ORIGINAL ARTICLE

Comparison of metabolic syndrome prevalence using eight different definitions: a critical approach

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Objective: Multiple definitions of the metabolic syndrome (MS) have been proposed for children, adolescents and adults. The aim of this study was to analyse the variations in the MS prevalence using different definitions and to examine which factors influence the frequency of the MS in childhood and adolescence.

Methods and design: The prevalence of the MS according to eight proposed definitions was studied in 1205 Caucasian overweight children and adolescents aged 4–16 years (mean body mass index (BMI) 27.3 kg/m^2, mean age 11.8 years, 46% males, 39% prepubertal). Blood pressure, waist circumference and fasting triglycerides, HDL-cholesterol, total cholesterol, insulin and glucose concentrations were determined. Overweight was defined according to the International Task Force of Obesity in Childhood. Degree of overweight was calculated as standard deviation score of BMI (SDS-BMI). Insulin resistance was estimated based on the HOMA model.

Results: The prevalence of the MS varied significantly ($p<0.001$), being between 6% and 39% depending on the different definitions. Only 2% of the children fulfilled the criteria of the MS in all definitions. Insulin resistance and degree of overweight were associated with the MS. In most definitions, pubertal stage did not influence the occurrence of the MS. In a principal component analysis, total cholesterol, triglycerides and waist circumference showed high final communality estimates.

Conclusions: Since the prevalence of the MS varied widely in overweight children and adolescents depending on the proposed definition used, an internationally accepted uniform definition of the MS is necessary to compare different populations and studies.

Obesity in childhood is an increasing phenomenon.[1] Childhood obesity is associated with a wide range of serious complications and increases the risk of early illness and death in later life.[1] As in adulthood, obesity in childhood contributes to an increased prevalence of cardiovascular risk factors, such as hypertension, hypertriglyceridaemia, low HDL-cholesterol and impaired glucose metabolism.[2 3] The clustering of these risk factors, which is associated with insulin resistance and occurs in overweight humans more often than might be expected by chance, is called the metabolic syndrome (MS), also known as syndrome X, the insulin resistance syndrome and the deadly quartet.[4] Studies reported an increased risk of cardiovascular diseases (CVD) in adults when glucose intolerance, insulin resistance, central obesity, dyslipidaemia and hypertension group together.[5 6]

Multiple definitions of the MS have been proposed for adults by the WHO,[7] the National Cholesterol Education Program's Adult Treatment Panel III,[8] the European Group for the Study of Insulin Resistance[9] and the International Diabetes Federation,[10] which all agreed on the essential components (glucose intolerance, central obesity, hypertension and dyslipidaemia) but differed in the detail.[4 11] These definitions were adapted for children and adolescents by different authors, who also used widely varying criteria (table 1).[12–15] Conversely, a uniform internationally accepted definition of the MS in childhood and adolescence would allow comparison of the prevalence data in different studies and populations.

Paediatricians have ''diagnosed'' the MS increasingly in recent years to describe the cardiovascular risk.[12–15] Furthermore, the MS seems to affect the management of the overweight child,[16] since the MS is based on the concept that the clustering of risk factors is predictive for CVD above and beyond the risk associated with its individual components.[4 11] Conversely, the concept of the MS has never been proven in childhood and adolescence.

There are very limited data on the variation in the MS prevalence in overweight children and adolescents using different proposed definitions. Furthermore, little is known concerning the factors influencing the frequency of the MS in childhood. Therefore, the aims of this study were to compare the prevalence of the MS according to the different existing definitions in a large sample of overweight children and adolescents, and to analyse the impact of degree of overweight, insulin resistance and pubertal stage on the frequency of the MS.

METHODS

We collected the clinical data and information on cardiovascular risk factors of all Caucasian non-syndromally overweight children aged 4–16 years who presented consecutively at the outpatient obesity clinic for children and adolescents at Vestische Hospital, Datteln, Germany, between 1 October 1999 and 31 December 2005. Children with endocrine, genetic or metabolic disorders including type 2 diabetes mellitus were excluded from the study. The control group consisted of 84 normal weight healthy children of the same age, gender and pubertal stage.

