Assessment of Body Composition, Fat Distribution and Serum lipid Profile in Obese School Children

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Abstract: Objective: To determine the relationship between body compositions, fat distribution and blood lipid profile in obese school children aged 7 to 18 years. Methodology: In this cross-sectional study, 150 pupils between the ages of 7 to 18 years were included. Anthropometric measures of adiposity (BMI, waist circumference, waist-to-hip ratio, peripheral adiposity: as the sum of triceps and biceps skinfold thickness, central adiposity: as the sum of sub scapular, suprailiac and abdominal skinfold thickness), body composition and serum total lipids profile were assessed. Results: There are significant sex differences in ages 7 -18 years regarding BMI, abdominal skinfold thickness and TC/ HDL-C, and in peripheral adiposity at young age (7-11 years) and central one at adolescents (12-18 years). Body composition and fat distribution showed significant sex differences in adolescent period only; and in fat distribution in young age period. For young age, triglycerides and HDL-C are correlated to most of the body composition and anthropometric parameters in boys and not in girls. For adolescents, there is no correlation between any one of the lipid profile and the body composition and anthropometric parameters in either gender. Conclusion: This study has shown that in comparison to girls, the correlation of body composition, fat distribution and lipid profiles were higher in boys aged 7 – 11 years only, with a tendency to develop the higher risk level of cardio vascular disease. Particular attention should be focused on the time prevention of childhood obesity.

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1. Introduction:

Obesity; which is an excessive amount of body fat; is currently a global pandemic, and represents an important health problem both in developed and developing countries [1] and Egypt is not spared.

According to the Centers for Disease Control and Prevention (CDC), the prevalence of childhood obesity in 2006 reached 27.5% in USA, 25.5% in Europe and 12.5% in Egypt and North Africa [2]. In 2008, the rate of overweight and obese children in the United States was 32% [3].

With a growing incidence of obesity in childhood, this problem is even more alarming when its progression and associations are considered because metabolic changes and the consequence of obesity, formerly observed in adults, are now observed in younger individuals [4]. The multiple associated co- morbidities increase the cardiovascular mortality risk and reduce the quality of life in adulthood. Among the different situations associated with adult obesity, hypertension, dyslipidemia and alterations in glucose metabolism have also been found in children with excess weight [4, 5]. In the school age group, early vascular complications have also been detected, and they are as feared as those in adults, particularly when their progressive character is considered [6].

The relationship of obesity to risk factors is not only defined by the level of obesity but also by distribution of fat [7]. Anthropometric measurements; including body weight , height, circumferences and skin fold thickness; can be used to assess body size and proportions as well as total body and regional body compositions especially fat distribution. The anthropometric indices of adiposity include body mass index (BMI), waist circumference, waist-to-hip ratio, peripheral adiposity; as the sum of triceps and biceps skin fold thickness; central adiposity; as the sum of sub scapular, suprailiac and abdominal skin fold thickness; and body composition [8, 9]. Waist circumference reflects central adiposity as well as general adiposity, based on waist circumference which uniquely related to disease risk [10]. The use of BMI to classify children and adolescents as overweight and obesity is well established [11].

Prospective and retrospective studies have shown that risk factors related to cardiovascular diseases (CVD) namely obesity, lipid profiles, unhealthy diets and sedentary lifestyle, have their roots in childhood and tend to track into adulthood [12]. In childhood, obesity is associated with high levels of blood pressure, very low-density lipoprotein cholesterol (VLDL-C) and insulin, lower levels of high density lipoprotein cholesterol (HDL-C), increased heart rate and increased cardiac output [13]. Abnormal serum concentrations of lipids such as total cholesterol (TC) and low- density lipoprotein-cholesterol (LDL-C) are strongly correlated with early atherosclerotic lesions [14]. Lima et al., 2004 [15], stated that serum lipid levels may be affected by obesity or body fat distribution patterns.

Few studies have tested whether fat distribution is associated with cardiovascular risk factors irrespective of the total amount of fat in children [10, 16]. None of these studies analyzed genders separately.

The present study was planned and performed with the aim of identifying and determining the relationship between body composition, fat distribution and the serum lipid profile in obese school-aged children (aged 7 to 18 years) for each gender separately.

