International Journal of Food, Nutrition and Public Health, Vol. 3, No. 1, 2010

ASSOCIATION OF ANTHROPOMETRIC PARAMETERS WITH RISK OF CARDIOVASCULAR DISEASE IN OBESE AND NON-OBESE EGYPTIAN CHILDREN

Ebtissam M. Salah*

National Research Center, Egypt

Mai M. Youssef, Samar M.E. Salem and Hala S. Megahed†

National Research Center, Egypt

Nagwa A. Kantoush‡

National Research Center, Egypt

Abstract: The aim of this study was to evaluate the association between simple anthropometric parameters (body mass index, waist circumference, waist to stature ratio and sum of skinfolds thickness) with cardiovascular risk factors (total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, triglycerides, atherogenic index, fasting blood glucose, serum insulin level, systolic blood pressure and diastolic blood pressure) in obese and non-obese Egyptian children. The results showed that all anthropometric indices were positively correlated with all examined cardiovascular risk factors and negatively correlated with HDL-C. Obese children were significantly more likely to have two or more risk factors than non-obese participants. In obese children, the most prevalent CVD risk factors were hypertriglyceridemia (90%), followed by high LDL-C (76.6%) and low HDL-C (56.6%). The results indicated that obese children are at great risk for developing CVD. BMI and WSR are the best indices predicting CVD risk factors.

Keywords: cardiovascular disease; risk factors; obesity; children; anthropometry.

*Corresponding author: Department of Child Health, Medical Division, National Research Center, El Bohoth Street, El Dokki, Giza, Egypt; e-mail: Ebtissam2006@yahoo.com

†Department of Child Health, National Research Center, El Bohoth Street, El Dokki, Giza, Egypt; e-mail: dr.maiyoussef@hotmail.com, samarmsalem@hotmail.co.uk, mhany59@hotmail.com

‡Department of Clinical Pathology, National Research Center, El Bohoth Street, El Dokki, Giza, Egypt

INTRODUCTION

Chronic diseases represent a major problem and public health burden in developing countries. It represents 60% of global disease burden (Lopez et al., 2006). In Egypt, there is an emerging evidence that diabetes mellitus, obesity, hypertension and hyperlipidemia contribute to national morbidity and mortality; as about 41% of all deaths related to chronic diseases (WHO, 2004).

With changing food habits and increasingly sedentary lifestyles, the prevalence of obesity has increased markedly in Egypt over recent decades (Shaheen et al., 2004). Obesity in children and adolescents is associated with several metabolic and hemodynamic abnormalities: dyslipidemia, high blood pressure (BP), impaired glucose tolerance, insulin resistance and assorted cardiovascular risk factors (Ogden et al., 2007). In addition, atherosclerosis reportedly begins in childhood (Lu et al., 2008). Interest in childhood precursors to chronic diseases notably cardiovascular disease (CVD) is increasing, because both behavioural and biological risk factors of such diseases persist from childhood into adulthood (Personen and Liuba, 2004), and several risk factors including overweight, dyslipidemia and high BP are tracked from childhood to adult life (Cohen, 2004).

The growing prevalence of childhood obesity highlights the need to determine ways to screen for disease in children and adolescents and develop preventive programmes to reduce the incidence of chronic disease (Kelishadi et al., 2007). In adults, both central and general obesity are associated with metabolic risks. Many studies found that body mass index (BMI) and waist circumference (WC) were the best cardiovascular risk predictors for men, and WC and waist to hip ratio (WHR) were the best for women (Ho et al., 2001; Mykkanen et al., 1992). In children, it is not known which of the available obesity parameters can best predict the increased risk for obesity-related diseases and mortality (Geiû et al., 2001). Although, abdominal viscera adipose tissue measured by computed tomography (CT) or magnetic resonance imaging (MRI) may more accurately reflect fat distribution and more correctly predict metabolic risks, their inherent high cost and radiation hazard prevent their use in large-scale epidemiological studies or self-assessments (Caprio et al., 1996). An ideal obesity parameter should be universally applicable, inexpensive, non-invasive and allow the best uniform prediction of cardiovascular risk to facilitate further screening and treatment decisions (Geiû et al., 2001).

The aim of this study was to evaluate the association between simple anthropometric parameters (BMI, WC, WSR and sum of skinfold thickness) with cardiovascular risk factors (total cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), triglycerides (TG), atherogenic index, fasting blood glucose, serum insulin level, systolic blood pressure (SBP) and diastolic blood pressure (DBP) in obese and non-obese children, and to investigate which of these parameters best predicts cardiovascular risk factors to be used as a simple tool for identifying those at risk.

SUBJECTS AND METHODS

This study was performed as a part of the project of the Medical Researches Division which entitled 'Risk of osteoporosis in obese children and adolescents'. It was a case-control study. The study population is a sub-sample of the participants of the project. Sixty obese children (34 boys and 26 girls) aged 8–12 years were recruited randomly between 2005 and 2007 from the paediatric obesity clinic in National Research Center (NRC). These children had BMI ≥95th

percentile according to 2007 WHO growth reference for school-aged children and adolescents (De Onis et al., 2007). Another 60 non-obese children (had 5th percentile < BMI < 85th percentile) were invited to participate in the study as a control group. They were age and sex matched with the obese group, and they were recruited from the students of the nearby primary schools. The aim of the study and the methods used were explained to the participants and their parents who gave their written informed consent. The study was approved by the Medical Ethical Committee of the NRC. None of the study population was taking any medication or had clinical evidence of endocrine or metabolic disease.

