Objective: To compare the body mass index (BMI) (calculated as weight in kilograms divided by the square of height in meters) and the prevalence of BMI at or above the 85th centile and 95th centile (overweight) in adolescents.


Setting: Austria, Czech Republic, Denmark, Flemish Belgium, Finland, France, Germany, Greece, Lithuania, Ireland, Israel, Portugal, Slovakia, Sweden, and the United States.

Participants: A total of 29,242 boys and girls, aged 13 and 15 years.

Main Outcome Measures: The BMI, BMI at or above the 85th centile, and BMI at or above the 95th centile (overweight) from self-reported height and weight.

Results: The highest prevalence of overweight was found in the United States and the lowest in Lithuania. On the basis of the study reference standard, the prevalence of overweight (percentage) in the United States was 12.6% in 13-year-old boys, 10.8% in 13-year-old girls, 13.9% in 15-year-old boys, and 15.1% in 15-year-old girls, all significantly increased. Prevalence of overweight in Lithuania was significantly below the expected 5%, with 1.8% in 13-year-old boys, 2.6% in 13-year-old girls, 0.8% in 15-year-old boys, and 2.1% in 15-year-old girls. Relative rankings among countries were similar for BMI at or above the 85th centile, although there were less dramatic differences at this level.

Conclusions: The highest prevalences of overweight were found in the United States, Ireland, Greece, and Portugal.

The data from 15 countries were included in an international data file of all countries’ data on self-reported height and weight. Adolescents at ages less than 13, 14, or greater than or equal to 16 years were excluded to yield measures for age in months at 13 and 15 years. Adolescents were excluded from the international file if month or year of birth was unknown.

Two items measured height and weight: “How much do you weigh without clothes?” and “How tall are you?” The BMI was calculated from self-reported height and weight. Some countries allowed reporting in stones, pounds, ounces, feet, or inches, which were then converted to kilograms and centimeters, as appropriate.

In 12 countries, either height or weight was missing in 8% or less of cases; missing data involved 13% of total students surveyed in Israel, 21% in Lithuania, and 39% in Ireland. Use of multiple languages and types of measures within a country was considered the probable reason for missing reports in these latter countries after the completed questionnaires were double-checked. For example, Ireland asked for the weight measures to be reported in stones, pounds and ounces, or kilograms and grams; and height in feet and inches or centimeters. Irish students frequently just left these questions blank.

Data on height and weight were deemed valid for inclusion on the basis of height and weight range specifications available from the NHANES III.24 The NHANES III ranges were created to exclude values due to measurement errors resulting in extremely improbable heights and weights for a given age. Height ranges allowed for boys aged 13 and 15 years, respectively, were 130 to 199 cm and 140 to 199 cm, and for girls, 130 to 199 cm and 135 to 199 cm. The lowest weight allowed in both sexes aged 13 and 15 years was 25 and 32 kg, respectively, and the highest was 115 kg. Across the 15 countries, 2311 and 1189 records were excluded because of missing values on height and weight, and 91 and 52 because of extreme values for height and weight, respectively. Furthermore, 50 were excluded because of extreme low values of BMI (lowest accepted value was 12), resulting in a final analytic data file of 29242 adolescents aged 13 and 15 years from 15 countries.
From each country, the following numbers of adolescents were included: Austria, n = 1946; Belgium, n = 2643; Czech Republic, n = 1988; Denmark, n = 1910; Finland, n = 2170; France, n = 2243; Germany, n = 2516; Greece, n = 2301; Ireland, n = 826; Israel, n = 991; Lithuania, n = 1724; Portugal, n = 1460; Slovakia, n = 2233; Sweden, n = 2223; and United States, n = 2068. Means ages for all countries combined were 13.5 and 15.5 years for both boys and girls. Across countries, mean ages varied among 13-year-old boys from 13.3 to 13.7 years, among 13-year-old girls from 13.3 to 13.8 years, and in 15-year-old boys and girls from 15.3 to 15.7 years. The SEs for age were very small and varied little across countries, sex, and age (from 0.01 to 0.03).

**STATISTICAL ANALYSES**

Univariate analyses of the mean, median, and centile distributions of age, height, weight, and BMI were completed for each country. We present the country-specific 85th and 95th centile levels for BMI, since they are frequently recommended for the assessment of risk of overweight status. The SEs and CIs based on variance estimates for each country were calculated by means of SUDAAN, which adjusts variance estimates for complex sample survey designs. The school was the primary sampling unit for each country’s survey, so the variance estimates were adjusted for clustering of adolescents within schools for this analysis. All CIs are shown at the 95% level.

