Children and adolescents with type 1 diabetes in Germany are more overweight than healthy controls: results comparing DPV database and CrescNet database

Abstract

Aims: To describe the development of weight in children and adolescents with type 1 diabetes in Germany.

Methods: We analyzed the body mass index (BMI) of the most recent treatment year of each patient with diabetes in the Pediatric Quality Initiative (DPV) database. BMI SD score (SDS) was calculated based on pooled historical German normative data (AGA) and based on healthy children from the CrescNet database. Thus, 25,762 children and adolescents with diabetes were compared with more than 75,000 healthy controls.

Results: BMI-SDS was 0.49±0.88 and 0.26±0.79 when children and adolescents, respectively, with diabetes were compared with AGA reference or with CrescNet controls from the same year. In both analyses, female patients (0.57±0.89 and 0.30±0.79) had significantly higher BMI-SDS than male patients (0.41±0.86 and 0.22±0.78; p<0.0001). Analysis of different age groups showed highest BMI-SDS in patients below 6 years (0.61 and 0.56, respectively). After adjustment for metabolic control, center, and insulin treatment, BMI-SDS was significantly influenced by diabetes duration, age, and female gender.

Conclusions: BMI of children and adolescents with type 1 diabetes is higher compared with healthy children measured in the same year. Especially, very young children and adolescent girls are at risk for overweight independent of annual trends.

Keywords: adolescents; body mass index; children; obesity; overweight; type 1 diabetes mellitus.
Patients and methods

Methods

Data were provided by the Pediatric Quality Initiative (DPV). Longitudinal anonymized data of 25,762 patients (age 3–16 years) were included (database from March 2007). These patients were treated in 223 diabetes centres in Germany and Austria (see Acknowledgments). Data are checked for plausibility at data entry and data acquisition by the software and correction of uncertain data is enforced every 6 months.

BMI (kg/m²) was calculated as the median BMI over the last treatment year in the DPV database. To adjust for age and gender, BMI was expressed as BMI SD score (SDS) based on two German normative reference populations using the LMS transformation suggested by Cole and Green (5), which adjusts the BMI distribution for skewness and allows BMI in individual subjects to be expressed as an SDS.

The data by Kromeyer-Hauschild et al. (3) are used as normative data by the German working group for obesity in childhood. These data are pooled from different German data sets including healthy children and adolescents collected between 1985 and 1999. In this report, BMI-SDS levels based on these references will be labeled BMI-SDS AGA. Overweight was defined as BMI between 90 and 97 percentiles of German normative data (AGA) and obesity was defined as BMI above 97 percentile.

The CrescNet database served as a second normative source for German BMI data (4, 6). This computer-based auxologic collaborative network with 350 general pediatricians is based at the hospital for children and adolescents in Leipzig, Germany. From 1999 to 2006, 627,449 single measurements were included in the calculation of reference values. Thus, it is possible to generate reference values for BMI for every single year. In this report, the standardized BMI using CrescNet reference data will be called BMI-SDS CrescNet.

The patients were subdivided into three age groups for analysis of age-dependent variation of BMI as follows: group A (<6 years), group B (6.1–12 years), and group C (12.1–16 years). In addition, patients with different diabetes duration (<2, 2–4, and >4 years) were compared. To adjust for interaction, we analyzed the influence of the chronological year of observation after multiple adjustment for center, gender, age, diabetes duration, metabolic control, and insulin treatment.

Table 1 Clinical data of the entire study group and the study population in three age groups (data from the most recent year per patient).

<table>
<thead>
<tr>
<th></th>
<th>Entire study population</th>
<th>A (&lt;6 years)</th>
<th>B (6.1–12 years)</th>
<th>C (12.1–16 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>25,672</td>
<td>1866</td>
<td>8324</td>
<td>15,572</td>
</tr>
<tr>
<td>Age, years</td>
<td>12.2±3.4</td>
<td>4.7±0.8</td>
<td>7.9±1.7</td>
<td>14.6±1.1</td>
</tr>
<tr>
<td>Female, %</td>
<td>47.9</td>
<td>47.9</td>
<td>48.9</td>
<td>47.3</td>
</tr>
<tr>
<td>Age at diagnosis, years</td>
<td>7.8±3.9</td>
<td>3.1±1.3</td>
<td>6.1±2.8</td>
<td>9.3±3.7</td>
</tr>
<tr>
<td>Duration of diabetes, years</td>
<td>4.3±3.5</td>
<td>1.5±1.2</td>
<td>3.2±2.6</td>
<td>5.3±3.7</td>
</tr>
<tr>
<td>Insulin (units/kg body weight)</td>
<td>0.85±0.33</td>
<td>0.65±0.27</td>
<td>0.73±0.27</td>
<td>0.85±0.29</td>
</tr>
<tr>
<td>Injections/day</td>
<td>4.8±1.9</td>
<td>4.2±2.2</td>
<td>4.5±2.8</td>
<td>4.9±1.8</td>
</tr>
<tr>
<td>BMI</td>
<td>20.2±3.7</td>
<td>16.5±1.5</td>
<td>18.0±2.6</td>
<td>21.8±3.5</td>
</tr>
<tr>
<td>BMI-SDS AGA</td>
<td>0.49±0.88</td>
<td>0.61±0.025</td>
<td>0.41±0.013</td>
<td>0.49±0.011</td>
</tr>
<tr>
<td>BMI-SDS CrescNet</td>
<td>0.25±0.79</td>
<td>0.56±0.022</td>
<td>0.21±0.011</td>
<td>0.23±0.012</td>
</tr>
</tbody>
</table>

Data are mean±SD or percentage.

