Methodological considerations for childhood surveillance systems: the case of obesity[1]

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Abstract

An international consensus on the methodology of a public health surveillance system will be essential in order to have a correct understanding of the progress of the growing challenge posed by the epidemic of obesity, to make inter-country comparisons possible, and overall to evaluate the effectiveness of preventive programmes and interventions. Recently, the European Charter on Counteracting Obesity, adopted at the WHO European Ministerial Conference on Counteracting Obesity in November 2006, called as well for the development of internationally comparable core indicators for inclusion in national health surveillance systems to be used for advocacy, policy making and monitoring purposes. At present, however, there is not yet a universal agreement on the appropriate methodology to carry out an epidemiological study or surveillance system to assess the prevalence and incidence of both overweight and obesity and monitor their trends over time in children and adolescents. The current disagreement involves the diagnosis method for overweight and obesity, the reference values and cut-off points to be applied and the age of the subjects. At the moment body mass index (BMI) is the most accepted anthropometric measure to assess overweight and obesity in epidemiological studies. The new WHO child growth standards from 0 to 5 years and the International Obesity Task Force internationally based criteria for overweight and obesity among children and adolescents aged 2 to 18 years are useful tools for international comparisons.

Background: obesity as a public health problem

In 2000, body weight excess in both adult and paediatric populations was recognized by the World Health Organization (WHO) and the International Obesity Task Force as "… the most prevalent nutrition-related problem in western societies. Childhood obesity is rapidly emerging as a global epidemic…" (WHO 2000). Since then, childhood obesity has become a daily problem for most paediatricians as well as for parents in most economically developed countries and is starting to become a burden for developing countries as well (Lobstein et al. 2004). The increased burden of childhood obesity in these last years involves not only its increase in prevalence, but also its development at earlier ages and the more frequent occurrence of its associated co-morbidities, such as diabetes mellitus type 2, cardiovascular diseases, and hypertension (Freedman et al. 1999a; Krassas and Tzotzas 2004; Maleka-Tendera et al. 2004).

It is recognized that prevention is the only feasible option for curbing this epidemic since current treatment practices for obese children and adolescents are largely aimed at bringing the problem under control rather than effecting a cure (Lobstein et al. 2004). However, standard evidence for successfully preventing obesity is hard to obtain. Randomized controlled trials are not easily performed in open populations, and most controlled trials have been conducted in schools, health centres and workplaces, settings that offer the greatest opportunities for control and manipulation, thus creating a settings bias in the evidence base for policy-making. Micro-scale interventions are likely to have small effects unless supported by macro-scale interventions, such as in food labelling, pricing and availability (WHO Regional Office for Europe 2007a).

The need for a public health surveillance system to monitor a health-related event is determined by a number of parameters that include (German RR et al. 2001):

- indices of frequency, such as prevalence and incidence;
- indices of severity;
- disparities or inequities associated with the health-related event;
- costs associated with the health-related event;
- preventability;
- potential clinical course in the absence of an intervention; and
- public interest.

Obesity scores almost the maximum in each of these criteria, urging the need for national surveillance systems to assess the prevalence and incidence of both overweight and obesity and monitor their trends over time in children and adolescents, as well as to evaluate the effects of preventive and therapeutic interventions and correlate the diagnosis of obesity with early signs of metabolic complications. Recently, the European Charter on Counteracting Obesity (WHO Regional Office for Europe 2007b), which was adopted at the WHO European Ministerial Conference on Counteracting Obesity (Istanbul, Turkey, 15-17 November 2006), called for the development of internationally comparable core indicators for inclusion in national health surveillance systems to be used for advocacy, policy-making and monitoring purposes.

Although there is a wide consensus to this, there is not yet a universal agreement on the appropriate methodology to carry out an epidemiological study or surveillance system on overweight and obesity. This may underestimate the extent of the problem worldwide. A study performed in Italy using eight different indicators in combination with four different cut-off points showed how these different approaches to assessing excess body weight influence the prevalence of obesity (Table 1) (Baglio et al. 1998).

Table 1. Prevalence of obesity, according to different methods in the same sample of 8-year-old children (adapted from Baglio et al. 1998)[a]

Indicator	Reference	Cut-off point	Prevalence of obesity (%)	
			Boys	Girls
Relative overweight[b]	Must et al. 1991	> 20%	17.8	16.7
BMI	Must et al. 1991	> 85th percentile	29.9	33.3
Relative BMI[c]	Must et al. 1991	> 20%	21.5	19.3
Triceps skinfold	Must et al. 1991	> 85th percentile	16.8	12.3
Relative triceps skinfold[d]	Must et al. 1991	> 20%	28.0	15.8
BMI z score	Rolland-Cachera et al. 1991	> 2SD	25.2	28.9
Relative BMI[c]	Rolland-Cachera et al. 1991	> 20%	22.4	26.3
Fat %[e]		> 20% M > 25% F	25.2	16.7

[a] BMI, body mass index; F, female; M, male; SD, standard deviation.
[b] Relative overweight: [(weight - ideal weight)/ideal weight] x 100.
[c] Relative BMI: [(BMI - BMI 50th percentile)/BMI 50th percentile] x 100.
[d] Relative triceps skinfold (TS): [(TS - TS 50th percentile)/TS 50th percentile] x 100.
[e] Estimated by using the Lohman fat formula (Slaughter et al. 1988).

