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Impact of Increasing Body Mass Index Categories on Left Ventricular Diastolic Function

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Abstract:

Background: Adults with obesity are at increased risk of heart failure with preserved ejection fraction (HFpEF). This study aimed to assess and compare diastolic function in non-comorbid obese. **Methods:** This comparative cross-sectional study included 150 asymptomatic medically free individuals with no documented CAD. The patients were divided into three equal groups: Group {A} individuals with BMI less than 25. Group {B} individuals with BMI more than 25 due to increased fat. Group {C} individuals with BMI more than 25 due to increased muscle mass. **Results:** E wave was significantly increased in C group in comparison to A and B groups. E wave was significantly decreased in B group in comparison to A group. Septal e′ and lateral e′ were significantly increased in C group in comparison to A and B groups. septal e′ and lateral e′ were significantly increased in A group in comparison to B group (P-value <0.001). **Conclusion:** Based on our findings, individuals with increased muscle mass percentage and normal body fat percentage has super normal diastolic compliance in spite of increased body mass index. But this group has increased Lt atrial volume index and TR velocity which indicates chronic biventricular pressure overload. It is not fair enough to put muscle builders in the same group with increased fat persons only due to their equal BMI, as our study showed a significant difference between both groups regarding diastolic function.

Keywords: Body Mass Index; Left Ventricular; Diastolic Function; Systolic Dysfunction.

Introduction

There is currently a worldwide epidemic of obesity. The latest projection by the World Health Organization estimated that globally in 2005, approximately 1.6 billion adults over the age of 15 years were overweight, and at least 400 million adults were obese [1].

Adults with obesity are at increased risk of heart failure with preserved ejection fraction (HFpEF). Obesity represents an epidemic in the eastern and western countries. The prevalence of obesity in adults is 38% and up to 30% in children. Non-invasive assessment of diastolic function remains challenging in population as the findings of diastolic dysfunction may be the end point for long term exposure to harmful events, thus early detection is important to prevent development of heart failure symptoms [2].

Obese patients are particularly susceptible to develop diastolic dysfunction owing to association of ultra-structural and metabolic abnormalities in the myocardium that impair myocardial relaxation. Such diastolic filling abnormalities can be seen early in the course of obesity even before onset of hypertension, DM, renal disease and vasculopathy. Diastolic dysfunction is an important risk factor for development of heart failure and morbidity in obese patients. Early recognition and treatment can prevent its progress to heart failure [3].

Left atrium (LA) maximum volume has been shown to strongly correlate with cardiovascular outcomes and has improved prognostic and diagnostic information in the assessment of LV diastolic function. LA dilation results from chronically elevated LV filling pressures and thus is a late finding that happens in late stage I or stage II diastolic dysfunction. However, recent literature suggests that LA function measures may be more sensitive early markers of LV diastolic dysfunction than LA volume data and LA strain impairment as measured by speckle tracking echocardiography may be one of the first signs of diastolic dysfunction [4].

Body mass index (BMI) the most common way to assess obesity is not considering the increased proportion of body components, thus it may be different when fat of body is more than normal or muscle mass is high even if the BMI is equal in both cases. So, we should study the effect of both probabilities on diastolic function [5].

Bioelectrical Impedance analysis (BIA) is a new technology which can calculate the percentage of all body components separately, thus it help us to differentiate between the increased BMI due to high fat accumulation and increased BMI due to increased muscle mass. Using this technology present in body composition analyzers enables us studying both groups separately [6].

The purpose of this study was to assess and compare diastolic function in non-comorbid obese.

Patients and methods

This comparative cross-sectional study included 150 asymptomatic medically free individuals with no documented CAD. The study was conducted at Cardiology department at “Benha University hospital” during the period from March 2023 to July 2023.

Informed consents were obtained from all participants, and the study was approved by the ethical committee on research involving human subjects of Faculty of Medicine – Benha University.

