Overweight and obesity at school entry as predictor of overweight in adolescence in an Arctic child population

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Background: The aim of this study was to analyse the changes in the prevalence of overweight, obesity, and in mean body mass index (BMI) among school children, and to analyse the predictive value of overweight and obesity at school entry to overweight and obesity in adolescence in an Arctic child population. Methods: Retrospective cohort study. A database was created on the basis of files from health examinations. Data on children aged 5–7 years and 13–17 years and the subsample of children followed from school entry to adolescence was analysed. Results: During the years 1972–2002 the prevalence of overweight and obesity increased significantly, and mean BMI rose by 5.6% at school entry and by 4.7% in adolescence. Sensitivity and specificity: Of the children being obese in adolescence, 56.3% were already obese at school entry; for the overweight children, 50.6% were also overweight or obese at school entry. Of the children with normal weight in adolescence, 91.9% were also normal weight at school entry. The positive predictive value of being overweight or obese combined at school entry was 59.5%, i.e. more than every second retained their overweight or obesity in adolescence. Only 10% of the obese school entry children had gained normal weight in adolescence. The negative predictive value for normal weight children at school entry was 91.3%. Conclusion: The study showed that during 30 years from 1972, overweight and obesity among school children in Greenland have increased dramatically. Overweight and obesity at school entry were shown to be a good predictor of overweight or obesity in adolescence.

Keywords: body mass index, Nuuk, overweight, prediction, school children

Introduction

The issue of childhood obesity is accelerating throughout the world, and the long-term association of obesity with morbidity outcomes raises the level of importance for understanding overweight as a major public health concern for children and adolescents.¹–³ Overweight and obesity is regarded as a complex, multifactorial disease that develops from the interaction of genetic, metabolic, social, behavioural and cultural factors.¹ In recent years the prevalence of obesity has increased also in the child populations in the Arctic region.⁴,⁵ This increase has been observed parallel to the westernization of life style,⁶ but recently the extent of westernization was not found correlated to obesity in Greenland.⁷

Obesity results from an imbalance between energy intake and energy expenditure, and changes in life style are presumed to be the major contributor to the increase by changes in diet and lower levels of physical activity.⁸ Greenlandic children have a relatively high intake of sweets and soft drinks. In 2002, 36% of 15-year-old school children reported to eat sweets every day, and a similar proportion drank soft drinks daily, while 21% reported to have an intake of both sweets and soft drink. Only half of Greenlandic children reached the recommended level of 1 h of physical activity per day.⁹

Potential interventions for obesity in youth span a continuum from preventing the development of obesity to treating established obesity and its complications,¹⁰ but tailoring preventive programmes requires knowledge on the distribution and tracking of weight in children. This study was initiated to analyse the predictive value of overweight and obesity at school entry into adolescence, and to analyse the development of overweight, obesity, and of mean BMI in school children over a period of 30 years in an Arctic child population, as no data yet have been published on the development of overweight and obesity in Greenlandic adolescents. Further, predictive value of overweight and obesity at school entry into adolescence was analysed to assess the most important time of intervention.

Methods

All children in Greenland are offered routine health examinations from birth to the end of school. Height is measured without shoes and weight is measured in light clothes in school children.¹⁰ This study was based on a database created on height and weight data derived from files from routine health examinations during preschool and school in the child population in Nuuk, Greenland from 1970 to 2004. The database contained a total of 19 909 measurements in 4213 children. All information was computerized into and analysed in SPSS version 12.0 for the purpose of the study.

From the database, data on children from school entry (mean age 6.3 years (SD 0.41)) and adolescence were selected. Adolescence was defined as the examination from 13 to 17 years of age closest to age 15 (mean age 14.4 years (SD 0.65)). On the basis of international cut-off points of body mass index (BMI) among children and adolescents proposed by Tim Cole and colleagues, body mass index (BMI, kg/m²) was used to classify the children into normal weight, overweight, or obese. The selected cut-off points correspond to the most widely used adult cut-off points of 25 and 30 kg/m², respectively, for overweight and obesity.¹¹ The age at the examination was rounded up to 0.5 years (5.75–6.24 = 6 years, 6.25–6.74 = 6.5 years, etc.) for appropriate use with regard to the cut-off points. For the total sample of children the proportions being classified into normal weight, overweight, and obese
are presented in 5 year intervals, i.e. children born 1972–1976, 1977–1981, 1982–1986, 1987–1991, 1992–1996, and 1997–2001. To show the development over time, Odds Ratios (OR) are presented as e.g. the odds of being obese when born in a later time interval compared to the odds of being obese when born in first. Also mean BMI at school entry and in adolescence was determined in the 5 year intervals.

