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Prevalence and risk factors of metabolic syndrome in Brazilian and Italian obese adolescents: a comparison study

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SUMMARY

Background: Metabolic syndrome (MS) prevalence between different populations in obese adolescents is scanty to date. **Objective:** To compare the MS prevalence and related risk factors in Brazilian and Italian obese adolescents. **Methods:** A total of 509 adolescents (110 Brazilian, 399 Italian), aged 15–19 years. Anthropometric characteristics, triglycerides (TG), total, low-density lipoprotein (LDL)-, high-density lipoprotein (HDL)-cholesterol, fasting plasma glucose (FPG), insulin, homeostasis model assessment of insulin resistance (HOMA-IR) and blood pressure were measured. **Results:** Age, body mass index (BMI) and BMI z-score were not significantly different between the two subgroups. BMI z-score, TG, FPG, HOMA-IR and systolic blood pressure (SBP) were significantly higher in boys than in girls both in Brazilian and Italian adolescents, while HDL-cholesterol levels were lower in boys than in girls. No significant differences were observed in BMI, LDL and total-cholesterol and DBP in two genders and groups. Insulin, FPG, HOMA-IR and TG were significantly higher, while LDL-cholesterol and SBP were significantly lower in Brazilian than in Italian subjects, both in males and females. HDL and total-cholesterol and diastolic blood pressure (DBP) were not significantly different between the two subgroups and genders. MS prevalence was higher in Brazilian than in Italian obese boys (34.8 vs. 23.6%, $p < 0.001$) and girls (15.6 vs. 12.5%, $p < 0.01$). The most frequently altered parameter was HOMA-IR both in subjects with MS (100% in Brazilian and 81.8% in Italian) and without MS (42.9% and 11.7%). **Conclusion:** Metabolic syndrome represents a worldwide emerging health problem in different ethnical populations, the alterations of the risk factors related to MS (different in their prevalence between different subgroups) being strictly linked to the degree of obesity.

Introduction

Childhood and adolescent obesity is an important worldwide reality, because of the progressively increasing prevalence and associated morbidities and represents a major public health problem for several countries (1).

Recent data suggest that the prevalence of overweight [body mass index (BMI) > 95th percentile for age and gender] in Latino children and adolescents has approximately doubled in the past 10 years, resulting in a prevalence of overweight of 23% (2). A similar trend was also observed in several European countries, the estimated prevalence rates ranging from 10% to 12% up to 36% (3).

Metabolic syndrome (MS) is a constellation of interrelated risk factors of metabolic origin – i.e. metabolic risk factors – which appear to directly promote the development of atherosclerotic cardiovascular disease (4,5). Several studies showed that obesity is strictly associated with the MS, which represents the major risk factor for cardiovascular diseases and type 2 diabetes (6). The MS encompasses the clustering of several anthropometric and metabolic parameters [BMI, blood pressure (BP), total- and high-density lipoprotein (HDL)-cholesterol, triglycerides (TG), fasting glucose, etc.], variously combined in between.

Different individuals with a diagnosis of MS (even based on the same definition criteria) may naturally

What's known

Metabolic syndrome prevalence is progressively increasing in obese children and adolescents of different ethnic groups.

What's new

The present study compares the MS prevalence and the contribution of the related risk factors in a large group of age-, gender- and BMI z-score-matched Brazilian and Italian obese adolescents.

be highly heterogeneous as far as the contribution of the single different parameters is concerned. Moreover, it cannot be ruled out the presence of systematic differences in the composition of the syndrome across different ethnic groups, this heterogeneity reflecting different clinical entities with substantial differences in the risk for health outcomes (7).

Although the definition of MS in children and adolescents could actually be based on the same parameters as in adults (8), the relevant changes in growth and development occurring during childhood need age-related cut-off values for the single parameters to be used (9).

Aims of the present study were to compare the prevalence of MS and the contribution of the related risk factors in a large group of age-, gender- and BMI z-score-matched Brazilian and Italian obese adolescents.

