



# Study of Cardiovascular Changes in Adolescents with Simple Obesity

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## Abstract

Obesity is a risk factor for cardiovascular morbidity and mortality that has deleterious effects on cardiovascular function. The aim of this work was to screen early cardiovascular abnormalities in obese asymptomatic adolescents using Conventional Echocardiography and Electrocardiogram. Fifty asymptomatic obese adolescents selected from National Heart Institute were compared to fifty non-obese normal controls with mean age of ( $12.44 \pm 1.91$ ) and ( $11.99 \pm 1.89$ ) years respectively. All studied adolescents were subjected to: careful history taking, complete clinical examination, laboratory investigation: fasting blood glucose, lipid profile, fasting insulin, insulin resistance, echocardiography and ECG. **Results:** It revealed statistical significant differences between obese and non-obese groups regarding left ventricle septal wall in diastole (LVSD), posterior wall thickness in diastole (LVPWd), relative wall thickness (RWT), LV end diastolic and systolic diameter (LVEDD and LVESD) and LV mass (P-value: 0.000). The left atrial dimensions (LA) were also significantly higher in the obese subjects than in the control group (P-value: 0.000). For the Doppler measurements, the early and late mitral valve velocity and the ratio between them (MVE velocity, MVA velocity and MV E/A) were significantly higher in obese than control subjects (P-value: 0.000). A strong positive correlation was noted between BMI and left atrial size (P-value: 0.003), left ventricular septum in diastole (LVSD) (P-value: 0.000), LVEDD (P-value: 0.005) and LVESD (P-value: 0.000), posterior wall thickness in diastole (LVPWd) (P-value: 0.012), left ventricle septal wall in diastole (LVSD) (P-value: 0.000) and left ventricular mass (P-value: 0.010). **Conclusion:** This study demonstrated that asymptomatic obese adolescents had significant changes in left ventricular dimensions and early diastolic filling compared to non-obese subjects.

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## Subject Areas

Cardiology

## Keywords

Obesity, Left Ventricular Function

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## 1. Introduction

Obesity in adolescence has reached epidemic proportions around the world, with the prevalence of severe obesity increasing at least 4-fold over the last 35 years. Most youths with obesity carry their excess adiposity into adulthood [1]. This represents a situation that demands urgent attention to avoid its potential morbidity and mortality [2].

Obesity is a risk factor for cardiovascular morbidity and mortality that has deleterious effects on cardiovascular function [3]. There have been some reports that obesity in children and adolescents causes echocardiographic as well as ECG abnormalities with an increased risk of adverse cardiovascular outcomes [4]. Subclinical changes in myocardial function and endothelial regulation, and tendency to hypertension have been reported among obese children and adolescents [5].

There is strong evidence that weight loss in overweight or obese individuals reduces the risk of diabetes and cardiovascular diseases [6].

### 1.1. Aim of the Work

To screen early cardiovascular abnormalities in obese asymptomatic adolescents using conventional echocardiography and electrocardiogram.

### 1.2. Subjects and Methods

The current study was a cross sectional comparative study that included 100 adolescents: 50 of them had simple obesity and were free of cardiac symptoms and the remaining 50 were apparently healthy non-obese adolescents. Cases were randomly selected from obesity clinic of National Nutrition Institute, during the period of March 2017 to March 2019. The eligibility criteria for participants of the obese subjects were the ones defined by WHO percentile Body Mass Index “BMI”/age for males and females [7]. Any participant having secondary obesity or a chronic illness involving the heart, or being taking medications associated with weight change was excluded from this study.

**All studied adolescents were subjected to:** complete medical history, thorough clinical examination to exclude secondary obesity & chronic disease, anthropometric measurements (weight, height, waist circumference & BMI), laboratory investigation (lipid profile, fasting blood glucose & fasting insulin), echocardiographic measurements and electrocardiography.

### 1.3. Ethical Considerations

Written informed consent from all participant families was taken prior to their enrolment into the study.

## 2. Methodology

- **Anthropometric measures** were measured according to standardized methods of WHO [7]. BMI was calculated as weight divided by the square of height ( $\text{kg/m}^2$ ) [8]. The WHO percentile body mass index “BMI”/age for males and females charts was used to determine the body status [7] (Table 1).
- **Laboratory investigation.** Participants were asked to fast the night before the blood was collected from them. Fasting blood glucose [9], fasting insulin [10] and lipid profile [11] were determined.
- **Echocardiographic measurements.** All measurements had been performed according to the recommendations of the American Society of Echocardiography (ASE) [12] including:

*Standard resting transthoracic echocardiography (TTE):* all patients had undergone TTE using General Electric VIVID 7, Echo ultrasonography machine 2008, and M4S transducer, with a frequency of 1.5 - 4.3 MHz and 5 S with frequency 5 MHz.

