To cite this article: Atik F, Şanlı C, Törel Ergür A, Alpcan A. Impact of childhood obesity on cardiac structure and functions. Turk J Clin Lab 2017; 8(1): 6-10.

Original Article

Impact of childhood obesity on cardiac structure and functions

Çocukluk çağı obezitesinin kardiyak yapı ve fonksiyonlara etkisi

Fatih ATİK[1], Cihat ŞANLI[2], Ayça TÖREL ERGÜR[3], Ayşegül ALPCAN[4a]

[1]Türkiye Yüksek İhtisas Training and Resarch Hospital, Department of Pediatric Cardiology, Ankara
[2]Kırıkkale University, Faculty of Medicine, Department of Pediatric Cardiology, Kırıkkale
[3]Kırıkkale University, Faculty of Medicine, Department of Pediatric Endocrinology, Kırıkkale
[4]Kırıkkale University, Faculty of Medicine, Department of Pediatrics, Kırıkkale, TURKEY

ABSTRACT

Aim: The aim of this study was to compare the left ventricle structure and its functions in obese children without established complications and none obese children.

Material and Methods: Anthropometric and conventional echocardiographic parameters of cardiac geometry and left ventricular function were obtained in 40 obese children without any other disease and complication of obesity like hypertension, hypercholesterolemia, and a control group of 40 healthy lean. Fasting plasma glucose, insulin levels were obtained and homeostatic model assessment of insulin resistance (HOMA-IR) were calculated.

Results: Height, weight, body surface area and body mass index (BMI), were found significantly higher in the obese group ($P < 0.001$). Insulin and HOMA-IR scores were higher in obese group. No significant differences were observed for left ventricular systolic and diastolic diameter ($P > 0.05$). Left ventricular mass (LVM), LVM/ht, LVM/BMI and relative wall thickness (RWT) were significantly increased in obese children than the controls ($P < 0.001$) and most of them had eccentric left ventricular (LV) hypertrophy. Ejection fraction was significantly decreased seen obese group. A positive correlation was seen between BMI and LV posterior wall thickness and interventricular septal thickness ($R > 0.45$, $P < 0.05$). Both types of hypertrophy were seen in insulin resistant obese group.

Conclusion: The known causes are altered homeostatic and neurohumoral mechanisms and compensation of higher metabolic demands and increased left ventricular mass, reduced myocardial performance due to hemodynamic load associated with higher cardiovascular morbidity and mortality rates.

Keywords: Pediatric obesity, ventricular dysfunction, echocardiography

Corresponding Author[a]: Ayşegül ALPCAN, MD, Kırıkkale Üniversitesi Tıp Fakültesi, Pediatri Anabilim Dalı, Kırıkkale, TURKEY.
Phone: +903183335000
e-mail: ozcalk@yahoo.com
Received 09.05.2016, accepted 10.06.2016

Volume 8 Number 1 p: 6-10

ÖZ

Amaç: Bu çalışmada nonkomplike obez ve obez olmayan çocuklarda sol ventrikül yapı ve fonksiyonların karşılaştırılması amaçlandı.

Gereç ve Yöntemler: 40 sağlıklı obez olmayan ve obezitenin komplikasyonu (hipertansiyon, hiperkolesterolemi vs) veya başka bir hastalığı olmayan 40 obez çocukta kardiyak geometrinin antropometik ve konvansiyonel ekokardiyografik parametreleri ve sol ventrikül fonksiyonu elde edildi. Açlık plazma glukozu ve insülini bakılıp insülin direnç parametresi (HOMA-IR) hesaplandı.