Research design and methods

Study group

One hundred and ten Brazilian and 399 Italian obese adolescents, aged 15–19 years, were enrolled in this study. The Brazilian subjects were recruited from the Federal University of São Paulo, UNIFESP, São Paulo and the Italian from the Division of Auxology, Italian Institute for Auxology, IRCCS, Piancavallo (VB).

Inclusion criteria were: (i) BMI above the 95th percentile for gender and chronological age according with the CDC growth charts (10), (ii) Tanner stage (11) more than four, (iii) sedentary life-style (median weekly physical activity < 1 h). Exclusion criteria were: (i) use of medication known to alter BP or glucose or lipid metabolism, (ii) identified genetic diseases, (iii) metabolic and/or endocrine diseases, (iv) previous use of drugs, such as glucocorticoids, insulin sensitizers or psychotropics, which may affect appetite regulation.

The experimental protocol was conducted in accordance with the guidelines in the Declaration of Helsinki and was formally approved by the Ethical Committees of the Federal University of São Paulo – Paulista Medicine School and of the Italian Institute for Auxology, Milan and Piancavallo (VB) respectively. In addition, the purpose and objectives were carefully explained to each adolescent and his/her parents and a written informed consent was obtained.

Anthropometric and biochemical measurements

Body mass was measured to the nearest 0.1 kg with a manual weighing scale; height was measured to

the nearest 0.5 cm on a standardised wall-mounted height board. Body mass index was calculated as weight (kg)/stature² (m) (12). The standard deviation score for BMI was determined using the LMS method, which summarises the data in terms of three smooth age specific curves called L (lambda), M (mu), and S (sigma). The M and S curves correspond to the median and coefficient of variation of body mass index at each age whereas the L curve allows for the substantial age dependent skewness in the distribution of body mass index (13). Pubertal stage was assessed by an expert auxologist according to the standardised Tanner criteria (11).

Blood samples were collected after an overnight fast in standard tubes. TG and HDL-, low-density lipoprotein (LDL)- and total-cholesterol, as well as fasting plasma glucose (FPG) and insulin concentrations were immediately measured with enzymatic-colorimetric methods (CELM, Barueri, for Brazilian samples and Hitachi Instrument, Japan, for Italian samples), after appropriate processing. A comparative study performed in a small number of samples revealed no significant differences in the results obtained by using the different methods for all the parameters tested (data not shown). Insulin resistance was assessed by homeostasis model assessment of insulin resistance (HOMA-IR). HOMA-IR was calculated by the following formula: fasting insulin (μU/ml) × fasting glucose (mmol/l)/22.5 (14).

Blood pressure

Blood pressure was measured on the right arm using a mercury-gravity manometer with appropriate cuff size. Two BP determinations were made after the subjects had been sitting at least 5 min and the mean value was used for analyses.

Metabolic syndrome definition

The diagnosis of MS was based on the presence of at least three of the following criteria, according to the World Health Organization criteria (15,16) and the National Cholesterol Education Program Adult Treatment Panel III recommendations (17). The criteria included (18–22):

- Obesity, defined in the presence of a BMI ≥ 95th percentile for age and gender (2–20 years, Centers for Disease Control and Prevention using CDC growth charts, USA (10).
- Abnormal glucose homeostasis, defined in the presence of one of the following:
 - (a) hyperinsulinaemia (≥ 20 μU/ml) (15,23),
 - (b) insulin resistance, defined using the HOMA-IR > 3.16 (21,23,24),
 - (c) elevated fasting glucose (FPG): ≥ 110 mg/dl (6.1 mmol/l) (23).

- Hypertension, i.e. systolic/diastolic BP \geq 95th percentile for age and sex (25).
- Dyslipidaemia, i.e. the presence of one of the following (26):
 - (a) triglycerides \geq 95th percentile for age and gender,
 - (b) high-density lipoprotein-cholesterol $<$ 5th percentile for age and gender,
 - (c) total- or LDL-cholesterol \geq 95th percentile for age and gender.

