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Relationship between Childhood Obesity and Left Ventricular Hypertrophy- An Echocardiographic Evaluation

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Abstract*: *Background: *Childhood obesity is one of the most serious public health challenges of 21st century. Although obesity affects all age groups, the prevalence of childhood obesity is at a rise. Obese children exhibit a tendency to develop abnormal cardiac geometry and left ventricular hypertrophy. Initially it was thought that this association between obesity and left ventricular hypertrophy occurs in response to systemic hypertension, but later several studies demonstrated that the relationship between obesity and left ventricular hypertrophy is independent of hypertension*

Aim & objective*: To find out any relation between childhood obesity and left ventricular hypertrophy and to determine whether the association between childhood obesity and left ventricular hypertrophy is independent of hypertension or not.*

Material &method:*Children aged between 2 years and 12 years, who attended the outpatient department of Dr B C Roy Post Graduate Institute of Paediatric Sciences and found to have obesity (as judged by BMI at or above 95th percentile, as per Centres for Disease Control and Prevention (CDC) Body mass index-for-age percentile chart) were taken for detailed cardiological evaluation including echocardiography.*

Result & analysis: *In the present study, the obese group had the minimum LVM (g) of 23.08 and the maximum LVM of 222.29 (SD 36.29). On the other side, the non-obese group had a minimum LVM of 24.30 and maximum of 125.43 (SD17.11). Likewise, the mean LVM (g) of the obese group and non-obese group were 80.64 and 60.90 respectively. The difference is statistically significant (p value=<0.0001).The calculated LVM is then indexed. In the present study, the mean left ventricular mass index (LVMI in g/m^2) is significantly greater in obese group (mean LVMI= 45.3) compared to non-obese group (mean LVMI 36.08)**.** In our study we found that 15 (6.1%) obese children had hypertension. Out of these 15 hypertensive children 10 (66.7%) have LVH. On the other hand, only 3 (1.2%) non-obese children had hypertension and none of them had LVH. The association between hypertension and occurrence of LVH in obese children is statistically significant (p value 0.0047).*

Conclusion: *In this study, we found that out of 264 obese children, 82 (33.3%) had LVH, on the other hand only 8 (3.3%) non-obese children had LVH. The mean left ventricular mass index (LVMI in g/m^2) was significantly greater in obese group (45.38) compared to non-obese group (35.08). Therefore, we can conclude that left ventricular hypertrophy is moreprevalent in obese children as compared to non-obese children. Furthermore, we also found that out 15 hypertensive obese children, 10 (66.7%) had LVH. Among 231 normotensive obese children 72 (31.2%) had LVH. From this we can also conclude that hypertension have some role in the development of left ventricular hypertrophy in obese children.*

Abbreviation:BMI*:body massindex,****LVM:****left ventricular mass,****LVMI****:left ventricular mass index,****SD:*** *standard deviation, **LVH:** left ventricular hypertrophy*

Keyword: *obesity,left ventricular hypertrophy, left ventricular mass, left ventricular mass index, hypertension*

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I. Introduction

Childhood obesity is one of the most serious public health challenges of 21st century. Although obesity affects all age groups, **the prevalence of childhood obesity is at a rise**(1). The World Health Organisation (WHO) global database on childhood overweight and obesity states that "over 38 million children aged under 5, living with overweight or obesity in2017"(2). In just **40 years** the number of school age **children and adolescents with obesity has risen more than ten folds, from 11million to 124 million (2016 estimate)** (3).

Obese children exhibit a tendency to develop abnormal cardiac geometry and left ventricular hypertrophy(7),(14).Initially it was thought that this association between obesity and left ventricular hypertrophy occurs in response to systemic hypertension, but later several studies demonstrated that the relationship between obesity and left ventricular hypertrophy is independent of hypertension. Several hemodynamic and non- hemodynamic factors hypothesized to link obesity with left ventricular hypertrophy(4).Left ventricular hypertrophy is a form of end organ damage usually remains asymptomatic in children. Early diagnosis of left ventricular hypertrophy and appropriate management will result in regression of left ventricular mass and normalization of cardiac structure.This relationship between obesity and left ventricular hypertrophy is well demonstrated in foreign literature but there is paucity of studies in India.Hence our study aims at finding out whether there is any relationship between childhood obesity and left ventricular hypertrophy, and if so then whether this association is independent of hypertension or not.