Physical examination

Children were subjected to thorough clinical examination that included chest, heart and abdominal examination. Anthropometric measurements included weight (to the nearest 0.1 kg), height (to the nearest 0.5 cm) and BMI have been calculated as weight height^{-2} (kg m^{-2}). Skinfold thickness for biceps, triceps, sub-scapular and suprailiac reg0ions were measured and sum of skinfold thickness was calculated. All skinfold measures were done in triplicate and mean values were used for analysis. Waist and hip circumferences were measured and the WHR and waist to stature ratio (WSR) were calculated. The landmarks, instruments used and techniques followed the standardised anthropometric methods (WHO, 1995). After resting for 5 min, BP was measured in the sitting position using an appropriate sized cuff on both arms (NHBPEP, 2004). The SBP and DBP used for analysis are derived from the mean BP measured on both arms. Sexual maturation was assessed using Tanner's criteria on a scale of 1–5, with 1 being prepubertal and 5 being adult (Tanner, 1962).

Laboratory determinations

A venous blood sample was withdrawn from each child after an overnight fast of 12 hr. Serum was separated and stored at –20°C until analysis. For each child, a lipid profile, fasting blood glucose and serum insulin level were determined. Total cholesterol and TG were measured by quantitative enzymatic calorimetric technique (Titez, 1982) using Bio Merieux Kit No. 61224 and No. 61234, respectively. Serum HDL was measured by the phosphotungstate precipitation method of Lopez-Virella et al. (1977) using Merieux Kit. Serum LDL was calculated using the Friedewald formula (Friedewald et al., 1972): LDL = total cholesterol – (HDL – triglyceride/5). Atherogenic index was calculated using the following equation, that is, (Total cholesterol – HDL-C)/ HDL-C (Takasaki, 2005). Fasting plasma glucose was measured by the routine glucose oxidase method via Olymbus 400 autoanalyser. Fasting serum insulin was measured by radioimmuno assay kit for Human Insulin of BIO Source (Belgiun). Several monoclonal antibodies directed against distinct epitopes of insulin have been used.

Definition of risk factors

Unfortunately, in Egypt and third world countries, there are neither guidelines for prevention of atherosclerotic CVD in children nor definitions of cut points of risk factors (The Egyptian Guidelines, 2006).

The National Cholesterol Education Program (NCEP) expert panel on blood cholesterol in children and adolescents recommended the following definitions for acceptable, borderline and high total and LDL-C levels in children and adolescents between 2 and 19 years: Acceptable levels of total cholesterol and LDL-C are <170 mg dl^{-1} and ≤110 mg dl^{-1}, respectively; borderline levels, 170–199 and 110–129 mg dl^{-1}; and

high levels, >200 and >130 mg dl^{-1} (NCEP, 1992). The NCEP did not provide paediatric cut points for concentrations of TG or HDL which are more important risk factors. The American Heart Association has recommended that triglyceride concentrations of >150 mg dl^{-1} and HDL concentrations of <35 mg dl^{-1} be considered abnormal for children and adolescents (Kavey et al., 2003). The sensitivity and specificity of these cut-point concentrations for predicting adult lipid status may vary widely according to age and sexual maturation of the paediatric patient (Friedman et al., 2006). In this study, the threshold for lipids and lipoproteins was corresponding to the 95th percentile (thresholds of 200 mg dl^{-1} for total cholesterol and 130 mg dl^{-1} for LDL-C, 35 mg dl^{-1} for HDL-C and 130 mg dl^{-1} for TG) (Daniels et al., 2008). Increasing the cut points (e.g. from the 75th to the 95th percentile) increases the specificity and the predictive power of a positive test (Kwiterovich, 2008).

Fasting plasma glucose higher than 110 mg dl^{-1} was considered as impaired fasting glucose, according to the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus (American Diabetes Association, 2003). High BP was defined when SBP or DBP exceeding the 90th age and sex specific percentile (NHBPEP, 2004).

Statistical analysis

Data analysis was carried out using SPSS package; version 10. Descriptive statistics of physical and biochemical characteristics were carried out using student's *t*-test. Qualitative data were summarised as percentages and

Table 1 Comparison of age and physical characteristics between obese and control groups

Variable	Obese N = 60	Non-obese N = 60	t	p
	Mean (SD)	Mean (SD)		
Age (years)	9.43 (1.64)	9.19 (1.54)	0.58	0.566
Weight (kg)	40.98 (8.87)	26.68 (4.45)	7.89	0.001
Height (cm)	127.18 (11.54)	124.77 (7.75)	0.95	0.345
BMI (kg m^{-2})	24.72 (1.41)	17.03 (1.09)	23.72	0.001
Waist circumference (cm)	74.83 (7.49)	53.73 (2.62)	14.57	0.001
Hip circumference (cm)	91.17 (8.73)	64.82 (3.53)	15.33	0.001
Waist to hip ratio	0.82 (0.03)	0.83 (0.02)	–1.29	0.201
Waist to stature ratio	0.59 (0.02)	0.43 (0.01)	30.95	0.001
Biceps skinfold (mm)	11.8 (2.60)	7.03 (1.50)	9.04	0.001
Triceps skinfold (mm)	16.80 (3.07)	10.19 (1.96)	9.94	0.001
Sub-scapular skinfold (mm)	14.08 (4.23)	7.00 (1.44)	8.68	0.001
Spurailiac skinfold (mm)	15.33 (4.82)	8.70 (2.55)	6.67	0.001
Sum of skinfold (cm)	58.03 (13.60)	32.92 (6.80)	8.73	0.001
Systolic BP (mmhg)	111.33 (4.90)	98.83 (4.54)	10.25	0.001
Diastolic BP (mmhg)	69.83 (5.62)	61.27 (2.38)	7.69	0.001
			X^2	*p*
Tanner stage	80% stages 1–2 20% stage 3	78% stages 1–2 22% stage 3	0.91	0.453

$p < 0.05$ significant.

