Early Adulthood Obesity Impact on Left and Right Ventricular Function Assessed by Speckle Tracking Echocardiography

Basant Zahid*, Hesham Rashid, Ahmed Osama, Al-Shimaa Mohammed Sabry
Department of Cardiology, Benha Faculty of Medicine, Benha University, Egypt
***Corresponding author:** Basant Zahid, **Mobile:** (+20) 01154631249,
E-mail: basantsamy97@yahoo.com, **ORCID:** https://orcid.org/0000-0002-2773-4659

ABSTRACT

Background: With the increased prevalence of obesity worldwide, even in young adults with a lack of data on its effect on cardiac function in these age groups, the need to detect the possible changes in cardiac function with different degrees of obesity has emerged.

Objective: We aimed to use 2-dimensional (2D) deformation imaging to evaluate the potential changes in cardiac function in variable degrees of obesity.

Patients and methods: Our study is a single-center observational study. During the study period between September 2022 and September 2023, 323 volunteers without evidence of metabolic syndrome in their first decade of adulthood (18 to 30 years of age) with a BMI more than 25 kg/m^2 were evaluated at the Cardiology Department, Faculty of Medicine, Benha University. 123 cases were excluded due to the presence of significant valvular disease (n=53), atrial fibrillation (n= 36), systolic heart failure (n= 27), and poor image quality (n=7). Finally, the study included 200 patients as follows: Overweight (n=100) and obese (n=100). Forty participants were enrolled (n=40) as a control group. Conventional and speckle-tracking echocardiography evaluated the right (RV) and the left ventricle (LV) function and global longitudinal strain (GLS).

Results: No noticeable differences were detected among the groups regarding conventional functional and dimensional echocardiographic parameters. However, significant differences between the groups were noticed regarding 2D speckle tracking of RV global longitudinal strain (GLS), RV free-wall strain, and LV GLS ($p<0.001$), with worse deformation in obese subjects.

Conclusion: Obesity, even in younger ages without metabolic syndrome, is hazardous to LV and RV function, represented by worse myocardial deformation. This finding could be used in risk stratification of obese young individuals.

Keywords: Obesity, speckle tracking echocardiography, global longitudinal strain.

INTRODUCTION

Premature deaths caused by obesity are estimated at 4.7 million annually and considered one of the leading preventable causes of death, ranked fifth, and making 8.4% of deaths worldwide [1]. Heart failure, peripheral vascular disease, and coronary artery disease are significant consequences of obesity [2].

In Egypt, very few studies have been concerned with the complex burden of obesity and its comorbidities [3]. The main focus of the studies that shaped our knowledge of obesity and its impact on cardiac dysfunction was on patients in their middle and later years who most likely have metabolic syndrome [4, 5].

Fewer studies concerned obese children's left ventricular function. However, the cardiac function of obese young adults without metabolic syndrome did not attract the least attention of studies. The widely used conventional transthoracic echocardiography could not be counted upon to detect subtle cardiac dysfunction. At the same time, deformation imaging provides additional information about cardiac mechanics, providing detection of subclinical impairment of cardiac function [6, 7].

Therefore, in this study, we aimed to detect obesity's impact on cardiac structure and function using conventional and advanced echocardiographic parameters in healthy young adults.

PATIENTS AND METHODS

Study population: Our study is a single-center observational study that was conducted through the period between September 2022 and September 2023. 323 volunteers without evidence of metabolic syndrome in their first decade of adulthood (18 to 30 years of age) with a BMI above 25 kg/m^2 were evaluated at the cardiology department of our university hospital. 123 cases were excluded due to presence of significant valvular disease (n=53), atrial fibrillation (n= 36), systolic heart failure (n= 27), and poor image quality (n=7). Finally, the study included 200 patients and 40 healthy participants were enrolled as a control group.

Exclusion criteria: Patients with valvular pathologies (more than mild stenosis or insufficiency), history of systolic HF, pericardial diseases, active infection, pulmonary embolism, acute myocardial ischemia, being pregnant, atrial fibrillation, myocarditis and poor image quality.