2. Subjects and Methods

Subjects

This research was a cross-sectional one, conducted in 6 public schools (two Primary Schools, two preparatory and two secondary schools) situated in Giza governorate, Egypt; during the period of October, 2007 to April 2009. With parental consent, 150 obese pupils (70 boys, 80 girls), were recruited for this research. These pupils were required to meet the following inclusion criteria: age, 7–18 years and BMI, greater than the 95^{th} percentile for age and gender based on the Egyptian Growth Reference Charts [17]. Pupils were excluded if they had a prior major illness, including type 1 or 2 diabetes, recieve medications or had a condition known to influence body composition, insulin action or insulin secretion (e.g. glucocorticoid therapy, hypothyroidism and Cushing's disease). The sample was divided into 2 groups according to their age:

Group (I): including 62 pupils (32 boys and 30 girls) of the primary school, aged 7 -11 years $\pm$ 6 months.

Group (II): including 88 pupils (38 boys and 50 girls) of the preparatory and secondary schools, aged 12 -18 years $\pm$ 6 months.

Permission to perform the study was granted by the Ministry of Education, and the directors of the school included in the research. Parents were informed about the purpose of the study and their permission in the form of written consent was obtained. Approval to conduct this survey was granted by the "Ethical Committee" of the "National Research Centre".

Anthropometric measures:

Each pupil underwent a complete physical examination, including anthropometric measures. The height, weight, waist and hip circumferences and skinfold thickness were measured following the recommendations of the International Biological program [18]. The height was measured to the nearest 0.1 cm on a Holtain portable anthropometer, and the weight was determined to the nearest 0.01 kg on a Seca Scale Balance, with the subject wearing minimal clothing and no shoes. Waist circumference (central adiposity) was measured at the level of the umbilicus with the subject standing and breathing normally, hip circumference at the level of the iliac crest, using non-stretchable plastic tape to the nearest 0.1 cm. Skin folds thickness were taken at five sites: triceps, biceps, sub scapular, suprailiac and abdominal. Each skinfold was measured three times on the left side of the body; with Holtain skin fold caliper to the nearest 0.2 mm, and the mean was recorded. The following adiposity indices were calculated:

- Body mass index (BMI): as weight (in kilograms) divided by height (in meters) squared.
- Waist/ Hip ratio (cm/ cm).
- Peripheral adiposity: as the sum of triceps and biceps skinfold thickness.
- Central adiposity: as the sum of sub scapular, suprailiac and abdominal skinfold thickness.

Body Composition:

Whole body resistance and reactance (capacitance) were measured using a Bioelectrical Impedance Analyzer (HOLTAIN LIMITED). As specified by the manufacturer, the unit was calibrated before testing using 400-ohm resistor, and electrodes were placed on right wrist and ankle. By using pupil sex, age, weight and height approximated to the nearest unit, the percentage body fat (Fat %), fat mass (FM) and fat free mass (FFM) were derived.

Plasma Lipid profile:

Early morning venous blood samples were taken from each pupil for biochemical screening tests after 12-hours overnight fasting. Professional staff performed venipuncture. The blood samples were left to clot; sera were separated by centrifugation for 10 minutes at 5000 rpm then stored at –80ºC until assays. Serum concentrations of total cholesterol (TC) [19], triglycerides (TG) [20] and high-density lipoprotein-cholesterol (HDL-C) [21] were measured using commercially available kits provided by STANBIO Laboratory Inc.(1261 North Main Street Boerne Texas 78006 USA). LDL-C was calculated according to an equation developed by Friedewald et al., 1972 [22] as follows:

LDL-C= Total cholesterol –Triglycerides/5+ HDL-C.

The ratio between total cholesterol and high-density lipoprotein-cholesterol (TC/HDL-C) was calculated.

Statistical Analysis:

All values are reported as the mean ± SD. Statistical evaluation of the results was performed with the SPSS 9.05 computer program. Student's *t test* was used to examine the sex differences. Pearson's correlation coefficients were used to assess relationships between independent variables. The level of significance was set at a probability of less than 5% ($p<0.05$).

