Ultrasonographic assessment of Body Fat Distribution in Obese Children

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Abstract: Objective: Pattern of fat distribution rather than obesity is of importance for metabolic disorders and for cardio- vascular morbidity and mortality. The purpose of this study was to assess body fat distribution by ultrasound (US) and to compare between ultrasonographic finding and the anthropometric findings .**Patients and Methods :** This study is a cross-sectional comparative study. The study included 40 obese children (21 males and 19 females), with ages ranged from 4 to 16 years , and 40 non-obese children (20 males and 20 females), with ages ranged from 3 to 16 years. Ultrasonographic assessment of body fat were performed for all participants, including ; abdominal preperitoneal (P), subcutaneous (S) fat at their maximum (max) and minimum (min) thickness sites, visceral (V), triceps (TrUS) and subscapular (SsUS) fat thicknesses .Also anthropometric measurements were taken for all children, including body mass index (BMI), waist circumference (WC), waist to hip ratio (WHR), waist to height ratio (WHtR), triceps (Tr) and subscapular (Ss) skin fold thickness. **Results:** There was a highly significant difference between obese and control group in both US measurements and anthropamtric measurements except waist to hip ratio (WHR). BMI and WC were significantly correlated to all US measurements. No relation was found between WHR and US measurements. Multiple regression analysis using (V) as the dependent variable and anthropometric parameters and gender as the independent variables, reveled that BMI was the best single predictor of visceral fat thickness (V). In the obese children, 92.5% were found to have central obesity. **Conclusion:** From this study, Ultrasound has been proposed as an alternative non-invasive technique to measure subcutaneous and visceral fat thickness. In this study, BMI provided the best estimate of body fat. On the contrary to that in adults, WHR was not a good index to show intra-abdominal adiposity in children and adolescents. WC and WHtR were more reliable in this clinical study.

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1. Introduction

The prevalence of obesity has increased dramatically in the last few decades through the world and is associated with a range of medical and psychological complications. It is now recognized that obesity is one of the most important public health problems of our time ***(Richard and Neil, 2007).***

Obesity is a multifactorial disease. Contributing factors include a modern environment of plentiful calories and low physical activity combined with inherited risk genes ***(Lyon and Hirschhorn, 2005).***

Pattern of fat distribution rather than obesity is of importance for cardiovascular morbidity and mortality. The accurate measurement of total and regional fat mass requires sophisticated and often expensive methods that have limited applicability in the clinical setting ***(Semiz et al., 2007).***

Anthropometry is the single most portable, universally applicable, inexpensive and non invasive method available to assess the proportions, size and composition of the human body ***(Duren et al., 2008).*** However it con not differentiate between the intra abdominal and subcutaneous fat deposits ***(Maynard et al., 2001).***

In contrast to anthropometry, the most prominent virtue of imaging technique is to distinguish subcutaneous from visceral fat. Although CT and MRI have been established as gold standard, radiation exposure, the cost, special equipment and field requirements make them less feasible ***(Siegel et al., 2007).***

As one of the non invasive techniques, US has been received increasingly with a wide publicity because of its cost effectiveness and convenience ***(Zhang et al., 2009).***

Aim of the Work

To evaluate body fat distribution using ultrasound (US); by measuring visceral, preperitoneal and subcutaneous fat layers , triceps and subscapular fat thickness.

To compare between ultrasonographic and anthropometric findings.

2. Patients and Methods

This study is a cross-sectional comparative study. The study group comprised forty obese children (diagnosed as obese according to the BMI classification of children and adolescents, BMI >95th percentile diagnose obesity *(Vogels et al., 2006).* They were 19 females, 21 males with age group 4 to 16 years. Forty non-obese children, with normal growth and development and without any health problems were recruited as a control group , They were 20 females, 20 males, their ages ranged from 3 to 16 years.