This paper addresses methodological issues that need to be considered for the conduct of public health surveillance systems to assess and monitor overweight and obesity in childhood and adolescence, and for which an international consensus is essential to gain a correct understanding of the progress of this epidemic and to make intercountry and inter-study comparisons possible. The current disagreement involves the following aspects: 1) diagnosis method; 2) reference values; 3) cut-off points; and, 4) subject's age.

Methods of overweight and obesity diagnosis

For children and adolescents, there are different methods of diagnosing overweight and obesity. In the past, obesity has been defined as a visible excess of body fat. However, the main uncertainty in this definition was the understanding of how much an excess of body fat was. Clinically evident obesity can be diagnosed easily, even by people not expert in the field, but overweight as a risk factor of ill health is not easy to diagnose. Fat mass increases in terms of absolute values with age, but its ratio with height and weight physiologically varies and it varies differently in the two sexes, making more problematic the definition of its excess as total amount and as percentage (WHO 1995).

The ideal method to assess overweight or obesity should accurately calculate the fat mass, be independent of other covariates of body mass such as height, be acceptable and reproducible, and have low costs and appropriate values of normality (Power et al. 1997). In vivo it is not possible to directly measure the body fat, thus, several indirect methods have been developed (e.g. underwater weighing, dual energy x-ray absorptiometry) (Reilly et al. 1995; Pietrobelli et al. 1998) to evaluate body composition and specifically the total fat mass. However, many of these laboratory indirect methods are expensive and invasive, require special equipment, and are thus inadequate for use in public health and in children.

Anthropometric measures are less accurate for measuring the excess of body fat than the indirect laboratory methods, but are more practical and easy to use in surveying childhood obesity. The most used ones are subcutaneous skinfolds, height, weight – in different ratios – and body circumferences (WHO 1995).

Skinfolds

The measurement of triceps, biceps, subscapular, and superiliac skinfold thickness directly measures subcutaneous fat and indirectly the total fat mass. The ratio between subcutaneous and total body fat is not constant but varies with race, sex, and age (Wells 2001) and subcutaneous fat is not related to a risk of metabolic complications, as is the case of visceral fat (Freedman et al.1999b). The main difficulty in using skinfold thickness is the standardization of the four mentioned skinfold measurements, which show a high inter-operator variability and hence require very well trained operators (Wells 2001).

Indices based on weight and height measures

Weight and height are easy to measure, but the anthropometric indices derived from these measures are often considered more useful than the measures alone (WHO 1995). During childhood and adolescence the ratio between height and weight varies with sex and age. Weight is dependent on height, thus, in choosing a ratio to define obesity, attention has to be paid to choosing the ratio where height shows the least influence on weight (Franklin 1999).
Weight-for-height is in that respect considered as a most useful index for use in pre-school children (WHO 1995). With the release of the new WHO standards for body mass index for age (BMI-for-age) in 2006, this index – calculated as weight (kg) divided by height squared

(m^2) – is also recommended for use in this population group. For older children and adolescents, the currently frequently used weight/height ratio is the BMI although its use has limitations (Prentice and Jebbs 2001). BMI provides only a crude measure of body fatness, since it does not distinguish between weight associated with muscle and weight associated with fat (WHO 2000). Further, it shows physiological fluctuations due to the fluctuations of weight and height growth velocities at different age points in childhood and adolescence; they increase during the first year of life, decrease from 1 to 6–7 years of age and, after that, increase again until final height is attained (Rolland-Cachera et al. 1994).

Body circumferences

Although commonly used, BMI does not give an indication of the distribution of fat; waist circumference can be a good indicator of the amount of abdominal fat. The measurement of abdominal fat is important, since an excess of abdominal fat (independently of total body fat) is associated with metabolic abnormalities, such as hyperinsulinemia and dislipidemia (Freedman et al. 1999c). In addition, a high waist circumference in childhood tracks well into adulthood (Goran et al. 1998). Hip measurements provide additional valuable information related to gluteofemural muscle mass and bone structure (WHO 2000). The waist/hip ratio may be a useful measure, since it also includes accumulation of fat on the hips, which may be of beneficial value for health (Seidell et al. 2001). As a result, the measurement of waist and hip circumference, singularly or reciprocally associated in different ratios, has been proposed as a simple and reliable method to diagnose excess body weight and mostly cardiovascular risk (Taylor et al. 2000; Higgins et al. 2001; Maffeis et al. 2001).