Inclusion criteria were age 20 to 40 years old, both genders, asymptomatic free medical history, and both control (normal BMI) and obese persons was selected according to WHO definition of lean and obese persons using weight (by Kg) / height2 (by meters) with result > 25 is obese and from 18.5 to 25 is lean (normal) [7].

Exclusion criteria were patients refused to be in the study, diabetics, hypertensive, documented ischemic heart disease, reduced LV systolic function. EF <52 %, age less than 20 or more than 40 years, rhythm other than sinus rhythm, moderate or severe valvopathy, congenital heart disease and symptomatic (Dyspneic) patients.

Grouping: The study members divided according to body mass index, fat and muscle percentages using body composition analyzer machine(InBody Xian Triumph Tech Co. KSY284) to the following three equal groups: **Group {A}** individuals with BMI less than 25. **Group {B}** individuals with BMI more than 25 due to increased fat. **Group {C}** individuals with BMI more than 25 due to increased muscle mass.

All studied cases were subjected to the following: Detailed history taking, including [Age, gender, history of dyspnea and history of any chronic illness]. **Examination: including [**Height, weight, ABP, BMI, and body composition analyzer]. L**aboratory investigations [**RBS, HbA1c]. ECG, Transthoracic echocardiography.

Transthoracic echocardiography:

Conventional echocardiographic study was done for all participants by using a GE 7 Vivid ultrasound machine (Vivid Medical Systems) with a broadband transducer (X5-1, 5-1 MHz) using the standard views parasternal long, short axis, apical 3, 2, 4 and 5 chamber views at rest to assess: Left ventricular end systolic and end diastolic dimensions by M-mode. Left ventricular systolic function using 2D method (Teicholz method). Right ventricular size and systolic function using Tricuspid annular plane systolic excursion (TAPSE). Segmental wall motion abnormality at rest. Any valvular heart disease. Presence of pericardial effusion.

Diastolic function was assessed using the recommendations of the American Society of Echocardiography and the European Association of Cardiovascular Imaging (8) and the following echocardiographic parameters was measured: Peak mitral inflow velocity in early diastole (E wave). Peak mitral inflow velocity in late diastole (A wave). The E/A ratio and deceleration time. Medial and Lateral Tissue Doppler early diastolic relaxation velocity (e´). Average peak mitral inflow velocity in early diastole /tissue Doppler early diastolic relaxation velocity (E/ e´). Left atrial volume by measuring both volumes in 4 chambers and 2 chambers views. Tricuspid regurgitation velocity (TR).

Statistical analysis

Statistical analysis was done by SPSS v20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative variables were presented as mean and standard deviation (SD) and compared by a one-way analysis of variance (ANOVA). Post Hoc test: Least Significant Difference (LSD) was used for multiple comparisons between different variables. Qualitative variables were presented as frequency and percentage (%) and were analyzed utilizing the Chi-square test. A two tailed P value < 0.05 was considered statistically significant [(9)].

Results

Comparison between the three groups according to demographic ddata & ABP;

There was no statistically significant difference between 3 groups as regard to age and gender. There was highly statistically significant difference between the three groups according to body mass index as individuals of group A had statistically significant lower BMI in comparison to those of group B and C (P-value <0.001). But individuals of group C had statistically insignificant lower BMI in comparison to those of group B (P-value >0.05). There was no statistically significant difference between three groups as regard to ABP measurements**.** Table 1

Comparison between three groups according to fat, muscle percentages;

As regard analysis of InBody results of all study participants to compare fat percentage and muscle mass percentage there was statistically high significant difference between three groups. By analysis of body fat percentages of the three groups we found that; there was statistically significant increase in group B in comparison to the other two groups (A and C).There was no significant difference between group A and group C as regard to body fat percentage (P-value >0.05). By analysis of muscle mass percentages of the three groups we found that; there was statistically significant increase in group C in comparison to the other two groups (A and B) as mean muscle mass was [43.66±0.46 vs. 35.43±2.49 vs. 36.07±1.57; respectively (P-value <0.001)]. There was no statistically significant difference between group A and group B as regard to muscle mass percentage (P-value >0.05). Table 2

