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Original Article (Pages: 18355-18361)

Echocardiographic Comparison of Myocardial Performance between Obese and Normal Weight Children and Adolescents

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Abstract

Background: Obesity prevalence has increased alarmingly in recent decades as a result of lifestyle changes. Obesity can have adverse effects during childhood and adolescence, which often persist into adulthood. Some studies have shown that echocardiographic findings are associated with obesity, accompanied by an increase in the left ventricle's size, diameter, and weight. This study compared Tissue Doppler and Pulse Doppler echocardiographic changes between obese and normal weight children and adolescents.

Method: In 2021, this research was conducted on 66 children and adolescents aged 9 to 18 in Birjand. It included 33 individuals, comprising 25 boys and 8 girls, with a Body Mass Index (BMI) greater than 95, classified as the obese group, and 33 individuals, comprising 21 boys and 12 girls with a BMI between 10 and 85, ranked as the control group. The two groups' parameters were measured using Tissue Doppler Index (echocardiography), and the data was analyzed using SPSS version 16 at a significance level of less than 0.05.

Result: The obese and normal weight groups had average ages of 12.84±1.92 and 12.87±2.87, respectively. In the obese group, the average BMI was 28.52±4.3, while in the control group, it was 16.55±2.21. The average EF (Ejection Fraction) in the obese group was 247.13±32.44, and in the control group, it was 249.6±24.68.

In the obese group, the mean values of the parameters S´, A', and A were 12.91±2.63, 12.61±2.75 and 74.83±16.75, while in the control group, they were 11.47±2.66, 10.28±2.72, and 63.21±15.41. The obese group had substantially higher values compared to the control group ($P<0.05$). The mean values of IVRT, IVCT, MPI, E', and E were more significant in the obese group than in the control group, whereas ET and E/A were more significant in the control group. These differences, however, were not statistically significant.

Conclusion: The significant increase in diastolic dysfunction parameters, including A' and E'/A', in the obese group may indicate a severe type of LV Compliance Decrease.

Key Words: Adolescents, Children, Diastolic function, Echocardiography, Obesity.

* Please cite this article as: Salehi F, Arianejad M, Taheri F, Chahkandi T. Echocardiographic Comparison of Myocardial Performance between Obese and Normal Weight Children and Adolescents. Int J Pediatr 2023; 11 (11):18355-18361. DOI: **10.22038/ijp.2023.75142.5370**

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Received date: Sep.25,2023; Accepted date: Nov.26,2023

1- INTRODUCTION

The prevalence and severity of childhood obesity have increased dramatically worldwide over the past decades (1). According to some studies, obesity is the second leading cause of mortality worldwide (2). The adverse consequences of childhood obesity appear during childhood and adolescence and continue into adulthood. Obesity is associated with various diseases, such as cardiovascular disease, type 2 diabetes, hypertension, dyslipidemia, and non-alcoholic fatty liver disease (3).

Individuals with a Body Mass Index (BMI) percentile between 10 and 85 are considered normal based on age and gender for children and adolescents up to 18. Individuals with a BMI percentile between 85 and 95 are classified as overweight, whereas those with a BMI above 95 are classified as obese (4).

In addition, the prevalence of adolescent obesity and overweight is increasing in many developed and developing nations (6). In Iran, the prevalence of obesity and overweight has increased dramatically and reached an alarming level (7, 8).

Childhood obesity is regarded as a predictor of adult obesity, which is substantially associated with an increased morbidity due to chronic diseases in adulthood and a higher risk of early death, mainly due to coronary heart disease and certain cancers (9-11).

Obesity is also associated with increased vascular resistance and left ventricular hypertrophy (11). Obesity can indeed cause alterations in the structure and function of the heart, thereby elevating the risk of cardiovascular disorders. Numerous studies have demonstrated a correlation between obesity and cardiovascular disorders such as hypertension, arrhythmias, left atrium enlargement, and decreased diastolic and systolic function (12-14).

In the study conducted by Aryanejad et al., on 9 to 18-year-old children and adolescents, electrocardiographic findings revealed significant differences between the obese group and the standard group. This study demonstrated that obesity can harm the electrocardiographic patterns of young children and adolescents compared to normal-weight individuals. This study showed a statistically significant difference in the e-Tp interval dispersion, representing the difference between the shortest and longest e-Tp intervals in all 12 leads. This finding suggests that a greater dispersion of the e-Tp interval is associated with an increased risk of arrhythmias (15). In another study on 209 children and adolescents investigating the relationship between QT variables and left ventricular dimensions in athletes and obese children, Yıldırım et al. discovered that QT dispersion had increased in both athletes and obese children (16).

Some studies have reported that echocardiographic findings are associated with obesity, including an increase in the left ventricle's size, thickness, and weight (3-6). There are few reports on the association between childhood obesity and the cardiovascular system and echocardiographic parameters in children (17-19). Considering the above information and the lack of studies on echocardiographic findings in obese children, the purpose of this study was to compare echocardiographic changes in tissue Doppler imaging (TDI) and pulse Doppler between obese children and adolescents and their age-matched peers with average weight.