Overweight was defined according the International Task Force of Obesity in Childhood (IOTF).[17] The degree of overweight was quantified using Cole's least mean square method, which normalised the body mass index (BMI) skewed

Abbreviations: BMI, body mass index; CVD, cardiovascular disease; HOMA, homeostasis model assessment; IOTF, International Task Force of Obesity in Childhood; MS, metabolic syndrome; NHBPEP, National High Blood Pressure Education Program; oGTT, oral glucose tolerance test; PCA, principal component analysis; SDS, standard deviation score

Table 1 Age, gender, pubertal stage and body mass index in overweight and normal weight children and adolescents included in the study

	Overweight	Normal weight
Number	1205	84
Age (years)	11.8 (9.5–13.4)	11.3 (9.1–13.3)
Male	557 (46%)	42 (50%)
Prepubertal	479 (39%)	36 (43%)
Pubertal	454 (38%)	32 (38%)
Late/postpubertal	272 (23%)	16 (19%)
BMI (kg/m^2)	27.3 (24.8–30.8)	17.7 (15.5–20.4)

Data as percentage or median and interquartile range. BMI, body mass index.

distribution in childhood and expressed BMI as a standard deviation score (SDS-BMI).[18] Reference data for German children were used since the IOTF percentiles did not allow us to calculate SDS-BMI.[17 19]

The pubic hair stage was determined according to Marshall and Tanner. The pubertal developmental stage was categorised into three groups based on pubic hair and genital stages (prepubertal: boys with pubic hair stage I and gonadal stage I, girls with pubic hair stage I and breast stage I; pubertal: boys with pubic hair stage ⩾II or gonadal stage ⩾II and girls with pubic hair stage ⩾II or breast stage ⩾II; late/postpubertal: girls with menarche and boys with change of voice).

Serum fasting triglyceride, HDL-cholesterol, total cholesterol and glucose concentrations were measured using commercially available test kits (HDL-C Plus, Roche Diagnostics, Mannheim, Germany; Vitros analyser, Ortho Clinical Diagnostics, Neckargemuend, Germany; MEIA, Abbott, Wiesbaden, Germany). Fasting insulin concentrations were measured by high-specific microparticle enhanced immunometric assay (MEIA Abbott, Wiesbaden, Germany). Intra- and interassay variations were less than 5% in all methods. Homeostasis model assessment (HOMA) was used to detect the degree of insulin resistance.[20] The resistance can be assessed from the fasting glucose and insulin concentrations by the formula: resistance (HOMA) = (insulin (mU/l) ×glucose (mmol/l))/22.5.

An oral glucose tolerance test (oGTT) was performed in obese children and adolescents with at least two risk factors (first degree relatives with type 2 diabetes mellitus, dyslipidaemia, hypertension, acanthosis nigricans) according to the recommendations of the American Diabetes Association.[21]

Blood pressure was measured according to the guidelines of the National High Blood Pressure Education Program (NHBPEP).[22] Systolic and diastolic blood pressure were measured twice at the right arm after a 10 min rest in the supine position using a calibrated sphygmomanometer and averaged. The cuff size, which was based on the length and circumference of the upper arm, was chosen to be as large as possible without having the elbow skin crease obstruct the stethoscope.[22]

The MS was defined according to the criteria of Weiss,[12] Viner,[14] De Ferranti,[15] Cook,[13] WHO,[7] EGIR,[9] ATPIII[8] and IDF.[10] Following the German guidelines for overweight children,[23] we used BMI percentiles of German children[19] to define the 95th and 97th BMI percentiles in the definition of Viner and Weiss, the age- and height-related percentiles of NHBPEP for blood pressure,[22] the cut-off points of lipids for German children[23] in the definition of Weiss, and the percentiles of Dutch children for waist circumferences.[24] Impaired fasting glucose was defined as fasting serum glucose ⩾100 mg/dl according to the new WHO definition.[25] Impaired glucose tolerance was defined as 2 h serum glucose >140 mg/dl in the oGTT. Since oGTT was not performed in every child but impaired glucose tolerance was part of the definition in some proposed definitions for the MS, we alternatively used the following definition for disturbed glucose metabolism based on the proposal of Viner.[14] Disturbed glucose metabolism was defined as impaired fasting glucose, hyperinsulinaemia (⩾15 mU/l for prepubertal children, ⩾30 mU/l for pubertal children, ⩾20 mU/l for postpubertal children) or impaired glucose tolerance.

Statistical analysis

Data were presented as median and interquartile range. Significance was tested by χ^2 test. A random error of $\alpha = 0.05$ was considered as level of significance. Correlation analyses and principal component analysis (PCA)[26] were used to show patterns of the variables considered to define the MS. First, correlation matrices (Pearson's coefficients) of puberty specific criteria were constructed. These matrices were further studied by PCA, an exploratory factor analysis method that allows identification of unobservable latent factors that underlie or structure a set of variables. Only factors with eigenvalues >1 were considered. The cumulative variance explained by these factors was estimated and factor loadings with correlations >0.75 were classified as high. Additionally, final communality estimates were estimated.