Table 1: Comparison between the three groups according to demographic data & ABP

Demographic data and ABP	**Groups**			**p-value**
	Group A ***(n=50)***	**Group B** ***(n=50)***	**Group C** ***(n=50)***	
Age (years)	29.4±8.88	31.8±8.7	30.6±9.68	0.421
Sex				
Female	20	18	15	0.574
Male	30	32	35	
BMI (m^2/Kg)	20.98±6.03	27.1±3.66	26.4±4.54	<0.001* P1<0.001* P2<0.001* P3=0.398
Systolic ABP (mmHg)	115±11.81	120±10.52	118±13.91	0.121
DiastolicABP (mmHg)	75±5	75±4.18	76±6.52	0.557

Data are represented as Mean±SD or frequency P1: Comparison between Group A and Group B, P2:Comparison between Group A and Group C, P3: Comparison between Group B and Group C, *: statistically significant as P value <0.05.

Table 2: Comparison between three groups according to fat, muscle percentages and ABP.

Body fat and muscle mass %	**Groups**			**ANOVA**	**Post HOC**		
	Group A ***(n=50)***	**Group B** ***(n=50)***	**Group C** ***(n=50)***	**p-value**	**P1**	**P2**	**P3**
Fat	15.66±2.36	26.52±3.33	15.07±2.21	<0.001**	<0.001*	0.2	<0.001*
muscle	35.43±2.49	36.07±1.57	43.66±0.46	<0.001**	0.127	<0.001*	<0.001*

Data are represented as Mean±SD or frequency P1: Comparison between Group A and Group B, P2:Comparison between Group A and Group C, P3: Comparison between Group B and Group C, *: statistically significant as P value <0.05.

Comparison between three groups according to Echocardiographic data;

There was statistically significant difference between three groups as regard to pulsed wave doppler measurements between the three groups. As regard E wave there was significant increase in C group in comparison to A and B groups. E wave was significantly decreased in B group in comparison to A group (P-value <0.001). As regard A wave there was significant decrease in C group in comparison to A and B groups. A wave was insignificantly decreased in B group in comparison to A group (P-value >0.05). As regard E/A ratio there was significant increase in C group in comparison to A and B groups. However, as regard A and B groups E/A ratio was insignificantly decreased in B group in comparison to A group (P-value >0.05). Table 3

There was statistically high significant difference between three groups as regard to tissue doppler measurements between the three groups. septal e′ and lateral e′ were significantly increased in C group in comparison to A and B groups. septal e′ and lateral e′ were significantly increased in A group in comparison to B group (P-value <0.001). Average E/ e′ was significantly decreased in C group in comparison to A and B groups, also it was significantly decreased in A group in comparison to B group (P-value <0.001). Table 3

Although all groups had normal parameters but by forming correlation between fat versus muscle and average E/ e′ the results were as following: The body fat percentage showed a significant positive correlation with value of average E/ e′ (r= 0.6966& P< 0.05) which indicates that average E/ e′ increased progressively with increased body fat percentage. The muscle mass percentage showed a significant negative correlation with value of average E/ e′ (r= -0.5797& P< 0.05) which indicates that average E/ e′ decreased progressively with increased muscle mass percentage. Figure 1

As regard TR velocity there was significant increase in C group in comparison to A and B groups as mean TR velocity was insignificantly decreased in A group in comparison to B group (P-value >0.05). Table 3

LAVI was significantly increased in C group in comparison to A and B groups. It was significantly decreased in A group in comparison to B group (P-value <0.05). Table 4

Although all values are in normal range but both TRV and LAVI are significantly increased in group C which may indicates biventricular pressure over load.