Bulgular: Boy, ağırlık, vücut yüzey alanı, vücut kitle indeksi obez grupta anlamlı olarak yüksek tespit edildi ($P < 0,001$). İnsülin ve HOMA-IR obez grupta yüksekti. Sol ventrikül sistolik ve diyastolik çapları arasında fark tespit edilmedi ($P > 0,05$). Sol ventrikül kitlesi (LVM), LVM/ht, LVM/BMI, rölatif duvar kalınlığı (RWT), obez çocuklarda kontrol grubuna göre oldukça artmıştı ($P < 0,001$) ve bunların da en önemli olanı ekzantrik sol ventrikül hipertrofisiydi. Ejeksiyon fraksiyon belirgin olarak azalmıştı. BMI, LV posterior duvar kalınlığı ve interventriküler septal kalınlık arasında belirgin korelasyon görüldü ($R > 0,45$, $P < 0,05$). İnsülin rezistan obez grupta hipertrofinin her iki tipi de görüldü.

Sonuçlar: Değişen homeostatik ve nörohumoral mekanizmaların, yüksek metabolik ihtiyacın kompansasyonunun artmış sol ventrikül kitlesi, azalmış myokardiyal performans hemodinamik yük sebebi olduğu, bunun da yüksek kardiyovasküler morbidite ve mortalite oranları ile ilişkili olduğu biliniyor. Değişmiş homeostatik ve nörohumoral mekanizmalar, artmış metabolik gereksinimler, artmış ventriküler kitle, azalmış myokardiyal performans hemodinamik yol ile ilişkili olarak kardiyovasküler morbidite ve mortalite oranlarını artırmaktadır.

Anahtar kelimeler: Çocukluk çağı, venriküler disfonksiyon, ekokardiyografi

Introduction

Childhood obesity is recognized as a global health care problem especially in developed countries [1,2]. The American Heart Association stresses the importance of obesity as an independent but modifiable risk factor for coronary artery disease, ventricular dysfunction, congestive heart failure and cardiac arrhythmias [3,4]. There is an increasing prevalence of childhood obesity which is in association with left ventricular dysfunction in adults [5-7].

Several studies revealed that obesity, when complicated with hypertension, hyperlipidemia and insulin resistance results in cardiac dysfunction due to ventricular hypertrophy and chamber enlargement increase cardiovascular mortality and morbidity [8-10].

The aim of this study is to investigate the impact of uncomplicated obesity on ventricular morphology and functions in pediatric age group.

Materials and Methods

Study Group

The investigation was performed on 40 obese children (19 females, 21 males, mean age 12.21 ± 1.14 years) and a control group of 40 healthy children (18 females, 22 males, age 11.67 ± 1.63 years). This prospective study was conducted in accordance with the principles of the Declaration of Helsinki (1975). Exclusion criteria included patients with congenital or acquired heart disease, obesity complicated with obvious hypertension, hyperlipidemia and obesity caused by secondary reasons. The study protocol was approved by the local research ethics committee and an informed consent was taken from all subjects.

Assesment

A wall mounted stadiometer and a mechanic scale used to measure heights and weights. Body mass index (BMI) was calculated using the formula; BMI = weight(kg)/height(m2). BMI for age percentile charts for Turkish Children were used [11].

Children above %95 percentile for sex and age were accepted as obese according to the National Center for Health Statistics [12]. Serum fasting glucose and fasting plasma insulin were obtained from all objects. HOMA-IR was calculated for assessing the insulin resistance by the formula; HOMA-IR= [fasting insulin (μU/ml) x fasting glucose (mmol/L) /22,5] [13].

Echocardiographic Examination

All subjects underwent two dimensional and M-mode echocardiographic examination using a VIVID 7 machine (GE, Vingmed, Norway) equipped with 3 and 5 Mhz Sector probes. The dimensions of left ventricle (LV) were obtained at end-diastole and systole, from M-mode traces, using the recommendations of the American Society of Echocardiography [14].

Measurements of LV dimensions and wall thicknesses were made on 2D parasternal long-axis views according to American Society of Echocardiography standards. LV mass was calculated using an autopsy-validated formula and indexed for height2.7 [2,15-17]. Left ventricular mass was calculated using the Devereux Formula as LVM=0.8 [1.04(IVSd+LVDd+LVPWd)3-(LVDd)3] + 0.6)15. LVM was divided to body surface area (BSA) to obtain LVM index (LVMI) [16-18].

