.150) values were similar between the patient group and the control group. e' (p<0.001) and septal e' (p=0.049) were significantly higher in the control group. Left atrium (LA) volume index (p<0.001), peak tricuspid regurgitation (TR) velocity (p<0.001) and E/e' (p<0.001) were significantly higher in the patient group (Table 1).

The sample consisted of 50 patients and 50 healthy controls. There was no significant difference between the groups in terms of age (p=0.101), gender (p=0.534), and BMI (p=0.070) (Table 1).

Table 1. Sociodemographic and Clinical Variables of Patient and Control Groups

Variables		Patient Group (n=50)	Control Group (n=50)	*p* value
Age (years)		34.90±9.86	30.58±8.55	0.101
Gender	**Male**	17 (34%)	20 (40%)	0.534
	Female	33 (66%)	30 (60%)	
Grade of DD	**Normal**	21 (42%)	42 (84%)	<0.001**
	Grade 1	15 (30%)	5 (10%)	
	Grade 2	14 (28%)	3 (6%)	
mMRC	**Grade 0**	22 (44%)	36 (72%)	0.010*
	Grade 1	22 (44%)	13 (26%)	
	Grade 2	6 (12%)	1 (2%)	
BMI		25.57±3.41	24.54±2.94	0.070
EF		64.00±3.23	62.72±3.80	0.073
E		0.78±0.04	0.78±0.04	0.717
A		0.75±0.04	0.75±0.03	0.475
E/A Ratio		1.03±0.09	1.04±0.02	0.557
e’		5.62±1.02	6.95±0.73	<0.001**
E/e’ Ratio		14.31±2.00	11.46±1.43	<0.001**
Septal e’		7.32±1.30	7.78±0.74	0.049*
Lateral e’		10.60±1.65	11.19±1.03	0.061
LA Volume Index		32.97±3.54	30.31±2.79	<0.001**
TR Velocity		2.77±0.33	2.58±0.16	<0.001**
Pulse		69.04±9.02	70.14±9.07	0.545
QT		372.90±20.65	377.50±17.06	0.228
QTc		142.33±14.05	146.49±14.63	0.150
White blood cell (10^3/uL)		7.97±1.87	8.00±1.50	0.914
Hemoglobin (g/dL)		14.46±1.46	14.59±1.48	0.665
Neutrophil (10^6/uL)		4.73±1.65	4.88±1.40	0.606
Lymphocyte (10^3/uL)		2.53±0.88	2.37±0.61	0.305
Monocyte (10^3/uL)		0.51±0.19	0.49±0.17	0.578
Eosinophil (10^3/uL)		0.18±0.16	0.19±0.18	0.703
Basophil (10^3/uL)		0.09±0.05	0.07±0.05	0.593
CRP (m/L)		0.50±0.56	0.26±0.18	0.005*
D-Dimer (µg/L)		281.64±88.84	239.54±67.74	0.009*

**p<0.05; **p<0.001; Student’s t-test and chi-square test were used; Abbreviations= E: Early Wave; A: Atrial Wave; LA: Left Atrium; TR: Tricuspid Regurgitation; DD: Diastolic Dysfunction; mMRC: Modified Medical Research Council Dyspnea Scale; BMI: Body Mass Index: EF: Ejection Fraction; QTc: Corrected QT Interval; CRP: C-Reactive Protein*

White blood cell (p=0.914), hemoglobin (p=0.665), neutrophil count (p=0.606), lymphocyte count (p=0.305), monocyte count (p=0.578), eosinophil count (p=0.703) and basophil count (p=0.593) values were similar between the patient group and the control group. C-reactive protein (CRP) (p=0.005) and D-dimer (p=0.009) were significantly higher in the patient group (Table 1).

According to the logistic regression analysis, BMI was found to have a predictive effect on the diagnosis of DD (p=0.007) (Table 4).