In order to assess the impact of degree of overweight (SDS-BMI) and insulin resistance (HOMA) on the occurrence of the MS according to different definitions, we calculated multivariate logistic regression models adjusted for age and sex. Non-significant ($p>0.05$) interaction terms between SDS-BMI and HOMA were removed in respective models.

All analyses were performed using Winstat and SAS 9.1 (SAS Institute, Cary, NC, USA). The local ethics committee of the University of Witten/Herdecke approved this study. Informed consent was obtained from all subjects and their parents.

RESULTS

A total of 1205 overweight, including 965 (80%) obese children, and 84 normal weight children were included in the study (table 1). The overweight and normal weight children did not differ in age, gender or pubertal stage.

Among the normal weight children, six (7%) demonstrated fasting insulin levels above the threshold suggested by Viner.[14] None of the normal weight children had glucose levels >100 mg/dl. Two (2%) children had blood pressure values >90th percentile, but none were >97th percentile. One child (1%) demonstrated HDL-cholesterol below 40 mg/dl, but none had cholesterol levels >95th percentile. Nine children (11%) had triglycerides >110 mg/dl and four (5%) >150 mg/dl. None of the 84 normal weight children fulfilled any of the proposed definitions of the MS. Regardless of the type of definition, the MS was observed significantly ($p<0.001$) more frequently in overweight children as compared with normal weight children.

The different prevalences of the MS and the frequencies of the used criteria in the 1205 overweight children according to the different definitions for children and adolescents are shown in table 2. In table 3, the frequencies of the MS based on the definition for adults are shown. The frequency of the MS varied significantly ($p<0.001$) between the different definitions. A total of 114 (9%) children fulfilled the criteria of the MS in all proposed definitions for children and 22 (2%) fulfilled the criteria of the MS in all proposed definition including the definition for adults. A total of 1170 (97%) children demonstrated at least one criterion and 990 (82%) had at least two of the criteria used to define the MS.

We performed an oGTT in 194 obese children and detected impaired glucose tolerance in 27 (14%) of these children. If only impaired glucose tolerance was used as the criterion and not the alternative definition of disturbed glucose metabolism, 13%

Table 2 Prevalences of the metabolic syndrome and the frequencies of its criteria according to the different proposed definitions for childhood and adolescence in 1205 overweight Caucasian children and adolescents

Cook *et al*[13]	(%)	De Ferranti *et al*[15]	(%)	Viner *et al*[14]	(%)	Weiss *et al*[12]	(%)
⩾3 of the 5 criteria below:	21	⩾3 of the 5 criteria below:	39	⩾3 of the 4 criteria below:	18	⩾3 of the 5 criteria below:	29
WC ⩾90th percentile for age and gender	78	WC ⩾75th percentile for age and gender	80	BMI ⩾95th percentile for age and gender	89	BMI >97th percentile for age and gender	80
BP ⩾90th percentile	32	BP ⩾90th percentile	32	Systolic BP ⩾95th percentile	22	BP ⩾95th percentile	22
Triglycerides ⩾110 mg/dl	43	Triglycerides ⩾100 mg/dl	52	1 of the 3 criteria below:	36	Triglycerides >110 mg/dl	43
HDL-chol ⩽40 mg/dl	17	HDL-chol	54	Triglycerides ⩾150 mg/dl	21	HDL-chol <40 mg/dl	17
Impaired fasting glucose	1	⩽50 mg/dl (female) or ⩽45 mg/dl (male)		HDL-chol <35 mg/dl	6	Impaired glucose tolerance*	14
		Impaired fasting glucose	1	Total chol ⩾95th percentile	18		
				1 of the 3 criteria below:	27		
				Impaired fasting glucose	1		
				Impaired glucose tolerance*	14		
				Fasting insulin: ⩾15 mU/l prepubertal ⩾30 mU/l pubertal ⩾20 mU/l late/postpubertal	26		

*Oral glucose tolerance test was performed in 194 children; disturbed glucose metabolism was defined in the other children by impaired fasting glucose or hyperinsulinaemia (⩾15 mU/l for prepubertal children, ⩾30 mU/l for pubertal children, ⩾20 mU/l for postpubertal children).
BP, blood pressure; chol, cholesterol; WC, waist circumference.

of the children fulfilled the definition of Weiss and 1% of the children fulfilled the definition of the WHO for the MS.

