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Establishing a standard definition for child overweight and obesity worldwide: international survey.
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Abstract

Objective To develop an internationally acceptable definition of child overweight and obesity, specifying the measurement, the reference population, and the age and sex specific cut off points.

Design International survey of six large nationally representative cross sectional growth studies.

Setting Brazil, Great Britain, Hong Kong, the Netherlands, Singapore, and the United States.

Subjects 97 876 males and 94 851 females from birth to 25 years of age.

Main outcome measure Body mass index (weight/[height.sup.2]).

Results For each of the surveys, centile curves were drawn that at age 18 years passed through the widely used cut off points of 25 and 30 kg/[m.sup.2] for adult overweight and obesity. The resulting curves were averaged to provide age and sex specific cut off points from 2-18 years.

Conclusions The proposed cut off points, which are less arbitrary and more internationally based than current alternatives, should help to provide internationally comparable prevalence rates of overweight and obesity in children.

Introduction

The prevalence of child obesity is increasing rapidly worldwide.[1] It is associated with several risk factors for later heart disease and other chronic diseases including hyperlipidaemia, hyperinsulinaemia, hypertension, and early atherosclerosis.[2-4]

Because of their public health importance, the trends in child obesity should be closely monitored. Trends are, however, difficult to quantify or to compare internationally, as a wide variety of definitions of child obesity are in use, and no commonly accepted standard has yet emerged. The ideal definition, based on percentage body fat, is impracticable for epidemiological use. Although less sensitive than skinfold thicknesses,[5] the body mass index (weight/[height.sup.2]) is widely used in adult populations, and a cut off point of 30 kg/[m.sup.2] is recognised internationally as a definition of adult obesity.[6]

Body mass index in childhood changes substantially with age.[7 8] At birth the median is as low as 13 kg/[m.sup.2], increases to 17 kg/[m.sup.2] at age 1, decreases to 15.5 kg/[m.sup.2] at age 6, then increases to 21 kg/[m.sup.2] at age 20. Clearly a cut off point related to age is needed to define child obesity, based on the same principle at different ages, for example, using reference centiles.[9] In the United States, the 85th and 95th centiles of body mass index for age and sex based on nationally representative survey

data have been recommended as cut off points to identify overweight and obesity.[10] For wider international use this definition raises two questions: why base it on data from the United States, and why use the 85th or 95th centile?

A reference population could be obtained by pooling data from several sources, if sufficiently homogeneous. A centile cut off point could in theory be identified as the point on the distribution of body mass index where the health risk of obesity starts to rise steeply. Unfortunately such a point cannot be identified with any precision: children have less disease related to obesity than adults, and the association between child obesity and adult health risk may be mediated through adult obesity, which is associated both with child obesity and adult disease.

The adult cut off points in widest use--a body mass index of 25 kg/[m.sup.2] for overweight and 30 kg/[m.sup.2] for obesity--are related to health risk[1] but are also convenient round numbers. A workshop organised by the International Obesity Task Force proposed that these adult cut off points be linked to body mass index centiles for children to provide child cut off points.[11 12] We describe the development of age and sex specific cut off points for body mass index for overweight and obesity in children, using dataset specific centiles linked to adult cut off points.

Subjects and methods

Subjects

We obtained data on body mass index for children from six large nationally representative cross sectional surveys on growth from Brazil, Great Britain, Hong Kong, the Netherlands, Singapore, and the United States. Each survey had over 10 000 subjects, with ages ranging from 6-18 years.

Centile curves

Centile curves for body mass index were constructed for each dataset by sex Using the LMS method.[13] The fitted LMS curves allow an extra centile curve to be drawn for each dataset, passing through the adult cut off point for obesity of 30 kg/[m.sup.2] at age 18. Superimposing the curves of the six datasets leads to a cluster of centile curves that all pass through the adult cut off point yet represent a wide range of obesity. The hypothesis is that the relation between cut off point and prevalence at different ages gives the same curve shape irrespective of country or obesity. If sufficiently similar the curves can be averaged to provide a single smooth curve passing through the adult cut off point. The curve is representative of all the datasets involved but is unrelated to their obesity--the cut off point is effectively independent of the spectrum of obesity in the reference data. A curve for overweight passing through 25 kg/[m.sup.2] at age 18 is obtained in the same way.