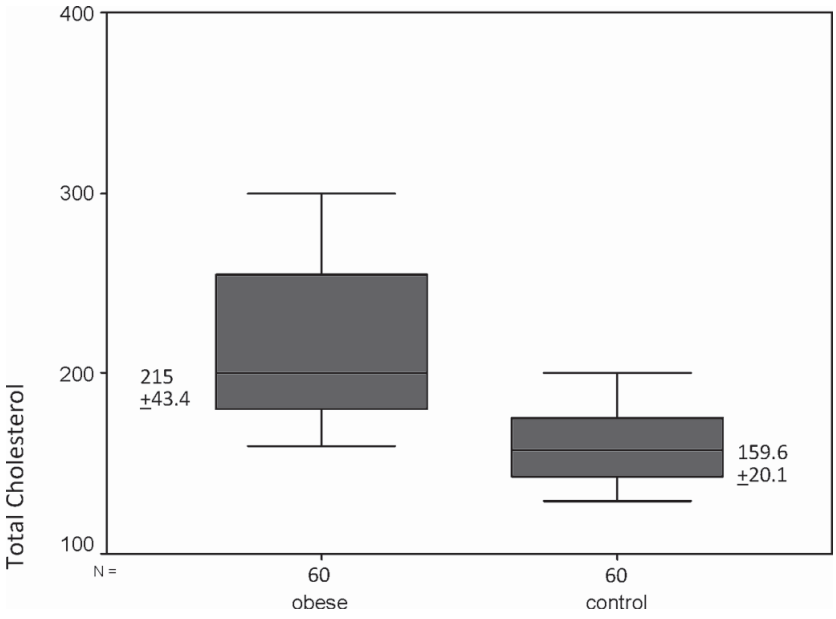
comparison between groups was done using χ^2- and *t*-test for proportions. Odds ratio (OR) was used to estimate the relative risk (RR) to have a particular health disorder among the obese children in comparison to non-obese group. Pearson correlation coefficients were used to evaluate the associations between obesity parameters and CVD risk factors. Regression analysis was performed to examine the predictive power of obesity parameters.

RESULTS

Descriptive characteristics

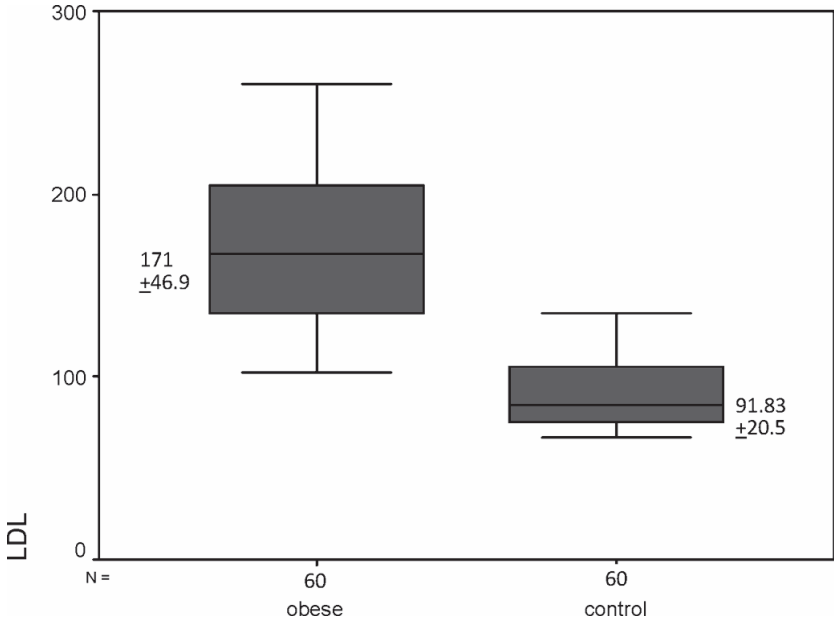
Table 1 shows the mean ± SD of age, anthropometric parameters, BP and Tanner stage in obese and control children. Age and height show no significant difference between the two groups ($p > 0.05$), while weight, BMI, skinfold thickness and circumferences were significantly higher in obese group ($p < 0.001$). WHR was not different ($p > 0.05$). SBP and DBP were significantly higher in obese children ($p < 0.01$). Eighty percent of the study population was considered in stages 1–2 of Tanner's classification and 20% was in stage 3 with no significant difference between both groups. No girl in the study population has reached menarche. There were no significant differences in physical or biochemical parameters between boys and girls in each group (data not shown), so analyses were performed collectively.

Figure 1 shows the mean of biochemical parameters in obese and control children through stem and leaf plot. It shows that total cholesterol, LDL-C, TG and atherogenic index are significantly higher in obese children. On the other hand, obese children had much lower level of HDL-C than control group. Both the mean of fasting blood glucose and serum insulin show