BMI was determined as weight in kilograms divided by height in meters squared (kg/m^2). The Adult Treatment Panel III criteria were utilized to diagnose metabolic syndrome [8, 9]. The WHO standards were used to define individuals as obese (BMI > 30 kg/m^2) or overweight (BMI 25-29.9 kg/m^2) and were compared to the control group (19-24.9 kg/m^2) [2].

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STUDY PROTOCOL

Echocardiography: All the exams were done using a Philips EPIC 7C machine (USA) with the S5-1probe with ECG signal recorded simultaneously. At the end of expiration, the three cardiac cycles' echocardiographic images were recorded. Then, the images were moved to a workstation dedicated to the vendor and examined using Philips EPIC 7C machine (USA) software. The latest guidelines were the reference for performing all the echocardiographic measurements [10].

M-mode was used to measure the left ventricular wall thickness and chamber dimensions. The Modified Simpson's technique was used to compute the LV ejection fraction (EF). Global longitudinal strain (GLS) of the left ventricle (LV) and right ventricle (RV) was measured using speckle tracking echocardiography (STE). The end-diastole for 2D STE analysis was determined by placing the ECG trigger point on the R wave's peak. The aortic and pulmonary valve closure times were determined using pulsed wave Doppler acquisitions of the LV and RV outflow tract respectively. To cover the myocardium and delineate the region of interest (ROI), endocardial and epicardial outlines were established on the corresponding boundaries. The tracking points' motion and the underlying myocardium's motion were compared to evaluate tracking quality. To compute LVGLS, the longitudinal strain values from the three apical views of LV were averaged. Markings were applied starting from the lateral annulus and finishing at the septal annulus of the tricuspid valve to identify the endocardial surface for RV assessment [11]. The average of all six segments of the RV was used to measure RV GLS, whereas the average of only three lateral segments was used to measure RV free wall (FW) [12].

Ethical statement: Participants signed informed permissions after explaining the study's procedure to them. The Clinical Research Ethics Committee of Faculty of Medicine, Benha University approved the study (March 25, 2022; Final approval date after conduction of the study: September 2023; Certificate Number: 1017). This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical methods:

For data management and statistical analysis, SPSS version 28 was utilized. The normality of quantitative data was evaluated using the Shapiro-Wilk test, the Kolmogorov-Smirnov test, and direct data visualization techniques. Mean ± SD were employed to condense quantitative data. The summary of the categorical data was done using numbers and percentages. The quantitative data between the groups under study were compared using a one-way ANOVA test. If there was a substantial overall impact, post hoc comparisons were carried out. Multiple comparisons were taken into account in all post hoc analyses. X^2-test analysis was performed on categorical data. Using Pearson's correlation, relationships between BMI and other variables were examined. Each and every statistical test had two sides. $P \leq 0.05$ was considered significant.

RESULTS

The baseline clinical characteristics and demographics of participants were described in table **(**1) and were matched among the groups. LV and RV conventional echocardiographic parameters are shown in tables (2) and (3). No differences were detected between the groups for conventional functional and dimensional parameters.

Table (1): Demographics of the studied groups

	Overweight (n = 100)	**Obese (n = 100)**	**Control (n = 40)**	**P-value**
Age (years)	25 ±4	25 ±4	25 ±4	0.87
Sex Males Females	 66 (66) 34 (34)	 63 (63) 37 (37)	 28 (70) 12 (30)	 0.724
Weight (Kg)	86 ±8 ^{a}	98 ±9 ^{b}	70 ±4 ^{c}	**<0.001***
Height (cm)	174 ±6	174 ±6	176 ±6	0.246
BMI (kg/m^2)	28.1 ±1.1 ^{a}	32.4 ±1.7 ^{b}	22.9 ±1.4 ^{c}	**<0.001***
BSA (m^2)	2.04 ±0.12 ^{a}	2.18 ±0.14 ^{b}	1.85 ±0.07 ^{c}	**<0.001***
Waist circumference (cm)	91 ±7 ^{a}	98 ±7 ^{b}	80 ±5 ^{c}	**<0.001***
Smoking	33 (33)	35 (35)	19 (47.5)	0.257
Systolic blood pressure (mmHg)	115 ±10	114 ±9	114 ±8	0.807
Diastolic blood pressure (mmHg)	71 ±8	72 ±6	71 ±7	0.509
HR (BPM)	74 ±5	75 ±6	74 ±6	0.427