In the comparison between genders in the patient group, there was no significant difference in parameters (BMI, EF, E, A, E/A ratio, pulse, QT, QTc, e’, E/e’ , septal e’, lateral e’, left atrium volume index, tricuspid regurgitation velocity, white blood cell, neutrophil count, lymphocyte count, monocyte count, eosinophil count, basophil count, CRP, D-dimer) (p>0.05) other than hemoglobin (p<0.001).

There was a significant difference in mMRC between the patient and control groups (p=0.010). All cases in the sample had grade 2, grade 1 DD, or normal diastolic function. There was a significant difference between the patient group and the control group in terms of DD (p<0.001) (Table 1).

In the patient group, patients with normal diastolic function (NDF) and patients with DD (grade 1 or grade 2 DD) were compared in terms of clinical parameters. Age (p<0.001), BMI (p<0.001) and eosinophil count (p=0.031) of DD patients were significantly higher. EF, E, A, EA, e’, septal e’, lateral e’, E/e’, left atrium volume index, tricuspid regurgitation velocity, and D-dimer were significantly different between patients with NDF and patients with DD. Hemogram and QTc values were similar between the groups (p>0.05). The findings are shown in Table 2.

When controlling for the effect of age in the patient group, a significant positive correlation was found between BMI and E/e’ ratio (r=0.428; p=0.001), while this significance was not detected in the control group (r=0.118; p=0.414).

According to the linear regression analysis, BMI had a significant and positive predictive effect on the E/e' ratio (p=0.004) (Table 3).

Table 2. Comparison of Clinical Parameters Between Patients with Normal Diastolic Function and Patients with Diastolic Dysfunction in the Patient Group

Variables	NDF (n=21)	DD (n=29)	*p value*
Age (years)	28.85±6.19	39.27±9.77	<0.001**
BMI	23.35±2.69	27.18±2.96	<0.001**
EF	66±2.46	62.55±2.97	<0.001**
E	0.81±0.01	0.76±0.04	<0.001**
A	0.72±0.03	0.78±0.04	<0.001**
E/A Ratio	1.12±0.05	0.97±0.07	<0.001**
e’	6.62±0.46	4.89±0.69	<0.001**
E/e’ Ratio	12.39±0.85	15.69±1.33	<0.001**
Septal e’	8.54±0.69	6.44±0.85	<0.001**
Lateral e’	12.15±0.87	9.48±1.08	<0.001**
LA Volume Index	29.90±1.69	35.20±2.78	<0.001**
TR Velocity	2.56±0.11	2.93±0.36	<0.001**
Pulse	70.95±9.98	67.65±8.16	0.206
QT	364.52±18.83	378.96±20.06	0.013*
QTc	142.95±15.17	141.89±13.44	0.796
White blood cell (10^3/uL)	7.77±1.93	8.11±1.84	0.537
Hemoglobin (g/dL)	14.49±1.63	14.43±1.35	0.884
Neutrophil (10^6/uL)	4.41±1.34	4.96±1.84	0.253
Lymphocyte (10^3/uL)	2.68±1.12	2.42±0.66	0.351
Monocyte (10^3/uL)	0.49±0.20	0.52±0.19	0.544
Eosinophil (10^3/uL)	0.13±0.11	0.22±0.18	0.031*
Basophil (10^3/uL)	0.09±0.20	0.09±0.14	0.992
CRP (m/L)	0.49±0.65	0.51±0.49	0.893
D-Dimer (µg/L)	251.04±71.58	303.79±94.56	0.037*

**p<0.05; **p<0.001; Student’s t-test was used; Abbreviations= NDF: Normal Diastolic Function; DD: Diastolic Dysfunction; E: Early Wave; A: Atrial Wave; BMI: Body Mass Index: EF: Ejection Fraction; LA: Left Atrium; TR: Tricuspid Regurgitation; IVRT: Isovolumetric Relaxation Time; QTc: Corrected QT Interval; CRP: C-Reactive Protein*