There was no statistically significant difference between three groups as regard LVEF by 2D Simpson method and LV global longitudinal strain. Table 4

Table 3: Comparison between three groups according to pulsed wave parameters, TDI parameters and TR velocity

Pulsed wave parameters	**Groups**			**ANOVA**	**Post HOC**		
	Group A ***(n=50)***	**Group B** ***(n=50)***	**Group C** ***(n=50)***	**p-value**	**P1**	**P2**	**P3**
E (cm/s)	75.6±7.7	61.8±12.97	85.6±5.73	<0.001*	<0.001*	<0.001*	<0.001*
A (cm/s)	51.1±7.13	49.95±11.26	44.6±4.93	<0.001*	0.543	<0.001*	<0.05*
E/A ratio	1.41±0.94	1.39±0.47	1.93±0.09	<0.001*	0.893	<0.001*	<0.001*
Dec. time (sec)	183±21.14	217.8±65.91	309.6±37	<0.001*	<0.001*	<0.001*	<0.001*
TDI parameters (cm/s)							
Septal e′	13.4±1.89	10.6±2.7	16.5±1.58	<0.001*	<0.001*	<0.001*	<0.001*
Lateral e′	18.2±1.3	12.6±2.3	22.8±1.68	<0.001*	<0.001*	<0.001*	<0.001*
Average E/ e′	4.78±0.58	5.43±0.7	4.29±0.31	<0.001*	<0.001*	<0.001*	<0.001*
TR velocity (m/s.)	1.91±0.27	1.96±0.18	2.12±0.47	<0.05*	0.279	<0.05*	<0.05*

Data are represented as Mean±SD or frequency P1: Comparison between Group A and Group B, P2:Comparison between Group A and Group C, P3: Comparison between Group B and Group C, *: statistically significant as P value <0.05, TR: tricuspid regurge

Table 4: Comparison between three groups according to Lt. atrial volume index, and LVEF%.

	Groups			**ANOVA**		**Post HOC**		
	Group A ***(n=50)***	**Group B** ***(n=50)***	**Group C** ***(n=50)***	**F**	**p-value**	**P1**	**P2**	**P3**
LAVI (ml/m^2)	20.59±2.6	22.42±4.59	32.79±2.01	203.75	<0.001*	<0.05*	<0.001*	<0.001*
LVEF%	65±10.271	63±11.845	66±9.67	1.159	0.317	0.369	0.617	0.169
GLS %	-18.09±1.21	-17.94±0.93	-17.89±0.75	0.562	0.571	0.489	0.323	0.768

Data are represented as Mean±SD or frequency P1: Comparison between Group A and Group B, P2: Comparison between Group A and Group C, P3: Comparison between Group B and Group C, *: statistically significant as P value <0.05, LAVI : left atrial volume index, LVEF: left ventricle ejection fraction, GLS: global longitudinal strain .