Statistical analysis

Statistical analyses were performed using Wilcoxon rank-sum test or binominal test for comparison between groups followed by Bonferroni stepdown correction (Holm method) in case of multiple comparisons (SAS for Windows version 9.2, SAS Institute, Cary NC, USA).

To adjust for potential confounding by interaction between treatment year as variable of interest and age, gender, diabetes duration, insulin therapy, and metabolic control, a hierarchic mixed linear model with treatment centers as random factor was implemented using SAS proc glimmix with either BMI-SDS AGA or BMI-SDS CrescNet as dependent variable.

Adjusted means for categorical variables, at observed marginal frequencies of covariables, were calculated for visualization. Newton-Raphson method was used for optimization, and denominator degrees-of-freedom were calculated according to Kenward-Roger. For multiple comparisons among groups, p values were adjusted according to Tukey. For all statistical tests, p<0.05 was considered significant.

Results

In 1999, 10.5% of the children and adolescents with diabetes were overweight and 5.6% were obese when the AGA normative data were used. In the following years, we saw an increase of overweight up to 13.6% in 2004 and obesity up to 7.6%. In the last 2 analyzed years, there was a slight decrement to 12.2% overweight and 5.7% obesity, respectively, for the year 2006.

Children and adolescents with diabetes in this study had significantly higher BMI-SDS than healthy children and adolescents from either of the two normative cohorts used. However, BMI-SDS was significantly different when those children and adolescents were standardized to AGA data (0.49±0.88) or CrescNet data (0.26±0.79) recorded during the same year (p<0.00001; Table 1). Female patients had significantly higher BMI-SDS than male patients (Figure 1). Adjusted subanalysis of the
different age groups showed highest BMI-SDS in the youngest age group followed by the oldest age group and lowest BMI-SDS in the age 6.1–12 years (Table 1). The difference between the BMI-SDS based on historical BMI normative data was significantly higher than with the data of the same year from CrescNet database.

With longer diabetes duration, BMI-SDS increases significantly after 2 years leveling off with more than 4 years of diabetes duration in our cohort. The degree of overweight in the children with diabetes did not increase during the observation period, when CrescNet data were used as reference. CrescNet data represent more or less the increase of the general population in BMI. Interestingly, a recent analysis showed a leveling off of the BMI increment in the CrescNet database (13). This is in accordance with the rate of overweight and obesity in the diabetes cohort analyzed, where we saw an increment until 2004 followed by a leveling off for the last 2 analyzed years.

The factors influencing the development of the weight gain and BMI increase in children and adolescents with diabetes can be various. In our study, using multiple adjustment for confounders, mainly female gender, age, and diabetes duration did statistically correlate with BMI. Metabolic control did not contribute significantly in this model.

There was no gender difference in overweight or obesity in the German National Health Interview (14) nor in the CrescNet database. However, girls with diabetes are more affected by weight gain in adolescence. Interestingly, this situation has changed for Germany. In 1986–1996, adolescent boys and girls with diabetes had higher BMI than healthy controls (12). An increase in BMI was seen in puberty in this study in contrast to our data where the very young children had a very high BMI. These data are in accordance with the accelerator or overload hypothesis (15–17). Children who acquire their diabetes at a very young age tend to have more weight before the onset of diabetes. These patients might be more prone to develop obesity after the onset of diabetes.

Insulin substitution in diabetes is still not physiologic. This leads to a hyperinsulization that could increase appetite and subsequently weight gain. Hypoglycemia that occurs in tight metabolic control also has to be treated by extra carbohydrates and might add extra calorie intake. Dietary intake does not always match the recommendations. Many adolescents consume fewer calories from carbohydrates but more calories from fat than healthy peers (18). Those children and adolescents with diabetes that have unhealthy eating habits tend to have worse metabolic control, worse lipid profiles, and higher BMI (19). Overweight in type 1 diabetes itself promotes the development of insulin resistance possibly through a vicious circle (11, 20). Physical activity in children and adolescents with type 1 diabetes, however, is generally not different to healthy peers; some authors see an even higher activity (21, 22).
Increasing BMI in those children also has influence on diabetic complications and cardiovascular risk. We could demonstrate the influence of BMI on hypertension in children and adolescents with type 1 diabetes (23). Raile et al. (24) described the risk for microalbuminuria and diabetic nephropathy with higher BMI. High-sensitivity C-reactive protein is also associated with higher BMI in these patients (8, 25). Retinopathy and diabetic neuropathy are more prevalent in type 1 diabetics with higher BMI (26). Data from the DPV database showed an association between lower high-density lipoprotein cholesterol and higher low-density lipoprotein cholesterol and higher triglycerides as further risk factors in obese children and adolescents with diabetes (27).

The increasing BMI especially in the first 2 years after the onset of type 1 diabetes may require a more pronounced education about healthy diet and physical activity in the structured diabetes education programs at onset and at follow-up.

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References


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