Degree of overweight and insulin resistance were significantly associated with occurrence of the MS regardless of the definition and after adjustment for age and sex (table 4).

The frequencies of the MS based on definitions for children and adolescents separated into gender and pubertal stage are shown in fig 1. In each proposed definition, the differences in the frequency of the MS between the prepubertal, pubertal and late/postpubertal girls were not significant. In the definitions of Cook and De Ferranti but not in the definitions of Viner and Weiss, the MS was detected significantly more frequently in pubertal than in prepubertal boys (fig 1). Analysing prepubertal, pubertal and late/postpubertal children separately, the frequency of the MS varied significantly ($p<0.001$) between the different definitions.

The correlation matrix between the criteria systolic blood pressure, waist circumference, BMI and levels of fasting glucose, total cholesterol, HDL-cholesterol, triglycerides and insulin showed high correlation coefficients ($r>0.4$) only for BMI and insulin levels with $r = 0.49$.

PCA by pubertal stage yielded four, three and three factors explaining 70%, 56% and 58% of variance for pre-pubertal, pubertal and post-pubertal children, respectively. The final communality estimates showed three components as main explanatory variables for the variation between overweight children. Among pre-pubertal children high final communality estimates (>0.75) were observed for cholesterol level and waist circumference, while among pubertal and post-pubertal children a high communality estimate was only observed for triglycerides.

DISCUSSION

Our study demonstrated that the prevalence of the MS was associated with degree of overweight and the insulin resistance index HOMA, and had a wide range (6–39%) using the different proposed definitions. Only 9% of the children fulfilled all the definitions of the MS for children and adolescents, pointing to a low degree of overlap between the different proposed definitions for the MS. These findings are in concordance with one small study in childhood.[16] Therefore, a comparison between studies using different definitions of the MS is not meaningful in childhood. To compare different populations and studies, an internationally accepted practical uniform definition of the MS has to be established for children and adolescents.

Table 3 Prevalences of the metabolic syndrome and the frequencies of its criteria according to the different proposed definitions for adults in 1205 overweight Caucasian children and adolescents

EGIR[9]	(%)	WHO[7]	(%)	ATP III[8]	(%)	IDF[10]	(%)
Insulin resistance + ⩾2 of the 5 criteria below:	8	Impaired glucose regulation* + ⩾2 of the 3 criteria below:	6	⩾3 of the 5 criteria below:	13	Central obesity + ⩾2 of the 4 criteria below:	14
Waist circumference >94 cm (male) or >80 cm (female)	56	Waist/hip ratio >0.9 (male) or >0.85 (female) or BMI >30 kg/m^2	42	Waist circumference >102 cm (male) or >88 cm (female)	45	Waist circumference >94 cm (male) or >80 cm (female)	56
BP ⩾140/90 mm Hg	12	BP ⩾140/90 mm Hg	12	BP ⩾130/85 mm Hg	23	BP ⩾130/85 mm g	23
Triglycerides >176 mg/dl	14	1 of the criteria below:	29	Triglycerides >150 mg/dl	21	Triglycerides ⩾150 mg/dl	21
HDL-chol <40 mg/dl	17	Triglycerides ⩾150 mg/dl	21	HDL-chol <40 mg/dl (male) or <50 mg/dl (female)	43	HDL-chol <40 mg/dl (male) or <50 mg/dl (female)	43
Impaired glucose tolerance*	14	HDL-chol <35 mg/dl (male) or <39 mg/dl (female)	11	Impaired fasting glucose	1	Impaired fasting glucose	1
		Impaired glucose tolerance or insulin resistance in clamp studies*	14				

*Oral glucose tolerance test was performed in 194 children; disturbed glucose metabolism was defined in the other children by impaired fasting glucose or hyperinsulinaemia (⩾15 mU/l for prepubertal children, ⩾30 mU/l for pubertal children, ⩾20 mU/l for postpubertal children).
BP, blood pressure; chol, cholesterol.