*Significant P-value: Small letters indicate a significant pair if different and a non-significant pair if similar

Table (2): Two-D Echo findings in the studied groups

	Overweight (n = 100)	**Obese (n = 100)**	**Control (n = 40)**	**P-value**
LVEF (%)	66 ±5	65 ±5	65 ±4	0.374
LVESV (ml)	30 ±5	30 ±5	30 ±5	0.915
LVEDV (ml)	88 ±9	88 ±7	88 ±7	0.942
RV basal diameter (cm)	3.2 ±0.4	3.2 ±0.5	3.1 ±0.4	0.554
RV mid diameter (cm)	2.9 ±0.4	2.9 ±0.4	2.8 ±0.5	0.238
RV longitudinal diameter (cm)	6.8 ±0.6	6.7 ±0.6	6.7 ±0.6	0.532
RV end diastolic area index (cm^2/m^2)	8.9 ±1.1	8.8 ±1.4	8.8 ±0.9	0.673
RV end-systolic area index (cm^2/m^2)	4.7 ±0.7	4.6 ±0.8	4.6 ±0.6	0.672
RV FAC (%)	47.7 ±3.5	48.1 ±4	47.2 ±3.3	0.369
RA longitudinal axis (cm)	3.6 ±0.6	3.6 ±0.4	3.6 ±0.4	0.732
RA short axis (cm)	2.5 ±0.5	2.5 ±0.5	2.5 ±0.4	0.767
RA end-systolic area (cm^2)	16.8 ±2.2	16.9 ±2.3	16.5 ±1.5	0.539
TAPSE (mm)	24 ±3	24 ±3	24 ±3	0.458
LA volume index (mL/m^2)	23 ±3.7	23.6 ±2.8	23 ±3.5	0.357

LVEF: Left ventricular ejection fraction; LVESV: Left ventricular end-systolic volume; LVESDV: Left ventricular end-diastolic volume; FAC: Fractional Area Change; TAPSE: Tricuspid Annular Plane Systolic Excursion.

Table (3): M-mode echo findings in the studied groups

	Overweight (n = 100)	**Obese (n = 100)**	**Control (n = 40)**	**P-value**
IVSd (cm)	1 ±0.1	1 ±0.1	1 ±0.1	0.441
IVSs (cm)	1.5 ±0.1	1.5 ±0.1	1.5 ±0.1	0.388
PWDD (cm)	1 ±0.1	1 ±0.1	1 ±0.1	0.64
PWSD (cm)	1.5 ±0.1	1.5 ±0.1	1.5 ±0.1	0.066
LVESD (cm)	3.11 ±0.32	3.18 ±0.22	3.1 ±0.27	0.135
LVEDD (cm)	4.6 ±0.4	4.5 ±0.3	4.6 ±0.3	0.122
LA diameter (cm)	3.3 ±0.3	3.3 ±0.3	3.3 ±0.3	0.564
Aortic root diameter (cm)	2.5 ±0.4	2.4 ±0.4	2.4 ±0.3	0.153

IVSd: Interventricular Septal thickness at end-diastole; IVSs: Interventricular Septal thickness at end-systole; PWDD: Posterior Wall Diastolic Dimension; PWSD: Posterior Wall Systolic Dimension; LVESD: Left ventricular end-systolic dimension; LVEDD: Left ventricular end-diastolic dimension; LA: Left atrial.

Two-dimensional STE-derived LV GLS, RV GLS, and RV FW were significantly lower in the obese subjects. Moreover, they were lower significantly in the overweight group than in the control group (Table 4 and figure 1).