From the database, the subsample of children followed from school entry to adolescence was identified. The sample included 729 children born between 1972 and 1991 (352 boys, 374 girls, and 3 with unknown gender). Using this sample the ability to predict weight status (normal, overweight, obese) in adolescence using the corresponding classification at school entry on the same children was assessed. Positive and negative predictive values, and sensitivity and specificity were calculated for this purpose.

To scrutinize the changes occurring from school entry to adolescence, mean BMI values at school entry in the subsample were divided into quartiles. This method was used due to a lack of standard national curves for BMI for Greenlandic children. Corresponding analyses were done also for the weight quartiles.

To evaluate the presence of a cohort effect, during the 20 years investigated, the subsample was subdivided in children born in the first part (from 1972 to 1981) and the mean BMI was compared with the children born in the second half (1982 to 1991).

Presented confidence intervals are on the 95% level and differences are regarded as significant when p-value < 0.05.

**Results**

**At school entry**

Among children born from 1972 to 1976, 8.8% were classified as overweight and 0.8% as obese. For children born during 1997–2001, this proportion had increased to 16.6% overweight and 5.9% obese. The odds ratio for being overweight or obese increased gradually to 2.7 (95% CI: 1.6–4.7) for children in the first cohort compared to children in the latter. During the same period mean BMI at school entry increased by 5.6% from 15.9 (95% CI: 15.8–16.1) to 16.8 (95% CI: 16.5–17.2) (p < 0.001) (table 1).

**In adolescence**

Of the children born during 1972–76, 12.0% were classified as overweight and 1.0% as obese, and this proportion increased to 14.6% being overweight and 4.7% obese when born between 1987 and 1991. The odds ratio for being overweight or obese in adolescence was 1.6 (95% CI: 1.0–2.5) for children born in 1987–1991 compared to the first 5 year period (p = 0.04), and mean BMI increased by 4.0% from 20.28 (95% CI: 19.93–20.62) to 21.09 (95% CI: 20.64–21.34) (p = 0.02) (table 1).

Of the 729 children followed into adolescence, a total of 82.7% were normal weight, while 12.9% were overweight, and 4.4% were obese in adolescence.

**Prediction of weight**

Prediction of weight status was defined as the maintenance of a relative position from school entry into adolescence.

**Sensitivity**

Of the children being obese in adolescence, 56.3% (95% CI: 39.1–73.5) were already obese at school entry, and of the overweight children in adolescence 50.6% (95% CI: 40.4–60.7) were also overweight or obese at school entry.

**Specificity**

Of the normal weight children in adolescence, 91.9% (95% CI: 89.7–94.1) were also normal weight at school entry. The positive predictive value of overweight and obesity combined at school entry was 59.5% (95% CI: 50.9–68.1). For obesity alone it was 60% (95% CI: 42.2–77.5), and for overweight alone it was 41.7% (95% CI: 31.6–51.8). Only 10% (95% CI: 0.1–20.7) of the obese school entry children had attained normal weight in adolescence. The negative predictive value of normal weight children at school entry: 91.3% (95% CI: 89.1–93.4) was still normal weight in adolescence, and 1.1% (95% CI: 0.2–1.9) had become obese (table 2).

**Prediction of weight quartile at school entry**

When comparing BMI quartiles at 6 years with the international BMI cut-off points for normal weight, overweight, and

<table>
<thead>
<tr>
<th>Year of birth</th>
<th>School entry (N = 2813) % with overweight</th>
<th>School entry (N = 2813) % obese</th>
<th>OR***</th>
<th>Mean BMI**</th>
<th>Adolescence (N = 1106) % with overweight</th>
<th>Adolescence (N = 1106) % obese</th>
<th>OR***</th>
<th>Mean BMI**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8.8</td>
<td>10.5</td>
<td>15.9</td>
<td>17.1</td>
<td>16.6</td>
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<td></td>
<td>0.8</td>
<td>1.5</td>
<td>3.9</td>
<td>4.7</td>
<td>4.6</td>
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<td></td>
<td>1.0</td>
<td>1.3</td>
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<td></td>
<td>(0.8–2.1)</td>
<td>(1.3–3.5)</td>
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<tr>
<td></td>
<td>OR***</td>
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<td></td>
<td></td>
<td>2.4</td>
<td>(1.6–3.8)</td>
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<td></td>
<td>1.6</td>
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<td></td>
<td>2.7</td>
<td>(1.7–4.1)</td>
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<td></td>
<td>Mean BMI**</td>
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<td></td>
<td>15.94</td>
<td>15.85</td>
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<tr>
<td></td>
<td>% with overweight</td>
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<td></td>
<td>(16.53–17.15)</td>
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<tr>
<td></td>
<td>12.0</td>
<td>12.7</td>
<td>11.5</td>
<td>14.6</td>
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<tr>
<td></td>
<td>% obese</td>
<td></td>
<td></td>
<td></td>
<td>1.0</td>
<td>3.3</td>
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<td></td>
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<tr>
<td></td>
<td>OR***</td>
<td></td>
<td></td>
<td></td>
<td>1.3</td>
<td>(0.8–2.0)</td>
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<tr>
<td></td>
<td>Mean BMI**</td>
<td></td>
<td></td>
<td></td>
<td>20.28</td>
<td>20.71</td>
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</tbody>
</table>