3. Results:

The total sample included 150 students, 46.7% were boys (n: 70) and 53.3% were girls (n: 80). Descriptive data for the anthropometric measures, body composition and lipid profile for boys and girls are shown in tables I and II. Analyses of the pupils of group (I) aged 7- 11 years ± 6 months (table 1) revealed significant differences between gender for body weight, BMI, biceps, sub scapular and abdominal skinfold thickness, peripheral adiposity and TC/HDL-C ($p<0.05$). Girls had significantly higher mean values of body weight, BMI, and sub scapular skinfold thickness than boys, while skinfold thickness at the biceps and abdominal areas, peripheral adiposity and TC/HDL-C mean values were significantly higher in the boys. Insignificant sex differences were recorded regarding the body composition in this age.

Group (II) aged 12- 18 years ± 6 months (table 2) had significant differences between gender for, BMI, abdominal skinfold thickness, central adiposity, body composition parameters (fat % , fat mass , fat free mass) and TC/HDL-C ($p<0.05$). Girls had significantly higher mean values of BMI, fat %, fat mass and TC/HDL-C while abdominal skinfold thickness, central adiposity and fat free mass mean values were significantly higher in the boys. There is insignificant sex difference in TG, TC, HDL-C and LDL-C for both groups.

Correlation of lipid profiles to body composition and fat distribution for both groups by gender are presented in tables III and IV. For boys in group (I) aged 7- 11 years ± 6 months (table III) , a highly significant positive correlations were observed between triglyceride and all the anthropometric measures and indices; body composition parameters except waist/ hip ratio which show insignificant positive correlation. HDL-C showed highly significant positive correlations with weight and fat free mass, and significant positive correlations with BMI and fat%, while highly significant negative correlations were found in HDL-C and skinfold thickness at the biceps and abdominal areas, peripheral and central adiposity. Both TC and LDL-C showed significant positive correlations with suprailiac skinfold thickness, while TC only showed highly significant positive correlation with fat %, and LDL-C had significant negative correlation with fat free mass. Moreover, TC/ HDL-C showed significant negative correlations with body weight, BMI, hip circumference and fat free mass. However, none of the parameters under study showed any correlation in girls of this group, except triglyceride which had significant positive correlations with body weight, and highly significant positive correlations with hip circumference.

For group (II) aged 12- 18 years ± 6 months (table IV), none of the parameters under study showed any significant correlation in both gender except triglyceride which had significant negative correlation with biceps skinfold thickness.

4. Discussion:

Childhood obesity represents a high risk of morbidity and mortality, and it perpetuation into adulthood strongly increases the risk of cardiovascular disease [7, 23]. This constellation is caused by excessive food and decrease in physical activity which leads to accumulation of body fat [5, 24].

Obesity and changes in blood lipid profile during childhood increases cardiovascular disease risk (CVD) in adulthood. Therefore in CVD examination, one of most important parameters is the analysis of total lipid profiles [25].

BMI increase lipid mobilization leading to increase in triglycerides and LDL. Obesity appears to influence the accumulation of fat, which in turn related to the development of major risk factors. Once thought to only be inactive energy storage area in which excess calories were stored as fat, it is now known that adipose tissue also functions as an endocrine gland [26, 27]. Fat cells secrete free fatty acid, which may stimulate hepatic triglyceride and low density lipoprotein cholesterol (LDL) production in adults [28].There is evidence to suggest a similar relationship in youth [9]. So, the purpose of this research is to identify and determine the relationship between body composition, fat distribution and the serum lipid profile in obese school-aged children (aged 7 to 18 years) for each gender separately.