The relative wall thickness (RWT) was calculated as: RWT=[2xLPWth]/[LVED] where PWth=posterior wall thickness at end diastole, LVED: LV end diastole diameter [18].

Statistical Analyses

Statistical analyses were performed using statistical package for social sciences software (SPSS inc., Chicago, Illinois, USA) for Microsoft Windows Operating system. Data are presented as mean ± standart deviation (SD) for variables. A P value smaller than 0.05 was considered statistically significant. A pearson linear regression analysis was used to corralate multiple echo variables and independent variables.

Results

Forty obese children with a mean age of 12.21 ± 1.14 years and 40 healthy children with a mean age of 11.67 ± 1.63 years were recruited in the study. Body mass index in the obese group (24.87 ± 2.78) was evidently higher than the control group (15.41 ± 1.89). Furthermore, compared to the control group, height, weight, and body surface area were found significantly higher in the obese group (p<0.001). Mean fasting plasma insulin was 18.32 ± 4.67 mIU/ml and mean HOMA-IR was 2.73 ± 1.25 in obese group (Table 1).

Table 1. Characteristics of obese and non-obese subjects

Variable	Obese subjects mean ± SD	Non-obese subjects mean ± SD	P value
Male/female	21/19	22/18	0.35
Age (years)	12.21 ± 1.14	11.67 ± 1.63	< 0.001
Height (cm)	143.8 ± 1.5	131.6 ± 1.7	< 0.001
Weight (kg)	56.45 ± 14.12	28.62 ± 11.22	< 0.001
BMI (kg/m2)	24.87 ± 2.78	15.41 ± 1.89	< 0.001
BSA (m2)	0.056 ± 0.008	0.0364 ± 0.005	0.026
Glucose, mg/dl	92.22 ± 9.86	84.117 ± 6.75	
Insulin, mIU/ml	18.32 ± 4.67		
HOMA-IR	2.73 ± 1.25		

S: Statistically significant (P < 0.05), NS: Statistically non significant (P > 0.05)

According to M-mode echocardiography results, the difference between systolic and diastolic thicknesses of IVS and LVID and LVPW diastolic thickness in the obese group was seen at an advanced level compared to the control group (P < 0.001).

No difference was observed between both groups for LVID systolic and diastolic diameter and LVPW systolic thickness (P > 0.05). LVM, LVM/ht2.7, LVM/BSA and RWT were significantly greater in obese children than the controls (P < 0.001) (Table 2).

Table 2. Echocardiographic measurements of left ventricular structure in obese and non-obese subjects

Variable	Obese subjects mean ± SD	Non-obese subjects mean ± SD	P value
IVSd	1.33 ± 0.67	0.82 ± 0.31	< 0.001
IVSs	1.32 ± 0.43	0.93 ± 0.21	< 0.001
LVIDd	3.87 ± 0.66	3.81 ± 0.57	0.47
LVIDs	2.58 ± 0.31	2.23 ± 0.46	0.44
LVPWd	1.21 ± 0.45	0.66 ± 0.23	< 0.001
LVPWs	1.78 ± 0.65	1.23 ± 0.32	0.036
EDV	76.45 ± 23.67	61.47 ± 20.71	0.029
EF (%)	64.57 ± 6.24	70.66 ± 4.67	< 0.001
FS	32.24 ± 5.57	41.23 ± 4.43	< 0.001
LV mass (LVM) (g)	187.45 ± 62.21	87.43 ± 47.25	< 0.001
LVM/height(ht) index (g/m) (z)	128.34 ± 41.13	65.56 ± 25.54	< 0.001
LVM /height2.7 index (g/m2.7)	127.23 ± 43.21	23.54 ± 11.43	< 0.001
LVM/BSA (g/m2) (k)	3546.32 ± 654.92	2278.45 ± 757.54	< 0.001
RWT	0.72 ± 0.45	0.43 ± 0.78	0.001