The reliability of waist circumference to measure intra-abdominal fat has been validated against magnetic resonance imaging (Brambilla et al 2006). This measurement, requiring only a non-elastic steel tape, however, also needs to be carried out according to a standardized protocol in order to get comparable results.

Reference values

Several national BMI-for-age curves have been developed for boys and girls separately and are used to assess the nutritional status of children and adolescents (Must et al. 1991; Cole et al. 1995; Savva et al. 2001; Kuczmarski et al. 2002; Rolland-Cachera et al. 2002; Cacciari et al. 2006). The concept of "reference values" embraces the notion of normality, of a desirable, ideal pattern and/or target; thus, the growth pattern of a single country cannot be considered as the gold standard against which to compare all the others because it is not possible to indicate which country should be considered as the gold standard. National curves, thus, will only allow an intracountry comparison over time or by regions, but cannot be used to compare between countries.

The currently recommended United States National Center for Health Statistics/WHO BMI growth curves for school-aged children and adolescents were drawn from the first National Health and Nutrition Examination Survey that was conducted in the United States between 1963 and 1974 (Must et al. 1991; WHO 1995). The drawbacks of this reference, such as the marked skewing of the age-specific distributions towards higher values, focused the discussion of a WHO expert committee meeting on the appropriateness of these BMI data from United States children and adolescents for international comparison. As a result, it was recommended to promote the development and establishment of international reference growth data based on data from several countries (WHO 1995).

Cole and his co-workers constructed in 2000 a growth reference for children and adolescents aged 2–18 years for use in international comparisons of the prevalence of overweight and

obesity. These curves were based on pooled, measured, cross-sectional, nationally representative data from six different countries on three continents (Cole et al. 2000).

The advantages brought by these curves are:

- reference to a population from six countries to avoid a single country being the international gold standard;
- the possibility of objectively comparing data from different countries; and
- BMI as a continuum indicator for children and adolescents to obtain a longitudinal evaluation.

They have also been criticized, however, because:

- they are theoretical, as they have been drawn from countries with a wide range of childhood overweight and obesity prevalence; and
- the western population is over represented and thus using this reference with non-western populations could be inappropriate.

(Reilly et al. 2000; Fu et al. 2003; Zimmermann et al. 2004; Wickramasinghe et al. 2005).

In order to overcome these limitations, WHO is working on the development of a single internationally agreed reference for school-aged children and adolescents taking into careful consideration the population and individual selection criteria, study design, sample size, measurements and statistical modelling of primary growth and secondary ancillary data (Butte et al. 2007).
In April 2006, the new WHO growth standards for children from 0 to 5 years, based on a prescriptive approach and thus representing how children should and could grow when living in an appropriate environment, were released. They included the weight-for-age, the weight-for-height, the height-for-age and the BMI-for-age curves (WHO 2006). They have been clinically validated and field tested to check whether they properly assess the nutritional status (both under- and overnutrition) of young children up to 5 years (Onyango et al. 2007). These growth curves can be considered as the ideal normal standard, as they have been constructed only on children who have been breastfed for at least 6 months and received complementary food gradually, lived in a smoke-free environment and did not have any economic constraints on their access to paediatric care or immunization (de Onis et al. 2004).

At present, there is no common waist or hip circumference reference available for children and adolescents to which measurement can be compared. As for BMI curves, national curves and various cut-off points exist for waist circumference, in the absence of an international one (Zannolli and Morgese 1996; Gillum 1999; Moreno et al. 1999; Savva et al. 2001; McCarthy et al. 2002). The main limitation of the available national data sets for waist circumference, which could eventually be used for the construction of an internationally agreed common reference, is that they cannot be pooled because of the different ages of the surveyed subjects (mainly as of 6 years of age and rarely in under-fives), different sites of measurements (the midpoint between superiliac crest and the lowest portion of the rib cage, the circumference at the most narrow point of the trunk) and different survey years.

Cut-off points

Up to 2000, the cut-off points mostly used to diagnose overweight and obesity were respectively the 85th and the 95th percentile of the above-mentioned American reference curves constructed by Must et al (1991), as well as the 90th and the 97th percentiles based on the Rolland-Cachera reference tables (1991) and recommended by the European Childhood Obesity Group (Poskitt et al. 1995).