Table 1: Anthropometric characteristics and Lipid profile of the group (I) by sex (Age 7-11 ± 6 months)

Parameters	Boys (N = 32)		Girls (N = 30)		p
	Mean	±SD	Mean	±SD	
Weight (Kg)	53.75	±12.50	60.37	±13.19	0.047*
Height (cm)	140.40	±9.82	144.8	±10.85	0.097
BMI (Kg/cm²)	26.84	±2.49	28.41	±3.07	0.030*
Waist C (cm)	78.91	±8.34	82.62	±15.33	0.238
Hip C(cm)	91.93	±8.40	95.02	±9.31	0.174
Waist/Hip ratio	0.86	±0.04	0.88	±0.21	0.593
Skinfold (mm)					
Triceps	27.25	±4.62	25.07	±6.10	0.119
Biceps	20.63	±4.74	16.70	±5.63	0.004**
Subscaular	23.93	±3.09	26.61	±4.56	0.009**
Suprailiac	26.50	±4.13	26.57	±6.08	0.961
Abdominal	28.68	±5.44	24.36	±6.46	0.006**
Peripheral fat	47.88	±8.34	41.77	±9.50	0.010**
Central fat	79.10	±11.23	77.53	±14.54	0.638
Body Composition					
Fat %	43.39	±15.24	39.10	±4.66	0.165
Fat mass (Kg)	23.01	±8.70	25.48	±7.62	0.270
Fat free mass (Kg)	35.03	±6.85	38.86	±7.69	0.056
Lipid profile					
TG (mg/dl)	125.86	±33.99	136.19	±39.63	0.274
TC (mg/dl)	195.13	±60.94	177.70	±53.45	0.237
HDL-C(mg/dl)	37.77	±15.26	42.96	±20.55	0.265
LDL-C(mg/dl)	132.09	±61.16	108.11	±53.48	0.110
TC/HDL-C	0.048	±0.03	0.032	±0.02	0.016**

Table 2: Anthropometric characteristics and Lipid profile **of the group (II) by sex (Age 12-18 ± 6 months)**

Parameters	Boys (N=38)		Girls (N= 50)		
	Mean	±SD	Mean	±SD	p
Weight (Kg)	84.18	±13.58	85.70	±11.23	0.567
Height (cm)	162.37	±9.96	159.13	±7.12	0.093
BMI (Kg/cm²)	31.76	±2.77	33.82	±3.73	0.005**
Waist C (cm)	101.50	±13.86	96.18	±17.94	0.139
Hip C(cm)	111.77	±9.11	110.64	±11.83	0.631
Waist/Hip ratio	0.91	±0.12	0.89	±0.27	0.653
Skinfold (mm)					
Triceps	26.45	±6.09	28.23	±7.08	0.243
Biceps	20.11	±7.69	20.95	±6.82	0.602
Subscaular	31.31	±7.01	30.62	±7.49	0.674
Suprailiac	27.32	±9.42	25.28	±7.80	0.287
Abdominal	34.21	±7.69	26.24	±7.44	0.000**
Peripheral fat	46.56	±12.37	49.18	±12.62	0.355
Central fat	92.85	±20.00	82.14	±19.46	0.018**
Body Composition					
Fat %	35.13	±9.14	42.94	±3.94	0.000**
Fat mass (Kg)	30.45	±10.76	38.67	±7.97	0.000**
Fat free mass (Kg)	55.79	±11.78	49.30	± 5.04	0.001**
Lipid profile					
TG (mg/dl)	131.59	±59.98	143.36	±62.72	0.380
TC (mg/dl)	171.95	±50.71	180.84	±61.35	0.474
HDL-C(mg/dl)	41.57	±14.97	45.10	±29.64	0.477
LDL-C(mg/dl)	104.47	±53.82	108.36	±68.10	0.768
TC/HDL-C	0.03	±0.02	0.04	±0.03	0.046*

Table 3: Correlation between serum lipid profile and whole body composition and fat distribution by gender for group I (Age 7-11 ± 6 months)