II. Aims and Objectives

1.To find out any relation between childhood obesity and left ventricular hypertrophy.
2.To determine whether the association between childhood obesity and left ventricular hypertrophy is independent of hypertension or not.

III. Material And Methods

STUDY AREA: This study was carried in the Department of Paediatric Medicine.Dr B. C. Roy Post Graduate institute of Paediatric Science,111, Narkeldanga Main Road.Kolkata -700054, West Bengal, India.
STUDY PERIOD: From November 2017 to October 2018.
STUDY DESIGN: Hospital based, Prospective, Analytical, Cross-Sectional,Case Control study.
STUDY POPULATION: Children aged between 2 years and 12 years, who attended the outpatient department of Dr B C Roy Post Graduate Institute of Paediatric Sciences and found to have obesity (as judged by BMI at or above 95th percentile, as per Centres for Disease Control and Prevention(CDC) Body mass index-for-age percentile chart) were taken for detailed cardiological evaluation including echocardiography. Children of age between 2 years and 12 years, who got admitted in the in-patient department of Dr B C Roy Post Graduate Institute of Paediatric Sciences and found to have obesity (as judged by BMI at or above 95th percentile as per Centres for Disease Control and Prevention(CDC) Body mass index-for-age percentile chart) were taken for detailed cardiological evaluation including echocardiography.Equal number of age and sex matchedNon-obese children (BMI less than 85th percentile) were taken as comparator.

INCLUSION CRITERIA:

Children between age 2 years and 12 years, who attended the outpatient department or who got admitted in the inpatient department of Dr B C Roy Post Graduate Institute of Paediatric Sciences and found to have obesity (as judged by BMI at or above 95th percentile).

EXCLUSION CRITERIA:
Children below 2 years of age.
Children with demonstrable structural cardiac disease.
Children with chronic illness.
Critically ill patient.
Children whose parents will notgive consent to include their child in this study

SAMPLE SIZE AND JUSTIFICATION OF SAMPLE SIZE: Sample size is calculated using the formula; Sample size (N) = $[Z^2 \times (p) \times (1-p)] / c^2$. Where Z= Z value; p= population proportion; c= confidence interval.In our study Z= 1.96 (95%confidencen level); p=0.2 (population proportion 20%) and c= 0.05 (confidence interval +/- 5). Sample size = $[1.96^2 \times (0.2) \times (1-0.2)] / 0.05^2$=246 **.**So the estimated sample size in our study was**246.**Equal number of age and sex matched Non-obese children taken as comparator.

IV. Methodology

A detailed history of the patient was taken from parents. A predesigned proforma was used to interview the informant in which, the necessary information was recorded which include-

Patient's name, age, sex, address.Presentingcomplaints.Past history of medical and surgical illness.Familyhistory.A thorough general physical examination, vitals, anthropometric measurement (including weight, height, BMI) was done. Patients, who had obesity (as judged by BMI at or above 95th percentile as per Centres for Disease Control and Prevention (CDC) Body mass index-for-age percentile chart) were taken for detailed echocardiographic evaluation. 2D and M-mode echocardiography were performed to estimate the left ventricular mass. At first, the left ventricular end diastolic internal dimension (LVEDD), posterior wall thickness (PWT), interventricular septal thickness (IVSd) were estimated. Now using the Devereux and Reichek formula, (i.e. LVM= 0.81 x 1.04 [$(LVEDD + PWT + IVSd)^3 – (LVEDD)^3$] + 0.6 gram) the left ventricular mass was calculated. The calculated left ventricular mass was then indexed using the indexing method recommended by National High Blood Pressure Education Program Working group on High Blood Pressure in Children and Adolescence is to divide LVM by height (in meter) increase to a power of 2.7. (LVMI=LVM/(height$^{2.7}$). The obtained LVMI was then plotted in the LVMI percentile chart (Park's Paediatric Cardiology, 6th edition). Left ventricular hypertrophy is diagnosed if left ventricular mass index (LVMI) is at or above 95th percentile

STATISTICAL ANALYSIS: For statistical analysis data were entered into a Microsoft excel spreadsheet and then analyzed by SPSS 24.0. and Graph Pad Prism version 5. Two-sample t-tests for a difference in mean involved independent samples or unpaired samples**.**Each of these statistics can be used to carry out either a one-tailed test or a two-tailed test. Once a *t* value is determined, a *p*-value can be found using a table of values from Student's t-distribution. If the calculated *p*-value is below the threshold chosen for statistical significance (usually the 0.10, the 0.05, or 0.01 level), then the null hypothesis is rejected in favor of the alternative hypothesis. p-value ≤ 0.05 was considered for statistically significant. .