Results

Table 1 gives the centiles for overweight and obesity corresponding to a body mass index of 25 and 30 kg/[m.sup.2] at age 18 for each dataset by sex. The prevalence range at 18 years is 4.7-18.1% for overweight and 0.1-4.0% for obesity.

Table 1 Centiles and z scores for overweight and obesity corresponding to body mass index of 25 kg/[m.sup.2] and 30 kg/[m.sup.2] at age 18 years in six datasets, derived from fitted LMS curves

	Males		
Country	Centile	z score	% above cut off point
Body mass index 25 kg/[m.sup.2]			
Brazil	95.3	1.68	4.7
Great Britain	90.4	1.30	9.6
Hong Kong	88.3	1.19	11.7
Netherlands	94.5	1.60	5.5
Singapore	89.5	1.25	10.5
United States	81.9	0.91	18.1
Body mass index 30 kg/[m.sup.2]			
Brazil	99.9	3.05	0.1
Great Britain	99.1	2.37	0.9
Hong Kong	96.9	1.86	3.1
Netherlands	99.7	2.71	0.3
Singapore	98.3	2.12	1.7
United States	96.7	1.84	3.3
	Females		
Country	Centile	z score	% above cut off point
Body mass index 25 kg/[m.sup.2]			
Brazil	84.8	1.03	15.2
Great Britain	88.3	1.19	11.7
Hong Kong	90.2	1.29	9.8
Netherlands	93.5	1.52	6.5
Singapore	93.0	1.48	7.0
United States	83.5	0.97	16.5
Body mass index 30 kg/[m.sup.2]			
Brazil	98.0	2.06	2.0
Great Britain	98.8	2.25	1.2
Hong Kong	98.2	2.10	1.8
Netherlands	99.7	2.73	0.3
Singapore	99.0	2.33	1.0
United States	96.0	1.76	4.0

Figure 1 presents the centile curves for overweight for the six datasets by sex, passing through the adult cut off point of 25 kg/[m.sup.2] at age 18. Figure 2 gives the corresponding centile curves for obesity in each dataset, passing through a body mass index of 30 kg/[m.sup.2] at age 18. The curves are reasonably consistent across countries between ages 8 and 18, although those for Singapore are higher between ages 10 and 15. This is due partly to an increased median and partly to greater variability.

[Figures 1-2 ILLUSTRATION OMITTED]

Table 2 and figure 3 show international cut off points for body mass index for overweight and obesity from 2-18 years, obtained by averaging the centile curves in figures 1 and 2. From 2-6 years the cut off points do not include Singapore because its data start at age 6 years.

[Figure 3 ILLUSTRATION OMITTED]

Table 2 International cut off points for body mass index for overweight and obesity by sex between 2 and 18 years, defined to pass through body mass index of 25 and 30 kg/[m.sup.2] at age 18, obtained by averaging data from Brazil, Great Britain, Hong Kong, Netherlands, Singapore, and United States

	Body mass index 25 kg/[m.sup.2]		Body mass index 30 kg/[m.sup.2]	
Age (years)	Males	Females	Males	Females
2	18.4	18.0	20.1	20.1
2.5	18.1	17.8	19.8	19.5
3	17.9	17.6	19.6	19.4
3.5	17.7	17.4	19.4	19.2
4	17.6	17.3	19.3	19.1
4.5	17.5	17.2	19.3	19.1
5	17.4	17.1	19.3	19.2
5.5	17.5	17.2	19.5	19.3
6	17.6	17.3	19.8	19.7
6.5	17.7	17.5	20.2	20.1
7	17.9	17.8	20.6	20.5
7.5	18.2	18.0	21.1	21.0
8	18.4	18.3	21.6	21.6
8.5	18.8	18.7	22.2	22.2
9	19.1	19.1	22.8	22.8
9.5	19.5	19.5	23.4	23.5
10	19.8	19.9	24.0	24.1
10.5	20.2	20.3	24.6	24.8
11	20.6	20.7	25.1	25.4
11.5	20.9	21.2	25.6	26.1
12	21.2	21.7	26.0	26.7
12.5	21.6	22.1	26.4	27.2
13	21.9	22.6	26.8	27.8
13.5	22.3	23.0	27.2	28.2
14	22.6	23.3	27.6	28.6
14.5	23.0	23.7	28.0	28.9
15	23.3	23.9	28.3	29.1
15.5	23.6	24.2	28.6	29.3
16	23.9	24.4	28.9	29.4
16.5	24.2	24.5	29.1	29.6
17	24.5	24.7	29.4	29.7
17.5	24.7	24.8	29.7	29.8
18	25	25	30	30