2- MATERIALS AND METHODS

This case-control study was conducted on children and adolescents aged 9 to 18 who visited a pediatric clinic in Birjand in 2021-2022. There were 33 normal-weight individuals in the control group and 33 obese individuals in the case group. Based on the research conducted by

Herszkowicz et al. and the mean Iso-Volumic Relaxation Time (IVRT) in the two obese and control groups, the sample size for this study was determined to be 33 participants in each group (20). The individuals' weight and height were measured. Body Mass Index (BMI) was calculated by dividing the children's weight by a square of their height. Those with a BMI greater than 95 were considered obese, whereas those with a BMI percentile between 10 and 85 comprised the study's controls. Through interviews with the parents, demographic information, including age, medical history, and medication use, was obtained and recorded in the checklist. Individuals with known acute or chronic diseases or medication use in the previous week were excluded from the study, and they were invited back for a comprehensive examination and echocardiography one week later.

A pediatric cardiologist performed echocardiography under standard conditions. Tissue Doppler echocardiography using the Samsung HS 70 device and a Multi-frequency transducer with a 2-4 MHz frequency range were used to evaluate echocardiography parameters for the two groups. Furthermore, the interpretation was based on simultaneous ECG recording on Doppler echocardiography traces.

In both groups, parameters for diastolic dysfunction, such as E', E/A, E'/A', E/E', MPI, E, A, E/A, A', and IVRT, were evaluated and compared. In explaining the parameters of Tissue Doppler, the systolic mitral wave (S'), the two subsequent waves at the beginning of diastole (E'), atrial contraction wave (A'), IVRT (Isovolumic Relaxation Time), and IVCT (Isovolumic Contraction Time) were measured. IVRT (Isovolumic Relaxation Time) is the duration between the S wave's end and the E wave's beginning. IVCT (Isovolumic Contraction Time) is the interval between the end of the A wave and the beginning of the S wave.

The MPI (Myocardial Performance Index) is calculated using the formula MPI = (IVCT + IVRT) / ET. The TDI (Tissue Doppler Imaging) method is utilized for this calculation.

2-1. Data analysis

The collected data were entered into version 16 of the SPSS software. Descriptive statistics were reported using central tendency and dispersion measures. The Kolmogorov-Smirnov test was used to assess the normality of quantitative data. Then, the independent t-test was used for comparing data with a normal distribution, and the Mann-Whitney U test was used for non-normal distributions, with a significance level of less than 0.05. The Chi-Square test or Fisher's exact test was used to compare qualitative data.

3- RESULTS

Tables 1 and **2** show demographic data for the two groups, including age, gender, average weight, height, and BMI. The average values of IVRT, IVCT, MPI, E', and E parameters in the obese group are higher than those in the normal group.

Still, this difference was not statistically significant (**Table 3**).

Table-1: Comparison of the gender frequency distribution in the two groups

Studied Groups Gender	Obese Group Frequency (%)	Group Control Frequency (%)	Independent t-test values
Male	25 (75.8)	21 (63.6)	P=0.422
Female	8 (24.2)	12 (36.4)	

Table-2: Demographic data for both of the obese and control groups

Parameters of the Study Groups	Mean ± SD (q3 – q1) Median		Independent t-test values
	Group Control	Obese group	
Age (year)	12.87 ±2.87	12.84 ±1.92	P=0.265
Height (meter)	1.48 ±0.13	1.58 ±0.12	P=0.002
Weight (kg)	37.2 ±11.05	72.69 ±19.15	P<0.001*
BMI (kg/m2)	16.55 ±2.21	28.52 ±4.3	P<0.001*
BMI percentile	19.27 ±21.03	96.84 ±1.69	P<0.001*

BMI= Body mass index

Table-3: Comparison of the mean echocardiography parameters in the obese and control groups

Parameters of the Study Groups	Normal range	P values	Mean ± SD	
			Control group	Obese group
IVRT (msec)	49 ± 10.3	0.233	59.72 ± 13.44	64.07 ± 15.81
IVCT (msec)	46.7 ± 13	0.101	45.62 ± 11.2	50.31 ± 11.7
ET (msec)	222 ± 83	0.369	249.6 ± 24.68	247.13 ± 32.44
MPI (Tei)	0.41 ± 0.13	0.060	0.42 ± 0.09	0.47 ± 0.09
S´ (cm/s)	10.8 ± 3	0.026	11.47 ± 2.66	12.91 ±2.63
E´ (cm/s)	16.2 ± 3.7	0.918	18.98 ± 4.48	19.44 ± 3.45
A´ (cm/s)	7.9 ± 1.8	0.001	10.28 ± 2.72	12.61 ± 2.75
E (cm/s)	1 ± 0.14	0.223	108.7 ± 16.13	114.8 ± 23.8
A (cm/s)	0.6 ± 0.12	0.005	63.21 ± 15.41	74.83 ± 16.75
E/A	1.8 ± 0.4	0.057	1.77 ± 0.38	1.6 ± 0.32
E´/A´	1.1 ± 0.2	0.001	1.59 ± 0.36	1.91 ± 0.46
E/ E´	≥ 10	0.686	6.13 ± 1.88	6.19 ± 2.31