Table (4): Speckle tracking echo findings in the studied groups

	Overweight (n = 100)	**Obese (n = 100)**	**Control (n = 40)**	**P-value**
LV GLS	-21.5 ±2.4 [a]	-20 ±2.3 [b]	-23.2 ±2.5 [c]	**<0.001***
RV GLS	-23.9 ±2.4 [a]	-21.3 ±2 [b]	-25.5 ±3.1 [b]	**<0.001***
RV Free Wall LS	-23.7 ±2.3 [a]	-21 ±2 [b]	-25.5 ±3.1 [c]	**<0.001***

*Significant P-value; Small letters indicate a significant pair if different and a non-significant pair if similar; GLS: Global Longitudinal Strain

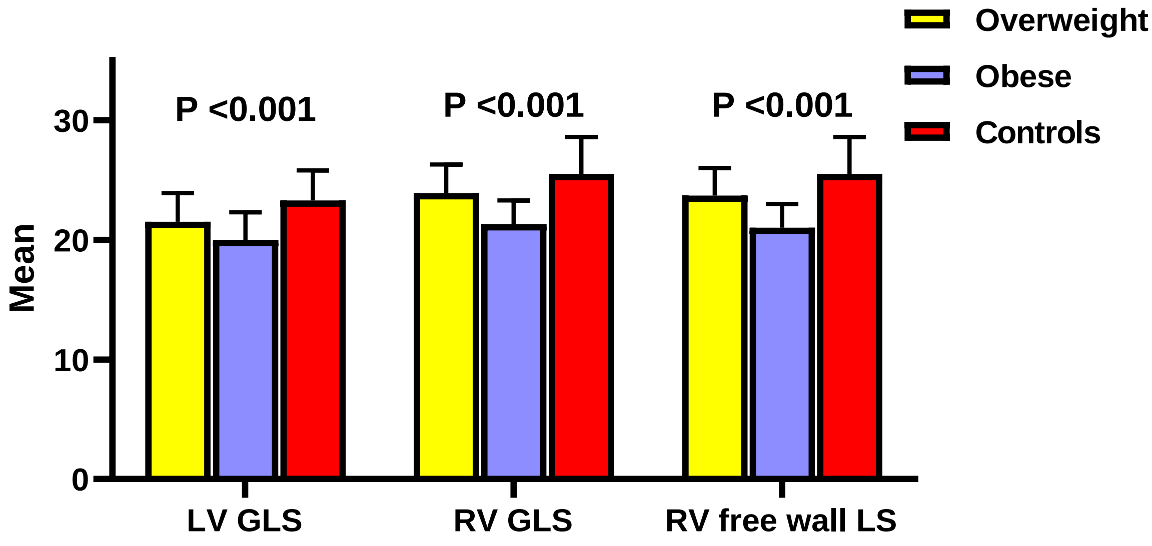

Figure (1): Speckle tracking echo findings in the studied groups.

Correlation between BMI and conventional echocardiography dimensional and functional parameters revealed significant positive correlations between BMI and RA end-systolic (r = 0.149, P = 0.021), LA volume index (r = 0.148, P =0.022), mitral E wave velocity (r = 0.183, P = 0.004) and E/E' (r = 0.162, P = 0.012). In contrast, significantly negative correlations between BMI and LV GLS (r = -0.409, P < 0.001), RV GLS (r = -0.472, P < 0.001), and RV FWS (r = -0.503, P < 0.001) were observed (Table 5 and figures 2, 3 & 4).

Table (5): Correlation between BMI and 2D echo parameters

	BMI (kg/m^2)	
	r	**P**
RA end-systolic area (cm^2)	.149	**0.021***
LA volume index (mL/m^2)	.148	**0.022***
Mitral E Wave Velocity (cm/s)	.183	**0.004***
E/E'	.162	**0.012***
LV GLS	-.409**	**<0.001***
RV GLS	-.472**	**<0.001***
RV FWS	-.503**	**<0.001***
LV GLS	-.409**	**<0.001***

*Significant P-value; LVEF: Left ventricular ejection fraction; LVESV: Left ventricular end systolic volume; LVESDV: Left ventricular end diastolic volume; FAC: Fractional Area Change; TAPSE: Tricuspid Annular Plane Systolic Excursion.