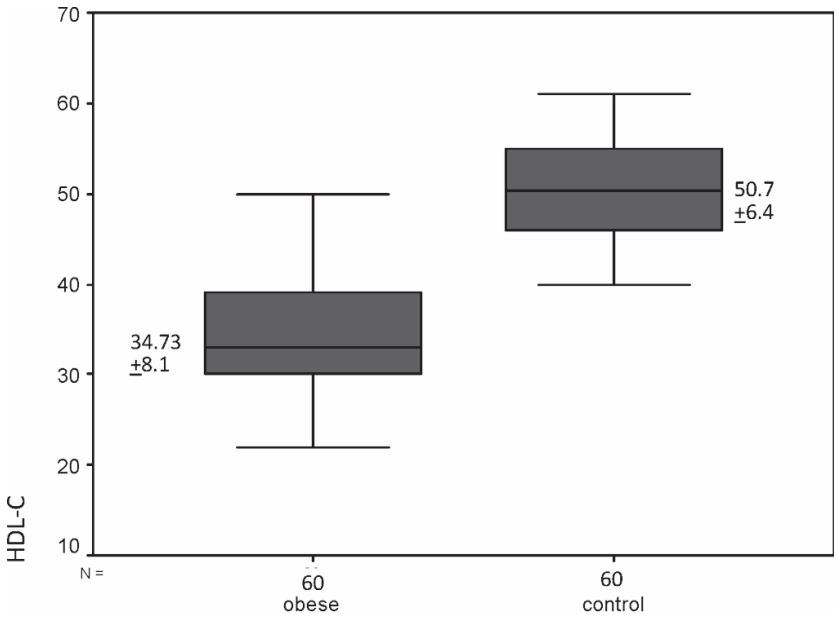


$p < 0.001$

Figure 1 Comparison of cardiovascular risk factors between obese and control groups

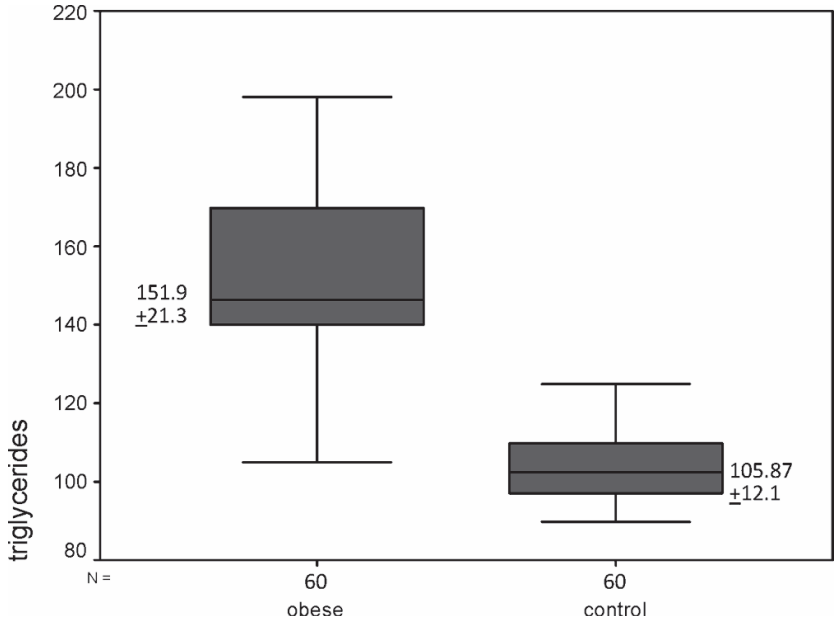


$p < 0.001$

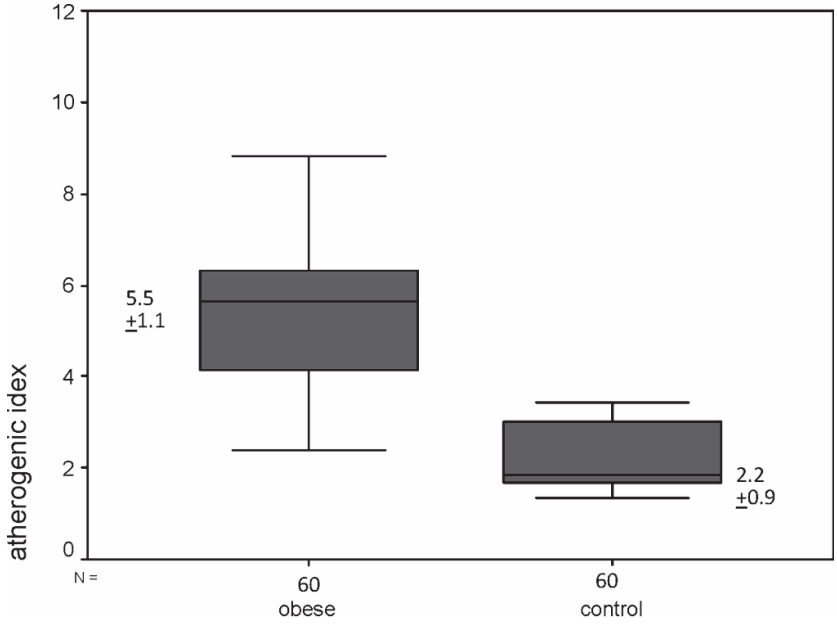


$p < 0.001$

Figure 1 Comparison of cardiovascular risk factors between obese and control groups (continued)