Exclusion criteria;

Obese children with any other illnesses, endocrinological problems, or on medications that may cause weight gain or changes in body composition as steroids, some antidepressants, atypical anti-psychotics and certain anticonvulsants (phenytoin and valproate).

The participants were recruited from the pediatric outpatients clinic, Al-Zahraa University Hospital from April 2011 to November 2011. An informed consent was obtained from parents of all children.

All children included in the study were subjected to detailed medical history taking , physical examination, anthropometric measurements and ultrasonographic assessment.

Anthropometric measurements; Body weight was measured to the nearest 0.1kg with the RGZ-120 health scale, and height was measured to the nearest 0.1cm on a stadiometer, with subjects lightly dressed and without shoes (*Justus, 2004).*

The body mass index (BMI) was calculated as weight (kg) divided by height square (m2) *(Mei et al., 2002).*

Using a plastic measuring tape, waist circumference (WC) was measured between the lower rib margin and the iliac crest, hip circumference (HC) was measured at the widest point over the great trochanters. Both circumferences were measured in the standing position and at the end of gentle expiration *(Ng and Lai, 2004).*

Waist to hip (WHR) and waist to height (WHtR) ratios were calculated.

Skin fold thickness (triceps, subscapular) was measured using skin fold meter at the following sites;

Triceps (Tr): Half-way between the acromion and the olecranon *(Ng and Lai, 2004).*

Subscapular (Ss): 1cm below the inferior angle of the scapula *(Rodriguez et al., 2004).*

Ultrasonography:

Abdominal preperitoneal (P), subcutaneous (S) fat at their maximum (max) and minimum (min) thickness sites, visceral (V), triceps (TrUS) and subscapular (SsUS) fat thicknesses were measured ultrasonographically to all participants. Sonoscape US machine was used for the US measurements. A 7.5MHz linear-array probe was used to measure the subcutaneous and preperitoneal fat layers and 3.5MHz convex-array probe was used to evaluate visceral fat thickness.

Trus and Ssus measurements were performed at the same marked sites where the anthropometric measurements were carried out *(Armellini et al., 1991).* Fatty liver, as one of the complications of obesity, was also investigated ultrasonographically.

3. Results

The family history of obesity was significantly higher in obese group compared to control group (figure,1).

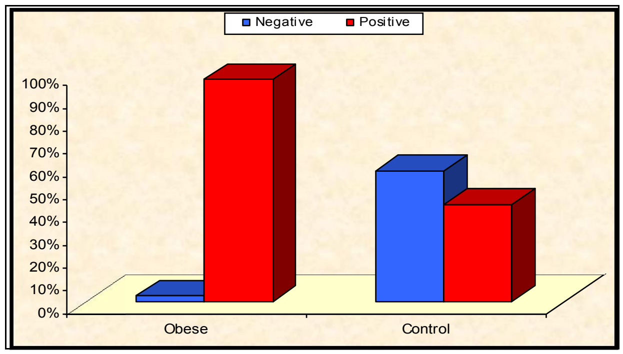

Figure (1): Comparison between the obese and control groups as regard family history of obesity.

The most frequent complaints in the obese group were easy fatigability, abdominal pain and knee pain (Table 1).

Table(1) :Complaint in obese group

Complaint	No.	%
Easy fatigability	34	85
Abdominal pain	18	45
Knee pain	16	40
Shortness of breath	11	27.5
Distension	9	22.5
Snoring	7	17.5
Headache	6	15
Leg pain	6	15
Heart burn	4	10
Chest pain	3	7.5
Low back ache	3	7.5
Motion abnormality	2	5

Anthropometric measurements showed significant difference between obese group and control group except for WHR (Table 2).

Ultrasonographic measurements and blood pressure values showed significant difference in obese group compared to control group (Table 3).

There was a highly positive correlation between WC and BMI in the obese group (Figure,2).

There was a highly positive correlation between WHtR and BMI in the obese group (Figure,3).