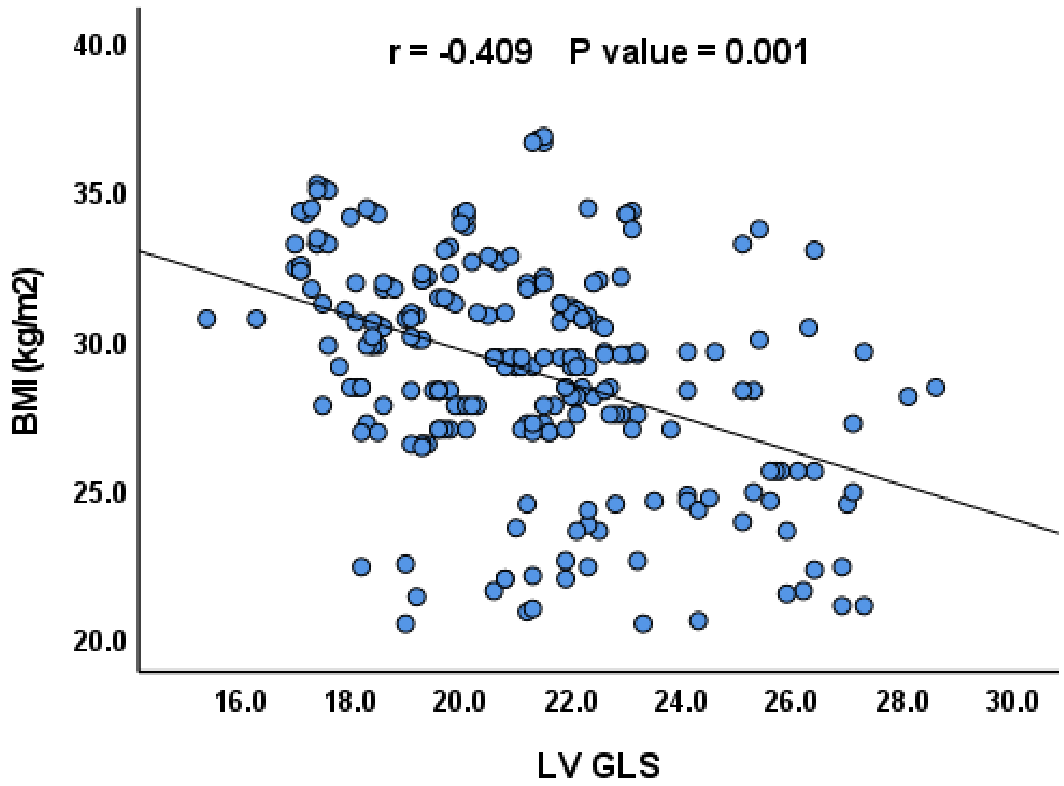

Figure (2): Correlation between BMI and LV GLS

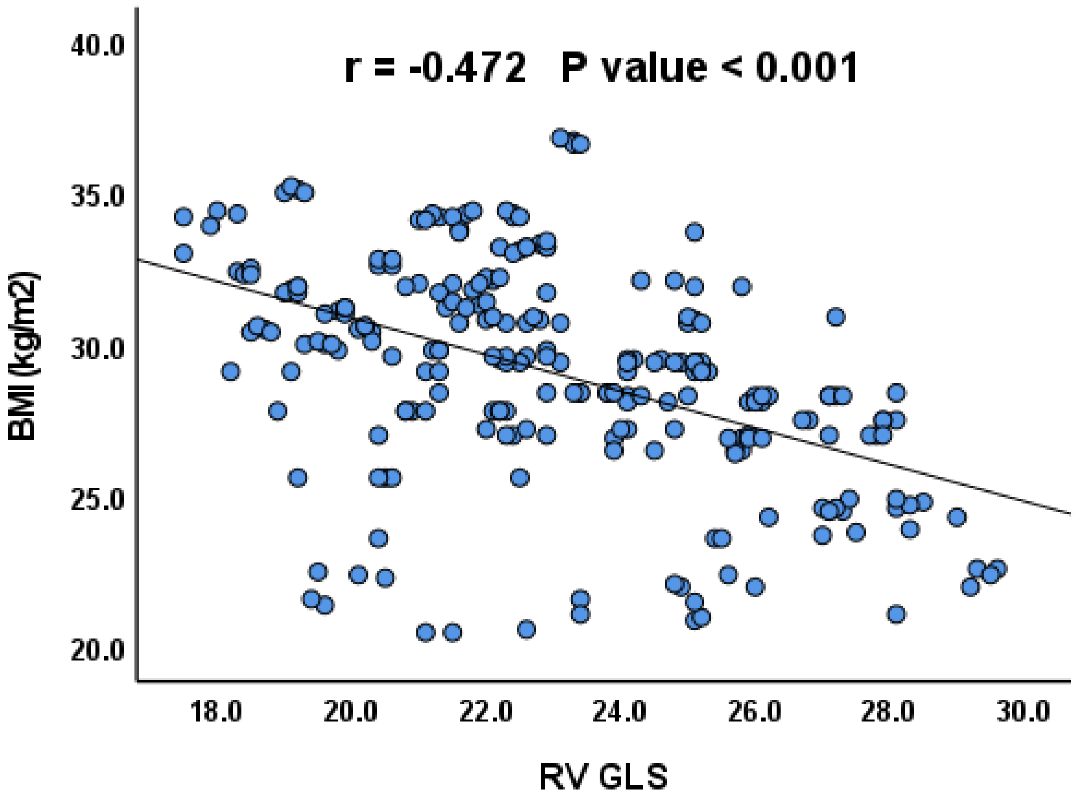

