J Physiol Biochem, **65** (4), 415-420, 2009

Abdominal fat and metabolic risk in obese children and adolescents

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(Received on ~~December~~ 2009)

REVENGA-FRAUCA, J., GONZÁLEZ-GIL, E.M., BUENO-LOZANO, G., DE MIGUEL-ETAYO, P., VELASCO-MARTÍNEZ, P., REY-LÓPEZ, J.P., BUENO-LOZANO, O. and L. A. MORENO. *Abdominal fat and metabolic risk in obese children and adolescents.* J Physiol Biochem, **65** (4), 415-420, 2009.

The aim of this study was to investigate fat distribution, mainly abdominal fat, and its relationship with metabolic risk variables in a group of 126 children and adolescents (60 males and 66 females) aged 5.0 to 14.9. According to IOTF criteria, 46 were classified as normal weight, 28 overweight and 52 obese. Weight, height, waist (WC) and hip circumferences were measured. The body mass index (BMI) was calculated. Total body fat, trunkal and abdominal fat were also assessed by dual energy x-ray absorptiometry (DXA). Glucose, insulin, HDL-Cholesterol, triglycerides (TG), ferritine, homocystein and C-reactive protein (CRP) were measured. Obesity status was related with insulin concentrations, CRP, TG and HDL. Obese patients had higher abdominal fat and higher CRP values than overweight and normal subjects. All markers of central body adiposity were related with insulin and lipid metabolism; however, they were not related with homocystein or ferritin. A simple anthropometric measurement, like waist circumference, seems to be a good predictor of the majority of the obesity related metabolic risk variables.

Key words: Fat distribution, Abdominal fat, Metabolic risk, Obesity, Children, Adolescents.

Abdominal fat has been identified as the main determinant of several metabolic disorders (12). Obesity is often related to oxidative stress (18), insulin resistance and type 2 diabetes (1) and non-alcoholic fatty liver disease (3, 18). In addition, obesity has been recognized as an inflammatory process often related with an increase of some markers like C-reactive protein (CRP), homocystein and, recently, ferritin (9, 14, 17, 23). As obesity is a chronic disease, it seems necessary to know if metabolic risk markers are still present in obese children and adolescents as some studies have already shown (4, 21).

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Accurate and simple methods to assess body composition are required to assess total and abdominal fat (6, 16) Dual energy X-ray absorptiometry (DXA) can be used to assess abdominal and trunkal fat (10). Waist circumference has also been used as a good predictor of metabolic risk in children (8, 12). Currently it is not know to what extent WC captures the full metabolic risk associated with abdominal obesity. Therefore, the aim of this study was to evaluate the relationship between abdominal fat, assessed by WC and DXA, and obesity related metabolic risk markers, in a group of children and adolescents.

Material and Methods

Subjects.– 126 children and adolescents (60 males and 66 females), mean age 9.45 ± 2.47 were selected from the Department of Paediatrics of the University Hospital and from schools both in Zaragoza (Spain). Inclusion criteria were healthy male and female children, age 5.0 to 14.9 years, without endogenous obesity. Exclusion criteria were chronic disease or malnutrition and the use of medication that alters blood pressure, glucose or lipid metabolism. Written consent was obtained from the parents, as well as children's assent. The protocol was performed in accordance with the *Declaration of Helsinki* (revision of Edinburgh 2000) and approved by the Research Ethics Committee of the Government of Aragón (CEICA; Spain).

Anthropometric measurements.– Body height and weight were measured to the nearest 0.1 cm and 100 g respectively. Overweight and obesity were defined by using the body mass index (BMI) according to Cole et al. cut-off values (2). Waist and hip circumferences were measured to the nearest 1 mm. WC was measured halfway between lower rib and iliac crest (12). The hip circumference measurement was taken at the maximum circumference over the buttocks, with the tape held in a horizontal plane (11). The same trained investigator made all measurements and reliability was greater than 95%.

Pubertal stage was determined in each patient using Tanner's criteria (19). 77 patients were prepubertal (Tanner I) and 49 of them were pubertal (Tanner II to V).

Body fat was also assessed by Dual Energy X-Ray Absorptiometry (DXA). A paediatric version of the software (QDR-Explorer, Hologic Corp., Software version 12.4, Walthman, MA, USA) was used for the study. Total body fat (TBF), trunk fat and total body lean (TBL) were calculated. Abdominal fat was also assessed at three different regions, R1, R2 and R3 as described elsewhere (10). As results obtained for the three regions were similar, we only considered R1, because it was estimated at the same level WC was measured.

