


# Identifying the “Tipping Point” Age for Overweight Pediatric Patients

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## Abstract

According to the National Health and Nutrition Examination Survey in 2007, nearly half of all American children are either overweight or obese. Retrospective chart review identified patients with the diagnostic codes for overweight, obese, and/or excessive weight gain. Inclusion criteria were current age between 2 and 20 years, a minimum of 5 visits with weight and height measurements, and a body mass index (BMI) at or above the 85th percentile. A total of 184 patients met inclusion criteria. More than half the children became overweight before age 2, and all patients were obese or overweight by age 10. The rate of gain is approximately 1 excess BMI unit/year, therefore causing most children to be overweight by age 2 ( $R^2 = .53$ ). This study indicates that the critical period for preventing childhood obesity in this subset of identified patients is during the first 2 years of life and for many by 3 months of age.

## Keywords

childhood obesity, body mass index (BMI), onset age, primary care, prevention

## Background

Obesity in children has become one of the most prominent public health concerns in the United States today.<sup>1</sup> The epidemic appears to be affecting children at younger ages, with an increasing number of children under age 4 with abnormally high body mass index (BMI).<sup>2</sup> Initially, the focus of research and intervention had been on treatment after the child had developed medical problems related to his or her obesity, such as hypertension<sup>3</sup> or diabetes,<sup>4</sup> but recently this has shifted to earlier recognition and prevention strategies.<sup>5–8</sup> Over the past 2 years, the terminology has reflected the new emphasis on recognizing that an overweight child is not just at risk anymore. It is now acceptable to refer to children with a BMI of 95th percentile or greater as “obese” and children with a BMI at or above the 85th percentile but less than the 95th percentile as “overweight” versus the more innocuous terms of *overweight* and *at risk for being overweight* categories. Recognition and treatment of overweight and obese children has suffered because of the complex problems of parental underrecognition of their child’s weight problem and the physician belief that children will lose their “baby fat” as they get older.<sup>9–11</sup> The most recent comprehensive national survey conducted by the Centers for Disease Control and Prevention

(CDC) in 2005–2006, called the National Health and Nutrition Examination Survey, indicates that 16% of American children are obese and an additional 32% are overweight.<sup>12</sup>

Since the early 1980s, the prevalence of obesity among 2- to 5-year-old children has increased steadily, especially among African American and Latino children.<sup>13,14</sup> In addition, childhood obesity is a strong positive predictor for adult obesity.<sup>12,14</sup> The higher the child’s BMI percentile and the older the child, the greater the risk the child has becoming an overweight adult, with 80% to 90% of obese adolescents becoming obese adults.<sup>14,15</sup> For this reason, it is important to intervene as early as possible to prevent the risks of childhood obesity. The American Academy of Pediatrics (AAP) recommends an annual BMI screening as a part of preventive primary care for children and adolescents.<sup>16</sup>

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However, reports show that the overweight or obese child is still not recognized or documented as having an elevated BMI by the primary physician over half the time.<sup>17</sup> The inability and denial of this problem is shared by all the interested stakeholders: the parent, the child, and, to a lesser degree, the physician.<sup>10,18</sup> Unfortunately, the “chubby” healthy baby myth is alive and well despite the high prevalence of childhood obesity, with only 20% to 50% of overweight children being diagnosed and even fewer receiving documented or effective treatments.<sup>17,19,20</sup> Barriers to BMI screening range from lack of familiarity with BMI charts, agreement among providers on who to screen, and skepticism about treatment effectiveness.<sup>18,21,22</sup>

The objective of our study was to identify a child who is overweight and then extrapolate when that child first became overweight while in the care of their primary care provider. This information will hopefully allow health care providers to focus on a critical “tipping point” period when the child is most at risk for becoming overweight and design appropriate age-specific guidelines to help prevent future childhood and subsequent adult obesity and the medical complications they acquire.