Statistical analysis

Statistical analyses were performed using the Statistica for Windows (Kernel version 5.5 A, StatSoft, Maisons-Alfort, France) with significance set at $p < 0.05$. All the results were expressed as mean \pm SD. The effects of BMI, FPG, HOMA-IR, systolic blood pressure (SBP) or DBP, TG, LDL-, HDL-, total-cholesterol levels on the MS prevalence were evaluated by means of a multivariate binary logistic regression analysis. The effects of gender, nationality and interaction (gender \times nationality) on physical characteristics and metabolic parameters of subjects were tested using ANOVA analysis.

Results

The physical and clinical characteristics of the Brazilian and Italian obese adolescents are shown in

Table 1. All subjects were above the 95th percentile for gender and chronological age according to CDC growth charts (10); mean Tanner stage (11) of the two subgroups was comparable, both in males and females. Chronological age, body mass, stature, BMI and BMI z -score were not significantly different between the two subgroups.

Body mass, stature, BMI z -score, insulin, HOMA-IR, FPG, SBP and TG were significantly higher in boys than in girls, both in Brazilian and Italian adolescents, while HDL-cholesterol levels were lower in boys than in girls. No significant differences were observed in BMI, DBP, total- and LDL-cholesterol in the genders and groups.

Mean insulin, HOMA-IR, FPG and TG were significantly higher in Brazilian than in Italian subjects, while LDL-cholesterol and SBP were significantly lower in Brazilian than in Italian subjects, both in males and females. HDL-cholesterol, total-cholesterol and DBP were not significantly different between two the subgroups and genders.

Metabolic syndrome prevalence was higher in Brazilian than in Italian obese boys (34.8% vs. 23.6%, $p < 0.001$) and girls (15.6% vs. 12.5%, $p < 0.01$), the difference resulting more evident in boys than in girls. The prevalence of MS in boys was almost twice than that observed in girls of both subgroups.

The prevalence of the single parameters related to MS in Brazilian and Italian obese adolescents (with

Table 1 Physical and clinical characteristics of Brazilian and Italian obese adolescents

	Boys		Girls		p-value		
	Brazilian (n = 46)	Italian (n = 144)	Brazilian (n = 64)	Italian (n = 255)	Gender	Nation	Gender \times nation
Age (years)	16.5 \pm 0.2	16.2 \pm 0.1	16.6 \pm 0.1	16.2 \pm 0.1	0.868	0.109	0.991
Body mass (kg)	104.8 \pm 2.3	110.2 \pm 1.3	92.8 \pm 1.9	95.2 \pm 1.0	0.001	0.125	0.393
Stature (m)	1.72 \pm 0.01	1.72 \pm 0.01	1.63 \pm 0.01	1.61 \pm 0.01	0.001	0.376	0.591
BMI (kg/m ²)	35.5 \pm 0.7	37.3 \pm 0.4	35.1 \pm 0.6	36.5 \pm 0.3	0.255	0.103	0.729
BMI z-score	2.9 \pm 0.1	3.1 \pm 0.1	2.8 \pm 0.1	2.9 \pm 0.1	0.010	0.119	0.466
Insulin (μ U/ml)	20.7 \pm 1.1	14.1 \pm 0.6	15.7 \pm 0.9	12.5 \pm 0.5	0.001	0.001	0.041
HOMA-IR	4.8 \pm 0.2	2.7 \pm 0.1	3.5 \pm 0.2	2.3 \pm 0.1	0.001	0.001	0.013
FPG (mg/dl)	92.5 \pm 1.0	76.3 \pm 0.6	90.7 \pm 0.9	73.9 \pm 0.4	0.006	0.001	0.716
SBP (mmHg)	125.2 \pm 1.7	129.3 \pm 1.0	120.3 \pm 1.5	122.8 \pm 0.7	0.001	0.010	0.549
DBP (mmHg)	78.0 \pm 1.1	78.2 \pm 0.6	77.4 \pm 0.9	76.7 \pm 0.5	0.209	0.722	0.619
Triglycerides (mg/dl)	130.9 \pm 6.8	105.6 \pm 3.8	109.9 \pm 5.7	90.4 \pm 2.9	0.001	0.001	0.566
HDL-cholesterol (mg/dl)	44.2 \pm 1.5	43.5 \pm 0.9	50.7 \pm 1.3	48.7 \pm 0.7	0.001	0.224	0.553
Total-cholesterol (mg/dl)	164.6 \pm 4.7	162.8 \pm 2.6	162.7 \pm 3.9	162.1 \pm 1.9	0.723	0.731	0.860
LDL-cholesterol (mg/dl)	94.2 \pm 4.1	106.9 \pm 2.3	90.0 \pm 3.5	102.8 \pm 1.7	0.171	0.001	0.986
Prevalence of MS							
Obese adolescents (%)	34.8	23.6	15.6	12.5	0.001	0.001	0.736