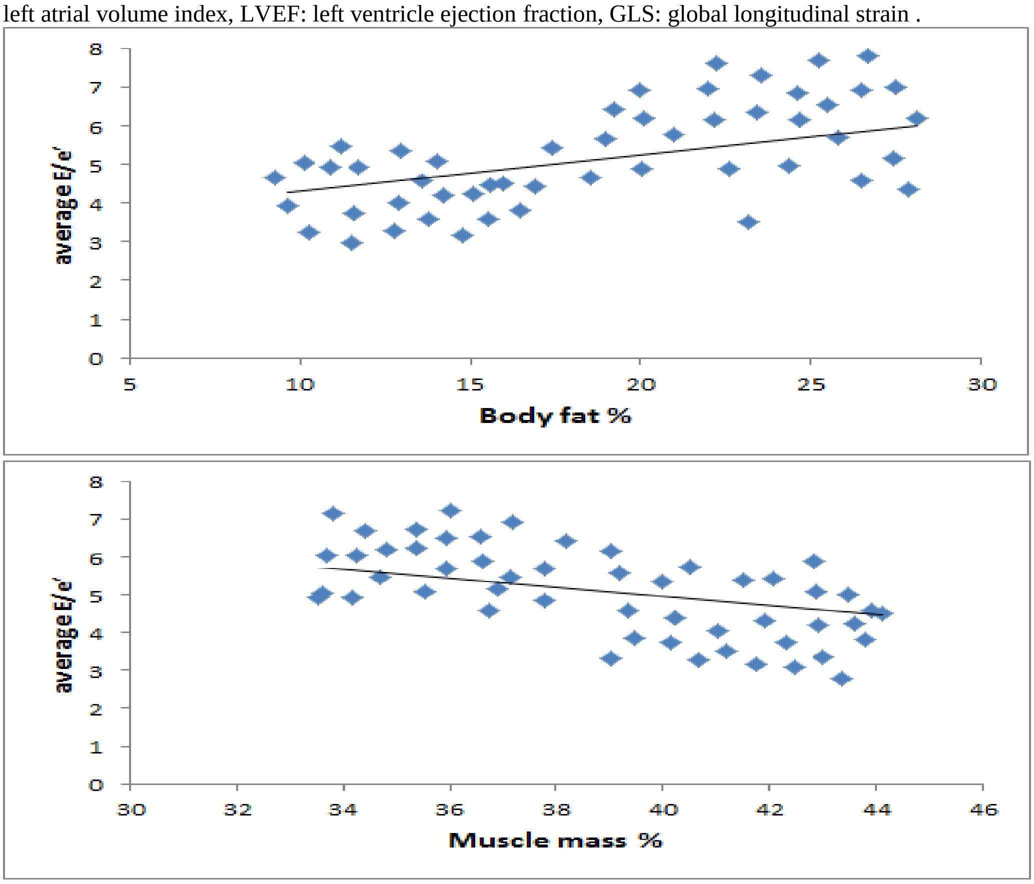

Figure 1: Correlation between Fat and average E/ e′ versus muscle mass and Average E/ e′.

Discussion

There is currently a worldwide epidemic of obesity. Body mass index (BMI) the most common way to assess obesity is not considering the increased proportion of body components, thus it may be different when fat of body is more than normal or muscle mass is high even if the BMI is equal in both cases. So, we should study the effect of both probabilities on diastolic function, In recent years, usage of Bioelectrical Impedance analysis (BIA) which can calculate the percentage of all body components separately, enables us studying both groups separately

Our study results were concordant with Kossaify et al., who studied the impact of overweight and obesity on left ventricular diastolic function and value of tissue Doppler echocardiography regarding the demographic data (age & sex) and ABP, there was no statistically significant difference between the groups of the study. Which confirm that any difference in diastolic function between the three groups was not due to age differences, other demographic data or ABP variation and the study results were valuable for both sexes. [(10)]

Regarding pulsed wave doppler imaging in our results; E wave was significantly increased in group C in comparison to A & B groups. E wave was significantly decreased in B group versus A group. A wave and E/A ratio were significantly decreased in C group in comparison to A&B groups. However; A wave and E/A ratio were insignificantly decreased in group B in comparison to A group. The study results were consistent with the study conducted by Shemirani et al., who found that obesity decreases E wave significantly in comparison to individuals