Tablo 3. Effect of BMI and Laboratory Parameters on E/e’ ratio

Parameters	β	*p* value	$r_{partial}$	%95 Confidence Interval	
				Lower	Upper
BMI	0.421	0.004**	0.428	0.082	0.412
Hemoglobin (g/dL)	0.078	0.626	0.076	0.003	0.005
Lymphocyte (10^3/uL)	0.089	0.521	0.101	0.000	0.001
Monocyte (10^3/uL)	0.117	0.387	0.135	0.002	0.004
Eosinophil (10^3/uL)	0.191	0.194	0.202	0.001	0.006
CRP	0.015	0.922	0.181	1.032	1.138
D-Dimer	0.191	0.220	0.015	0.003	0.011
Constant		0.250		3.603	13.462

***p<0.01; Lineer regression analyses were used. Abbreviations= BMI: Body Mass Index; CRP: C-Reactive Protein.*

Table 4. Effect of BMI and Laboratory Parameters on Diastolic Dysfunction

Parameters	*p* value	Odds ratio	%95 Confidence Interval	
			Lower	Upper
BMI	0.007**	1.478	1.115	1.958
White blood cell (10^3/uL)	0.558	0.998	0.993	1.004
Hemoglobin (g/dL)	0.694	0.999	0.993	1.004
Neutrophil (10^6/uL)	0.504	1.002	0.996	1.007
Lymphocyte (10^3/uL)	0.787	1.001	0.995	1.006
Monocyte (10^3/uL)	0.496	1.003	0.995	1.010
Eosinophil (10^3/uL)	0.178	1.006	0.996	1.016
CRP	0.574	0.591	0.095	3.696
D-Dimer	0.215	1.006	0.996	1.016
Constant	0.102	<0.001		

***p<0.01; Logistic regression analyses were used. Abbreviations= BMI: Body Mass Index; CRP: C-Reactive Protein*.

Discussion

While most patients with COVID-19 recover and turn back to normal health, some patients can have complaints that can last for weeks or even months after recovery from acute illness (13). Insomuch as patients who are not hospitalized and have mild symptoms can experience persistent or subsequent symptoms (14). Late symptoms may be related to psychiatric, renal, neurological, dermatologic, cardiovascular, and respiratory (13). Dyspnea, a respiratory sign, is a subjective experience of breathing discomfort that can only be known through a patient's report and may occur after COVID-19 (18). Although dyspnea due to acute COVID-19 has been studied frequently, information is lacking on dyspnea that persists after recovery (14). This study compared patients who had no history of dyspnea before COVID-19 with healthy controls. DD was significantly higher in the patient group. Although BMI values were similar between groups, there was a significant positive correlation between BMI and E/e' ratio in the patient group, but not in the control group.

Rozenbaum et al. (19) investigated the relation between BMI and diastolic function in a relatively large cohort of metabolically healthy obese with preserved EF. They defined the metabolically healthy as lack of known diabetes mellitus, hypertension, and hyperlipidemia. Eventually, they suggested that high BMI is associated with an increased risk of DD even in metabolically healthy patients. Peterson et al. (20) designed a study to determine the effects of obesity on LV function in young metabolically healthy obese women, and they reported that obesity in young otherwise-healthy women is associated with decreased diastolic function. Peterson et al. (20) stated that decreased diastolic function was negatively correlated with BMI. Chadha et al. (9) investigated the impact of obesity on the alteration of LV functions in non-diabetic, non-hypertensive, and normolipidemic obese Asian Indians and reported that DD is significantly higher in obese subjects. Iacobellis et al. (21) evaluated cardiac parameters in uncomplicated obese subjects with long-term obesity, normal glucose tolerance, normal blood pressure, and regular plasma lipids and demonstrated that obese participants presented DD compared with normal subjects. Pascual et al. (22) reported that BMI correlated significantly with indices of LV function in obese subjects who had no other pathological conditions.

More of the studies mentioned above can be found in the literature. Although the significant relationship between BMI and DD was studied in these studies, the relationship between BMI and DD, which did not meet the obesity criteria, was not studied sufficiently. A similar situation is valid for COVID-19. Many studies have examined the negative impact of obesity on the COVID-19 process (1). In COVID-19, as in many other conditions, a significant relationship was found between obesity and DD (2). However, on the border of overweight, the relationship between BMI and DD has not yet been investigated in COVID-19.