Table 4 Results of multivariate logistic regression models assessing the impact of degree of overweight (SDS-BMI) and insulin resistance (HOMA) on the occurrence of the metabolic syndrome according to the different proposals

	Age- and sex adjusted odds ratio (95% CI)	
Metabolic syndrome defined by	**Per 1 unit increase of SDS-BMI**	**Per 1 unit increase of HOMA**
Viner[14]	3.31 (2.35 to 4.67)	1.34 (1.25 to 1.44)
Cook[13]	2.06 (1.53 to 2.76)	1.12 (1.07 to 1.18)
De Ferranti[15]	2.25 (1.73 to 2.92)	1.11 (1.06 to 1.18)
Weiss[12]	3.81 (2.72 to 5.32)	1.32 (1.23 to 1.41)
ATP III[8]	2.05 (1.45 to 2.90)	1.16 (1.10 to 1.24)
WHO[7]	*	*
EGIR[9]	*	*
IDF[10]	1.72 (1.23 to 2.41)	1.12 (1.06 to 1.18)

*Model contains significant interaction term for SDS and HOMA.

Not only did the prevalence of the MS vary widely between the different definitions, but also the impact of puberty on the prevalence of the MS varied widely as well. De Ferranti and Cook reported a 3–5-fold higher prevalence of the MS in pubertal adolescents compared with prepubertal children.[13 15] Using their definition, we also found a higher prevalence of the MS in pubertal adolescents but only in boys and not in girls. Conversely, the other definitions of the MS proposed for childhood and adolescence demonstrated no influence of pubertal stage on the MS. The proposed definitions of the MS for children and adolescents differed widely in their criteria and the thresholds of their components. These facts likely explained the difference in frequencies of the MS and the different effect of pubertal stage on the MS.

PCA demonstrated that total cholesterol, triglycerides and waist circumference explained most of the variance between the analysed children and adolescents. Therefore, inclusion of these criteria in the definition of the MS helps to differentiate the children.

One major difference between the proposed criteria for the MS was the definition of insulin resistance. Insulin levels without respect to glucose concentrations are not a good predictor of insulin resistance.[27] Furthermore, values of fasting insulin levels are limited by great intra- and interindividual variability.[27] Accurate assessment of insulin resistance as suggested by the WHO requires a complicated test (eg, the hyperinsulinaemic euglycyaemic clamp technique).[7] Its application in children is invasive and impractical, so clinicians prefer simple tools such as fasting glucose. Conversely, only 1% of the overweight children demonstrated impaired fasting glucose even if we used the new WHO definition.[25] However, the insulin resistance index HOMA was associated with the MS in all definitions for children and adolescents. Moreover, previous longitudinal studies reported that insulin resistance was more closely related to components of the MS as compared with degree of overweight.[4 28]

Furthermore, central obesity is one major element in the definition of the MS in adults[7–10] and not the degree of overweight as used in some proposals for children.[12 14] However, the cut-offs of the waist circumference percentiles for European children do not seem to be very specific since the majority of our overweight children had waist circumferences above the proposed thresholds.

Most importantly, the entire concept of the MS is controversial.[4 11] A major concern in the definition of the MS refers to the use of cut-off points for the various risk factors, thus implying that the values above the specified thresholds are associated with an excess risk, yet the rationale for the different cut-off points has never been delineated.[11] Moreover, the dichotomous use of continuous data such as lipids, waist circumference and blood pressure values, seems inaccurate since they are not all-or-nothing values. In fact, the relationship is not even linear which makes it all the more difficult and opens up the issue of how risk in this conglomeration of the ''syndrome'' might be weighted more appropriately.

Finally, the MS is based on the concept that the clustering of risk factors is predictive for CVD above and beyond the risk associated with its individual components. In overweight children, dyslipidaemia, hypertension and disturbed glucose metabolism were related to intima-media thickness (IMT) of the common carotid artery,[29 30] which is predictive and related to the severity of CVD.[31 32] Therefore, the integration of these factors in the definition of the MS seems meaningful. However, it has not yet been determined whether the clustering of these risk factors is associated with an increased of CVD in childhood above the risk of the individual components. Without evidence of an increased risk in the MS beyond the sum of its parts, it may be better to pay individual attention to the well documented individual risk factors.

The frequencies of the cardinal factors of the MS (disturbed glucose metabolism, hypertension and dyslipidaemia) were similar to those found in previous studies in Caucasian children.[2 3 33 34] Most overweight and obese children had one or two of these cardiovascular risk factors. It was found that 6–14% children and adolescents fulfilled the criteria for the different definitions of the MS used in adulthood, underlining the fact that the components of the MS are already present in some children.