The following criteria have been evaluated:

1) Left ventricular systolic function; left ventricular end diastolic (EDD), end systolic diameter (ESD) and ejection fraction (EF) had been obtained in the parasternal short axis-papillary level view using M mode and in the leading edge methodology [12].

2) The relative wall thickness (RWT); has been calculated from the posterior wall thickness (PWT) and the EDD, as  $(2 \times \text{PWT})/\text{EDD}$ . Above normal values indicate increased RWT according to Neadorf and his colleagues [13].

3) The LV mass had been calculated using the following equation:

$$\text{LV mass} = 0.8 \left[ 1.4 \times (\text{PWT} + \text{VST} + \text{LVEDD})^3 - (\text{LVEDD})^3 \right] + 0.6$$
 . Above normal value indicates LV hypertrophy [14].

4) LV mass index; had been calculated as the LV mass/body surface area (BSA).  $\text{BSA} = 0.007184 \times (\text{weight in Kg})^{0.425} \times (\text{Height in M})^{0.725}$ . Above normal value indicates LV hypertrophy [13].

5) Left ventricular diastolic function: Pulsed Doppler measurements had been obtained in the apical four chambers view. The Doppler beam had been aligned perpendicular to the plane of the mitral annulus and a 5 mm-pulsed wave Doppler sample volume was placed between the tips of the mitral leaflets during

**Table 1.** BMI/age for males and females charts.

Normal Weight	5 <sup>th</sup> < 85 <sup>th</sup> percentile
Over-weight	85 <sup>th</sup> < 95 <sup>th</sup> percentile
Obese	>95 <sup>th</sup> percentile

diastole. The following variables had been calculated: maximum velocity of early mitral filling (E), maximum velocity of late mitral filling (A), ratio of early to late velocity (E/A) [14].

6) Cardiac morphology: left atrial diameter, left ventricular end diastolic diameter (LVEDD), the relative wall thickness (RWT) and left ventricular mass (LV mass) [15].

7) Diastolic function had been calculated by measuring the following velocities:

- *Early diastolic velocity (E)*: By measuring the peak velocity of early diastolic mitral inflow in all parts of mitral annulus (normal value is  $\geq 0.04$  m/sec, and if it is  $\leq 0.04$  m/sec, it indicated LV diastolic dysfunction).
- *Late diastolic velocity (A')*: by measuring the peak velocity of late diastolic mitral inflow in all parts of mitral annulus.
- *E/A' ratio* [16].
- **Electrocardiography.** Twelve-lead resting electrocardiogram (ECG) was conducted for all adolescents using Philips machine, model: CARDIOVIT-AT2, year of establishment: 1999 for assessment of ECG data including all waves, intervals, axis deviation and any arrhythmias.

**Statistical analysis.** Statistics was performed through IBM PC, using Statistical Package for Special Science (SPSS) software computer program version 23. The tests used were:

- 1) **Chi-square test** and/or **Fisher exact test** when the expected count in any cell found less than 5.
- 2) **Independent t-test** for parametric data while with nonparametric data were done by using **Mann-Whitney test**.
- 3) **Linear regression analysis** was used to assess the correlation between echo parameters with weight and BMI of the studied cases.
- 4) Confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the *p*-value was considered significant as the following:  
*P*-value > 0.05: Non significant (NS)  
*P*-value < 0.05: Significant (S).

### 3. Results

Results for this work are presented in **Tables 2-7**.

### 4. Discussion

Obesity in children and adolescents is one of the most alarming public health issues facing the world. It has long-term adverse effects on morbidity and mortality [17]. Adolescence has been identified as a critical period for the development of persistent obesity on the basis of the strong evidence for tracking of adolescent adiposity into adulthood. Adolescent obesity is associated with all the long-term risks of adult obesity and carries additional risks for metabolic disorders associated with the earlier onset [18]. The current study provided evidence