Fractional shortening (FS) value was 32.24 ± 5.57 in the obese group, and 41.23 ± 4.43 in the control group. The difference was found significant (P < 0.001). Ejection fraction in obese children was significantly decreased compared to the control group (Table 2). Only eighteen of 40 obese children had RWT ≥ 0.41, thus most of them had eccentric LV hypertrophy. Although the RWT in obese subjects were higher than in the control group, it was below the critical level reported for concentric remodeling. LVM, LVM/ht2.7 and RWT were correlated with BMI (R = 0.60, P < 0.001, R = 0.49, P < 0.01, R = 0.46, P < 0.01, respectively). Also a positive correlation was seen between BMI and LVPWd, IVSs, and IVSd (R > 0.45, P < 0.05) (Table 2). There were no correlation found between the types of hypertrophy and insulin resistance in the obese group.

Discussion

Obesity is becoming a major metabolic health problem especially in industrialized and developing countries in last two decades (19). The excessive adipose tissue, the major determinant of obesity in which accepted as an endocrine tissue, alters hemodynamic balances and increases cardiovascular morbidity and mortality by disturbing systemic resistance was highlighted by several investigators [3,4,20-24].

In a recent study about childhood obesity, Zeybek al [5] showed that LVM and LVMI increase, eccentric type of ventricular hypertrophy and diastolic dysfunction which are the major sequela of altered hemodynamics caused by increased systemic resistance and preload pressure. Many metabolic disturbances like dyslipidemia and insulin resistance worsen the clinical outcome. Nearly a great majority population of investigations about obesity and cardiovascular changes include obese people complicated with hypertension and dyslipidemia. Some papers conclude that obesity itself alone is not a cause of cardiovascular changes either functional or geometric [2,5,10,21-24].

Obesity, increasing left ventricular filling pressure and volume, negatively impacts left ventricular functions, and causes to dilation of the ventricles. Left ventricular volume proportionally increases with the stress on the ventricle wall. Consequently, myocardium adapts to obesity by increasing its mass. The end of this procedure results in left ventricular hypertrophy.

Researches indicated that there was a significant correlation between obesity and left ventricular mass. After weight loss, they showed that left ventricular wall thickness and left ventricular mass decreased. They suggested that, independent from blood pressure, weight lost by mild exercise and low-calorie diet decreased left ventricular mass in obese people [5]. In the present study left ventricular mass

in obese patient group was evidently higher than control group despite the evidence of obesity complications such as obvious hypertension, dyslipidemia ($P < 0.001$) (Table 1, 2). The correlation between BMI, LVM and left ventricular mass index were significant. Moreover, the correlations between body mass index and left ventricular mass, and left ventricular mass corrected for height were determined to be significant.

As in our study, echocardiographic studies showed that left ventricular end diastole diameter and septal and posterior wall diameters were higher in obese people [3,17,18]. The adaptation of heart to obesity is concentric and eccentric type hypertrophies. When the blood pressure remains normal, obesity causes eccentric type hypertrophy in left ventricle [17,21,30]. As seen in literature, in our study, RWT of the obese group was detected significantly higher than the control group ($P = 0.001$). In addition, children with eccentric hypertrophy findings in left ventricle were seen in the obese group.

This may partially be explained by the effects of hemodynamic load which causes increase in ventricular wall thickness and diastolic dysfunction [22,25-27]. Some investigators showed that macrophage recruitment in the adipose tissue enhance the release of adipokins and further derangement of metabolic – neurohumoral homeostasis such as water and electrolyte imbalance, sodium retention, insulin resistance and growth stimulation of insulin resulting in cardiovascular geometric and functional remodeling [22,25-27].

In our study the obvious signs of pressure effects, metabolic changes like dyslipidemia and electrolyte imbalance was eliminated from the obese group. Thereby the geometric and functional alterations suggested us different mechanisms such as the oxidative stress triggerring obesity related cardiovascular injury for these changes [25,27]. Insulin resistance, high insulin levels and growth stimulating effect may be the explanation but limited data showed that insulin resistance in normotensive and non – diabetic people was directly associated with an increase in left ventricular mass [13,20,25].