The overall prevalence of the MS was lower in our overweight children and adolescents as compared with the studies of Weiss (39% vs 12%) and Viner (33% vs 18%).[12 14] However, in our sample the overall prevalence of the MS was similar to that found in the study of Cook (29% vs 21%) and more frequent than that reported by De Ferranti (10% vs 39%).[13 15] Different age ranges, races, degrees of overweight, referral practices, geographical variation in obesity and epigenetic factors might explain these differences. While the subjects in our study and those of Viner and Weiss were recruited in specialised obesity/endocrine clinics, which probably meant the frequency of the MS was overestimated, the cohorts of Cook and De Ferranti originated from general populations and had a tendency to a lower prevalence of the MS. We analysed only Caucasian children, while the studies with the highest prevalence of the MS also included subjects of Hispanic, African and Asian origin, who are suggested to have a higher frequency of the MS.[12 14]

This study has a few potential important limitations. Data from clinical samples may not be representative of the general population, and selection and referral bias may have influenced our estimate of the prevalence of the MS. Furthermore, oGTT was not performed in every child. Finally, consideration of pubertal stage instead of dividing children into prepubertal, pubertal and late/postpubertal groups would be the ideal way to analyse the effect of puberty on the prevalence of the MS.

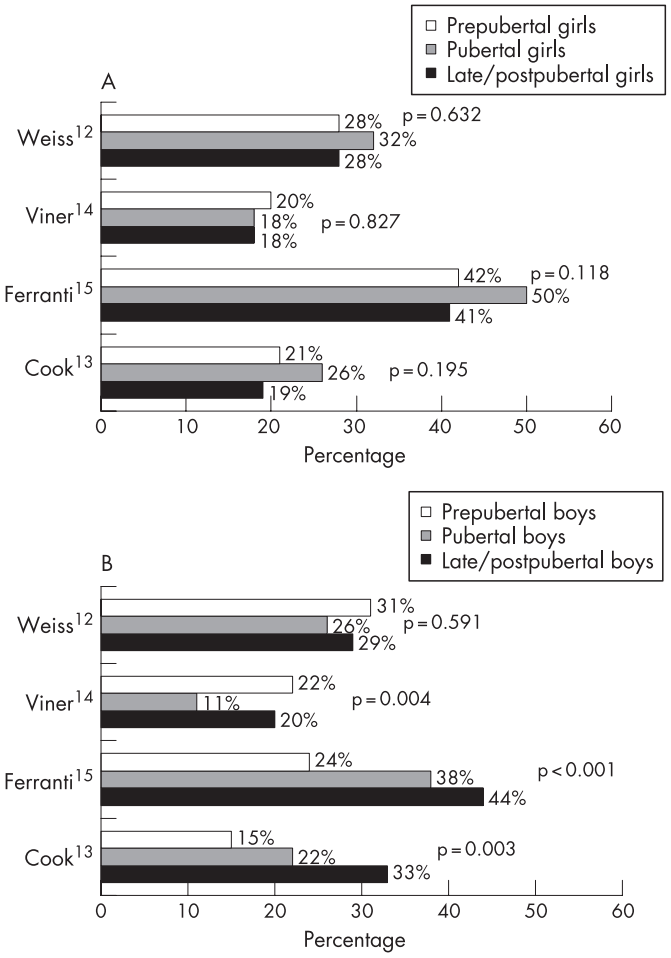

Figure 1 Frequencies of the MS separated into gender and pubertal stage using the different definitions of the MS for children and adolescents (A: 217 prepubertal girls, 223 pubertal girls, 208 late/postpubertal girls; B: 262 prepubertal boys, 231 pubertal boys, 64 late/postpubertal boys).

Conversely, performing such a study needs a very large sample size since children have not only to be divided according to different pubertal stage but also according to gender. Additionally, division into groups according to pubic hair and breast stages partially depends on the investigator.

In summary, definitive criteria for the MS for childhood and adolescence have not yet been determined. The MS was related to insulin resistance and weight status, and was independent of the pubertal stage in most definitions. The prevalence of the MS was quite different depending on the proposed definitions for children and adolescents. An internationally accepted uniform definition of the MS is needed to allow comparisons between different studies and populations. Furthermore, the concept of the MS that the clustering of risk factors is predictive for CVD above and beyond the risk associated with its individual components has to be proven in childhood and adolescence.

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Competing interests: None.

What is already known on this topic

- Multiple definitions for the metabolic syndrome (MS) in childhood and adolescence have been suggested.
- The variation of prevalence between the different definitions is unknown.

What is this study adds

- Since the prevalence of the MS varies widely (6–39%) between the different proposed definitions, an internationally accepted uniform definition of MS is necessary.
- The concept of the MS that the clustering of risk factors is predictive for cardiovascular disease above and beyond the risk associated with its individual components has to be proven for children and adolescents.