In 2000, WHO modified the definition of obesity by adding to "the presence of excessive body fat" the association "with high morbidity", thus focusing the diagnosis on its relation to health. In adults the BMI cut-off points of 25 and 30 are set to define overweight and obesity respectively, since these values are based on epidemiological and clinical parameters related to the risk of co-morbidities (WHO 2000). Cole and his co-workers proposed as cut-off points for overweight and obesity in childhood and adolescence the percentile values of BMI adjusted for age and gender that correspond to the adult BMI value of 25 and 30 kg/m^2 at age 18 years of age (Cole et al. 2000). It is not yet clear however, whether these cut-off points are also associated with adverse health effects in childhood and adolescence in worldwide populations. Moreover, they show a lower sensitivity compared to other curves and cut-off points in assessing obesity by an inconstant rate (Reilly et al. 2000; Fu et al. 2003; Zimmermann et al. 2004 Wickramasinghe et al. 2005; Vidal E et al. 2006).

The cut-off points of the 2006 WHO BMI-for-age reference for children from 0 to 5 years of age for the diagnosis of overweight and obesity have been set as the 97th and the 99th percentile, respectively, as a result of validation by field testing the curves in primary health care settings (Onyango et al. 2007).

Up to now, a consensus on the waist circumference cut-off point to divide normal values from at risk ones has not been widely reached. The waist circumference increases with age and this differs between males and females, so that the cut-off to be used has to be set according to age and gender and it cannot be one single value for children of 4 to adolescents of 18 years of age (Maffeis et al 2001; McCarthy et al. 2001).

Subject's age[2]

The last important disagreement in the assessment of obesity is the age at which children and adolescents should be measured for excess body weight. Which age range to choose depends mainly upon the aim of the surveillance system and how the information derived from this system will be used.

If the goal is to know the "pure prevalence" in children it is better to choose an age when obesity development is quite low, such as between 7 and 9 years (Lehingue 1999). At these ages the adiposity rebound and puberty, which are two moments when the development of new cases of obesity are more frequent, have already happened and not yet started, respectively. If the aim of the surveillance is to assess the prevalence of obesity in adolescents, then the age range should be the stage when, according to the national average, both boys and girls have entered the last stages of puberty, to avoid classifying subjects incorrectly. Furthermore, if the prevalence information is to be used to start preventive interventions, the young childhood age range should be chosen, in order to obtain data not only on the prevalence of excess body weight, but also on its development factors, and to intervene before obesity is stably established (O'Brien et al. 2004; McCallum and Gerner 2005; US Preventive Services Task Force 2005; Plourde 2006).

Conclusion

There is universal agreement in the use of the indicator BMI to classify underweight, overweight and obesity in adults as well as of their recommended definitions. In adults, excess body weight is defined as having a BMI ≥25 kg/m^2. Obesity is defined as a BMI ≥30

[2] According to WHO age categorization, children are aged 0-9 years and adolescents 10-19 years (WHO 1995).

kg/m^2; pre-obesity is used to define adults with a BMI of 25.0–29.9 kg/m^2 (WHO 1995; WHO 2000). BMI is recommended to be used for monitoring the response of individual overweight and obese children and adolescents to exercise and to modifications in diet, for assessing the need to continue, modify or discontinue efforts to promote such actions, as well as for nutritional surveillance to assess the risk of overweight and obesity in order to modify programmes and allocate resources (WHO 1995; WHO 2000; WHO 2006). At the moment, this index is considered as the most simple feasible measure and widely accepted to assess overweight and obesity in childhood and adolescence.

In young children, the 2006 WHO growth curves from 0 to 5 years of age, based on a prescriptive approach, can be considered as the optimal growth model and recommended for use as a screening tool for overweight and obesity among young children. The curves provide BMI-for-age values that can be used for the early detection of a growth pattern leading to an increased risk of obesity. For older children, the International Obesity TaskForce criteria are currently frequently used by many investigators so that intercountry comparisons are possible, but some investigators follow the WHO 1995 recommendation of using the Must et al. reference. Until a new international reference for school-aged children and adolescents has been constructed, data can be reported with both systems. National growth references should be used only when the aim is to make intracountry comparisons over time and by regions. Investigators who report on the figures for overweight and obesity prevalence among children and adolescents based on their own national growth curves are therefore requested to estimate and report the results referring to both the WHO constructed or recommended BMI-for-age curves, according to the age of the children (WHO 2006; Must et al.1991) and the International Obesity TaskForce criteria (Cole et al. 2000) at the same time.

Skinfold measurements are not practical for surveillance purposes owing to their high inter-operator variability and the difficulty of standardizing their measurement. Waist and hip circumferences could be very suitable for assessing obesity and the associated risk of morbidity, because of the indication of the amount of abdominal fat and the accumulation of the fat on the hips, respectively. Internationally agreed reference and adequate age- and gender-specific cut-off points are needed, however.

A universal agreement on the whole methodology is imperative for a correct understanding of the progress of the obesity epidemic among children and adolescents worldwide and hence, investigators and public health programmers are urged to consider the use of internationally comparable measures.

Conflict of interest

This study has not been supported by any public or private grant.
The authors have no conflicts of interest to declare.

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