*Odds ratio for overweight or obesity combined (test of trend)

**Mean and 95% CI
obesity in adolescence, it was found that only 4.6% of the children in the lowest quartile at school entry were overweight at 15 years and none were obese. In the highest quartile at school entry, only 50.3% were normal weight in adolescence, while 32.7% were overweight, and 17.0% obese. The odds ratio for being overweight in adolescence was 13.36 (95% CI: 6.28–28.42) for the children in the highest quartile compared to the lowest quartile children at school entry, whereas OR for being overweight or obese combined in adolescence was 20.3 (95% CI: 9.71–42.4) for children in the highest quartile at school entry compared to the lowest quartile (table 3).

Cohort effect in the subsample

Mean BMI at school entry increased from 16.1 (95% CI: 15.9–16.2) to 16.5 (95% CI: 16.3–16.7) (p < 0.002), and mean BMI in adolescence increased from 20.6 (95% CI: 20.3–21.0) to 21.3 (95% CI: 20.9–21.7) (p = 0.01) in the children born in the first half of the study (1972–1981) compared to the children born in the second half of the study. The OR of being overweight and obese combined at school entry increased from the first half of the study period to the second period to 1.5 (95% CI: 1.0–2.8) (p = 0.06), and in adolescence to 1.3 (95% CI: 0.9–2.0) (NS). The positive predictive value of overweight and obesity combined was 55.6% in the first part of the study and 59.2% in the second part (NS).

Discussion

The definition of childhood overweight remains problematic. BMI is a widely used proxy of obesity reasoned to its feasibility, and almost all definitions use some variant of BMI. BMI is useful for predicting overweight at the population level, but is an imperfect approximation of excess adiposity in children.3,12 The equivalents to overweight and obesity proposed by Cole and colleagues used here11 provide age and gender-specific BMI cut-off points, which are nearly equal to the 2000 CDC growth chart used as US standard13 and that secures comparability with other studies. The usefulness of BMI as an indicator of overweight among Inuit in general has been debated reasoned in different relative body composition tending to overestimate rates of overweight when using BMI as a proxy for body fat content,4 but no studies on its reliability in Greenlandic children have been published. This study investigates the development in BMI over time at the population level, and the method is considered valid and reliable for this purpose even if a possible underestimation of the increase in the proportion of overweight and obese individuals can be speculated. The underestimation is reasoned in the observed increase in the height for age among Greenlandic children in later years.14 Furthermore, a relative decrease in muscle mass as a result of a more sedentary lifestyle compared to earlier days might have affected the BMI increase negatively.

The study showed that a substantial increase in the prevalence of overweight and obesity among Greenlandic children has taken place not only at school entry, but was paralleled among adolescents, who had a mean BMI increased from 13.0 to 19.3 in the 20 years. In the latest year studied, the prevalence of overweight found was at the same level as in children in other western countries.8 This study found that, among children in Nuuk, weight status at school entry was a strong predictor of weight in adolescence both regarding overweight/obesity and in preserving normal weight. Approximately 60% of obese school entry children were still obese in adolescence and only 10% had gained normal weight, while nearly 50% of overweight children still were overweight or had become obese. This prediction was rather strong compared to other studies. In European and US studies the maintenance of childhood obesity into adulthood was found in approximately one third of all, but varied according to definition of obesity, the age of the children and the length of follow-up.15 A study from 1997 found that four out of five obese teenagers remained obese as adults.16 The data on the BMI quartile at school entry also revealed that, only 50% of children in the highest BMI quartile at school entry had normal weight in adolescence, while more than 95% of the children in the lowest quartile were normal weight in adolescence. This indicated that that weight might track differently in different weight groups and that the tracking of BMI is especially pronounced in the lowest and highest weight quartiles. This has previously been found by Wang and colleagues, who stated that BMI were more likely to track in lean and obese Chinese children,17 and that after six years of follow up 40% of children remained in the same weight quartile. Also Daniels and colleagues state that the examination of historical standards for defining overweight in children from many countries tells us that the distribution of BMI is becoming increasingly skewed. The lower part of the distribution has shifted relatively little whereas the upper part has