## Patients and Methods

We established 2 cohorts of patients identified from the billing databases of the Virginia Beach Tidewater Children’s Associates (TCA) private practice and the general academic pediatric practice at the teaching hospital Children’s Hospital of The King’s Daughters (CHKD). The diagnoses for overweight (278.00-278.02) or excessive weight gain (783.1) were searched and charts were pulled for review. The 2 cohorts were chosen because they were of similar size and to represent a predominately private insurance practice versus a predominately Medicaid practice. The TCA practice has more than 30 000 visits per year and approximately 12 000 total patients, and the CHKD practice sees 32 000 visits per year with approximately 15 000 total patients. To be included in the cohort, the patient must be at least 2 years old but no older than 20, have at least 5 visits with documented weight and height data recorded at the practice, and be overweight during 1 of their visits. In concordance with the CDC guidelines, this study defined overweight as having a BMI at or above the 85th percentile for visits of age 2 or greater. For children less than age 2 meeting the visit criteria overweight was defined as having a weight/length ratio at or above the 85th percentile.<sup>23</sup> Patients with a genetic or metabolic disorder that may impair their weight/height ratio, such as Turners, Prader Willi, cystic fibrosis, and diabetes,

were excluded from the cohort. Retrospective data including patient demographics, health insurance, birth information, comorbidities, and weight and height measurements for all visits were extracted when available from the patient’s charts.

For each visit with weight and height measurements, the BMI or weight/height<sup>2</sup> (kg/m<sup>2</sup>) was calculated for age of visit 2 years or older and weight/length ratio (kg/m) for less than age 2. These values were compared with the gender-specific and age-specific growth chart data table to determine the percentile.

## Statistical Analysis

Two approaches to describing the age at which children become overweight were used. The first involved an “onset age” calculation, which was defined as the age at which a patient was first observed, in an office visit, to be overweight and after which he or she remained overweight for at least half of the recorded visits. The second approach involved statistical modeling (using hierarchical linear modeling [HLM]) to create a composite of individual weight change trajectories. These were transformed to deviations from the 50th and 85th percentiles (based on population estimates provided by the CDC), so that ages corresponding to crossing a normal weight threshold (50th percentile) and exceeding a clinical cutoff (85th percentile) could be determined.

Because there are no national BMI norms for children younger than age 2, the patient’s BMI for visits less than age 2 is matched against the national gender-specific and length-specific weight/length data table to obtain the BMI discrepancy units. This method also effectively removes the curvilinear shape of expected weight change over childhood, allowing for reasonable linear modeling of discrepancy scores.

Growth plots for patients and all related analyses were based on BMI discrepancy by age of visit. Using various regression and multilevel model-based methods, an *x*-intercept was calculated to represent the age at which overweight children deviated from the 50th and 85th percentiles.

Data files were maintained with Microsoft Access 2007 with appropriate password-protected security measures. Basic analyses were performed with SPSS Statistics Package version 17.0 (SPSS Inc, Chicago, IL). Multilevel/hierarchical models were examined using Hierarchical Linear and Nonlinear Modeling Package version 6 (HLM; Scientific Software International Inc, Lincolnwood, IL).

The study protocol was approved by the institutional review board at Eastern Virginia Medical School.

**Table 1.** Demographic Characteristics of the Patient Population at VA Beach TCA and CHKD Clinic<sup>a</sup>

| Characteristics                     | VA Beach TCA      | CHKD              |
|-------------------------------------|-------------------|-------------------|
| Charts reviewed                     | 262               | 218               |
| N                                   | 111               | 73                |
| Gender (%)                          |                   |                   |
| Male                                | 57.7              | 47.3              |
| Mean age (months)                   | 144               | 121               |
| Ethnicity (%)                       |                   |                   |
| Black                               | 28.8 <sup>b</sup> | 94.5 <sup>b</sup> |
| White                               | 46.0 <sup>b</sup> | 2.2 <sup>b</sup>  |
| Other                               | 25.2 <sup>b</sup> | 3.3 <sup>b</sup>  |
| Health insurance (%)                |                   |                   |
| Private                             | 62.1 <sup>b</sup> | 12.1 <sup>b</sup> |
| Medicaid                            | 27.9 <sup>b</sup> | 87.9 <sup>b</sup> |
| Other                               | 10                | 0                 |
| Mean birth weight <sup>c</sup> (kg) | 3.5               | 3.2               |