**Table 2.** Comparison between left side heart dimensions among both studied groups.

Echo measurements		Obese group	Control group	Test value	P-value	Sig.
		No. = 50	No. = 50			
LVSd	Mean $\pm$ SD	0.85 $\pm$ 0.18	0.60 $\pm$ 0.06	9.134	0.000	HS
	Range	0.6 - 1.2	0.5 - 0.7			
LVSs	Mean $\pm$ SD	1.27 $\pm$ 0.31	0.80 $\pm$ 0.16	9.438	0.000	HS
	Range	0.7 - 1.9	0.7 - 1.1			
LVIDd	Mean $\pm$ SD	4.49 $\pm$ 0.49	3.92 $\pm$ 0.16	7.926	0.000	HS
	Range	3.7 - 5.5	3.8 - 4.2			
LVIDs	Mean $\pm$ SD	2.85 $\pm$ 0.53	2.38 $\pm$ 0.08	6.199	0.000	HS
	Range	2 - 4	2.3 - 2.5			
LV PWd	Mean $\pm$ SD	0.85 $\pm$ 0.24	0.48 $\pm$ 0.12	9.815	0.000	HS
	Range	0.5 - 1.7	0.4 - 0.7			
LA size	Mean $\pm$ SD	3.08 $\pm$ 0.54	2.18 $\pm$ 0.24	10.753	0.000	HS
	Range	2.2 - 3.8	2 - 2.6			

There was statistically significant increase in left ventricular dimensions and left atrium size among obese group compared to control group.

**Table 3.** Comparison between systolic function and LV mass among studied group.

ECHO finding		Obese group No. = 50	Control group No. = 50	Test value	P-value	Sig.
LV systolic function (EF%)	Mean $\pm$ SD	69.94 $\pm$ 6.84	69.92 $\pm$ 3.38	0.019•	0.985	NS
	Range	55 - 80	65 - 77			
RWT	Mean $\pm$ SD	0.37 $\pm$ 0.10	0.28 $\pm$ 0.08	4.970•	0.000	HS
	Range	0.23 - 0.73	0.21 - 0.39			
LV mass	Mean $\pm$ SD	124.52 $\pm$ 41.80	54.20 $\pm$ 14.42	11.244•	0.000	HS
	Range	62 - 194	41 - 78			
LV mass index	Mean $\pm$ SD	70.70 $\pm$ 22.63	44.00 $\pm$ 9.73	7.664•	0.000	HS
	Range	30 - 109	36 - 62			

There was statistically significant increase in RWT, LV mass and LV mass index among obese group compared to control group.

**Table 4.** Comparison between LV morphology among studied group.

ECHO finding		Obese group No. = 50	Control group No. = 50	Test value	P-value	Sig.
LV morphology	Normal	37 (74.0%)	50 (100.0%)	14.943*	0.010	HS
	Concentric remodeling	5 (10.0%)	0 (0.0%)			
	Concentric hypertrophy	8 (16.0%)	0 (0.0%)			

Obese adolescents showed significant LV concentric remodeling and hypertrophy when compared to controls.

**Table 5.** Comparison between diastolic function of left ventricle among both studied groups.

Echo measurements		Obese group	Control group	Test value	P-value	Sig.
		No. = 50	No. = 50			
MV E vel	Mean $\pm$ SD	1.07 $\pm$ 0.18	0.91 $\pm$ 0.12	5.361	0.000	HS
	Range	0.74 - 1.47	0.75 - 1.1			
MV A vel	Mean $\pm$ SD	0.63 $\pm$ 0.11	0.54 $\pm$ 0.06	5.252	0.000	HS
	Range	0.45 - 0.88	0.45 - 0.6			
E/A ratio	Mean $\pm$ SD	1.69 $\pm$ 0.31	1.44 $\pm$ 0.16	4.953*	0.000	HS
	Range	1.2 - 2.2	1.2 - 1.7			

There was significant increase in the E/A ratio among obese group when compared to control group. Indicating decrease diastolic function in obese group than control.

**Table 6.** Comparison between ECG finding among studied groups.

ECG		Obese cases	Normal cases	P-value	Sig.
		No. = 50	No. = 50		
Heart rate (BPM)	Mean $\pm$ SD	78.64 $\pm$ 10.59	77.10 $\pm$ 11.93	0.496	NS
	Range	64 - 98	56 - 98		
PR interval (ms)	Mean $\pm$ SD	113.60 $\pm$ 14.81	118.00 $\pm$ 14.57	0.137	NS
	Range	80 - 120	80 - 150		
QRS interval (ms)	Mean $\pm$ SD	118.80 $\pm$ 14.80	118.20 $\pm$ 16.25	0.847	NS
	Range	80 - 140	80 - 150		
ST segment (ms)	Mean $\pm$ SD	202.80 $\pm$ 40.66	199.20 $\pm$ 41.25	0.661	NS
	Range	150 - 280	120 - 280		
Corrected QT interval (ms)	Mean $\pm$ SD	321.60 $\pm$ 36.50	317.40 $\pm$ 33.86	0.552	NS
	Range	270 - 400	270 - 400		
Lt axis deviation	No	40 (80.0%)	50 (100.0%)	0.001	HS
	Yes	10 (20.0%)	0 (0.0%)		