Table 2 Percentage (95% CI) of school entry children still overweight or obese in adolescence

<table>
<thead>
<tr>
<th></th>
<th>N = 729</th>
<th>At 15 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal weight</td>
<td>Overweight</td>
</tr>
<tr>
<td>At school entry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal weight</td>
<td>91.3% (89.1–93.4)</td>
<td>7.6% (5.5–9.7)</td>
</tr>
<tr>
<td>Overweight</td>
<td>50.5% (40.2–60.8)</td>
<td>41.7% (31.6–51.8)</td>
</tr>
<tr>
<td>Obese</td>
<td>10.0% (0.1–20.7)</td>
<td>30.0% (13.6–46.4)</td>
</tr>
</tbody>
</table>

χ²: p < 0.001

Table 3 Prediction of BMI quartiles at school entry for overweight or obesity in adolescence (N = 729)

<table>
<thead>
<tr>
<th>BMI at school entry (quartiles)</th>
<th>Normal weight at 15 years (%)</th>
<th>Overweight at 15 years (%)</th>
<th>OR, overweight at 15 years*</th>
<th>Obesity at 15 years (%)</th>
<th>OR, Obesity at 15 years</th>
<th>OR Overweight and obesity combined*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowest quartile</td>
<td>95.4</td>
<td>4.6</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>Second quartile</td>
<td>95.2</td>
<td>4.3</td>
<td>0.92 (0.35–2.46)</td>
<td>0.5</td>
<td>1</td>
<td>1.1 (0.41–2.69)</td>
</tr>
<tr>
<td>Third quartile</td>
<td>84.8</td>
<td>13.0</td>
<td>3.16 (2.43–7.04)</td>
<td>2.2</td>
<td>4.11</td>
<td>3.69 (1.69–8.05)</td>
</tr>
<tr>
<td>Highest quartile</td>
<td>50.3</td>
<td>32.7</td>
<td>13.36 (6.28–28.42)</td>
<td>17.0</td>
<td>37.84</td>
<td>20.30 (9.71–42.40)</td>
</tr>
</tbody>
</table>

*OR (95% CI)
widened substantially. This finding suggests that many children may be more susceptible (genetically or socially) to influence by the changing environment. \(^1\) When the obesity epidemic is spreading, the increase in susceptibility to obesity in more children might make it more and more difficult to gain normal weight after having acquired overweight, even if children born in the latter half of the study period did not have higher risk of remaining overweight or obese compared to the first half of the study, further investigations are needed to determine if a significant cohort effect in the prediction of weight status exists.

Three critical periods in childhood overweight have been described earlier: infancy, early childhood, and adolescence. The original critical periods hypothesis suggested that obesity with onset in adolescence is more likely to persist into or exert its health effects in adulthood. \(^1\) In the present study, half of the children had developed their overweight before school age and the other half developed it during school age; however, the overweight when acquired for many was sustained. Potential interventions for obesity in youth span a continuum from preventing the development of obesity to treating established interventions for obesity in youth. The focus area in public health planning. The process of tailoring preventive programmes involves identifying points for intervention. In preventing childhood obesity, there are essentially six relevant areas to address: the family, nurseries, kindergartens and schools, health professionals, the government, the industry, and media. \(^13\) Obesity prevention in childhood might include both population-oriented and individual-oriented approaches. As treatment approaches and individually oriented prevention strategies must be intensive, are costly, and have low reach in terms of the number served, our results indicate that primary prevention by population approaches should be in focus from early in childhood and sustained through school age. Early intervention is also necessary recognizing that the individual’s life style is grounded in the early years. The findings also call for a continued monitoring of the prevalence of overweight and obesity among children and adolescents in Greenland, a task that is most feasible by centrally registration the data from health examinations among school children. \(^19\)

### Key points

- The paper is the first report on the prevalence of overweight and obesity in Greenlandic adolescents—and follows the prevalence through 20 years
- In a numerous child cohort the prediction of BMI group and BMI quartile are followed from school entry (6 years of age) to adolescence (15 years of age)
- The predictive value in adolescence of overweight and obesity at school entry is very high

### References


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