	Boys					Girls				
	TG (mg/dl)	**TC** (mg/dl)	**HDL-C** (mg/dl)	**TC/HDL-C**	**LDL-C** (mg/dl)	**TG** (mg/dl)	**TC** (mg/dl)	**HDL-C** (mg/dl)	**TC/HDL-C**	**LDL-C** (mg/dl)
Weight (Kg)	0.567**	-0.004	0.457**	- 0.401*	-0.179	0.380*	-0.054	-0.175	0.190	-0.028
BMI (Kg/cm²)	0.531**	-0.164	0.353*	- 0.442*	-0.309	0.306	0.078	-0.013	0.087	0.071
Waist C (cm)	0.679**	0.190	0.150	- 0.285	0.078	-0.014	0.000	- 0.202	0.313	0.080
Hip C(cm)	0.700**	0.104	0.255	- 0.383*	-0.035	0.548**	- 0.014	0.084	- 0.090	- 0.110
Waist/Hip ratio	0.213	0.293	-0.214	0.147	0.321	-0.244	0.002	- 0.224	0.317	0.117
Skinfold (mm)										
Triceps	0.551**	0.237	-0.207	-0.006	0.228	0.045	0.225	0.119	0.024	0.202
Biceps	0.409*	-0.005	-0.698**	0.274	0.123	- 0.197	0.053	0.042	0.155	0.049
Subscaular	0.712**	0.282	-0.156	-0.111	0.242	0.121	- 0.044	- 0.032	0.257	- 0.056
Suprailiac	0.675**	0.353*	-0.296	0.144	0.352*	0.049	- 0.213	0.145	- 0.069	- 0.261
Abdominal	0.376*	-0.038	-0.650**	0.279	0.082	- 0.251	- 0.097	0.061	0.093	- 0.098
Peripheral fat	0.537**	0.129	-0.511**	0.152	0.196	- 0.088	0.176	0.098	0.098	0.154
Central fat	0.626**	0.189	-0.467**	0.158	0.236	- 0.053	- 0.146	0.077	0.092	- 0.169
Fat %	0.678**	0.530**	0.438*	-0.011	0.314	0.287	- 0.283	- 0.049	- 0.137	- 0.363
Fat mass (Kg)	0.848**	0.185	0.251	-0.172	0.019	0.253	- 0.237	- 0.233	0.079	- 0.201
Fat free mass (Kg)	0.558**	-0.242	0.536**	-0.584**	-0.447*	0.099	- 0.120	- 0.291	0.224	0.000

Table 4: Correlation between serum lipid profile and whole body composition and fat distribution by gender for group II (Age 12-18 ± 6 months)

	Boys					Girls				
	TG (mg/dl)	**TC** (mg/dl)	**HDL-C** (mg/dl)	**TC/HDL-C**	**LDL-C** (mg/dl)	**TG** (mg/dl)	**TC** (mg/dl)	**HDL-C** (mg/dl)	**TC/HDL-C**	**LDL-C** (mg/dl)
Weight (Kg)	0.010	- 0.045	0.029	- 0.046	- 0.035	0.149	0.031	0.242	- 0.238	0 0.129
BMI (Kg/cm²)	- 0.115	- 0.291	0.108	- 0.296	- 0.274	- 0.059	0.137	0.060	0.017	0.081
Waist C (cm)	- 0.154	- 0.251	0.146	- 0.145	- 0.242	0.154	0.142	- 0.230	0.271	0.199
Hip C(cm)	- 0.290	- 0.191	0.100	- 0.241	- 0.247	- 0.139	- 0.038	0.077	- 0.062	- 0.068
Waist/Hip ratio	0.003	- 0.150	0.101	- 0.009	- 0.112	0.106	0.120	- 0.211	0.246	0.178
Skinfold (mm)										
Triceps	0.033	0.201	0.096	- 0.168	0.249	0.141	- 0.180	- 0.223	- 0.059	- 0.095
Biceps	-0.428*	0.330	0.262	- 0.222	0.246	0.075	- 0.050	0.013	- 0.188	- 0.089
Subscaular	- 0.210	0.112	0.111	- 0.048	0.144	0.166	- 0.090	- 0.98	- 0.131	- 0.067
Suprailiac	- 0.030	0.150	0.142	- 0.208	0.059	0.048	- 0.110	- 0.163	- 0.033	- 0.023
Abdominal	- 0.223	0.113	0.087	- 0.020	0.098	0.269	- 0.044	- 0.205	0.056	0.016
Peripheral fat	- 0.250	0.304	0.210	- 0.223	0.276	0.120	- 0.128	- 0.119	- 0.134	- 0.101
Central fat	- 0.171	0.152	0.139	- 0.122	0.116	0.186	- 0.096	- 0.182	- 0.042	- 0.029
Fat %	- 0.160	- 0.094	0.210	- 0.207	- 0.119	- 0.182	0.023	0.030	- 0.084	- 0.075
Fat mass (Kg)	- 0.115	- 0.120	0.235	- 0.217	- 0.153	- 0.023	- 0.023	0.090	- 0.216	- 0.125
Fat free mass (Kg)	0.157	0.029	- 0.074	0.101	0.036	0.278	- 0.065	0.106	- 0.243	- 0.146