All values are average \pm SD. BMI, body mass index; HOMA-IR, homeostasis model assessment of insulin resistance; FPG, fasting plasma glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein, MS, metabolic syndrome; %, prevalence of subjects.

Table 2 Prevalence of altered parameters in obese adolescents with and without metabolic syndrome

	Brazilian				Italian			
	With MS (n = 26)		Without MS (n = 84)		With MS (n = 66)		Without MS (n = 333)	
	(%)	f	(%)	f	(%)	f	(%)	f
BMI	100.0	(26/26)	100.0	(84/84)	100.0	(66/66)	100.0	(333/333)
Insulin (μ U/ml)	73.1	(19/26)	23.8	(20/84)	60.6	(40/66)	7.2	(24/333)
HOMA-IR	100	(26/26)	42.9	(36/84)	81.8	(54/66)	11.7	(39/333)
FPG (mg/dl)	0.0	(0/26)	0.0	(0/84)	0.0	(0/66)	0.0	(0/333)
SBP (mmHg)	57.6	(15/26)	11.9	(10/84)	80.3	(53/66)	24.0	(80/333)
DBP (mmHg)	34.6	(9/26)	10.7	(9/84)	31.8	(21/66)	6.9	(23/333)
Triglycerides (mg/dl)	42.3	(11/26)	1.2	(1/84)	9.1	(6/66)	1.5	(5/333)
HDL-cholesterol (mg/dl)	3.8	(1/26)	1.2	(1/84)	25.8	(17/66)	4.2	(14/333)
Total-cholesterol (mg/dl)	15.4	(4/26)	4.8	(4/84)	10.6	(7/66)	3.3	(11/333)
LDL-cholesterol (mg/dl)	3.8	(1/26)	1.2	(1/84)	18.1	(12/66)	2.4	(8/333)

MS, metabolic syndrome; %, prevalence of subjects; f, frequency of subjects; BMI, body mass index; HOMA-IR, homeostasis model assessment of insulin resistance; FPG, fasting plasma glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

MS or without MS) was shown in Table 2. According to the inclusion criteria, BMI was altered in all subjects with or without MS. The most frequently altered parameter was HOMA-IR both in subjects with MS (100% in Brazilian and 81.8% in Italian adolescents) and without MS (42.9% and 11.7% respectively). The second altered parameter in the order of prevalence differed between the two subgroups (both in subjects with MS and without MS), being insulin in Brazilian and SBP in Italian adolescents.

Table 3 shows the subdivision of the study group according to the degree of obesity (i.e. BMI z-score: < 2.49; 2.50–2.99; 3.00–3.49; > 3.50). MS prevalence was significantly higher in adolescents with higher BMI z-score, the prevalence increasing from 9.5% (BMI z-score: < 2.49) up to 31.8% (BMI z-score: > 3.5). The prevalence of altered insulin, HOMA-IR, SBP and DBP increased in parallel to the increasing severity of obesity, while the prevalence of altered dyslipidaemia did not change markedly in relation to

Table 3 Distribution of the frequency of cardiovascular risk factors of the entire study group categorised according to BMI z-scores