Obese hypertensive patients mostly have eccentric LV hypertrophy and the ventricular chamber sizes change in between high-normal to mild dilated. In normotensive obese patients, eccentric type of LV hypertrophy was the principal LV geometric abnormality and present findings are compatible with the presence of cardiac volume overload [22,27]. In contrast, concentric left ventricular hypertrophy, a result of increased afterload were more common in non-obese hypertensive patients (Table 2). In logistic analysis, body mass index (BMI) was the most potent predictor of increased LV mass/height 2.7 in both sexes exceeding the effect of blood pressure [22]. Our findings in concordance to other investigations suggesting the relationship between obesity and abnormalities in cardiac structure, but we could not exactly clarify why some of the subject had concentric remodeling without hypertension. The explanation can be the misdiagnosis of hypertension or the effect of high plasma insulin levels.

Framingham Heart Study points out the risk of heart failure in obese individuals was increased approximately two fold. They follow-up a cohort of 13,643 patients for 19 years and found out that overweight is an independent risk factor for the heart failure [28]. In contrast of the previous knowledge, some recent studies reported no correlation between obesity and LV systolic dysfunction [29,30]. In our study the results related with LV systolic dysfunction in some obese patients are compatible with the studies identifying mild LV systolic dysfunction. This may be related with the echocardiographic assessment technique and more sensitive manners need to detect the LV functions [31].

In this study, obese children both have eccentric and concentric remodeling and decreased systolic and diastolic function. These abnormalities in LV structure and function may have important implications in explaining the myocardial dysfunction associated with obesity and increased cardiovascular sequela. In conclusion, childhood obesity is of great importance for its negative impacts extends to future ages and lays a ground for cardiovascular complications in future life.

Limitations of our study are no complete data for cytokines, leptin, sympathetic nervous system, renin–angiotensin–aldosterone system activity and long term blood pressure measurements.

These data can give us useful information about the underlying causes of alterations related with obesity discussed above. Thus, further investigations designed with larger number of patients will be essential confirming and explaining the clinical implications of the findings in this study.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

References

1. McCrindle BW. Cardiovascular Consequences of Childhood Obesity. Can J Cardiol 2015; 31: 124-130.
2. Karuparthi PR, Yerram P, Govindarajan G, Hayden MR. Obesity and Cardiovascular Risk. Current Cardiovascular Risk Reports 2008; 2:113-9.