In the current research, there are significant gender differences in ages 7 -18 years regarding BMI, abdominal skin fold thickness and TC/ HDL-C, and in peripheral adiposity at young age (7-11 years) and central one at adolescents (12-18 years). Body composition showed significant sex differences in adolescent period only. In young age (7-11 years), in spite of girl's recorded significant higher values of BMI, boys had significant higher values of abdominal and peripheral adiposity. In adolescents (12-18 years), in spite of girl's recorded significant higher values of BMI, fat%, and fat mass, boys still recorded significant higher values of abdominal subcutaneous fat but with central adiposity. Regarding lipid profile, for young age, triglycerides and HDL-C are correlated nearly with all measures of adiposity (body composition and anthropometric parameters) in boys and not in girls which might have been influenced by frequency of pubertal stages in girls. Hormonal changes, found at this stage, may act as a protective factor against changes in lipid profile. Before and after menarche, changes in lipid profile are sensitive to the influence of sex hormones, especially estrogen, which has a favorable effect on lipoprotein by increasing HDL and reducing LDL [15]. This can be explained by such study found that trunk skin folds predicted cardiovascular disease risk factors to the same extent as total fat mass by DXA, and in some cases independently of total fatness [10]. In another study, Daniels et al., 1999 [29] , studied both the percent body fat and fat distribution in a stepwise multiple linear regression analysis and found that fat distribution was a more important independent correlate of cardiovascular risk factors (high triglycerides, low HDL cholesterol, high systolic blood pressure, high left ventricular mass) than percent fat mass. The associations found only in boys between the sum of skin folds and cardiovascular risk can be due to the fact that a central fat distribution is considered as a male specific pattern and an explanation for the high prevalence of cardiovascular disease in men compared to women [30].

This study assumed that the fat distribution is more homogeneously centrally distributed in boys and its effect on cardiovascular risk factors would not be distinguished from that of subcutaneous fat mass. Conversely in girls, there is more variability in the fat distribution, from a gynoid to an android pattern, for a given level of total fat mass. The subcutaneous fat mass has a role in the relation between fat distribution and cardiovascular disease risk in these young boys.

For adolescents, there is no correlation between any one of the lipid profile and the body composition and anthropometric indices in either gender.

Our results are in partial agreement with a previous report of Hu et al 2000 [31], who found that in boys, BMI was positively correlated with triglyceride and negatively correlated with HDL-cholesterol. Triglycerides increased with waist circumference and HDL cholesterol decreased with waist circumference. Flodmark et al 1994 [32] found also that BMI was significantly correlated with serum triglycerides. Chu et al., 2001[33]. proved that TG was positively associated with most anthropometric parameters. Also Okada et al, 1998 [34] found that the distribution of central-type fat accumulation was inversely correlated with the HDL-C level in both boys and girls, and showed a stronger correlation with both the triceps and the sub scapular skin fold thicknesses.

In this study both TC and LDL-C showed significant positive correlations with supra iliac skin fold thickness, while TC only showed highly significant positive correlation with fat %, TC/ HDL-C showed significant negative correlations with body weight, BMI, hip circumference and fat free mass. This coincides with the result of Takahashi et al., 1996 [35], who recorded that overweight and obese boys had significantly higher levels of total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C). Okada et al., 1998 [34] found also that the degree of obesity and the body mass index (BMI) were more strongly correlated with serum levels of lipids and apolipoproteins in boys than in girls. In boys, atherogenic lipoproteins, such as LDL-C, showed a stronger correlation with the thickness of the triceps skin fold.

5. Conclusion:

In young boys abdominal fat distribution is associated with cardiovascular risk factors, independently of overall adiposity. International definition of abdominal obesity in children is required to standardize studies and progress in the evaluation of childhood obesity and its consequences.

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