According to BMI, general population is classified in five categories: underweight (BMI < 18.5 kg/m2), normal weight (BMI 18.5-24.9 kg/m2), class I obesity - overweight (BMI 25.0-29.9 kg/m2), class II obesity - obesity (BMI 30.0-39.9 kg/m2), class III obesity - extreme obesity (BMI > 40 kg/m2) (23). In this study, both groups were at the limit of normal weight or overweight, and they did not have any confounding factors such as diabetes mellitus, hypertension, and cardiac pathology. The patients had dyspnea that started after COVID-19 and continued despite the improvement of the acute period of the infection. Subjects had grade 1, grade 2 DD, or NDF. DD in the patients group was significantly higher than in the control group. The TTE parameters of NDF and DD cases in the patient group were compared, and the findings were in favor of NDF. A significant relationship was found between the E/e’ ratio used in DD grading and BMI in the patient group. The findings showed that BMI can be used to predict the E/e’ ratio and DD that occurs following acute COVID-19 infection. Magoon (24) stated that the subclinical ventricular relaxation impairment, the conglomeration of factors specific to COVID-19 such as systemic inflammatory milieu, endothelial dysfunction, microvascular thrombosis, arrhythmias, disturbed ventricular cross-talk, and myocardial oxygen supply-demand perturbations might be associated with LV DD in COVID-19 despite a preserved LV EF. Although studies link DD with the use of high positive end-expiratory pressure, there is no such situation in our study (25).

CRP level was significantly different between the patient group and the control group. However, there was no difference between the NDF and the DD in the patient group. D-dimer was significantly different both between the patient group and the control group and between the NDF and the DD in the patient group. This study revealed that D-dimer could be used to exclude the post-COVID-19 DD. The relationship between D-dimer and COVID-19 has been known since the first studies in this field (26). Increased rates of D-dimer have a significant connection to mortality. The relationship between D-dimer levels and survival rate was examined in various studies.

Moreover, several studies have examined the relationship between D-dimer levels and the severity of the COVID-19 (27). The literature reports that recovered COVID-19 patients may have significantly higher D-dimer levels than healthy controls. Chen et al. (28) observed markedly higher D-dimer concentrations in a cohort in non-survivors compared to recovered COVID-19 patients. The findings of this study are compatible with the literature in this sense. On the other hand, it was seen in this study that eosinophil count gave significant results in predicting the E/e’ ratio. However, the hemogram parameters of the patient group and the control group and NDF and DD in the patient group were similar. The major limitation of this study is its cross-sectional design. A prospective method starting from the early days of COVID-19 with regular follow-up TTE measurements would yield more convincing results about the nature of dyspnea or DD in COVID-19. Another limitation is that weight changes were not known, and different adipose tissue locations may have other pathological effects. While hydration status may influence diastolic assessment, a reliable fluid balance was unavailable in all subjects. Alcohol consumption, smoking status, and illicit drug use, which may affect diastolic function, were unavailable.

In this study, we found that DD was more common in people who had recently had COVID-19 and did not have any other disease than the healthy control group.

Conclusions

This study is the first to examine late symptoms of COVID-19 in metabolically healthy people and address the relationship of higher BMI to DD. These early abnormalities in cardiac function may have important implications for explaining the DD associated with increased cardiopulmonary morbidity caused by higher BMI. This study suggested that higher BMI itself or indirect effects of adipose tissue affect LV function, not only its related metabolic comorbidities. Further studies are needed to evaluate whether these TTE findings translate into clinical settings.

Ethical Approval: The approval of the local ethics committee was obtained, and all study participants provided written informed consent (Adıyaman University Ethics Committee, Protocol number: 2021/01-7 Date: 19/01/2021).

Author Contributions:
Concept: S.A.
Literature Review: S.A.
Design : S.A.
Data acquisition: S.A.
Analysis and interpretation: S.A.
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