Laboratory determinations.– After overnight fasting, blood was obtained by vein puncture. Glucose, triglycerides (TG), and high density lipoprotein-cholesterol (HDL-c), were determined by enzymatic colorimetric assay with a Roche/Hitachi MODULAR P autoanalyser (Roche Laboratory Systems, Mannheim, Germany). Insulin was determined by radioimmunoassay (Axsym, Abbott Laboratories, Chicago, IL, USA). CRP was measured by using immunoturbidimetry (AU2700 biochemistry analyzer; Olympus, Rungis, France). Homocystein concentrartions were determined by high-performance liquid chromatography with fluorescence detection (ABBOT IMx

Analyzer). Ferritin was also determined using a Roche Diagnostics E170 analyzer.

Statistical analysis.– All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS, v. 16.0, SPSS Inc., Chicago, USA). Descriptive values are given as means, standard deviations and percentages. Analysis of variance or t-Student test were used to compare mean values. Lineal multiple regression models were fitted to evaluate relations between body composition variables (independent variables) and metabolic parameters (dependent variables). Statistical significance was established when $p < 0.05$.

Results

Obese patients had higher CRP than overweight and normal subjects, but no differences were found for ferritin and homocystein levels (Table I).

Multiple regression models showed a significant relationship between body composition and some metabolic markers. TG, HDL-cholesterol and insulin were related with BMI, WC and trunk and abdominal fat. By contrast, glucose levels were not significantly related with the adiposity indices (Table II). Only one inflammatory marker (CRP) was associated with WC and trunk and abdominal fat in the regression model (Table III).

Discussion

Abdominal fat is related to many cardiovascular risk factors, like dyslipidemia, hypertension and insulin resistance even in children and adolescents (20). This relationship was often assessed using WC (1).

Table I. *Body composition and metabolic risk factors depending on obesity degree.*

	Normal weight n = 46	Overweight n = 28	Obese N = 52	p
Age (years)	8.32 ± 2.13	10.51 ± 2.34	9.82 ± 2.47	
Tanner 1, 2 - 5	36, 10	11, 17	30, 22	
BMI	16.23 ± 1.71*	22.65 ± 2.76	27.46 ± 4.04*	0.000
WC (cm)	58.52 ± 6.38*	76.24 ± 9.58*	82.44 ± 18.07	0.000
WHR	0.86 ± 0.04	0.91 ± 0.64*	0.905 ± 0.068*	0.002
~~WBTot~~ FAT (Kg)	6.74 ± 2.73	17.33 ± 6.58*	24.04 ± 7.78	0.000
Trunk fat (Kg)	2.22 ± 1.005	6.87 ± 3.02	10.38 ± 3.72	0.000
R1 (Kg)	0.38 ± 0.21	1.29 ± 0.59	2.28 ± 0.9	0.000
R2 (Kg)	0.51 ± 0.26	1.74 ± 0.81*	3.04 ± 1.16	0.000
R3 (Kg)	0.55 ± 0.28	1.94 ± 0.93*	3.36 ± 1.26	0.000
~~WBTotLean~~ (Kg)	19.5 ± 5.58*	30.59 ± 9.98*	33.65 ± 9.32*	0.000
Fasting glucose (mg/dL)	87.51 ± 6.02	97.53 ± 7.7	87.80 ± 7.98	0.980
Fasting insulin (µU/mL)	4.40 ± 2.61	11.27 ± 5.65	16.14 ± 11.75	0.000
HDL (mg/dL)	67.37 ± 14.64	52.73 ± 12.87	49.15 ± 11.96	0.000
TG (mg/dL)	48.91 ± 12.50	79.23 ± 35.98	79.06 ± 33.35	0.000
Homocysteine (mol/L)	8.79 ± 1.86	9.38 ± 3.02	9.56 ± 2.84	0.366
CRP (mg/dL)	0.13 ± 0.30	0.21 ± 0.32	0.41 ± 0.47	0.000
Ferritine (ng/dL)	51.24 ± 20.43	57.13 ± 23.11	62.21 ± 31.6	0.174

*Refers differences between sexes in each group. p refers differences between obesity degree groups.

