

New curves for body mass index among children and adolescents

OPINIONS

PÉTUR BENEDIKT JÚLÍUSSON

E-mail: petur.juliusson@uib.no

Pétur Benedikt Júlíusson (born 1964), specialist in paediatrics at the Department of Paediatrics, Haukeland University Hospital, and the Morbid Obesity Centre, Vestfold Hospital Trust. He is professor at the Department of Clinical Science, University of Bergen.

The author has completed the ICMJE form and declares no conflicts of interest.

JØRAN HJELMESÆTH

Jørn Hjelmesæth (born 1957), specialist in internal medicine and nephrology, head of the Morbid Obesity Centre, Vestfold Hospital Trust, and professor at the University of Oslo.

The author has completed the ICMJE form and declares no conflicts of interest.

ROBERT BJERKNES

Robert Bjerknes (born 1958), specialist in paediatrics and senior consultant at the Department of Paediatrics, Haukeland University Hospital, with special competence in growth and endocrinology. He is professor and vice-rector at the University of Bergen.

The author has completed the ICMJE form and declares no conflicts of interest.

MATHIEU ROELANTS

Mathieu Roelants (born 1965), PhD, post-doctoral fellow at the Department of Public Health and Primary Care, University of Leuven, Belgium.

The author has completed the ICMJE form and declares no conflicts of interest.

The Norwegian curves for body mass index published in 2009 included international cut-off values for overweight and obesity in children and adolescents. Here, we present an update of this curve which now includes a cut-off for severe obesity, and argue why it should be used.

The body mass index (BMI), expressed in kg/m^2 , is used in clinical practice to identify children with aberrant weight. Because the BMI evolves naturally as children grow, BMI reference curves are used for evaluation, on which the BMI is plotted by age.

In 2009, our research group published BMI reference charts for Norwegian boys and girls (1). The cut-offs used since 2000 by the International Obesity Task Force (IOTF) to define overweight and obesity were added to these charts (2). The IOTF defines overweight and obesity by two lines, IOTF 25 and IOTF 30, which are referred to as iso-BMI 25 and iso-BMI 30 on the Norwegian charts. These two lines are based on the definitions of overweight and obesity in adults which correspond to a BMI of $25 \text{ kg}/\text{m}^2$ and $30 \text{ kg}/\text{m}^2$ respectively, at the age of 18 years.

The IOTF dataset includes cohorts from six countries (Brazil, UK, Hong Kong, Netherlands, Singapore and USA) with a total of 97 876 boys and 94 851 girls aged 0–25 years who were measured in the years 1968–93.

The IOTF cut-offs are used to assess the ‘weight class’ of boys and girls, i.e. to determine whether the child is of normal weight, or is overweight or obese. Later, in 2007, equivalent cut-off values for underweight were published based on the definition of underweight in adults, which corresponds to a BMI of $18.5 \text{ kg}/\text{m}^2$ (underweight grade 1), $17 \text{ kg}/\text{m}^2$ (underweight grade 2) or $16 \text{ kg}/\text{m}^2$ (underweight grade 3) at the age of 18 (3).

In 2011, the Directorate of Health published national guidelines for the primary health services in this area, under the title *Prevention, identification and treatment of overweight and obesity in children and adolescents* (4). The guidelines define intervention levels based on the IOTF definitions of overweight and obesity. However, at the time there was no equivalent definition of severe obesity. To address this shortcoming, severe obesity was defined as $\text{BMI} \geq \text{iso-BMI } 35$, a cut-off that was estimated by adding five BMI units to the IOTF threshold for obesity ($\text{IOTF } 30 + 5 = \text{iso-BMI } 35$).

New definition of severe obesity in children and adolescents

In 2012, Cole and Lobstein published an IOTF reference (5) that made it possible to estimate any percentile, and also to convert individual observations to standard deviation scores. With the original publication from 2000, this was

not possible (5). Moreover, the authors added a definition of ‘severe obesity’ on the basis of a BMI of 35 kg/m^2 at the age of 18, estimated in the same way as the cut-off values for overweight and obesity.

These two cut-off values for severe obesity, i.e. the iso-BMI 35 line (IOTF 30 + 5) from the Directorate of Health and the new IOTF 35 ‘severe obesity’ line are not identical, although they share the same basis, i.e. a BMI of 35 kg/m^2 at the age of 18 (Figure 1). For children under the age of ten, the new IOTF 35 definition is at a lower level than the old iso-BMI 35 threshold. This means that with the new definition, more children under the age of ten will be classified as severely obese. After the age of ten, there is almost no difference.



Figure 1 BMI curves for a) boys and b) girls. Comparison of the old (dotted line) and the new definition of severe obesity. The Norwegian reference (-2, -1, 0, +1, +2 standard deviations) is shown as pale green lines, IOTF’s definitions for underweight (grade 1, grade 2, grade 3), overweight, obesity and severe obesity as dark green lines, and the line for IOTF 30 + 5 BMI units as dotted.

The IOTF definition of severe obesity in children and adolescents is now incorporated in the growth-curve applications in many Norwegian hospitals and primary healthcare institutions. The discrepancy between these cut-offs and the definition from the Norwegian Directorate of Health leads to confusion, especially since the cut-off for severe obesity is used for referral to further assessment and follow-up in specialist health services (6).

Clinical consequences

The definition of severe obesity from the Norwegian Directorate of Health shows a clear bias compared to the corresponding IOTF cut-off, since the distance increases as the age decreases (Figure 1). It is therefore reasonable to replace this definition with the IOTF 35 cut-off value. The definition of severe obesity will then be constructed in exactly the same way as the definitions of overweight ($\text{BMI} \geq \text{iso-BMI } 25$) and obesity ($\text{BMI} \geq \text{iso-BMI } 30$).

We have revised the original BMI charts from 2009 and added the IOTF 35 cut-offs for severe obesity (júliussonappendiksENG). The charts show the BMI percentiles for Norwegian boys and girls in the age group 2–19 years, and the areas between the different cut-off values for overweight and underweight are

marked in grey. As a consequence of including the new cut-off value for severe obesity, more children under the age of ten will be classified as having this condition. However, this can also be interpreted as an earlier identification of individual children with this problem, and as such, the total number of children and adolescents referred will only show a temporary increase.

Identification of children with overweight and obesity can be challenging. However, it should be kept in mind that these lines are not diagnostic regarding each child, but are primarily complementary to a clinical examination. This is also explicitly pointed out in the text boxes that accompany the curves. Identifying severe obesity at an earlier stage can be appropriate, because early intervention appears to have a better outlook for subsequent weight development than an intervention at a later age (7). In addition, the risk of obesity becoming a permanent problem increases rapidly after the age of two (8).

BMI is a weight-for-height index and thus provides no information about the distribution of body fat. High values nevertheless reflect an increase in the amount of adipose tissue, and at group level the IOTF cut-off values have been shown to be rather conservative (low sensitivity, high specificity) when compared to measures of body composition (9).

The IOTF cut-off values have great epidemiological importance, not least for monitoring the prevalence within a population group or when comparing countries. In clinical practice, these cut-offs also play a key role in defining practices or intervention levels, such as in Norway. Regarding the clinical follow-up of children with aberrant weight, the distance to the iso-BMI cut-off values is often used to determine whether progress is positive or not.

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