STUDY TOOLS

Pre-Designed study proforma
Weighing Machine (Digital weighing machine)
Stadiometer
Sphygmomanometer (Mercury type)
Centres for Disease Control and Prevention (CDC) , Body mass index (BMI)-for-age percentile charts. 2D M & mode echocardiography machine (PHILIPS HD7 with cardio probe of 2-4 mega-hertz)
Left ventricular mass and Left ventricular mass index percentile chart. (Park's Paediatric Cardiology, 6th Edition, page 608.)
Blood Pressure level charts for boys and girls by age and height percentile. (The fourth report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents.)

V. Result And Analysis

Table1: Distribution of weight (kg).

		Number	Mean	SD	Minimum	Maximum	Median	p-value
Age	Case	246	91.4715	31.6010	25.0000	144.0000	94.5000	0.9080

		Number	Mean	SD	Minimum	Maximum	Median	p-value
Weight (kg)	Case	246	38.8450	13.5998	15.1962	68.5392	37.5056	<0.0001
	Control	246	24.2119	7.6703	9.9805	41.8500	23.6749	

In obese cases, the mean weight (mean± SD.) of obese children was 38.8450 ±13.5998 kg. In non-obese control group, the mean weight (mean ± SD.) was 24.2119 ±7.6703 kg. Distribution of mean weight among obese and non-obese group was statistically significant (p<0.0001).

Figure 1: Distribution of mean weight (kg).

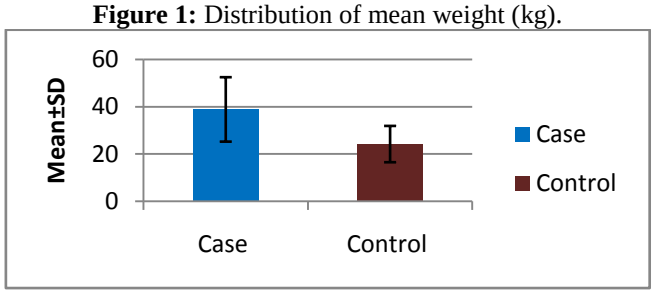


Table 2: Distribution of BMIof study population.

		Number	Mean	SD	Minimum	Maximum	Median	p-value
BMI	Case	246	24.9203	2.7667	19.2000	33.4000	24.7000	<0.0001
	Control	246	15.8841	1.5085	12.6000	20.2000	15.8000	

Among obese cases, the mean BMI (mean± SD.) was 24.9203 ± 2.7667 kg/m^2. In non-obese control, the mean BMI (mean± SD.)was 15.8841 ± 1.5085 kg/m^2. The difference of mean BMI is statistically significant (p<0.0001).

Figure 2: Distribution of mean BMI of study population.

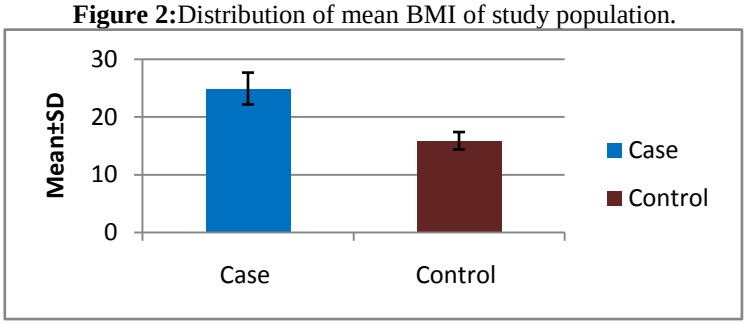


Table3: Association of Blood Pressure

	Obese Case	Non-ObeseControl	TOTAL
HTN Row % Col %	15 83.3 6.1	3 16.7 1.2	18 100.0 3.7
NORMAL BLOOD PRESSURE Row % Col %	231 48.7 93.9	243 51.3 98.8	474 100.0 96.3
TOTAL Row % Col %	246 50.0 100.0	246 50.0 100.0	492 100.0 100.0

Chi-square value: 8.3038; **p-value:**0.0039

Among the obese cases, 15(6.1%)children had HTN and 231(93.9%) children had normal blood pressure. In control group, 3(1.2%) patients had HTN and 243(98.8%) patients had normal blood pressure.