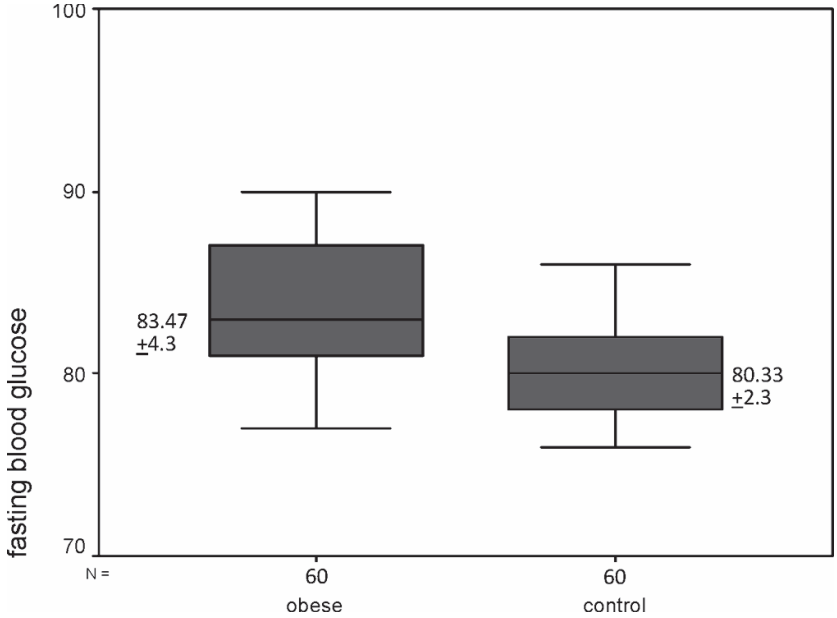


$p < 0.001$

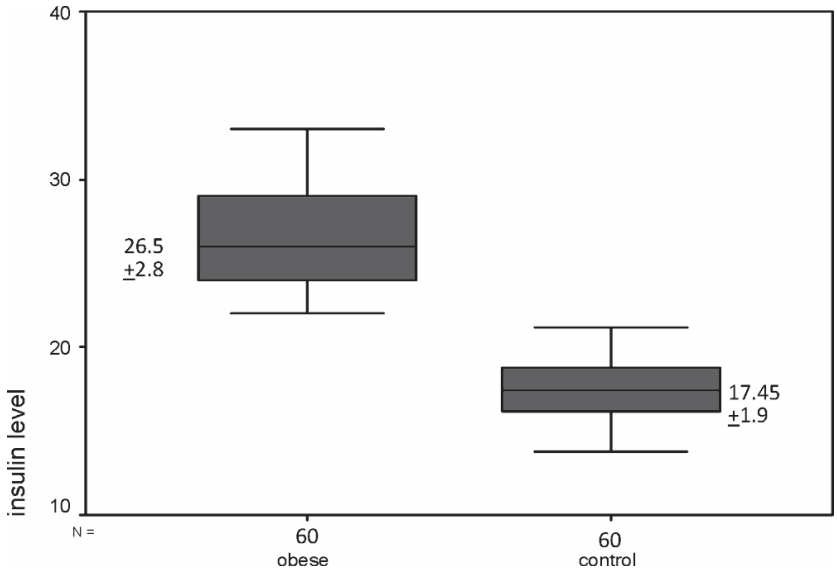


$p < 0.001$

Figure 1 Comparison of cardiovascular risk factors between obese and control groups (continued)



$p < 0.001$



$p > 0.05$

Figure 1 Comparison of cardiovascular risk factors between obese and control groups (continued)

Table 2 Prevalence of cardiovascular disease risk factors between obese and control groups and ORs for dyslipidemia and hypertension

Risk factors	Category	Positive cases N (%)			Odds ratio	95% CI
		Total	Boys	Girls		
Total cholesterol > 200 mgdl^{-1}	Obese[a]	32 (53)	33%	20%	16	2.26–113.12
	Control[b]	2 (3.3)	0%	3.3%		
HDL cholesterol < 35 mg dl^{-1}	Obese	34 (56.6)	30%	26.6%	NA	NA
	Control	0 (0)	0%	0%		
LDL cholesterol > 130 mg dl^{-1}	Obese	46 (76.6)	43.3%	33.3%	7.66	2.57–22.84
	Control	6 (10)	0%	10%		
Triglycerides > 130 mg dl^{-1}	Obese	54 (90)	56.6%	53.4%	13.5	3.52–51.78
	Control	4 (6.7)	0%	6.7%		
Systolic blood pressure (above 90th percentile for age, sex and height)	Obese	24 (40)	26.7%	13.3%	NA	NA
	Control	0 (0)	0%	0%		
Diastolic blood pressure (above 90th percentile for age, sex and height)	Obese	14 (23.3)	10%	13.3%	NA	NA
	Control	0 (0)	0%	0%		

[a]Number of obese children = 60.

[b]Number of control children = 60.

Note: NA, results not available owing to cell counts of 0 in the control group.

higher levels in obese than control group. All differences were statistically significant ($p < 0.01$).

Table 2 shows the prevalence of CVD risk factors between obese and control groups. Prevalence of all cardiovascular risk factors tended to be significantly higher in the obese group. The most prevalent cardiovascular risk factor was hypertriglyceridemia (90% of obese group vs. 6.7% of control group), followed by high LDL-C (76.6% of obese vs. 10% of non-obese). ORs revealed the risk estimate to have high levels of cardiovascular vascular risk factors in obese children. Obese children were more likely to have hypercholesterolemia 16 times more than controls, 13.5-fold of having hypertriglyceridemia and 7.66-fold of having high LDL-C. The most striking difference between obese and control children was for the prevalence of low HDL-C, since none of the controls had HDL-C level below the threshold while about 56.6% of obese had done.

The prevalence of cardiovascular risk factors appeared to be affected by gender; in obese children, the prevalence was higher among boys than girls, while in non-obese children, boys were protected and had no risk factors. Hyperglycemia was not a risk factor among our study population since no one had a fasting blood glucose ≥110 mg dl^{-1}.

Table 3 presents the prevalence of clustering of cardiovascular risk factors between obese and control children. Obese children were significantly more likely to have two or more risk factors than non-obese participants.