	Group I: < 2.49 (n = 84)	Group II: 2.50–2.99 (n = 159)	Group III: 3.00–3.49 (n = 182)	Group IV: > 3.50 (n = 85)	p-value
BMI z-score	2.2 \pm 0.2	2.7 \pm 0.1	3.2 \pm 0.1	3.7 \pm 0.3	0.001
MS (+)	8 (9.5%)	18 (11.3%)	39 (21.4%)	27 (31.8%)	0.001
Insulin (μ U/ml)	5 (6.0%)	29 (18.2%)	40 (22.0%)	29 (34.1%)	0.001
HOMA-IR	10 (11.9%)	40 (25.2%)	65 (35.7%)	40 (47.1%)	0.001
FPG (mg/dl)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.995
SBP (mmHg)	12 (14.3%)	45 (28.3%)	62 (34.1%)	39 (45.9%)	0.001
DBP (mmHg)	5 (6.0%)	15 (9.4%)	24 (13.2%)	18 (21.2%)	0.031
Triglycerides (mg/dl)	5 (6.0%)	4 (2.5%)	10 (5.5%)	4 (4.7%)	0.102
HDL-cholesterol (mg/dl)	4 (4.8%)	6 (3.8%)	16 (8.8%)	7 (8.2%)	0.031
Total-cholesterol (mg/dl)	7 (8.3%)	4 (2.5%)	12 (6.6%)	4 (4.7%)	0.081
LDL-cholesterol (mg/dl)	4 (4.8%)	3 (1.9%)	13 (7.1%)	2 (2.4%)	0.083

BMI values are average \pm SD. BMI, body mass index; MS (+), subjects with metabolic syndrome; %, prevalence of subjects; HOMA-IR, homeostasis model assessment of insulin resistance; FPG, fasting plasma glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

the increase of BMI *z*-score. Apart from obesity (which was an inclusion criteria for the admission to the present study), the most frequently altered parameters were HOMA-IR and SBP in all the classes of BMI *z*-score.

Discussion

The estimated MS prevalence has been reported to range from 5% to more than 40% in obese adolescents from different countries (27). To date, few studies have compared the MS prevalence between age-, gender- and BMI *z*-score-matched subgroups from different populations using comparable criteria.

The main findings of the present study were the different MS prevalence (23.6% vs. 16.5%, $p < 0.001$) and the different risk factors prevalence in Brazilian vs. Italian obese adolescents, both in males and females. In relation to the MS risk factors, insulin, HOMA-IR, FPG and TG were significantly higher in Brazilian than in Italian adolescents, while LDL-cholesterol and SBP were significantly lower in Brazilian than in Italian adolescents, in both genders (Table 1). This result confirms the notion that prevalence and risk factors of MS represents a serious and common problem in obese adolescents of different countries, progressively reaching the dramatic prevalence observed in US adolescents according to Weiss et al. (9) who observed that overall prevalence of MS was 38.4% in moderately obese and was 49.7% in severely obese children and adolescents. It is interesting to notice that the prevalence of MS risk factors are markedly heterogeneous in the two countries, probably reflecting dissimilar genetic environment, social and economical conditions, and dietary habits.

As far as the impact of gender on MS prevalence is concerned, there are several studies describing its impact on MS during pubertal development (18,23,28–30). In the present study, anthropometrics variables (body mass, stature and BMI *z*-score), insulin, HOMA-IR, FPG, SBP and TG were significantly higher in boys than in girls, both in Brazilian and Italian adolescents, while HDL-cholesterol levels were lower in boys than in girls (Table 1).

In this way, MS prevalence was higher in Brazilian than in Italian obese boys (34.8 vs. 23.6%, $p < 0.001$) and girls (15.6 vs. 12.5%, $p < 0.01$), the difference resulting more evident in males (Table 1). This observation is in line with previous studies (9,23,29,31,32), reporting a greater prevalence of MS in male compared with female children and adolescents. Our results illustrate a considerable difference in the prevalence of single risk factors between Brazilian and Italian populations, which may possibly contribute in different ways to healthy outcomes.