There was no significant difference between the two studied group in ECG findings except for left axis deviation.

that asymptomatic obese children already exhibit abnormalities in left ventricular structure and function (consisting of increase left ventricular wall dimensions, mass, and alteration in diastolic function). This is in agreement with Putte-Katier *et al.* (2008) [19] and Kibar *et al.* (2012) [20]. Our results had shown that obesity affected the cardiac morphology and the diastolic function of left ventricle more than the systolic function.

**Regarding the cardiac morphology,** our results had shown that there was high significant increase in left atrium diameter and left ventricular mass (LVM) in obese compared to non-obese subjects. The Bogalusa Heart Study showed a strong association between LVM in childhood and degree of obesity [21] in agreement with our results. Okpara *et al.* (2010) [2] suggested that left atrium enlargement is an independent risk factor for adverse cardiovascular outcome.

**Table 7.** Correlation between echocardiographic parameters and BMI.

	BMI	
	r	P-value
LA size	0.413	0.003**
RWT	-0.212	0.140
LV mass	0.361	0.010**
LVESD	0.484	0.000**
LVEDD	0.395	0.005**
LVPWd	0.354	0.012*
LVSD	0.485	0.000**
LVSs	-0.146	0.311
MV E vel	-0.062	0.666
MV A vel	-0.018	0.901

There was significant positive correlation between LA size, LV mass, LVESD, LVEDD, LVPWd, LVSD and BMI.

They also demonstrated that obesity was associated with increased left ventricle wall thickness (LVSD and PWTD), increased left ventricle internal diameter (LVID), increased LV mass and hypertrophy (LVM, LVH). These data are matched with ours. Deng *et al.* (2010) [22] reported that LVM and LV mass index were significantly higher in obese than non-obese group. We found that 10% had concentric remodeling and 16% had concentric hypertrophy versus 100% normal cardiac morphology in control group in agreement with our results. Peterson *et al.* (2004) [23], reported that concentric LV hypertrophy was a predominant finding in obese subjects. These results suggest that left ventricular hypertrophy (LVH) is one of the cardiac complications of obesity and echocardiographically determined LVH is a powerful independent predictor cardiovascular morbidity and mortality [24].

**Regarding Diastolic Function**, conventional Echo Doppler can detect the diastolic dysfunction subclinical left ventricular dysfunction in several disorders with normal standard parameters of global left ventricular systolic function [25]. The wide spread use of pulsed Doppler Echocardiography has facilitated the noninvasive evaluation of abnormalities in the hemodynamic events between left atrium (LA) and left ventricle (LV) by using transmitral flow velocity pattern [26]. In the present study, Conventional Doppler measurements indices of septal mitral annulus showed statistical significant difference in MVE, MVA and MVE/A ratio between the obese and non-obese groups. Supporting these findings, Wouter *et al.* (2018) [27] found that, in obese adolescents, mitral A-wave velocity, E-wave velocity were significantly elevated, as opposed to lean controls.

**Regarding the systolic function**, we observed no difference in left ventricular ejection fraction between obese and control groups, which was in agreement with the results of the study of Mehta *et al.* (2004) [28].

**Regarding the correlation** between cardiac findings with obesity & obesity

related complication in the present study, we found significant positive correlation between BMI and each of the following cardiac dimensions: LAD, LVIDs, LVIDd, LVPWd, LVSD and LV mass.

## 5. Conclusions and Recommendations

In conclusion, present study demonstrated that:

- Left sided cardiac dimensions were significantly increased in studied obese adolescents than controls.
- Both MVE and MVA as well as E/A ratio were significantly higher in obese adolescents compared to controls indicating LV diastolic dysfunction.
- Concentric LV hypertrophy was significantly higher in obese adolescents than controls.
- A significant positive correlation was found between LV dimensions and BMI in obese adolescents.

The onset of obesity associated cardiac disease is asymptomatic so, periodic cardiac monitoring is recommended for its detection & management.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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