Table4: Distribution of mean LVM

		Number	Mean	SD	Minimum	Maximum	Median	p-value
LVM (g)	Case	246	80.6410	36.2890	23.0845	222.2936	74.1788	<0.0001
	Control	246	60.9019	17.1133	24.3032	125.4326	58.2902	

The mean LVM (mean±SD.) among the obese cases was 80.6410 ± 36.2890 g and in non-obese cases was 60.9019 ± 17.1133 g. The difference is statistically significant (p<0.0001).

Figure 3: Distribution of mean LVM

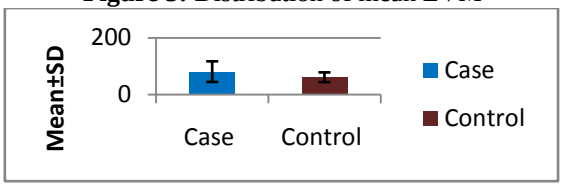


Table 5: Distribution of LVM-index (g/m2).

		Number	Mean	SD	Minimum	Maximum	Median	p-value
LVM-index g/m2)	Case	246	45.3877	12.9248	27.0067	92.6259	41.7743	<0.0001
	Control	246	36.0809	7.4047	21.2386	78.8254	35.1406	

The mean LVM-index (mean± SD.) among the obese children was45.3877 ± 12.9248 (g/m2).In comparison, the mean LVM-index (mean± SD.) of non-obese control group was 36.0809 ± 7.4047 (g/m2).The difference is statistically significant (p<0.0001).

Figure4: Distribution of Mean LVM-index (g/m2).

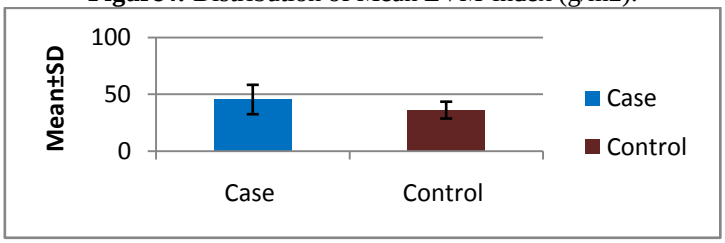


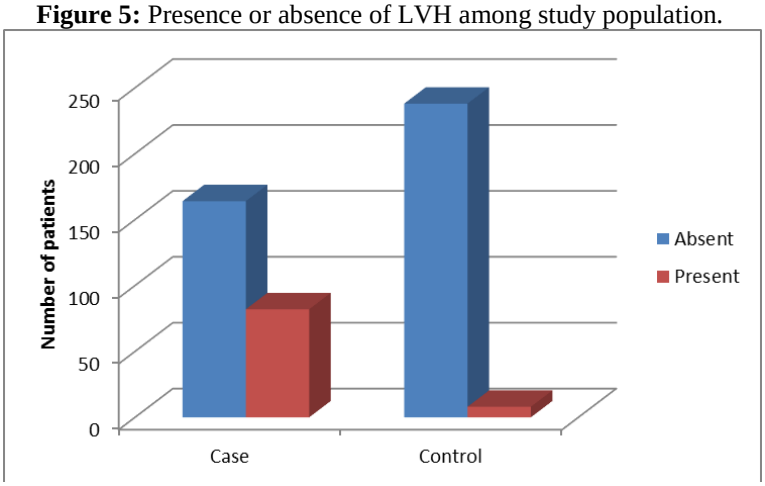
Table6: Presence or absence of LVH among study population.

LVH-PRESENT OR NOT	Obese Case	Non-ObeseControl	TOTAL
Absent Row % Col %	164 40.8 66.7	238 59.2 96.7	402 100.0 81.7
Present Row % Col %	82 91.1 33.3	8 8.9 3.3	90 100.0 18.3
TOTAL Row % Col %	246 50.0 100.0	246 50.0 100.0	492 100.0 100.0

Chi-square value: 74.4663; **p-value:**<0.0001

Out of 246 obese children, 82(33.3%) had present LVH. One the other hand only 8(3.3%) non-obese children had LVH. The difference is statistically significant (p <0.0001).

Figure 5: Presence or absence of LVH among study population.



Chi-square value: 0.1021; **p-value:**0.7493

Table 7: Association between blood pressure and LVH in Non-obese control group.