The most frequently altered parameter was HOMA-IR in the two populations (Table 2), both in adolescents with MS (100% in Brazilian vs. 81.8% in Italian adolescents) and in those without MS (42.9% vs. 11.7%). The second altered parameter in the order of prevalence differed between the two subgroups (both in adolescents with MS and without MS), being insulin in Brazilian and SBP in Italian adolescents. This finding confirms the results obtained in a recent study by our group performed in Brazilian obese adolescents, reporting an increased prevalence of insulin resistance (HOMA-IR) (31).

Several studies reported that MS prevalence is significantly higher in postpubertal than in prepubertal adolescents of both genders (23,28,33), probably as the result of a different clustering of the different risk factors. The criteria for the definition of MS used in the present study was adequately adjusted for the postpubertal stage (23), trying to find a compromise solution which was the most appropriate for the two populations (34) taking into account that, to our knowledge, no single nation-specific criteria for MS definition in adolescence is available to date.

Previous studies underlined the relationships between MS prevalence and the degree of obesity in both African American and Caucasian adolescents (35). Weiss et al. (9) reported that the risk of MS among obese children and adolescents increased by 50% with a 0.5-unit increment in the BMI *z*-score. Similarly in the present study, MS prevalence was significantly higher in adolescents with higher BMI *z*-score, the prevalence increasing from 9.5% (BMI *z*-score: < 2.49) up to 31.8% (BMI *z*-score: > 3.5) (Table 3). In line with this pattern, risk factors prevalence also increased in parallel to the increasing severity of obesity, thus contributing the central role of obesity-related abnormalities in the development of the paediatric MS.

As far as the mechanisms underlying MS pathophysiology is concerned, insulin resistance appears to be a critical component (in association with the severity of obesity) in determining the MS in adolescence. Although the role of insulin resistance still remains to be completely elucidated, several authors (36–38) hypothesised that insulin resistance was the main responsible factor for the underlying abnormalities of the syndrome. Apart from obesity (which was an inclusion criteria of the present study), HOMA-IR was actually the most frequent altered parameter related to the development of MS in Brazilian and Italian adolescents (Table 2). Although obesity and insulin resistance may be different potential pathogenic pathways in the aetiology of MS, their respective role remains difficult to identify (36).

It is noteworthy that the second altered parameter was systolic BP in Italian obese adolescents, confirming the strict relationships between BP and HOMA-IR already observed in previous studies (36,38,39). A possible limitation in interpreting the results of the present study could be the different composition of the two subgroups as far as food intake, social and cultural levels are concerned.

The eating habits of adolescents, although not explored in this study, could be considerably different among the subgroups and in spite of a similar level of obesity, might play a role in the different prevalence of the single abnormalities contribute to the MS. In fact, it is currently reported that the Mediterranean diet, likely followed by the Italian group has a favourable impact on cardiovascular health and a lower prevalence of the MS (40).

As far as social and cultural levels of the families where the adolescents lived and their median level of physical activity are concerned, no significant differences were present between the two subgroups. By contrast, the contribution of the different race-related genetic susceptibilities in Brazilian adolescents represents a possible confounding factor in the analysis of this heterogeneous population.

Further additional studies are requested to identify the associations between the different components of MS in different study populations, to provide information useful to better understand the clustering of the MS components and the possibilities for long-term effective multidisciplinary treatments in obese adolescents, according to our previous study that observed beneficial effects of this kind of therapy in obese adolescents (31).

In conclusion, MS represents a worldwide emerging health problem in different ethnical populations, the alterations of the risk factors related to MS (different in their prevalence between different subgroups) being strictly linked to the degree of obesity.

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Authors contributions

Guarantors: A. Sartorio and A. R. Dâmaso. **Contributors:** AS and ARD co-ordinated the study; DAC wrote the manuscript and analysed the results; SL contributed to the manuscript and performed the statistical analyses; FA and RZ recruited the Italian adolescents, collected their data and created the database; MTM and ST contributed to the manuscript and performed this study.