Abbreviations: VA Beach TCA, Virginia Beach Tidewater Children's Associates; CHKD, Children's Hospital of The King's Daughters.

<sup>a</sup>All percentages are calculated from the total number of patients.

<sup>b</sup>Indicates that the 2 groups had a difference with a *P* value <.001.

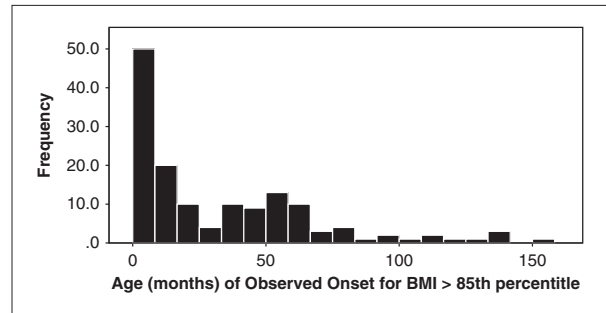
<sup>c</sup>Not every patient in the cohort has a documented birth weight in the medical record.

## Results

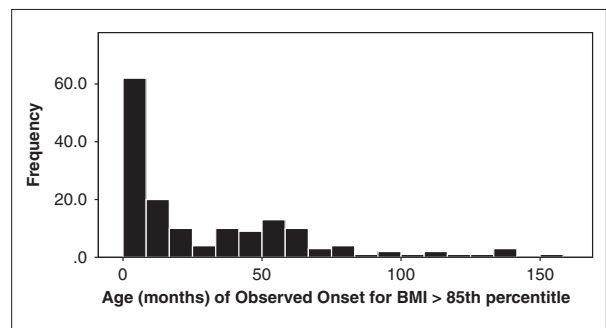
Among the 480 medical records that were reviewed, 184 patients met all inclusion and exclusion criteria and had complete visit/weight data. Patient demographics for the patient population at the private practice and the general pediatric outpatient clinic are shown in Table 1. The suburban patient population at the private practice is predominantly White, with the majority of patients having private health insurance. In contrast, the general pediatric population represents mostly an inner-city patient population and is predominantly African American with 87.9% on Medicaid. The mean age for the patient cohort at VA Beach TCA is 12 years (SD = 3.67) and at CHKD 10 years (SD = 4.32). When birth data were available by record versus history, the patients in both cohorts had average birth weight and were, on average, full-term gestational age. Despite observed demographic differences between the 2 study populations, average BMI and BMI discrepancy from the 50th percentile at the first, last, and middle visits were not significantly different.

### Onset and Tipping Age

Observed onset age was assigned for 111 (58.1%) of the subjects who were observed to have an onset of at BMI greater than the 85th percentile after their initial visit and maintenance of at-risk or above BMI for at least half of their subsequent visits. Of the remaining subjects,



**Figure 1.** Observed onsets for BMI greater than 85th percentile (cases greater than 85th percentile at first observation excluded)