The International Obesity Task Force and other country-specific reference curves were tested for use as a reference, but were not sensitive for comparing at BMI at or above the 85th and 95th centile (overweight) among most countries in our study. A distributional curve based on self-reported BMIs among HBSC countries appeared skewed in comparison with the International Obesity Task Force and other references. After extensive checking for country-specific consistency between self-reported and measured BMIs when such comparisons were available, less divergence was found within these countries when a BMI curve was used that included only the reports from 15 HBSC countries. For purposes of having an appropriate reference based on self-reported weights to be used just for this analysis, a study reference standard was created.

**STUDY REFERENCE STANDARD**

A reference curve, based on the 29,242 observations from all 15 countries, was created from self-reported heights and weights to establish cutoffs for BMI at or above the 85th centile and BMI at or above the 95th centile. Data were weighted so that the 15 countries were equally represented in the combined data set to address potential bias to the study reference standard from this survey showed similar trends, with the US adolescents reporting a higher

**RESULTS**

Table 2 describes mean weights, heights, and BMI for each country. Weights for boys ranged from the lowest in Lithuania to the highest in Greece, and the United States at both 13 and 15 years. Means and medians were very similar, usually with overlapping CIs. Data for medians are not shown because the distributions at the 85th and 95th centiles address issues of data skewness.

**COMMENT**

The first main finding was the strong contrast between countries, with the highest prevalence of BMI at or above the 85th and 95th centiles (overweight) being seen in the United States and the lowest in Lithuania. Among 13-year-olds, countries with significantly increased prevalence of BMI at or above the 85th centile were Ireland, Finland, and Greece. Countries with significantly lower prevalence of BMI at or above the 85th centile were the Czech Republic, Denmark, Flemish Belgium, France, Germany, Lithuania, and Sweden, although comparisons within and among countries by age and sex varied.

Prevalence of overweight (BMI ≥95th centile) using the study reference standard from this survey showed similar trends, with the US adolescents reporting a higher

**Table 1. Age- and Sex-Specific BMI Cutoff Points at 13.5 and 15.5 Years According to the Study Reference Standard for BMI at or Above 85th or 95th Centile**

<table>
<thead>
<tr>
<th>Age, y</th>
<th>BMI Centile</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.5</td>
<td>≥85th</td>
<td>22.1</td>
<td>21.7</td>
</tr>
<tr>
<td></td>
<td>≥95th</td>
<td>24.8</td>
<td>24.4</td>
</tr>
<tr>
<td>15.5</td>
<td>≥85th</td>
<td>23.2</td>
<td>22.8</td>
</tr>
<tr>
<td></td>
<td>≥95th</td>
<td>26.0</td>
<td>25.4</td>
</tr>
</tbody>
</table>

Abbreviation: BMI, body mass index (calculated as weight in kilograms divided by the square of height in meters).

**Figures 1, 2, 3, and 4** show the 85th and 95th centile values of BMI in each country for 13- and 15-year-old adolescents of each sex. The highest 85th and 95th centiles consistently were from the United States. The lowest 85th and 95th centiles of 13-year-old boys were those from Lithuania and Denmark.

Table 3 presents the proportion of children at or above the 85th centile and at or above the 95th centile of BMI distribution compared with the study reference standard (see the “Methods” section). For instance, 13-year-old boys from the following countries had statistically significantly increased prevalence at the 85th centile or greater (lower limit of CI at or above 15%): Greece (28.7%), Ireland (24.7%), the United States (25.5%), and Finland (19.4%). Girls showed the same pattern among 13-year-olds, with the addition of Portugal (22.8%).

For 13-year-olds, the prevalence of overweight at or above the 95th centile was statistically significantly increased (lower limit of CI at or above 5%) only in US boys (12.6%) and girls (10.8%) and in Greek boys (8.9%).

Among 15-year-old boys, US, Greek, and Israeli children had significantly increased prevalence of BMI at or above the 85th centile. Patterns of BMI at or above the 85th centile for 15-year-old girls were slightly different, although the United States was much higher than all other countries, with 31.0%. At age 15, only US (13.9%) and Greece (10.8%) boys and US (15.1%) and Portuguese (6.7%) girls were statistically significantly increased at the 95th centile.

prevalence of overweight than any of the European countries or regions or Israel. Other countries with significantly increased prevalence of overweight were Greece and Portugal.