References

- 1 World Health Organization (WHO). *Obesity: Preventing and Managing the Global Epidemic: Report of a WHO Consultation on Obesity*. Geneva: WHO, 1998.
- 2 Shaibi GQ, Cruz ML, Ball GDC et al. Cardiovascular fitness and metabolic syndrome in overweight Latino youths. *Med Sci Sports Exerc* 2005; **37**: 6.
- 3 Lobstein T, Frelut ML. Prevalence of overweight among children in Europe. *Obes Rev* 2003; **4**: 195–200.
- 4 Grundy SM, Cleeman IJ, Daniels SR et al. Diagnosis and management of metabolic syndrome. An American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. *Circulation* 2005; **112**: 2735–52.
- 5 Caranti DA, Tock L, Prado WL et al. Long-term multidisciplinary therapy decreases predictors and prevalence of metabolic syndrome in obese adolescents. *Nutr Metab Cardiovasc Dis* 2007; **17**: e11–3.
- 6 Malik S, Wong ND, Franklin SS et al. Impact of the metabolic syndrome on mortality from coronary heart disease, cardiovascular disease, and all causes in United States adults. *Circulation* 2004; **110**: 1245–50.
- 7 Leite MLC, Nicolosi A, Firmo JOA et al. Features of metabolic syndrome in non-diabetic Italians and Brazilians: a discriminant analysis. *Int J Clin Pract* 2007; **61**: 32–8.
- 8 Golley RK, Magarey AM, Steinbeck KS et al. Comparison of metabolic syndrome prevalence using six different definitions in overweight pre-pubertal children enrolled in a weight management study. *Int J Obes (Lond)* 2006; **30**: 853–60.
- 9 Weiss R, Dziura J, Burgert TS et al. Obesity and the metabolic syndrome in children and adolescents. *N Engl J Med* 2004; **350**: 2362–74.
- 10 Centers for disease control and prevention (1999–2000). *Prevalence of Overweight Among Children and Adolescents: United States*. <http://www.cdc.gov/growthcharts/htm> (accessed March 2008).
- 11 Tanner JM. *Growth at Adolescence*, 2 edn. Oxford: Blackwell Scientific Publications, 1961.
- 12 Quetelet LAJ. *A Treatise on Man and the Development of his Faculties. Comparative Statistics in the 19th Century*. Edinburgh: W. A. R. Chambers, 1842.
- 13 Cole TJ, Bellizzi MC, Flegal KM et al. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000; **320**: 1240–3.
- 14 Matthews DR, Hosker JP, Rudenski AS et al. Homeostasis model assessment: insulin resistance and β -cell function from fasting plasma glucose and insulin concentrations in man. *Diabetologia* 1985; **28**: 412–9.
- 15 Alberti KG, Zimmet PZ. Definition, diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. *Diabet Med* 1998; **15**: 539–53.