Among anthropometric measurements, only BMI and WC showed positive correlation with all US measurements, while there was no relation between WHR and US measurements (Table 4).

Multiple regression analysis, using V as the dependent variable and anthropometric parameters and gender as the independent variables, revealed that BMI was the best single predictor of V (Table,5)

Among the obese children, 92.5% had central obesity (WHtR > 0.5), (Table 6).

There was positive correlation between BMI percentiles and blood pressure percentiles, 17.5% of obese children developed hypertension and 5% were prehypertensive (Table, 7).

Complications in the obese group included; fatty liver (30%), hypertension (17.5%), and diabetes mellitus (5%), while psychological problems were observed in 36.6 % (Table, 8).

Table (2) :Comparison of anthropometry between obese and control group

Parameters	Obese		Control		t/z^	*p*-value
	SD	Mean	SD	t/z^		
Weight (kg)	24.24	28.85	13.96		6.199^	0.000*
Height (cm)	142.48	18.19	124.42	21.12	4.095	0.000*
BMI(Kg/m2)	30.04	5.87	17.70	2.68	12.099	0.000*
WC (cm)	86.30	15.39	59.60	9.69	9.286	0.000*
HC (cm)	96.30	17.19	68.15	11.78	8.544	0.000*
WHR	0.90	0.13	0.87	0.06	1.221	0.226
WHtR	0.61	0.09	0.48	0.05	7.964	0.000*
Tr (mm)	26.88	6.22	11.80	4.77	9.562	0.000*
Ss (mm)	25.30	5.10	8.65	4.20	7.700^	0.000*

Table (3) :Comparison of blood pressure and ultrasound measurements between obese and control groups

Parameters	Obese		Control		t/z^	*p*-value
	SD	Mean	SD	t/z^		
Systolic bl.Pr.	21.07	81.88	13.95		7.917	0.000*
Diastolic bl. Pr.	71.25	11.59	54.38	10.14	6.931	0.000*
Pmax (mm)	12.10	3.52	5.37	2.39	9.991	0.000*
Pmin (mm)	7.65	2.71	2.69	1.44	7.092^	0.000*
Smax(mm)	19.24	6.00	5.67	3.69	7.217^	0.000*
Smin (mm)	14.09	5.50	3.75	2.55	7.116^	0.000*
V (mm)	45.93	19.16	19.73	12.14	6.149^	0.000*
Tr US (mm)	10.07	4.44	2.93	1.60	7.092^	0.000*
SS US (mm)	9.10	5.21	2.36	1.87	6.924^	0.000*

Table (4): Correlation between anthropometry and US measurements in the obese group

	BMI (kg/m2)		Tr (mm)		SS (mm)		WHR		WHt R		WC (cm)	
	R	*p*	r	*p*	R	*p*	r	*p*	r	*p*	r	*p*
Pmax (mm)	0.483	0.002**	0.434	0.005**	0.322	0.043*	-0.046	0.78	0.220	0.173	0.625	0.000**
Pmin (mm)	0.561	0.000**	0.285	0.075	0.277	0.083	-0.014	0.934	0.210	0.193	0.495	0.001**
Smax (mm)	0.778	0.000**	0.509	0.001**	0.481	0.002**	-0.164	0.311	0.237	0.140	0.654	0.000**
Smin (mm)	0.57	0.000**	0.364	0.021*	0.319	0.045*	-0.303	0.058	0.029	0.860	0.338	0.033*
V (mm)	0.477	0.002**	0.077	0.638	0.07	0.67	0.139	0.392	0.535	0.000**	0.368	0.019*
Tr US (mm)	0.81	0.000**	0.589	0.000**	0.317	0.046*	-0.211	0.191	0.328	0.039*	0.508	0.001**
SSUs (mm)	0.644	0.000**	0.293	0.067	0.327	0.04*	0.021	0.9	0.535	0.000**	0.544	0.000**