Discussion

Our method addresses the two main problems of defining internationally

acceptable cut off points for body mass index for overweight and obesity in children.[11 12] The reference population was obtained by averaging across a heterogeneous mix of surveys from different countries, with widely differing prevalence rates for obesity, whereas the appropriate cut off point was defined in body mass index units in young adulthood and extrapolated to childhood, conserving the corresponding centile in each dataset.

Although less arbitrary and potentially more internationally acceptable than other cut off points, this approach still provides a statistical definition, with all the implied advantages and disadvantages.[14] Our terminology corresponds to adult cut off points, but the health consequences for children above the cut off points may differ from those for adults. Nonetheless, the cut off points based on a heterogeneous worldwide population can be applied widely to determine whether the children and adolescents they identify are at increased risk of morbidity related to obesity.

Agreement of the centile curves

The major uncertainty with our approach, and the test of its validity, is the extent to which the centile curves for the datasets are of the same shape. Figures 1 and 2 show that although the agreement is reasonable it is not perfect.

Nothing obvious explains Singapore's unusual pattern of overweight in puberty. Omitting it from the averaged country curves would lower the cut off points for both sexes by less than 0.4 body mass index units at age 11-12. Therefore, even though Singapore looks different from the other countries, its impact on the cut off points is only modest. Because there is no a priori reason to exclude Singapore, and because so little is known about growth patterns across countries, we have chosen to retain it in the reference population.

Extending the dataset

We recognise that the reference population made up of these countries is less than ideal. It probably reflects Western populations adequately but lacks representation from other parts of the world. The Hong Kong sample may, however, be fairly representative of the Chinese, and the Brazilian and US datasets include many subjects of African descent. Although additional datasets from Africa and Asia would be helpful, our stringent inclusion criteria of a large sample, national representativeness, minimum age range 6-18 years, and data quality control, mean that further datasets are unlikely to emerge from these continents in the foreseeable future. To our knowledge no other available surveys satisfy the criteria. It is not realistic to wait for them because there is an urgent need for international cut off points now. Also, our methodology aims to adjust for differences in overweight between countries, so it could be argued that adding other countries to the reference set would make little difference to the cut off points. None the less, further research is needed to explore patterns of body mass index in children in Africa and Asia.

Puberty

The body mass index curves in figure 3 show a fairly linear pattern for males but a higher and more concave shape for females. This sex difference

can also be seen in the individual curves of figures 1 and 2 reflecting earlier puberty in females. The sensitivity of the curve's shape to the timing of puberty may affect the performance of the cut off points in countries where puberty is appreciably delayed,[15] although delays of less than two years are unlikely to make much difference.

Conclusions

Our analysis provides cut off points for body mass index in childhood that are based on international data and linked to the widely accepted adult cut off points of a body mass index of 25 and 30 kg/[m.sup.2]. Our approach avoids some of the usual arbitrariness of choosing the reference data and cut off point. Applying the cut off points to the national datasets on which they are based gives a wide range of prevalence estimates at age 18 of 5-18% for overweight and 0.1-4% for obesity. A similar range of estimates is likely to be seen from age 2-18. The cut off points are recommended for use in international comparisons of prevalence of overweight and obesity.

What is already known on this topic

Child obesity is a serious public health problem that is surprisingly difficult to define

The 95th centile of the US body mass index reference has recently been proposed as a cut off point for child obesity, but like previous definitions it is far from universally accepted

What this study adds

A new definition of overweight and obesity in childhood, based on pooled international data for body mass index and linked to the widely used adult obesity cut off point of 30 kg/[m.sup.2], has been proposed

The definition is less arbitrary and more international than others, and should encourage direct comparison of trends in child obesity worldwide

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