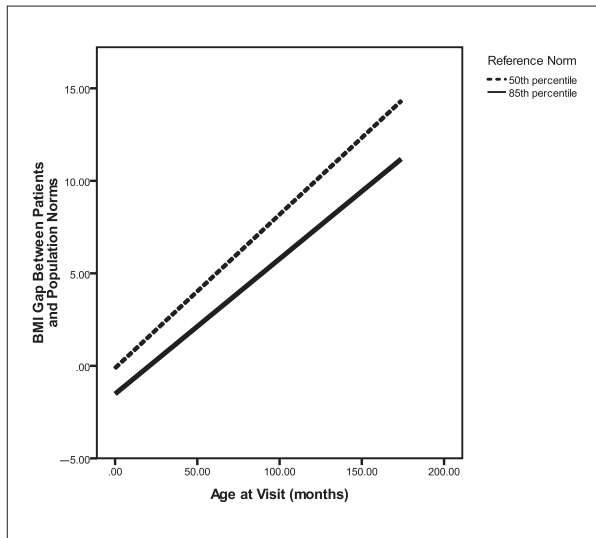


**Figure 2.** Observed onsets for BMI greater than 85th percentile (cases greater than 85th percentile at first observation included)

55 (28.7%) had a BMI at or above the 85th percentile at their initial visit, although these subjects were seen in-clinic for their first visit at an older age (median = 3 months vs median = 0 months). Twenty-five (13.1%) of the subjects did not maintain BMI at or above the 85th percentile after onset was documented. Seven of these cases had initial visit above-threshold scores and failed to maintain.

Based on the subjects with observed onset, the median onset age was 22 months, with an interquartile range of 48 months. Twenty-five percent of the subjects had an observed onset that occurred at or before 5 months of age. When including the first visit onset subjects, the median age of onset drops to 15 months, with 25% of the subjects having onset at or before 3 months of age (see Figures 1 and 2).

Using robust error estimation, an unadjusted HLM demonstrated a statistically significant (*P* < .001) increase in gap between study children's BMI values and the national norms. This discrepancy increased at a rate of .083 units per month (just less than 1 unit per year), crossing the 50th percentile at around age 1.5 months (predicted BMI deviation from 50th percentile =  $-0.12 + .083$



**Figure 3.** Change in BMI gap between patients and population norms over time (both 50th and 85th percentile reference norms plotted)

[age in months]). All the model adjustment variables (ethnicity, insurance, sex, etc), including the study/clinic from which they were derived, were nonsignificant. As such, adjusted effects are not reported (see Figure 3).

Using the same method to predict deviation from the 85th percentile from national BMI norms, a statistically significant ( $P < .001$ ) increase in the gap between study children's BMI values and national norms was observed across time, such that BMI discrepancy increased at a rate of .072 units per month, crossing the 85th percentile at around age 21 months (predicted BMI deviation from 85th percentile =  $-1.52 + .073$  [age in months]). See Figure 3.

## Discussion

Although a young child and adolescent may have high-risk periods for excessive weight gain, our study further emphasizes that obese children can become overweight during their infant/toddler/preschool years.<sup>15,24</sup> Both the onset age and the tipping age indicates that approximately half of the overweight children became overweight at less than 2 years of age and 90% at less than 5 years of age. Despite the identified mean age of 12 years, all patients in our cohort were overweight or obese by 10 years of age. The fact that both the onset age, determined from the patient's actual visit data, and the tipping age, determined from the best fit predictive regression model of that data, yielded the same results demonstrates that our analyses accurately interprets the data and provides a predictive tool for parents and practitioners.

Some studies have focused on the preschool period as the crucial time for the development of obesity.<sup>5,7,11</sup> There is a theoretical "adiposity rebound" between the ages of 3 to 7 years, where the BMI starts to increase after reaching its lowest amount.<sup>11,25</sup> However, this developmental increase has been shown to be in body fat and not lean muscle tissue.<sup>11</sup>

To our knowledge, this is the first study that predictively can determine when obese children become overweight. Our results correlate with prior findings that show that rapid weight gain occurs during the first 2 years of life.<sup>5,7,8,26</sup> Although the reason for this early rapid weight gain is not well understood, it has been suggested that improper diet, early introduction of solid food, and inadequate physical activity may lead to excessive weight gain.<sup>23</sup> Food preferences are also set at an early age, probably by age 2, so the introduction of nutritional advice and safeguards would need to be instituted much earlier to avoid the difficult behavior changes needed when the child is much older.<sup>27</sup>