Figure (3): Correlation between BMI and RV GLS

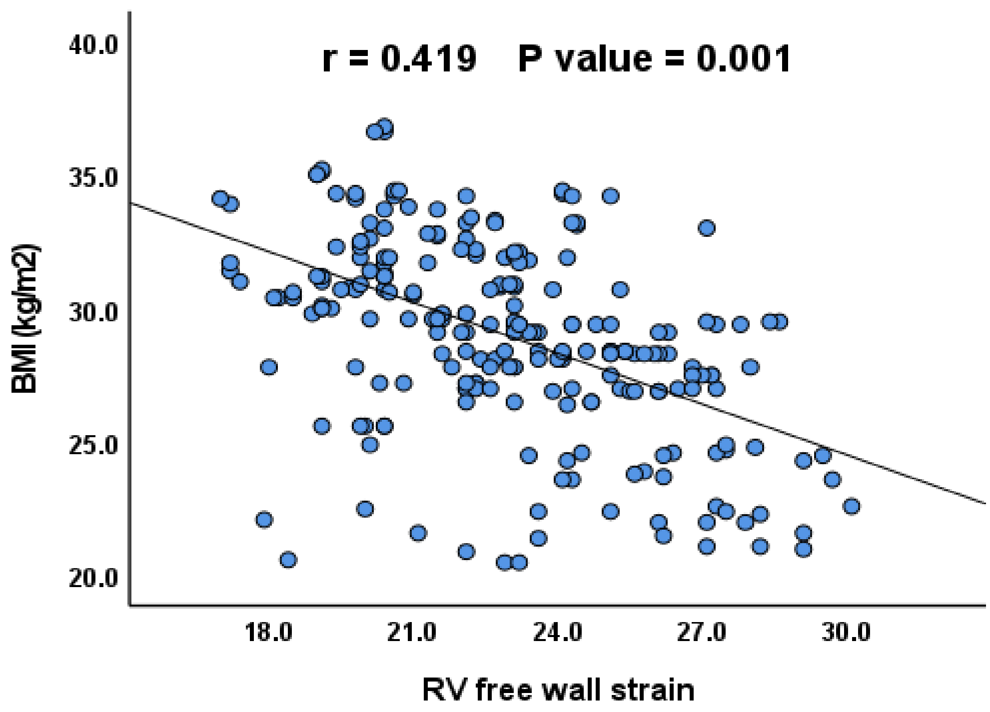

Figure (4): Correlation between BMI and RV-free wall strain.