with normal BMI [11]. The study results were consistent with the studies conducted by Kossaify et al., and Hassan et al., who studied the effect of obesity on left ventricular mass and diastolic function. The previous two studies found that there was no statistically significant difference regarding A wave and E/A ratio between the groups of the studies. [10,12]. Arad et al., who compared sedentary men with weight lifters was in agreement with our results as they showed that E wave & E/A ratio were significantly increased and A wave was significantly decreased in weight lifters group in comparison to sedentary group. However, no body mass index classification mentioned in this study. [13]
On the contrary to our study, the study carried out by Russo et al., who studied the relation between overweight, obesity and left ventricular diastolic function showed that higher BMI was associated with significantly higher E wave & peak A wave and significantly lower E/A ratio which clarify the effect of age and other comorbidities on ABP. [14]
Our study data regarding tissue doppler parameters showed that e′ was significantly increased in C group in comparison to A and B groups. It was significantly increased in A group in comparison to B group. Average E/ e′ was significantly decreased in C group in comparison to A and B groups. It was significantly decreased in A group in comparison to B group. Regarding the same tissue Doppler parameters, studies conducted by Kossaify et al., and Hassan et al., came with our study results regarding e′ wave and said that obesity decreased e′ wave significantly in comparison to individuals with normal BMI [10,12]. Our study results were similar to the study conducted by Shemirani et al., that found that obesity decreased e′ wave significantly in comparison to individuals with normal BMI. As such it showed also the same result as our study regarding average E/ e′ that was significantly increased in obesity versus individuals with normal BMI. [11] Our study results were concordant with the study conducted by Bekfani et al., who studied body composition in patients with diastolic dysfunction and its effect on muscle strength and exercise capacity. They found that patients with higher lean mass (body mass without fat) had significantly decreased E/ e′ in comparison to individuals with lower lean mass. [15] Also, our study results were identical to the study conducted by Yoo et al., that studied Relationship between skeletal muscle mass, sarcopenic obesity and diastolic dysfunction in Korean adults. They found that patients with higher skeletal muscle mass index had significantly decreased E/ e′ in comparison to individuals with lower skeletal muscle mass index. [16] On the contrary to our study, the study carried out by Pang et al., who studied the relation between grip strength, muscle mass and left ventricular diastolic function during aging in chines. They showed that elevated muscle strength, but not muscle mass, was associated with better left ventricular diastolic function. But the mentioned study compared diastolic function in male and female patients aged 25-95 years, which clarify the effect of age and exercise on diastolic function. [17]
In our study TR velocity was significantly increased in C group in comparison to A and B groups. But it was insignificantly decreased in A group in comparison to B group. Our study results were similar to the study conducted by Shemirani et al., who found that there is no significant difference between subjects with BMI < 25 and cases with high BMI regarding TR velocity [11]. This study was in agreement with our study results regarding comparison between A group and B group.
In the current study as regard LAVI; there was significant increase in group C in comparison to A and B groups. Also, it was significantly decreased in A group in comparison to B group. The study results went in line with the study conducted by Hassan et al., who found that obesity

increased LAVI significantly in comparison to individuals with normal BMI [12].

This study found that there was no statistically significant difference between the three groups as regard to LV systolic function by 2D Simpson method as showed by Karimian et al., who studied the impact of sever obesity and weight loss on systolic LV function and morphology. They found that there was no statistically significant difference between lean and obese individuals regarding LV systolic function [18].

Conclusion

Based on our findings, individuals with increased muscle mass percentage and normal body fat percentage has super normal diastolic compliance in spite of increased body mass index. But this group has increased Lt atrial volume index and TR velocity which indicates chronic biventricular pressure overload. It is not fair enough to put muscle builders in the same group with increased fat persons only due to their equal BMI, as our study showed a significant difference between both groups regarding diastolic function.

Limitations

A main limitation of our study was the small portion of population who exercise or body building trainee. Doing similar studies with larger sample, which wasn't available in our study, will empower the results and enable us to confidently develop a role model for use in the wider clinical context. Measurements of diastolic function parameters are in the millimeter range, so small motions of the trackball will result in a large difference (measurement error).