Both the overall and the hierarchical logistic models reveal that, as a group, overweight children begin gaining excess weight shortly after birth at the rate of 1 excess BMI unit/year. At this rate, these children become overweight at approximately 2 years of age. It has been well established that socioeconomic status and race/ethnicity influence the prevalence and degree of childhood obesity.<sup>12,17,28</sup> Despite having a significantly different ethnic and socioeconomic composition for the 2 practice cohorts, the gains of excessive weight were at approximately the same rate and age. This shows that the results obtained from our study may generalize across a variety of patient groups at this very young age and that race/ethnicity may take on a larger role at older ages.

One of the factors that this study also highlights is that most children or young adolescents were not recognized until they were much older than their tipping point. Dr Philip Nader uses a simple example in his book *You Can Lose Your Baby Fat* by showing that a normal weight for a 3-year-old child is 32 pounds. If children weighed only 4 pounds heavier at 36 pounds they would be overweight on the BMI scale, and if they weighed 38 pounds they would be considered obese.<sup>29</sup> If pediatricians are not doing a BMI measurement on children between the ages of 2 to 3, then this "minor" weight differential may not raise a red flag for the primary care physician, thereby missing this early opportunity to discuss weight concerns with the parents.

## Limitations

The sample size is small, but the number of measurements allows some degree of accuracy and validates the

numbers toward earlier screening. Reconciling the parameter changes of weight/height ratio to BMI discrepancy unit is a statistical manipulation that allows the data to be integrated and helps reveal an observable change. Other authors have tried to analyze the 0- to 2-year period and have suggested using the World Health Organization growth standards versus the CDC charts as a way to reveal this increase better.<sup>30</sup> This study was a retrospective review with the inherent problems of missing data and selected data based on the number of charts that were not included >50%. Unfortunately, we cannot generalize our results to all patients who are overweight for several reasons. Our patients were identified after the diagnosis had been established and therefore were self-selected as children who did not “thin out.” Prospectively speaking, there may have been some children who were unrecognized as overweight during their toddler years, and then later thinned out and were never diagnosed as being overweight. These children would not be counted in our study so our curve may be somewhat exaggerated for every child who is overweight as a toddler. In addition, there may be children who have not been recognized by their pediatrician as overweight or obese because the practice is not doing universal screening.

## Conclusions

The CDC and AAP consider childhood obesity a dominant national health concern (*Healthy People 2010*, AAP policy statement). By identifying when children become overweight, the results from this study allow health care providers to target intervention at the most critical period of the child’s life. This research methodology can be further expanded to a large-scale national cohort to examine the process of excessive weight gain adjusted for various parameters of interest. It may even be possible to create a nomogram, much like the predictive bilirubin charts used to guide the use of phototherapy, and institute interventions as the risk for overweight and obesity pass certain thresholds. Because this study shows that older identified overweight children arise from excessive weight gain in infancy/toddlers, future research should investigate prevention and treatment strategies to mitigate excessive weight gain at this early stage. Childhood obesity is associated with higher risks for developing comorbid diseases including hypertension, dyslipidemia, type II diabetes, and sleep apnea.<sup>3,4,31,32</sup> As preventative measures against childhood obesity, we recommend that health care providers begin screening for excessive weight gain as early as possible. Preventative clinical strategies may be to consider the crossing of 2 growth percentiles upward before age 2 as similar to falling downward 2 growth percentiles in children who we deem at risk for

failing to thrive. These types of measures may need to be done in the first year of life, but definitely by age 2.

Currently, most of our treatment for obesity start after the problem has already spiraled out of control. Getting parents and children to change habits that have already taken hold is a monumental challenge fraught with roadblocks and disappointments. This study indicates that we may need to discuss inappropriate weight gain early in infancy to affect meaningful changes in the current trend of obesity.

## Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the authorship and/or publication of this article.

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