REFERENCES

1 **Ebbeling CB**, Pawlaw DB, Ludwig DS. Childhood obesity: public-health crisis, common sense cure. *Lancet* 2002;**360**:473–82.
2 **Reinehr T**, Andler W, Denzer C, *et al*. Cardiovascular risk factors in overweight German children and adolescents: relation to gender, age, and degree of overweight. *Nutr Metab Cardiovasc Dis* 2005;**15**:181–7.
3 **Wabitsch M**, Hauner H, Hertrampf M, *et al*. Type II diabetes mellitus and impaired glucose regulation in Caucasian children and adolescents with obesity living in Germany. *Int J Obes Relat Metab Disord* 2004;**228**:307–13.
4 **Eckel RH**, Zimmet PZ. The metabolic syndrome. *Lancet* 2005;**365**:1415.
5 **Isomaa B**, Almgren P, Tuomi T, *et al*. Cardiovascular morbidity and mortality associated with the metabolic syndrome. *Diabetes Care* 2001;**24**:683–9.
6 **Lakka HM**, Laaksonen DE, Lakka TA, *et al*. The metabolic syndrome and total and cardiovascular disease mortality in middle-aged men. *JAMA* 2002;**288**:2709–16.
7 **Alberti KG**, Zimmet PZ. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: Diagnosis and classification of diabetes mellitus. Provisional report of a WHO consultation. *Diabet Med* 1998;**15**:539–93.
8 **Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults**. Executive summary of the Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And High Blood Cholesterol in Adults (Adult Treatment Panel III). *JAMA* 2001;**285**:2486–97.
9 **Balkau B**, Charles MA. Comment on the provisional report from the WHO consultation. European Group for the Study of Insulin Resistance (EGIR). *Diabet Med* 1999;**16**:442–3.
10 **Alberti KG**, Zimmet P, Shaw J. IDF Epidemiology Task Force Consensus Group. The metabolic syndrome--a new worldwide definition. *Lancet*, 2005;**366**:1059–62. Also see http://www.idf.org/webdata/docs/metac_syndrome_def.pdf (accessed 6 September 2007).
11 **Kahn R**, Buse J, Ferrannini E, *et al*. The metabolic syndrome: time for a critical appraisal: joint statement from the American Diabetes Association and the European Association for the Study of Diabetes. *Diabetes Care* 2005;**28**:2289–304.
12 **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.
13 **Cook S**, Weitzman M, Auinger P, *et al*. Prevalence of a metabolic syndrome phenotype in adolescents. Findings from the third National Heath and Nutrition Examination Survey, 1988–1994. *Arch Pediatr Adolesc Med* 2003;**157**:821–7.
14 **Viner RM**, Segal TY, Lichtarowicz-Krynska E, *et al*. Prevalence of the insulin resistance syndrome in obesity. *Arch Dis Child* 2005;**90**:10–14.
15 **De Ferranti SD**, Gauvreau K, Ludwig DS, *et al*. Prevalence of the metabolic syndrome in American adolescents: findings from the third National Health and Nutrition Examination Survey. *Circulation* 2004;**110**:2494–7.
16 **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* 2006;**30**:853–60.
17 **Cole TJ**, Bellizzi MC, Flegal KM, *et al*. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000;**320**:1–6.
18 **Cole TJ**. The LMS method for constructing normalized growth standards. *Eur J Clin Nutr* 1990;**44**:45–60.
19 **Kromeyer-Hauschild K**, Wabitsch M, Geller F, *et al*. Perzentile für den Body Mass Index für das Kindes- und Jugendalter unter Heranziehung verschiedener deutscher Stichproben. *Monatsschr Kinderheilkd* 2001;**149**:807–8.
20 **Matthews DR**, Hosker JP, Rudenski AS, *et al*. Homeostasis model assessment: insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. *Diabetologia* 1985;**28**:412–19.