DISCUSSION

Smith and Willius [13] discovered the relation between cardiac mass and obesity up till more recent literature linking obesity to left ventricular ejection fraction (LVEF), left ventricular mass, elevated cardiac output, and reduced peripheral vascular resistance (PVR) [14, 15, 16]. The significantly infiltrated heart tissue by fatty cells emerged in cardiomyopathy induced by obesity

The overweight and obesity prevalence has increased in adults in the last three decades in males from 28.8% to 36.9% and in females from 30% to 38% [18]. Although most of this increase was in developed countries, the developing countries also have their share [1], with a lack of data on the effect of obesity on young adult health in general and cardiac function in particular.

Worldwide, some studies focused on obesity in the elderly or childhood. In contrast, others focused on obesity in patients with other comorbidities like diabetes, hypertension, or even in patients with metabolic syndrome. Therefore, we aimed in our study to detect the obesity effect on cardiac structure and function in early adulthood individuals without any comorbidities, even metabolic syndrome. We divided the participants into overweight and obese groups for further detection of the slightest increase of BMI on cardiac function.

In our study, the demographic, clinical, and conventional echocardiographic parameters did not differ between the groups. **Gade *et al.*** [19] revealed that in the conventional echocardiographic parameters, only E/E`, E/A, LV ejection fraction, end ventricular systolic and diastolic volumes succeeded to show a significant difference between both groups being worse in the obese individuals. This discrepancy between this study and ours could be due to their inclusion of healthy individuals above 18 years with no age restriction, while our study only included young adults aged 18 to 30 years.

We observed that STE-derived LV GLS, RV GLS, and RV FW were significantly lower in obese subjects, and even the overweight group showed a significant difference from the control group. This finding is similar to that of **Ünlü and Taçoy** [2] who evaluated the LV and RV deformation indices in early adulthood obese individuals and found that the most impaired deformation indices, including LVGLS, RVGLS, and RVFW, were noticed in obese subjects compared to control and even overweight subjects.

The present study revealed significant positive correlations between BMI and RA end-systolic, mitral E wave velocity, E/E`, and LA volume index. This is in agreement with findings of **Lee *et al.*** [20], when studied the subclinical alterations in left ventricular function and structure according to metabolic health status and obesity. They divided volunteers into several phenotypes from metabolic healthy with normal weight (MHNW) to metabolic unhealthy obese (MUO). They found that the MHNW was the only group that showed favorable LAVi and E/E values with gradual deterioration of other groups till reaching the MUO, which demonstrated the worst values. Interestingly, in the same study, a gradual decline was noticed in LVGLS being best in the MHNW group and worst in the MUO. This comes in the agreement with our finding when BMI and LVGLS were correlated and showed a significant negative correlation.

These agreements prove the negative impact of the isolated increase of BMI on structural and various functional myocardial indices, even in the absence of metabolic syndrome, as was the case in our study.

LIMITATIONS

Our study used BMI to classify the participants and their degree of obesity; however, the distribution and percentage of body fats may better explain the relationship between obesity and the degree of impairment of myocardial function. Our study was cross-sectional, and the effect of obesity on deformation function differed between the groups but was still within the normal range. This finding sheds light on the importance of performing a longitudinal study with follow-up to detect the effect of obesity modification on myocardial function.

CONCLUSION

Obesity, even in younger ages without metabolic syndrome, has a negative impact on LV and RV function, represented by worse myocardial deformation. This finding could be used in risk stratification of obese young individuals.

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