Table (5): Multiple regression analysis for the prediction of visceral fat thickness from the independent variables

Independent Variable	Visceral Fat Thickness (V)	
	Independent Variable	Regression coefficient
Constant		-14.988-
Gender	2.317	0.472
BMI (Kg/m2)	1.954	0.000

Table (6): Classification of BMI percentiles in relation to presence of central obesity

Waist/height	BMI percentile				Chi-square test	
	Obese (n=40)		Control (n=40)		X^2	*P*-value
	No.	%	No.	%		
No central obesity	3	7.50	25	62.50	26.593	0.000*
central obesity	37	92.50	15	37.50		
Total	40	100.00	40	100.00		

Table (7): Relation between BMI percentiles and blood pressure percentiles

BMI centile	Blood pressure						Chi-square test	
	Normal		Pre-hypertension		Hypertension		X2	*P*-value
	No.	%	No.	%	No.	%		
Obese (n=40)	31	77.5	2	5.0	7	17.5	10.141	0.002*
Control (n=40)	40	100.0	0	0.00	0	0.00		

Table (8) :Complications in obese group

Complications	No.	%
Fatty liver	12	30.0
Hypertension	7	17.5
Diabetes Mellitus	2	5.0
Psychological problems		
Male	11	36.6
Female	19	63.3
Total	30	75

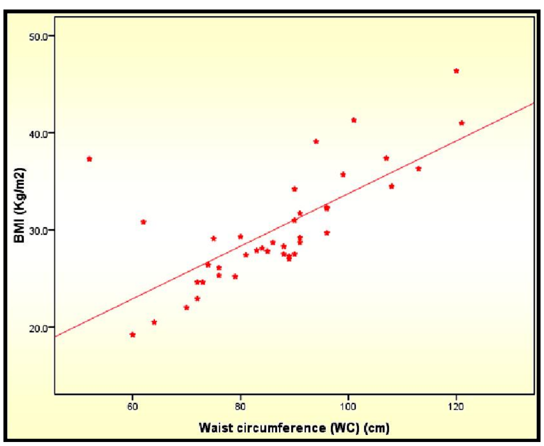

Figure (2) :Relation between BMI and waist circumference in the obese group

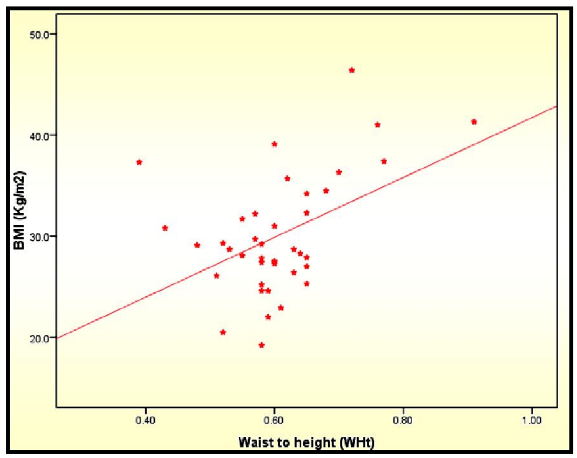

Figure (3) :Relation between BMI and waist to height ratio in the obese group

4. Discussion

Obesity in children and adolescents is associated with several metabolic and hemodynamic abnormalities including dyslipidemia, high blood pressure, impaired glucose tolerance, insulin resistance and cardiovascular risk factors ***(Ogden et al ., 2007).***

Pattern of fat distribution rather than obesity is of importance for metabolic disorders and for cardiovascular morbidity and mortality ***(Semiz et al., 2007)***.

Obesity in one or both parents probably influences the risk of obesity in their offspring because of shared genes and obesogenic environment

(Whitaker et al., 1997). The family history of obesity in the present study was significantly higher in obese compared to control group. A longitudinal study in Italy by ***Huerta et al. (2009)*** showed also that parents obesity was the most important risk factor for obesity in children.