Correlation analysis

To evaluate different obesity parameters with respect to cardiovascular risk factors, Pearson's correlation was carried out after controlling for age and Tanner stage. Pearson correlation coefficients are presented in Table 4 for the whole study population and in Figure 2(a) for the obese group and Figure 2(b) for the control group. Table 4 shows that all anthropometric parameters (BMI, WC, WSR and sum of skinfold thickness) are positively correlated with all examined cardiovascular risk factors and negatively correlated with HDL-C. All correlations are statistically significant with most being highly significant ($r > 0.28$; $p < 0.01$). BMI shows the strongest correlations with all cardiovascular risk factors (r: 0.43–0.85; $p < 0.01$). Among the cardiovascular risk factors, TG and LDL-C were strongly correlated with all anthropometric parameters (r: 0.66–0.85; $p < 0.01$), while fasting blood glucose shows the weakest correlations with obesity parameters. In Figure 2, the study population was separated into obese group (a) and control group (b). BMI was still positively associated with cholesterol, LDL-C, TG, atherogenic index (r: 0.37–0.72; $p < 0.01$) but not with HDL-C, fasting blood glucose, insulin level, SBP and

Table 3 Prevalence of clustering of cardiovascular risk factors between obese and control children

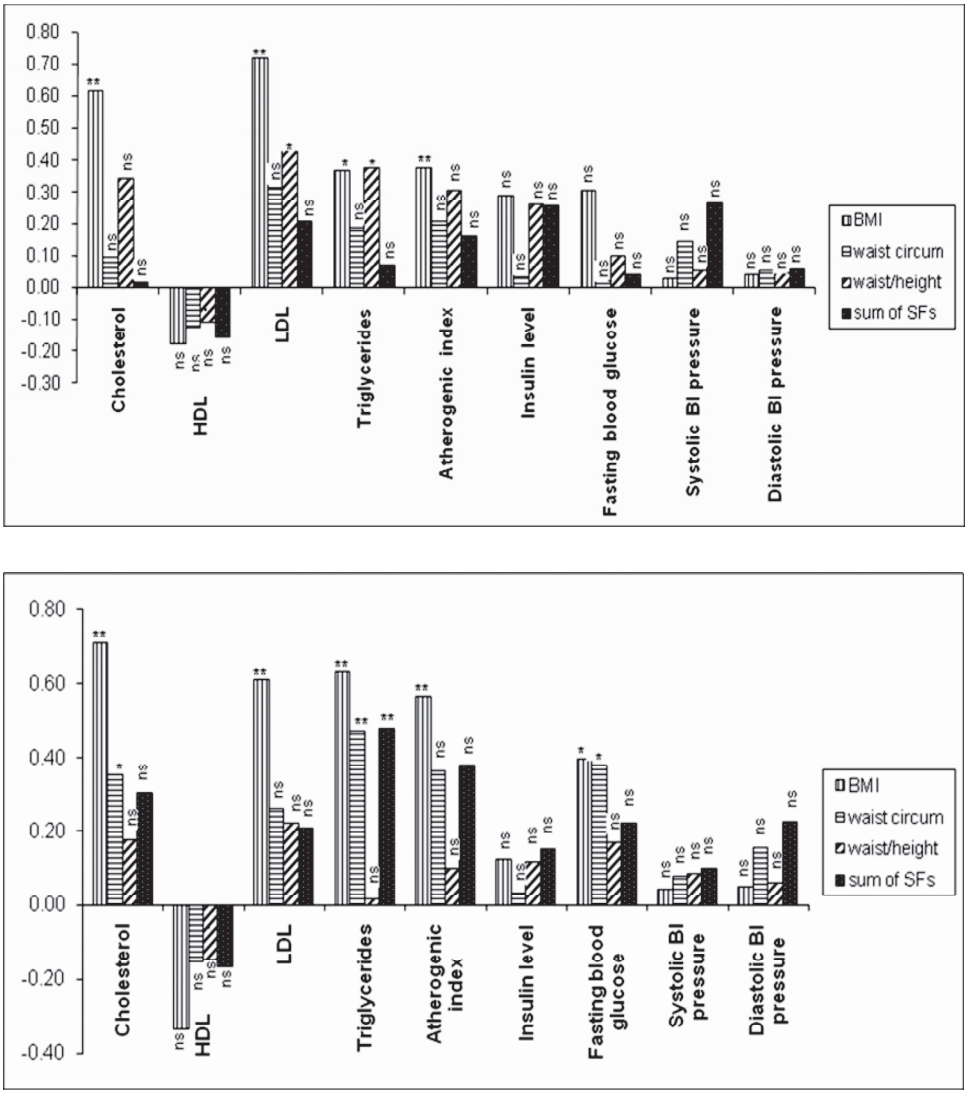
Number of risk factors	Obese (N=60)	Control (N=60)		
	N (%)	N (%)	X^2	p
Two	12 (20%)	2 (3.3%)	4.04	0.04
Three	16(26.7%)	2 (3.3%)	6.41	0.01
Four or more	28 (46.7%)	0 (0)	18.26	0.001

Table 4 Correlation coefficients for association between cardiovascular risk factors and anthropometric parameters in the study population

Cardiovascular risk factors	BMI	WC	WSR	Sum SFs
	r	r	r	r
Total cholesterol	0.76**	0.62**	0.68**	0.53**
HDL-C	–0.76**	–0.69**	–0.74**	–0.64**
LDL-C	0.85**	0.75**	0.78**	0.66**
Triglycerides	0.85**	0.78**	0.82**	0.68**
Atherogenic index	0.83**	0.71**	0.78**	0.61**
Fasting blood glucose	0.43**	0.34	0.38**	0.28*
Insulin level	0.87**	0.78	0.88**	0.63**
Systolic BP	0.76**	0.68	0.78**	0.54**
Diastolic BP	0.68**	0.61	0.69**	0.50**

*$p < 0.05$; **$p < 0.01$;

Note: BMI, body mass index; WC, waist circumference; WSR, waist-to-stature ratio; Sum SFs, sum of skinfold.