	LVH-PRESENT OR NOT		
BLOOD PRESSURE	**Absent**	**Present**	**TOTAL**
HTN Row % Col %	3 100.0 1.3	0 0.0 0.0	3 100.0 1.2
NORMAL Row % Col %	235 96.7 98.7	8 3.3 100.0	243 100.0 98.8
TOTAL Row % Col %	238 96.7 100.0	8 3.3 100.0	246 100.0 100.0

In non-obese control group, only 3(1.2%)children had HTN. None of hypertensive children had LVH.

VI. Discussion

The aim of the study was to find out whether there is any relationship between childhood obesity and left ventricular hypertrophy, and if so, whether this association is independent of hypertension or not. A total of 246 obese children were investigated and the findings were compared with 246 age and sex matched non-obese

The mean body weight (in kg) of obese study population (n=246) was 38.84, as compared to non-obese control group (n=246), which had a mean body weight of 24.21. The difference between the two group is statistically significant (p value <0.001).

The distribution of BMI (in kg/m^2) among the obese cases ranges from 19.2 to 33.4with a mean BMI of 24.9 and SD 2.76. Whereas, the minimum and maximum BMI among non-obese control group were 12.60 and 19,20 respectively, with a mean BMI of 15.88 and SD 1.50. The difference of BMI values between the two groups are statistically significant (p value= <0.0001).

LEFT VENTRICULAR MASS and LEFT VENTRICULAR MASS INDEX: In the present study, the obese group had the minimum LVM (g) of 23.08 and the maximum LVM of 222.29 (SD 36.29). On the other side, the non-obese group had a minimum LVM of 24.30 and maximum of 125.43 (SD17.11). Likewise, the mean LVM (g) of the obese group and non-obese group were 80.64 and 60.90 respectively. The difference is statistically significant (p value=<0.0001).The calculated LVM is then indexed. In the present study, the mean left ventricular mass index (LVMI in g/m^2) is significantly greater in obese group (mean LVMI= 45.3) compared to non-obese group (mean LVMI 36.08).

The following table summarizes the findings of different studies as compared to our study.

Table 27. Mean LVMI in obese and non-obese children.

	Study period	Mean LVMI(in Obese)		Mean LVMI(in Non-obese)		Statistical significance
Present study	**2017-18**	**45.38**	**(n=246)**	**36.08**	**(n=246)**	**p<0.0001**
Chinali M et.al.(5)	2006	35.97	(n=223)	30.21	(n=114)	p <0.05
Khositseth A et.al.(6)	2006	40.7	(n=28)			
Di Bonito et.al.(10)	2007	35.7	(n=111)	23.5	(n=30)	p <0.0001
Dhuperet.al.	2011	49.6	(n=213)	46.0	(n=130)	p =0.01
Osama Y et.al.	2014	61. 57	(n=35)	52.05	(n=26)	
Magneret.al.(10)	2014	40.0	(n=61)	28.7	(n=40)	p <0.001
Linyuan Jinget.al.(9)	2017	27	(n=31)	22	(n=37)	p <0.001

*LVMI obtained by cardiovascular magnetic resonance.

The table shows that the findings of our study is comparable with the findings of most of the other studies. The results of our study closely resemblewith that of Dhuperet.al.

The primary aim of our study is to find any relationship between childhood obesity andleft ventricular hypertrophy (LVH). In our study, we found that out of 246 obese cases LVH was present in 82 (33.3%) children, and only 8 (3.3%) children out of 246 non-obese control group had LVH. The findings are statistically significant with p value <0.0001.

Several cross-sectional and prospective studies have shown association between childhood obesity and left ventricular hypertrophy.

Table 28. Percentage of LVH in obese and non-obese children.

	Study period	% of children having LVH (in obese group)	% of children having LVH (non-obese group)	Statistical significance
Present study	**2017-18**	**33.3%**	**3.3%**	**pvalue<0.0001**
Magner N et.al	2014	47.5%	10.0%	p value <0.001
Movahedet.al.(11)	2009	10.32%	0.2%	p value <0.001
Khositseth A et.al(6)	2006	40.8%		
Chinali M et.al(5)	2006	33.5%	3.5%	p value <0.001
LinyuanJinget.al(9)*	2017	51.6%	16.2%	p value <0.001

*hypertrophy score obtained by cardiovascular magnetic resonance.