When we studied the most common complaints of obese children, we found that easy fatigability, GIT upset and musculoskeletal pain were the most common. In a study done by ***Stovitz et al. (2008)***. The majority of obese subjects (61%) complained of joint pain, mainly back pain followed by foot and knee pain. Another study by ***Castro-Pinero et al. (2011)***, revealed that unfit obese children reported more complaints than controls.

Body mass index (BMI) is a simple and convenient method for measurement of obesity in children and adult ***(Prentice., 1998).*** The major limitation with BMI is that it doesn't give any information about fat distribution ***(Maynard et al., 2001).***

Despite this limitation, our study showed a highly positive correlation between BMI and all the US measurements in the obese group. This finding was in agreement with a study done by ***Reinehr and Wunsch (2010)***, which revealed that BMI was significantly correlated to the ultrasonographic measurements of intra-abdominal fat mass. Multiple regression analysis, using V as the dependent variable and anthropometric parameters and gender as the independent variables, revealed that BMI was the best single predictor of V. Similar results were reported by ***Semiz et al. (2007).***

In the present study, there was a highly positive correlation between WC and BMI. Also WC showed significant correlation with all US measurements in the obese group. The study of ***Semiz et al. (2007)***, revealed a significant correlation between WC and Pmax , Smax and Smim. In the study of ***Reinehr and Wunsch (2010),*** WC was significantly correlated to BMI and to all US measurements of intra-abdominal fat mass.

In our study, there was no relation between WHR and US fat thickness measurements. This was in agreement with the results of ***Semiz et al. (2007),***who did not find any correlation between WHR and US measurements of intra-abdominal fat mass **.** On the contrary, ***kytnarova et al. (2004)***, found a significant dependence between intra-abdominal fat measured on ultrasound (IAT) and WHR in boys but not in girls.

Waist-to-height ratio (WHtR) is a relatively constant anthropometric index of abdominal obesity across different age, sex or racial group. The value of 0.5 was suggested as an appropriate cut off point for both adults and children ***(Mokka et al., 2010).***

Our study revealed that there was a highly positive correlation between WHtR and BMI in the obese group. Also there was a significant positive correlation between WHtR and V, TrUS and SsUS. Among the obese children 92.5% had central obesity. A study performed by ***Maffeis et al. (2008)*** revealed that overweight children with high WHtR (>0.5) had significantly high metabolic and cardiovascular risk than children with WHtR (< 0.5).

In this study, there was a significant positive correlation between Tr skin fold measurement and Pmax , Smax, Smin and TrUS , while Ss fold showed positive correlation with Pmax, Smax, Smin, TrUS and SsUS. These results were in agreement with the results of ***Semiz et al. (2007)***.

On the other hand, ***Kytnarova et al . (2004),*** proved a significant correlation between IAT and the Ss fold and abdominal fold, while the correlation between the skin fold of the extremities and IAT were not significant.

In this study, we found that the increase in BMI percentiles was associated with a highly significant increase in the blood pressure percentiles, 17.5% of obese children developed hypertension and 5% were prehypertensive, also 5% developed diabetes mellitus. A study performed by ***Lee et al. (2008)*** revealed that glucose intolerance was presenting 17.5 of the obese children and 4.5% had type 2 diabetes mellitus.

In the present study 30% of obese children developed fatty liver as detected by US. A study by ***Damaso et al. (2008)***, on 181 obese adolescents, revealed that fatty liver prevalence was 45.3% and it was suggested that the expansion of visceral fat was a determinant factor to increase fatty liver prevalence.

Conclusion:

Ultrasound has been proposed as an alternative non-invasive, easily available technique to measure subcutaneous and visceral fat thickness. BMI provided the best estimate of body fat. On the contrary to that in adults, WHR was not a good index to show intra-abdominal adiposity in children and adolescents. WC and WHtR were more reliable in this clinical study.

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