$^{**}p < 0.01$, $^{*}p < 0.05$; ns, not significant.

Figure 2 (a) Pearson's correlation between cardiovascular risk factors and anthropometric parameters adjusted for age and Tanner stage in (a) obese group and (b) control group

DBP ($p > 0.05$). In obese children (Figure 2(a)), LDL-C and TG remained positively correlated with some obesity parameters as WSR and BMI ($r = 0.37$, $r = 0.72$; $p < 0.05$, respectively) but not with other parameters. In control children (Figure 2(b)), TG remained correlated with BMI, waist C and sum of skinfold thickness ($r = 0.63$; $p < 0.01$; $r = 0.47$; $p < 0.01$; $r = 0.48$; $p < 0.01$, respectively).

Regression analysis

Results of stepwise linear regression analysis for each of the cardiovascular risk factor as

Table 5 stepwise regression analysis of each cardiovascular risk factor and anthropometric predictors

Cardiovascular risk factor as a dependent variable	predictors	Beta	p
Total Cholesterol	BMI	1.195	0.001
(Adjusted R^2=0.596)	WC	-0.477	0.025
HDL-C			
(Adjusted R^2=0.567)	BMI	-0.758	0.001
LDL-C			
(Adjusted R^2=0.709)	BMI	0.845	0.001
Triglycerides			
(Adjusted R^2=0.712)	BMI	0.846	0.001
Atherogenic index			
(Adjusted R^2=0.683)	BMI	0.83	0.001
Insulin	WSR	0.459	0.025
(Adjusted R^2=0.776)	BMI	0.438	0.032
Systolic BP			
(Adjusted R^2=0. 602)	WSR	0.78	0.001
Diastolic BP			
(Adjusted R^2=0.473)	WSR	0.694	0.001

a dependent variable are present in Table 5. BMI was a significant independent predictor of most cardiovascular risk factors. It represents a significant proportion of the variance of TG, LDL-C, HDL-C and atherogenic index (84.6%, 84.5%, 75.8% and 83%, respectively) WSR appeared as a significant predictor of insulin level, SBP and DBP.

DISCUSSION

Overweight and obesity are the most common nutritional disorders. They collectively comprise one of the most pressing health problems of the 21st century (Baba et al., 2006; Weiss et al., 2004). The epidemiologic transition in many developing countries along with rapid lifestyle changes made children prone to cardiovascular risk factors and as a result to chronic diseases later in life (Kelishadi, 2006). It is worth to investigate for simple measurement methods indicating the potential for future disease incidence and enable practitioners to identify at-risk children.

In this study, BMI and sum of skinfold thickness were used as indicators of overall adiposity. In a previous study by the author, BMI has been proved to be an excellent predictor of body fat percent measured by dual energy X-ray absorptiometry (DEXA) (Ebtissam, 2007). The sum of skinfold is reported as a reliable estimate of obesity and regional fat distribution (Wells and Fewtell, 2006). WC was used in our study as an indicator of central obesity. It is considered as an appropriate predictor of abdominal fat in children (Katzmarzyk et al., 2004) and adolescents (Daniels et al., 2000). Another indicator of abdominal adiposity is WSR, which is reported as a better indicator of adiposity independent of age and sex (Kahn et al., 2005). Ho et al. (2003) suggested that in adult, a simple message that's one's WC should not exceed half the stature could be

recommended to the public. This threshold may also be valid in young adults (Bertsias et al., 2003) and children (Botton et al., 2007). As there is no universal cutoff for WC, we depended on BMI for defining obesity. Obesity was defined as being at or above the 95th percentile of BMI for age and sex (Flodmark et al., 2004).

In obese children, weight, BMI, skinfold thickness and circumferences were significantly higher than that of the control group ($p < 0.001$). Height and WHR ratio showed no significant difference ($p > 0.05$) (Table 1). Our obese children had higher glucose and insulin concentrations, higher BP and more adverse lipid profile than non-obese children (Figure 1). These results are consistent with many other studies in different ethnic groups (Botton et al., 2007; Denney-Wilson et al., 2008).

According to the thresholds of blood lipid concentrations (Daniels et al., 2008), we found that prevalence of dyslipidemia tended to be significantly higher in obese children (Table 2). About 90% of obese children had hypertriglyceridemia vs. 6.7% of the control group. ORs and 95% CI revealed the risk estimate to have high levels of cardiovascular risk factors. (Obese children were nearly 16 times as likely to have hypercholesterolemia as were non-obese subjects.)

In spite of this higher prevalence of dyslipidemia among obese Egyptian children, our findings are nearly comparable with those among children from Finland (Raitakari et al., 1994), Germany (Reinehr et al., 2005) and the USA (Webber et al., 1995). This may be due to recent changes in life styles, dietary patterns or both. The food adequacy data from National Nutrition Institute in Egypt show that the percentage of children receiving more than 100% of their energy RDAS increased from about 14% in 1995 to about 46.9% in 2000. These data when added to decrease in physical activity explain the high prevalence of hyperlipidemia in children and adolescents (FAO/WHO, 2006).

Another important cardiovascular risk factor detected in our obese children was high SBP (40% of obese) and DBP (23.3% of obese) (Table 2). This result is consistent with other reports that showed that the prevalence of high-normal and elevated SBP are elevated in obese children and adolescents (Paradis et al., 2004).