This table also shows that the result of our study is more or less similar to that of most other studies. The findings of our study closely match the results of Chinali M et.al. The outcome of the study by Movahedet.al. markedly differs from our study.These differences may be attributed by the fact that the study population of Movahedet.al. was young obese and non-obese teenagers who are actively involved in athletic activities.

The above table shows that there is significant variation among the findings of different studies. Some study shows that eccentric hypertrophy is common, while other studies found that concentric hypertrophy is more prevalent. The result of our study has some similarity with the results of Di Bonito et.al. and Khositsethet.al.

ROLE OF HYPERTENSION

In our study we found that 15 (6.1%) obese children had hypertension. **Out of these 15 hypertensive children 10 (66.7%) have LVH**. On the other hand, only 3 (1.2%) non-obese children had hypertension and none of them had LVH. The association between hypertension and occurrence of LVH in obese children is statistically significant (p value 0.0047).Several studies have shown that the relation between hypertension and left ventricular hypertrophy in obese children. The following table summarizes the findings of those studies.

Table 30: Hypertension and LVH

Pierruzziet.al.(8)	526 obese children of age between 6years to 15 years.	Blood pressure values and hypertension are independently associated with cardiac hypertrophy (p value <0.001 and <0.05 respectively.
Falkner et.al(12)	301 adolescents with age 13 to 18 years.	LVMI was high in hypertensive children (19%) compared to children with normal blood pressure (12%) and it was highest in obese hypertensive children (57%)
A Jankauskieneet.al.	97 children with arterial hypertension	LVH was found in 40.7 % obese children with arterial hypertension as compared to 21.4% in non- obese children.
Pruetteet.al(13)	141 hypertensive children	LVH is more prevalent in obese and hypertensive children.
Karen et.al.	163 adolescents, 44 with normal BP, 116 with hypertension.	The prevalence of LVH in hypertensive children was higher (44.5%) compared to children with normal blood pressure (9.1%).
LinyuanJinget.al.(9)*	68 (37 healthy weight and 31 obese) children of age 8 to 17 years.	BMI and hypertension both were independently associated with LVH (p value <0.001 and <0.001 respectively.

*assessed by cardiovascular magnetic resonance.

In the present study, 82 obese and 8 non-obese children had LVH (as detected by 2D and M mode echocardiography). **Out of these 90 LVH cases 69 (76.6%) cases had shown features of left ventricular hypertrophy in ECG**.

LIMITATIONS

The findings based on the present study should be read against the backdrop of certain limitations.

The study was hospital based, not a community based, therefore the study population might not be representative ofpaediatric population in general.

In our study, we used standard 2D and M mode echocardiography to estimate the LVM. Echocardiographic estimation of ventricurlar measurements are less accurate as compared to magnetic resonance imaging, cine-computed tomography or 3D echocardiographic reconstruction(2).

VII. Summary

Our study aims at finding out any relation between childhood obesity and left ventricular hypertrophy and also to determine whether this association is independent of hypertension or not.During the study period, a total of 246 obese childrenwere investigated and findings were compared with equal number of age and sex matched non-obese childrenOut of 246obese children, 82 (33.3%) were found to have LVH, in contrast only 8 (3.3%) children in the non-obese group had LVH. The difference is statistically significant (p value <0.0001).Moreover, 66.7% of obese hypertensive children had LVH, in contrast 31.2% obese children with normal blood pressure had LVH. On the other hand, only 3 (1.2%) non-obese children had hypertension and none of them had LVH. The association between hypertension and occurrence of LVH in obese children is statistically significant (p value 0.0047

VIII. Conclusion

In this study, we found that out of 264 obese children, 82 (33.3%) had LVH, on the other hand only 8 (3.3%) non-obese children had LVH. The mean left ventricular mass index (LVMI in g/m^2) was significantly greater in obese group (45.38) compared to non-obese group (35.08). Therefore, we can conclude that left ventricular hypertrophy is more prevalent in obese children as compared to non-obese children. Furthermore, we also found that out 15 hypertensive obese children, 10 (66.7%) had LVH. Among 231 normotensive obese children 72 (31.2%) had LVH. From this we can also conclude that hypertension have some role in the development of left ventricular hypertrophy in obese children.

References

[1]. Han JC, Lawlor DA, Kimm SYS. Childhood obesity. Lancet (London, England) [Internet]. 2010 May 15;375(9727):1737–48. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20451244

[2]. Devereux RB. Detection of Left Ventricular Hypertrophy by M mode Echocardiography. Hypertens (suppl 2) [Internet]. 9(2). Available from: http://hyper.ahajournals.org

[3]. NCD Risk Factor Collaboration (NCD-RisC)(2017) Lancet 16;390:2627-2642.