21 **American Diabetes Association**. Diagnosis and classification of diabetes mellitus. *Diabetes Care* 2004;**27**:5–10.
22 **National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents**. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. *Pediatrics* 2004;**114**:555–76.
23 **Kuntze D**, Wabitsch M. Guidelines of the German working group on obese children and adolescents. Available from http://www.a-g-a.de/Leitlinie.pdf (accessed 6 September 2007).
24 **Fredriks AM**, van Buuren S, Fekkes M, *et al*. Are age references for waist circumference, hip circumference and waist-hip ratio in Dutch children useful in clinical practice? *Eur J Pediatr* 2005;**164**:216–22.
25 **Genuth S**, Alberti KG, Bennett P, *et al*. Follow-up report on the diagnosis of diabetes mellitus. *Diabetes Care* 2003;**26**:3160–7.
26 **Venables WN**, Ripley BD. *Modern applied statistics with S*. New York: Springer, 2002.
27 **Wallace TM**, Matthews DR. The assessment of insulin resistance in man. *Diabet Med* 2002;**19**:527–34.
28 **Reinehr T**, de Sousa G, Andler W. Longitudinal analyses between overweight, insulin resistance, and cardiovascular risk factors in children. *Obes Res* 2005;**13**:1824–33.
29 **Wunsch R**, de Sousa G, Reinehr T. Intima-media thickness in obesity: relation to hypertension and dyslipidemia. *Arch Dis Child*, 2005;90, 1097.
30 **Reinehr T**, Kiess W, de Sousa G, *et al*. Intima-media thickness in childhood obesity: relations to inflammatory marker, glucose metabolism, and blood pressure. *Metabolism* 2006;**55**:113–18.
31 **Raitakari OT**, Juonala M, Kahonen M, *et al*. Cardiovascular risk factors in childhood and carotid artery intima-media thickness in adulthood: the Cardiovascular Risk in Young Finns Study. *JAMA* 2003;**290**:2271–6.
32 **Davis PH**, Dawson JD, Riley WA, *et al*. Carotid intima-media thickness is related to cardiovascular risk factors measured from childhood through middle age: the Muscatine Study. *Circulation* 2001;**104**:2815–19.
33 **Reinehr T**, Wabitsch M, Andler W, *et al*. Medical care of obese children and adolescents. *Eur J Pediatr* 2004;**163**:308–12.
34 **Csabi G**, Torok K, Jeges S, *et al*. Presence of metabolic cardiovascular syndrome in obese children. *Eur J Pediatr* 2000;**159**:91–4.

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Latent coeliac disease

Do all children with coeliac disease need to stay on a gluten-free diet for life? It's a question that has been asked ever since the connection between dietary gluten and coeliac disease was discovered and the conventional answer, of course, is yes. Now researchers in Paris (Tamara Matysiak-Budnik and colleagues. *Gut* 2007;**56**:1379–86) have found that 13 of 61 adults with coeliac disease diagnosed in childhood had ''latent'' coeliac disease (asymptomatic and no villous atrophy on biopsy) on a long-term normal diet. (At this centre some children were allowed to return to a normal diet after gluten challenge if they were symptom free even though they had abnormal mucosal histology.)

The patients were re-evaluated at a median age of 26 years (17–53 years). The diagnosis of coeliac disease had been made at a median age of 17 months (6–192 months) and at the time of re-evaluation the patients had been taking a normal diet for an average of 10 years (2–44 years). They had remained free of major symptoms, although around 50% had minor symptoms such as episodic abdominal pain and bloating insufficient to make them resume a gluten-free diet. On repeat duodenal biopsy, 48 had ''silent'' coeliac disease (asymptomatic but total or partial villous atrophy) and 13 latent coeliac disease. Osteopenia or osteoporosis, defined by measurements of bone mineral density, was present in 25/42 patients tested (1/9 with latent coeliac disease and 23/33 with silent coeliac disease). The two groups (latent and silent) did not differ significantly as regards symptoms, current gluten consumption or duration on normal diet. The mean BMI was similar in the two groups, but eight patients in the silent group were underweight. On comparing the group with latent coeliac disease with a group of seven patients who had remained on a gluten-free diet since diagnosis, there were no significant differences in haemoglobin and iron status, serum biochemistries or bone mineral density. Coeliac disease specific antibodies were present in 5/13 vs 1/7 patients. Repeated duodenal biopsy in some patients in the latent group indicated that mucosal recovery might occur several years after resuming a normal diet. On further follow-up after this study, two of four patients in the latent coeliac disease group had clinical and histological relapse 3 years after the diagnosis of latency.

The authors of this paper suggest that up to 10% of children with coeliac disease could eventually recover normal mucosal histology after several years on a gluten-free diet. Serological abnormalities and abnormalities of intraepithelial leukocytes may persist, however, and histological relapse may occur on further follow-up. The risk of intestinal malignancy is not addressed in this paper. Careful follow-up with repeated biopsies would be necessary for all patients with latent disease and some might consider it not worth the risk involved.