Although mean fasting blood glucose was higher in obese children compared to non-obese population, none of our study population had fasting blood sugar >110 mg dl^{-1}, therefore, it cannot be encountered as a metabolic risk factor in our study. Similar finding was detected in a population of Iranian adolescents with hypertriglyceridemic waist phenotype, where they had higher prevalence of all metabolic risk factors except elevated fasting glucose (Esmaillzadeh et al., 2006). Dietary intake might be an important factor in determining blood glucose (Parillo and Riccardi, 2004).

One particular result from our study was the difference in the prevalence of CVD risk factors between boys and girls. In obese children, boys had a poorer lipid profile and higher SBP than girls. All obese boys had high triglyceride concentration above 130 mg dl^{-1}. A possible explanation is that obese boys may have more abdominal fat (android fat pattern) than total fat mass, and abdominal fat is more highly correlated with metabolic risk factors than is total fat (Denney-Wilson et al., 2008). Increased intra-abdominal fat in both children and adults results in increased delivery of lipid products to the liver, which in turn produces higher concentrations of LDL and VLDL and increases hepatic gluconeogenesis. On the other hand, elevated serum triacylglycerol could result in lower

concentrations of HDL-C. High intra-abdominal fat would also cause free fatty acid concentration to increase in body tissues, which results in the development of insulin resistance and hyperinsulinemia (Kahn and Valdez, 2003). On the contrary, non-obese girls (3.3%) had two or more CVD risk factors while non-obese boys had not any risk factors. This may be explained as non-obese girls undertake little exercise in their daily life activities in comparison to non-obese boys.

Risk factors tend to cluster within individuals and the presence of more than one risk factor in childhood presents an increased risk of CVD in adulthood (Berenson et al., 1998; Chu et al., 1998). In our study, there was a tendency for clustering of CVD risk factors. Twenty percent of obese children had two risk factors vs. 3.3% of non-obese children. Of particular concern is finding that 46.7% of obese children had four or more CVD risk factors, while two girls only of the non-obese children had not more than three CVD risk factors ($p < 0.001$) (Table 3).

The prevalence of clustered risk factors is a common feature in many studies (Esmaillzadeh et al., 2006; Katzmarzyk et al., 2004) and it tends to be stable traits that track well from childhood into adulthood.

While the relationship between obesity status and body fat distribution and the risk of chronic disease in adults has been shown repeatedly (Carey et al., 1997; Carmelli et al., 1997; Ho et al., 2001), population-based studies concerning the correlation of anthropometric indices and CVD risk factors in children and adolescents are limited, and comprise different age groups making the comparisons difficult (Kelishadi et al., 2007). In this study, all obesity parameters (BMI, WC, WSR and sum of skinfolds) were positively correlated with total cholesterol, LDL-C, TG, atherogenic index and negatively correlated with HDL-C in girls as in boys. BMI shows the strongest correlations with all CVD risk factors (Table 4) even when correlation analysis was performed for obese and non-obese children separately. BMI remained strongly correlated with most of CVD risk factors (total-cholesterol, LDL-C and TG) (Figure 2). The recent study of Kahn and Cheng (Kahn et al., 2005) in the US showed that WHR is a better index identifies youth with adverse CVD risk factor than sex- and age-specific BMI. In Cyprus, Savva et al. (2000) found that in children (with a mean age 11.4 years), WC and WSR are better predictors of CVD risk factors than BMI. In Portugal, Teixeira et al. (2001) showed that measures of central adiposity such as WC and WSR significantly correlated with serum lipid levels in obese children and adolescents but not in leaner individuals.

Results of linear regression analysis in our study population documented BMI as a significant predictor of serum lipids, and WSR as a predictor of insulin level, SBP and DBP (Table 5). These findings are in consistent with the results of Kelishadi et al. (2007) who concluded that BMI, WC and WSR were the most appropriate indices in predicting CVD risk factors. Many other studies confirming the predictive value of BMI for CVD risk factors (Denney-Wilson et al., 2008; Freedman et al., 2001; Katzmarzyk et al., 2004).

However, since BMI cannot distinguish fat from muscle mass, and cannot represent the fat distribution, some scientific groups stated that BMI could not be appropriate in predicting CVD (AAP, 2003). Different studies have documented that WC is a good predictor of CVD risk factors in children and adolescents (Weiss et al., 2003). However, still there is no global standard for WC in children. The cutoff values differ

between genders, different races and ethnic groups.

Therefore, rising prevalence of overweight and obesity with their adverse effects (e.g. hypertension, dyslipidemia, diabetes) among children and adolescents should elevate concern about the importance of early screening and management of young people. Primary care physicians should be equipped to provide opportunistic counselling regarding weight management at routine health visits. Identification and management of risk factors early in life may improve the long-term sequelae.

In conclusion, the results of this study showed that obese children are at great risk for developing CVD. BMI and WSR were the best indices predicting CVD risk factors. It may be clinically useful in the paediatric population to routinely assess WC and WSR in addition to BMI to identify those at particular risk.

BIOGRAPHY

Ebtissam Mohamed Salah El-Din is a Assistant Professor Researcher of Child Health, NRC, Egypt. A member of Developmental and Behavioral Assessment Clinic at the Medical Services Unit, NRC, Egypt.

Mai Mahmoud Youssef is a Professor Researcher of Child Health department since 2007. Special interested in Assessment of body composition, obesity, cardiovascular diseases, child nutrition.

Samar Mohamed El Maamoon Salem is a Assistant Professor Researcher of Child Health. Intervention trial to improve vitamin A status in children aged 2–5 years.

Hala Mohamed Salah Eldin Mostafa Megahed is a Assistant Professor Researcher of Child Health.

Nagwa Abdel Aziz Kantoush is a Assistant Professor Researcher of Clinical and Chemical Pathology.

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