[4]. Abel ED, Litwin SE, Sweeney G. Cardiac remodeling in obesity. Physiol Rev [Internet]. 2008 Apr;88(2):389–419. Available from: http://www.ncbi.nlm.nih.gov/pubmed/18391168

[5]. Chinali M, de Simone G, Roman MJ, Lee ET, Best LG, Howard B V., et al. Impact of Obesity on Cardiac Geometry and Function in a Population of Adolescents. J Am Coll Cardiol [Internet]. 2006 Jun;47(11):2267–73. Available from: http://linkinghub.elsevier.com/retrieve/pii/S073510970600619X

[6]. Khositseth A, Suthutvoravut U, Chongviriyaphan N. Left Ventricular Mass and Geometry in Obese Children. Asian J Clin Nutr [Internet]. 2009 Jan 1;1(1):58–64. Available from: http://www.scialert.net/abstract/?doi=ajcn.2009.58.64

[7]. Safdar OY, Shalaby MA, Elsafi E, Sabir ME, Alghamdi LA, Banjar LA, et al. Obesity is Associated with Increased Left Ventricular Mass in Children. J Obes Overweight [Internet]. 2016 Feb;2(1). Available from: http://www.annexpublishers.com/full-text/JOO/1304/Obesity-is-Associated-with-Increased-Left-Ventricular-Mass-in-Children.php

[8]. Pieruzzi F, Antolini L, Salerno FR, Giussani M, Brambilla P, Galbiati S, et al. The role of blood pressure, body weight and fat distribution on left ventricular mass, diastolic function and cardiac geometry in children. J Hypertens [Internet]. 2015 Jun;33(6):1182–92. Available from: http://content.wkhealth.com/linkback/openurl?sid=WKPTLP:landingpage&an=00004872-201506000-00012

[9]. Jing L, Nevius CD, Friday CM, Suever JD, Pulenthiran A, Mejia-Spiegeler A, et al. Ambulatory systolic blood pressure and obesity are independently associated with left ventricular hypertrophic remodeling in children. J Cardiovasc Magn Reson [Internet]. 2017 Dec 9;19(1):86. Available from: https://jcmr-online.biomedcentral.com/articles/10.1186/s12968-017-0401-3

[10]. Di Bonito P, Capaldo B, Forziato C, Sanguigno E, Di Fraia T, Scilla C, et al. Central adiposity and left ventricular mass in obese children. Nutr Metab Cardiovasc Dis [Internet]. 2008 Nov;18(9):613–7. Available from: http://linkinghub.elsevier.com/retrieve/pii/S093947530700172X

[11]. Movahed MR, Martinez A, Greaves J, Greaves S, Morrell H, Hashemzadeh M. Left Ventricular Hypertrophy Is Associated With Obesity, Male Gender, and Symptoms in Healthy Adolescents. Obesity [Internet]. 2009 Mar;17(3):606–10. Available from: http://doi.wiley.com/10.1038/oby.2008.563

[12]. Falkner B, DeLoach S, Keith SW, Gidding SS. High Risk Blood Pressure and Obesity Increase the Risk for Left Ventricular Hypertrophy in African-American Adolescents. J Pediatr [Internet]. 2013 Jan;162(1):94–100. Available from: https://linkinghub.elsevier.com/retrieve/pii/S002234761200649X

[13]. Pruette CS, Fivush BA, Flynn JT, Brady TM. Effects of obesity and race on left ventricular geometry in hypertensive children. Pediatr Nephrol [Internet]. 2013 Oct;28(10):2015–22. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23703719

[14]. McNiece KL, Gupta-Malhotra M, Samuels J, Bell C, Garcia K, Poffenbarger T, et al. Left Ventricular Hypertrophy in Hypertensive Adolescents. Hypertension [Internet]. 2007 Aug;50(2):392–5. Available from: https://www.ahajournals.org/doi/10.1161/HYPERTENSIONAHA.107.092197

[15]. Nuttall FQ. Body Mass Index: Obesity, BMI, and Health: A Critical Review. Nutr Today [Internet]. 2015 May;50(3):117–28. Available from: http://www.ncbi.nlm.nih.gov/pubmed/27340299

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