Table II. *Multiple linear regression models of metabolic variables and central and total fat adjusted by age, pubertal development and sex.*

Independent predictors	β	95% IC		R^2	R^2 Change	p
HDL-c						
Body mass index	-1.709	-2.219	-1.199	0.349	0.294	0.000
Waist circumference	- 0.766	-1.007	-0.525	0.379	0.303	0.000
Whole body total fat	t-0.001	-0.002	0.000	0.347	0.283	0.000
Trunk fat	-16.397	-20.620	-12.174	0.434	0.397	0.000
Abdominal fat	-13.811	-17.267	-10.335	0.474	0.410	0.000
Triglycerides						
Body mass index	0.029	0.015	0.042	0.315	0.110	0.000
Waist circumference	0.009	0.004	0.014	0.278	0.090	0.001
Whole body total fat	0.000	0.000	0.000	0.286	0.100	0.001
Trunk fat	0.239	0.125	0.354	0.315	0.129	0.000
Abdominal fat	0.202	0.109	0.295	0.318	0.139	0.000
Glucose						
Body mass index	-0.015	-0.293	0.264	0.072	0.000	0.917
Waist circumference	0.046	-0.039	0.131	0.126	0.011	0.284
Whole body total fat	t0.000	0.000	0.000	0.120	0.000	0.968
Trunk fat	-0.545	-2.829	1.740	0.122	0.002	0.637
Abdominal fat	-0.292	-2.186	1.602	0.121	0.001	0.760
Insulin						
Body mass index	0.096	0.075	0.118	0.658	0.293	0.000
Waist circumference	0.039	0.030	0.048	0.650	0.278	0.000
Whole body total fat	0.000	0.000	0.000	0.635	0.284	0.000
Trunk fat	0.789	0.616	0.962	0.676	0.325	0.000
Abdominal fat	0.637	0.492	0.782	0.664	0.316	0.000

In our study, not only abdominal and trunk fat assessed by DXA, but also WC were strongly related with insulin and lipid profile (high TG and low HDL-cholesterol) in children.

Abdominal obesity, high CRP and oxidative stress markers in childhood seem to be independently associated with arterial inflammatory processes related with atherosclerosis (7). CRP plays an active role in all stages of lipoid-rich cells depot, the beginning in the development of the atheromatous plaque (5). In our study, all indices of abdominal fat were related with CRP serum concentrations; however, R^2 change was lower for WC (0.257) than for abdominal fat (0.431). Another important inflammatory marker is homocystein, which is related with coronary heart disease risk and insulin resistance, although the underlying mechanisms are not still clear (9). Because cardiovascular disease often has origins in childhood we should control these inflammatory risk factors in obese and overweight children and adolescents. However, we have not found a significant relationship between homocysteine and total or abdominal adiposity. Nevertheless, similar results from previous studies are still controversial (13, 14). Fat loss and lifestyle changes seem to be relevant in

Table III. *Multiple linear regression models of inflammatory variables and central and total fat adjusted by age, pubertal development and sex.*

Independent predictors	β	95% IC		R^2	R^2 Change	p
CRP						
Body mass index	0.153	0.110	0.196	0.358	0.332	0.000
Waist circumference	0.056	0.036	0.076	0.276	0.257	0.00
Whole body total fat	0.000	0.000	0.000	0.450	0.438	0.000
Trunk fat	1.329	0.989	1.669	0.441	0.429	0.00
Abdominal fat	1.101	0.818	1.383	0.441	0.431	0.000
Homocysteine						
Body mass index	0.092	-0.009	0.193	0.145	0.028	0.205
Waist circumference	0.054	0.015	0.094	0.288	0.061	0.319
Whole body total fat	0.000	0.000	0.000	0.201	0.046	0.292
Trunk-fat	0.595	-0.205	1.395	0.177	0.022	0.197
Abdominal fat	0.502	-0.148	1.152	0.185	0.024	0.192
Ferritine						
Body mass index	1.144	0.079	2.210	0.093	0.024	0.263
Waist circumference	0.372	-0.087	0.830	0.063	0.028	0.299
Whole body total fat	0.001	0.000	0.002	0.111	0.056	0.328
Trunk fat	9.566	0.314	18.818	0.105	0.050	0.299
Abdominal fat	7.094	-0.549	14.736	0.091	0.041	0.255

* Refers differences between sexes in each group. p Refers differences between obesity degree groups.

order to improve inflammatory markers and metabolic risk values in obese children (15, 22, 23).

In conclusion, trunk and abdominal obesity, assess by DXA are strong body composition determinants of some obesity related metabolic and inflammatory markers in children and adolescents. Waist circumference also seems to reasonably capture the effect of abdominal fat deposition in the above mentioned markers.

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