Our findings are generally consistent with the available country-specific references. The US study population data are generally consistent with current measurements from the NHANES III survey performed in 1988 to 1991. The reference curve developed by Rolland-Cachera et al., based on French children, was also consistent with the French data of this study, but distributions in many countries appeared skewed in comparison as well. Comparisons with references based on British adolescents, who would be expected to be somewhat similar to those in neighboring countries included in this study, show 90th centile values similar to the 85th centiles of the Must curves based on US adolescents, with higher values for girls than for boys. By contrast, the 90th centiles for French adolescents are very similar for both sexes and are somewhat lower than both the Must 85th centile and British 90th centile.

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resentative national samples of adolescents with very high participation rates as recommended by an international work group. All countries performed the data collection within the same time span, providing a strong basis for international comparisons. Most adolescents answered the questions of height and weight properly.
One weakness is lack of physical examinations for measures of height and weight, although other studies have shown self-report to be relatively consistent.26,35,36

Teens may not know their current height and weight or may know it as of several months ago. For the present purpose, namely, to assess differences between the countries, it is probable that differences in reporting during rapid growth periods may average out in cross-country comparisons. To our knowledge, no other studies are available with height and weight from so many countries. The problem with self-report is that the obese tend to underreport their weight, resulting in a lower prevalence of obesity. Prevalence therefore is probably higher than reported herein. Also, minor sex differences in reporting by adolescents may occur, with some boys overestimating their weight and some overweight girls providing underestimates. These reporting biases probably are consistent among countries. A validation study performed before the data collection in Denmark showed the same reporting bias. The correlation between self-reported and measured BMI was 0.8 (I.L., unpublished data, 1997). Also, a later pilot study performed in Flemish Belgium showed that adolescents aged 10 to 17 years could be accurately ranked according to BMI (correlation coefficient, 0.9) on the basis of self-reports of height and weight (Carine Vereecken, MSc, and Lea Maes, PhD, unpublished data, 1998). This preliminary validations study showed that boys' reports are almost identical, while those of girls show more variance, especially in weight. Self-reported weights were slightly lower than those shown in measured Flemish Belgian references.

An additional limitation of this study is the lack of pubertal indicators to adjust the prevalence of overweight for intercountry differences in the timing of maturation, an approach that has been recommended by the WHO.30 Adjustment for the timing of maturation may be important because overweight status in girls is strongly associated with earlier maturation, while for boys early maturation is associated with a low BMI.37 Cross-country comparisons in prevalence of overweight and obesity that do not account for population differences in the timing of maturation in relation to the reference may be biased. This point was recently made by Wang and Adair,38 who found that, with the use of the WHO-recommended reference,39 maturity adjustment based on population differences in the timing of menarche for girls increased the estimated prevalence of overweight in China and Russia, where girls mature later, and decreased the estimated prevalence in the United States, where girls mature earlier. We would likewise expect that maturity adjustment would have somewhat attenuated the differences in prevalence rates of overweight and obesity among countries, but would not have significantly affected their relative rankings.

The cross-sectional design of this study does not allow for causal analysis of the mechanisms behind the differences. Since most obese adolescents remain obese as
Health Behaviour in School-aged Children

Health Behaviour in School-aged Children is a WHO-European Regional Office collaborative study. International coordinator of the 1997-1998 study was Candace Currie, University of Edinburgh, Edinburgh, Scotland; data bank manager, Oddrun Samdal, University of Bergen, Bergen, Norway. This publication on the 1997-1998 study reports on data from the following countries (principal investigators): Austria (Wolfgang Dur, MD), Flemish Belgium (Lea Maes, PhD), Czech Republic (Ladislav Cseny, PhD), Denmark (Bjørn E. Holsteen, MSS, and Pernille Due, MD), Finland (Lasse Kannas, PhD, and Jorma Tynjälä, PhD), France (Christiane Dressen, PhD), Germany (Klaus Hurrelmann, PhD), Greece (Anna Kokkevi, MD, PhD), Israel (Yossi Harel, PhD), Lithuania (Apolinaris Zaborskis, MD), Ireland (Saoirse Nic Gabhainn, PhD), Portugal (Margarida Gaspar de Matos, PhD), Slovakia (Miro Bronis, MD, PhD), Sweden (Ulla Marklund, PhD), and United States (Mary D. Overpeck, DrPH, and Peter Scheidt, MD).

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