ET=Ejection Time, IVRT=Iso-Volumic Relaxation Time, IVCT= Iso-Volumic Contraction Time

ET and E/A were more significant in the control group than in the obese group; however, this difference was not statistically significant (P > 0.05). The average values of parameters S', A,' and A were significantly higher in the obese group than in the control group (P<0.05). The E'/E ratio was within the normal range in both groups, and there was no statistically significant difference between the two groups. However, the E'/A' ratio was significantly higher in the obese group than in the control group, indicating that early diastolic dysfunction occurred earlier in the obese group.

4-DISCUSSION

A significant increase in two diastolic dysfunction parameters, A' and E'/A', could mean a severe decrease in LV compliance in the obese group. Based on the results of the present study, in the obese group, the IVRT and IVCT parameters were higher than those in the control group, but statistically, the difference was not significant. An elevated IVRT parameter may indicate diastolic dysfunction in its earliest stages. An increase in IVCT can indicate systolic dysfunction in the obese population caused by a rise in body mass index. The mean ET, which can indicate systolic dysfunction, was higher in the obese group than in the control group, but this difference was not statistically significant.

The average MPI (Myocardial Performance Index), which can indicate systolic and diastolic dysfunction, was more significant in the obese group than in the control group, but this difference was not statistically significant. The obese group had a statistically significant increase in the parameter S´ average value, compared to the control group. This suggests that both groups have an acceptable systolic function. The obese group's increased body mass may have caused the parameter S´ to be higher than that in the control group. This parameter indicates that systolic dysfunction in the obese group will likely be delayed and occur after diastolic dysfunction. It emphasizes the importance of evaluating diastolic indices for early intervention. Both the E´ and A´ parameters always indicate diastolic dysfunction. In the present study, the parameter E´ was more significant in the obese group than in the control group, but this difference was not statistically significant. In the obese group, the parameter A' was significantly higher than in the control group, indicating diastolic dysfunction.

Overall, based on the findings of this study, the mean values of IVRT, IVCT, MPI, E', and E were higher in the obese group than in the control group, but this difference was not statistically significant. ET and E/A were greater in the control group as compared to the obese group, but this difference did not reach the level of statistical significance ($P>0.05$). The means of the parameters S´, A', and A were substantially higher in the obese group as compared to the control group, indicating diastolic dysfunction in obese children and adolescents ($P<0.05$). These results are consistent with the research conducted by Ghandi et al. (21), in which TDI (which corresponds to MPI) was worse in the obese group than in the normal group. This is consistent with our findings regarding these two parameters. ET follows a similar pattern in our study, with the obese group having lower values than the normal group. This parameter difference suggests that diastolic dysfunction occurs earlier in the obese population. In the study by Gandhi et al., the IVRT and IVCT parameters were significantly higher in the obese group than in the control group. Similarly, in our study, these two parameters were higher in the obese group, but the difference was not statistically significant (21). In the study conducted by Üner et al. on 30 obese children and 30 normal children aged 8 to 17 years, an increase in the systolic base and diastolic end diameters indicative of diastolic dysfunction was observed in the obese group, which is consistent with the findings of our study (22). Ozdemir et al. examined echocardiographic indices, including systolic and diastolic function, in 106 obese and 62 thin children. They reported that the left atrial diameter and left ventricular mass had increased in the obese group compared to the normal group. The increased left atrial diameter observed in this study is equivalent to the increased E´ observed in our study of obese versus normal individuals (23).

In the study conducted by Mehta et al., pulsed tissue Doppler echocardiography was used to compare the diastolic myocardial performance of obese and normal children aged 10 to 18 years. The results of this study manifested that the A wave velocity is more significant in obese cases than in normal individuals, which is consistent with our findings. Furthermore, according to the findings of this research, the E/A ratio is lower in the obese group than in the control group, which is similar to our results. (24).

5- CONCLUSION

Several parameters of the present study indicate that obese children and adolescents have impaired myocardial function compared to normal individuals, with diastolic dysfunction-related parameters being the most prominent. In this context, it appears that diastolic dysfunction occurs before systolic dysfunction. Using these parameters as early indicators for monitoring overweight and obese kids of all ages is recommended. Early detection and appropriate interventions can help prevent further complications associated with these conditions.

6- ETHICAL CONSIDERATIONS

The study was approved by the university's Ethics Committee under the code of IR.BUMS.REC.1400.324.

ACKNOWLEDGEMENTS

This article is derived from a general medical thesis entitled "Investigation and Comparison of Myocardial Function Indices in Overweight Children and Adolescents with Normal-Weight Individuals," which was supported by Birjand University of Medical Sciences. We would like to express our appreciation and gratitude for their assistance.

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