3. Chinalli M, de Simone G, Roman MJ, et al. Impact of Obesity on Cardiac Geometry and Function in a Population of Adolescents. The Strong Heart Study. J Am Coll Cardiol 2006; 47: 2267-73.
4. Maron BJ, Thompson PD, Ackerman MJ, et al. American Heart Association Council on Nutrition, Physical Activity, and Metabolism. Circulation. 2007; 115: 1643-55.
5. Zeybek C, Celebi A, Aktuglu, Zeybek C, et al. The Effect of Low Carbohydrate Diet on Left Ventricular Diastolic Function in obese children. Pediatr Int 2010; 52: 218-23.
6. Freedman D, Dietz W, Srinivasan S, Berenson G. The relation of overweight to cardiovascular risk factors among children and adolescents: The Bogalusa heart study. Pediatrics 1999; 103:1175-82.
7. Pascual M, Pascual DA, Soria F et al. Effects of isolated obesity on systolic and diastolic left ventricular function. Heart 2003; 10:1152-6.
8. Weiss R, Dziura J, Burgert TS, et al. Obesity and the metabolic syndrome in children and adolescents. N Engl J Med 2004, 350: 2363-74.
9. Messerli FH. Cardiovascular effects of obesity and hypertension. Lancet 1982; 1:1165-8.
10. Ku CS, Lin SL, Wang DJ, Chang SK, Lee WJ. Left ventricular filling in young normotensive obese adults. Am J Cardiol 1994; 8: 613-5.
11. Ozturk A, Mazicioglu MM, Hatipoglu N et al. Reference body mass index curves for Turkish children 6 to 18 years of age. J Pediatr Endocrinol Metab 2008; 9: 827-36.
12. Kuczmarski RJ, Ogden CL, Guo SS, et al. 2000 CDC growth charts for the United States: methods and development. Vital Health Stat 2002; 246: 1-190.
13. Conwell LS, Trost SG, Brown WJ, Batch JA. Indexes of insulin resistance and secretion in obese children and adolescents. Diabetes Care. 2004; 27: 314-9.
14. Sahn DJ, DeMaria A, Kisslo J, Weyman A. Recommendations regarding quantitation in M mode echocardiography: Results of a survey of echocardiographic measurements. Circulation 1978; 58: 1072-83.
15. Teicholz LE, Cohen MV, Sonnenblick BM, Gorlin R. Study of left ventricular geometry and function by Biscan ultrasonography in patients with and without asynergy. N Engl J Med 1964; 291:120-8.
16. Devereux RB, Alonso DR, Lutas EM, et al. Echocardiographic assessment of left ventricular hypertrophy-comparison to necropsy findings. Am J Cardiol 1987; 56: 450-8.
17. Daniels SR, Meyer RA, Liang YC, Bove KE. Echocardiographically determined left ventricular mass index in normal children, adolescents and young adults. J Am Coll Cardiol 1988; 12: 703-8.
18. Schiller NB, Shah PM, Crawford M, et al. Recommendations for quantitation of the left ventricle by two-dimensional echocardiography. J Am Soc Echocardiogr 1989; 2: 358-67.
19. Williams CL, Hayman LL, Daniels SR, et al. Cardiovascular health in childhood: a statement for health professionals from the Committee on Atherosclerosis, Hypertension, and Obesity in the Young (AHOY) of the Council on Cardiovascular Disease in the Young, American Heart Association. Circulation 2002; 106: 143-60.
20. Hirschler V, Acebo HLP, Fernandez GB Gonzalez C, Jadzinsky M. The influence of obesity and, insulin resistance on left atrial size in children. Pediatric Diabetes 2006; 7: 39-44.
21. Peterson LR, Waggoner AD, Schechtman KB, et al. Alterations in left ventricular structure and function in young healthy obese women, assesment by echocardiography and tissue doppler imaging. J Am Coll Cardiol. 2004; 43:1399-404.
22. Koch R, Sharma AM. Obesity and Cardiovascular Hemodynamic Function. Current Hypertension Reports 1999; 1:127-130.
23. Movahed MR, Saito Y. Lack of Association between Obesity and Left Ventricular Systolic Dysfunction. Echocardıography 2009; 26: 128-132.
24. Berkalp B, Cesur V, Corapcioglu D, Erol C, Baskal N. Obesity and left ventricular diastolic dysfunction. Int J Cardiol 1995; 1: 23-6.
25. Chiarelli F, Marcovecchio ML. Insulin resistance and obesity in childhood. Eur J Endocrinol 2008; 159: 67-74.
26. Masugata H, Senda S, Goda F et al. Left ventricular diastolic dysfunction as assessed byechocardiography in metabolic syndrome. Hypertens Res 2006; 11: 897-903.
27. De Simone G, Devereux RB, Daniels SR, et al. Stroke volume and cardiac output in normotensive children and adults. Assessment of relations with body size and impact of overweight. Circulation 1997, 95: 1837-43.
28. Kenchaiah S, Evans JC, Levy D, et al. Obesity and the risk of heart failure. N Engl J Med 2002; 347: 305-13.
29. Dorbala S, Crugnale S, Yang D, et al. Effect of body mass index on left ventricular cavity size and ejection fraction. Am J Cardiol 2006; 97: 725-9.
30. Wong CY, O'Moore-Sullivan T, Leano R, et al. Alterations of left ventricular myocardial characteristics associated with obesity. Circulation 2004; 110: 3081-7.
31. Tumuklu MM, Etikan I, Kisacik B, Kayikcioglu M. Effect of obesity on left ventricular structure and myocardial systolic function: Assesment by tissue doppler imaging and strain/strain rate imaging. Echocardiography 2007; 24: 802-9.