- 16 World Healthy Organization (WHO). Report of a WHO consultation. In: Alwan A, King H, eds. *Definition, Diagnosis and Classification of Diabetes Mellitus and its Complications. Part 1: Diagnosis and Classification of Diabetes Mellitus*. Geneva, World Healthy Organization, Department of Noncommunicable Disease Surveillance, 1999: 1–59.
- 17 Executive summary of third report of The National Cholesterol Education Program (NCEP). Expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (adult treatment panel III). *JAMA* 2001; **285**: 2486–97.
- 18 Viner RM, Segal TY, Lichtarowicz-Krynska E et al. Prevalence of the insulin resistance syndrome in obesity. *Arch Dis Child* 2005; **90**: 10–4.
- 19 Abate N. Obesity and cardiovascular disease. Pathogenic role of metabolic syndrome and therapeutic implications. *J Diabetes Complicat* 2000; **14**: 154–74.
- 20 Cameron AJ, Shaw JE, Zimmet PZ. The metabolic syndrome: prevalence in worldwide populations. *Endocrinol Metab Clin North Am* 2004; **33**: 351–75.
- 21 Keskin M, Kortoglu S, Kendirce M et al. Homeostasis model assessment is more reliable than fasting glucose/insulin ratio and quantitative insulin sensitivity check index for assessing insulin resistance among obese children and adolescents. *Pediatrics* 2005; **155**: e500–3.
- 22 Molnár D. The prevalence of metabolic syndrome and type 2 diabetes mellitus in children and adolescents. *Int J Obes Relat Metab Disord* 2004; **28** (Suppl. 3): S70–4.
- 23 Sen Y, Kandemir N, Alikasifoglu A et al. Prevalence and risk factors of metabolic syndrome in obese children and adolescents: the role of severity obesity. *Eur J Pediatr* 2008; **17**: 1–14.
- 24 Conwell LS, Trost SG, Brown WJ et al. Indexes of insulin resistance and secretion in obese children and adolescents: a validation study. *Diabetes Care* 2004; **27**: 314–9.
- 25 Italian Society of Pediatrics. *Consensus Conference of the Italian Society of Pediatrics*. Pisa: Italian Society of Pediatrics, 2005 (abstract book).
- 26 Hickman TB, Briefel RR, Carroll MD et al. Distribution and trends of serum lipids among United States children and adolescents ages 4–19 years: data from the Third National Health and Nutrition Examination Survey. *Prev Med* 1998; **27**: 879–90.
- 27 DuBose KD, Eisenmann JC, Donnelly JE. Aerobic fitness attenuates the metabolic syndrome score in normal-weight, at-risk-for overweight, and overweight children. *Pediatrics* 2007; **120**: e1262–8.
- 28 Atabek ME, Pirgon O, Kurtoglu S. Prevalence of metabolic syndrome in obese Turkish children and adolescents. *Diabetes Res Clin Pract* 2006; **73**: 315–21.
- 29 Cruz ML, Weigensberg MJ, Huan TT et al. The metabolic syndrome in overweight Hispanic youth and the role of insulin sensitivity. *J Clin Endocrinol Metab* 2004; **89**: 108–13.
- 30 Csábi G, Török K, Jeges S et al. Presence of metabolic syndrome in obese children. *Eur J Pediatr* 2000; **159**: 91–4.
- 31 Caranti DA, Mello MT, Prado WL et al. Short- and long-term beneficial effects of a multidisciplinary therapy for the control of metabolic syndrome. *Metabolism* 2007; **56**: 1293–300.
- 32 Cook S, Weitzman M, Auinger P et al. Prevalence of a metabolic syndrome phenotype in adolescents: findings from the third National Health and Nutrition Examination Survey, 1988–1994. *Arch Pediatric Adolesc Med* 2003; **157**: 821–7.
- 33 Invitti C, Maffei C, Gilardini L et al. Metabolic syndrome and nontraditional CVD risk factors in obese children. *Int J Obes* 2006; **30**: 627–33.
- 34 Zimmet P, Alberti G, Kaufman F et al. International Diabetes Federation Task Force on Epidemiology and Prevention of Diabetes. The metabolic syndrome in children and adolescents. *Lancet* 2007; **369**: 2059–61.
- 35 Lee S, Bacha F, Gungor N et al. Comparison of different definitions of pediatric metabolic syndrome: relation to abdominal adiposity, insulin resistance, adiponectin and, inflammatory biomarkers. *J Pediatr* 2008; **152**: 177–84.
- 36 Reaven GM. Role of insulin resistance in human disease. *Diabetes* 1988; **37**: 1595–607.
- 37 Ferrannini E, Haffner SM, Mitchell BD et al. Hyperinsulinemia: the key feature of a cardiovascular and metabolic syndrome. *Diabetologia* 1991; **34**: 416–22.
- 38 Pei D, Kuo S-W, Wo D-A et al. The relationships between insulin resistance and components of metabolic syndrome in Taiwanese Asians. *Int J Clin Pract* 2005; **59**: 1408–16.
- 39 Goff DC Jr, Zaccaro DJ, Haffner SM et al. Insulin resistance Atherosclerosis Study. Insulin sensitivity and the risk of incident hypertension: insights from the Insulin Resistance Atherosclerosis Study. *Diabetes Care* 2003; **26**: 805–9.
- 40 Giugliano D, Esposito K. Mediterranean diet and metabolic diseases. *Curr Opin Lipidol* 2008; **19**: 63–8.

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