References

1. Boudina S, Sena S, Theobald H, Sheng X, Wright JJ, Hu XX, et al. Mitochondrial energetics in the heart in obesity-related diabetes: direct evidence for increased uncoupled respiration and activation of uncoupling proteins. Diabetes. 2007;56:2457-66.
2. Conley SM, Hickson LJ, Kellogg TA, McKenzie T, Heimbach JK, Taner T, et al. Human Obesity Induces Dysfunction and Early Senescence in Adipose Tissue-Derived Mesenchymal Stromal/Stem Cells. Front Cell Dev Biol. 2020;8:197.
3. Davids S, Lauffer H, Thoms K, Jagdhuhn M, Hirschfeld H, Domin M, et al. Increased dorsolateral prefrontal cortex activation in obese children during observation of food stimuli. Int J Obes (Lond). 2010;34:94-104.
4. Huynh QL, Kalam K, Iannaccone A, Negishi K, Thomas L, Marwick TH. Functional and Anatomic Responses of the Left Atrium to Change in Estimated Left Ventricular Filling Pressure. J Am Soc Echocardiogr. 2015;28:1428-33.e1.
5. Arnold K, Weinhold KR, Andridge R, Johnson K, Orchard TS. Improving Diet Quality Is Associated with Decreased Inflammation: Findings from a Pilot Intervention in Postmenopausal Women with Obesity. J Acad Nutr Diet. 2018;118:2135-43.
6. Tantisattamo E, Sy J, Kim J-C, Kopple JD, Kalantar-Zadeh K. Chapter 12 - Assessment and risk factors for protein-energy wasting and frailty in chronic kidney disease. In: Kopple JD, Massry SG, Kalantar-Zadeh K, Fouque D, editors. Nutritional Management of Renal Disease (Fourth Edition): Academic Press; 2022. p. 165-89.
7. Mason EE, Renquist KE. Gallbladder management in obesity surgery. Obes Surg. 2002;12:222-9.
8. Nagueh S, Smiseth O, Appleton C, Byrd BF, Dokainish H, Edvardsen T, et al. Recommendations for the evaluation of left ventricular diastolic function by echocardiography: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. European Journal of Echocardiography, 2016; 17(12): 121-1360
9. Peacock J, Peacock JL and Peacock P. Oxford handbook of medical statistics, 2021.
10. Kossaify A, Nicolas N. Impact of overweight and obesity on left ventricular diastolic function and value of tissue Doppler echocardiography. Clin Med Insights Cardiol. 2013;7:43-50.
11. Shemirani H, Tajmirriahi M, Nikneshan A, Kleidari B. The relation between obesity and left ventricular diastolic function in young people: A cross-sectional study. ARYA Atheroscler. 2021;17:1-6.
12. Hassan BA, Deli FA, Noaman AH, Mohammed SJ. Effect of obesity on left ventricular mass and diastolic function. Systematic Reviews in Pharmacy. 2020;11.

13. Arad M, Adler Y, Koren-Morag, Natanzon S, Sela BA, Dov IB, et al. Exercise training in advanced heart failure patients: discordance between improved exercise tolerance and unchanged NT-proBNP levels. *International journal of cardiology*. 2012; *126*(1): 114-119.
14. Russo C, Jin Z, Homma S, Rundek T, Elkind MS, Sacco RL, et al. Effect of obesity and overweight on left ventricular diastolic function: a community-based study in an elderly cohort. *Journal of the American College of Cardiology*. 2011; *57*(12): 1368-1374.
15. Bekfani T, Valentova M, Ebner N, Sandek A, Anker SD, Doehner W, et al. Body composition in patients with diastolic dysfunction and heart failure with preserved ejection fraction and its effect on muscle strength and exercise capacity. European Heart Journal. 2013; 34(suppl_1): P2441.
16. Yoo J, Park S, Jun J, Jin SM, Hur KY, Lee MK, et al. Relationship between low skeletal muscle mass, sarcopenic obesity and left ventricular diastolic dysfunction in Korean adults. Diabetes/Metabolism Research and Reviews. 2021 Jan; 37(1): e3363.
17. Pang S, Qi H, Chen S, Liu J, Sheng Y. Muscle Strength, but Not Muscle Mass, Is Associated with Left Ventricular Diastolic Function during Aging in Chinese. International Heart Journal. 2022 Nov 30; 63(6): 1115-20.
18. Karimian S, Stein J, Bauer B, Teupe C. Impact of Severe Obesity and Weight Loss on Systolic Left Ventricular Function and Morphology: Assessment by 2-Dimensional Speckle-Tracking Echocardiography. J Obes. 2016;2016:2732613.

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