Analysis of Growth Curves in Children After Adenotonsillectomy

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IMPORTANCE Several studies have documented that children gain more weight than expected after adenotonsillectomy.

OBJECTIVES To examine patterns of change in weight and stature percentiles in children after adenotonsillectomy and to analyze clinical and demographic correlates of shifts in the growth curve.

DESIGN, SETTING, AND PARTICIPANTS In this retrospective medical record review, we studied patients 18 years and younger who underwent adenotonsillectomy at an academic pediatric tertiary medical center and had at least one height and weight measurement recorded at each of the following time points: within 3 months before surgery, within 3 to 9 months after surgery, and within 12 to 27 months after surgery. Data were procured from all children from January 1, 2007, through October 31, 2012, and initially included 2893 surgical patients and 161,458 height and weight measurements. The final database consisted of 815 patients with adequate growth data and multiple time points. Logistic regression analysis was performed to examine patient age at surgery, preoperative weight, sex, and ethnic background for correlations with changes in weight, height, and body mass index percentiles.

MAIN OUTCOMES AND MEASURES Change in weight, height, and body mass index percentile before and after surgery.

RESULTS At 18 months after surgery, weight percentiles in the study group increased by a mean of 6.3 percentile points (P < .001). Body mass index percentiles increased by a mean of 8.0 percentile points (P < .001). The greatest increases in weight percentiles were observed in children who were between the 1st and 60th percentiles for weight (P < .001) and younger than 4 years at the time of surgery (P < .001). An increase in weight percentile was not observed in children who preoperatively were already above the 80th percentile in weight (P = .15).

CONCLUSIONS AND RELEVANCE Weight gain after adenotonsillectomy occurs primarily in patients who are smaller and younger at the time of surgery and does not correlate with increased rates of obesity.
Every year, approximately 500,000 children in the United States have their tonsils removed. Studies correlating adentotonsillectomy with postoperative weight gain can be found in otolaryngology and pediatric literature dating back to 1893. In many instances, the postoperative weight gain was regarded favorably. For example, children with failure to thrive often achieve a healthy weight after adentotonsillectomy, which is attributed to reduced dysphagia, improved sleep, and decreased metabolic demand from sleep-disordered breathing. However, during the past 20 years, the prevalence of obesity in US children has skyrocketed. Data from the Centers for Disease Control and Prevention for 1998-2010 report a pediatric obesity rate of 16.9% (>95th percentile for body mass index [BMI]; calculated as weight in kilograms divided by height in meters squared). The pediatric obesity rate has prompted a reevaluation of the question of weight gain after adentotonsillectomy.

A systematic review by Jeyakumar and colleagues suggested a correlation between adentotonsillectomy and weight gain in normal weight and overweight children, with a mean BMI increase of 7%. Two recent retrospective studies reported a significant increase in BMI percentile after adentotonsillectomy, particularly in children younger than 6 years, although no significant increase in rates of obesity was observed. Building on this work, we sought to perform a more extensive analysis of the correlates associated with weight gain after adentotonsillectomy and the longer-term temporal course of the growth change.

Methods

The Stanford Translational Research Integrated Database Environment (STRIDE) was used to procure a comprehensive database of weight and height measurements in a structured format. The study was reviewed and approved by the Stanford University School of Medicine Institutional Review Board. These data were procured from the data warehouse in deidentified status; therefore, the institutional review board determined that no informed consent was required. Data were procured from all children who underwent adentotonsillectomy from January 1, 2007, through October 31, 2012, at a tertiary pediatric hospital and initially included 2893 surgical patients and 161,458 height and weight measurements.

Patients who met the following criteria were included: 18 years or younger at time of surgery, at least one height and weight measurement recorded within 3 months before surgery, at least one height and weight measurement recorded within 3 to 9 months after surgery, and at least one height and weight measurement recorded within 12 to 27 months after surgery. Only 1340 of these patients had adequate preoperative height and weight measurements able to be abstracted from the STRIDE inquiry. Computer analysis of the large data set revealed that many of the measurements were either repeat measurements or were likely to be erroneous (eg, decrease in height over time or height-weight combinations that were physically impossible). A significant number of patients also did not have measurements recorded at all the time points required for inclusion in the analysis. A program using the Python programming language was written to calculate height, weight, and BMI percentiles, perform datascrubbing to eliminate patients with faulty or inadequate data, and format the data set into a temporal organization that was statistically analyzable. The final database consisted of 815 patients with adequate growth data at multiple time points. Demographic data on sex and ethnicity were also included in the final database of height and weight percentiles. These data were then analyzed for statistical significance using logistic regression analysis.

Results

Data from 815 patients met the criteria for inclusion in the analysis. The mean weight percentile for all patients increased by 6.3 percentile points (P < .001); however, the mean height change was 0.6 percentile points, which was not a statistically significant change (P = .91) (Table 1). Of the 815 study patients, 72 were considered outliers (preoperative weight <1st percentile or >99th percentile), leaving 743 patients for subgroup analyses.

The temporal course of weight gain is shown in Figure 1. The weight percentile gain was observed to peak at 18 to 24 months and does not plateau until 1 year after surgery, although 90% of this plateau was reached in the 4½-6-month postoperative period. For the entire patient group, preoperative BMI changed from a mean (SD) of 18.0 (3.8) to 19.0 (4.2). For purposes of analysis over time, these raw BMIs were converted to BMI percentiles for age. The patients’ mean BMI percentile increased from 64.0 percentile points preoperatively to 72.0 percentile points postoperatively (P < .001).

Preoperative Weight Percentile and BMI Percentile

Children who were smaller at the time of surgery (1st-60th percentiles) gained more weight postoperatively than larger children, with a mean weight percentile increase of 12.4 points. The median weight percentile change for the 1st through 60th percentile group was a gain of 10.6 percentile points, whereas that of the 61st through 80th percentile and 81st through 99th percentile groups were 7.64 and 0.77, respectively (Figure 2A). We combined the data for our first 3 quintiles into one subgroup because there was no difference observed in the mean weight percentile increase among the first 3 quintiles (11.8 points in the 1st-20th percentiles, n = 124; 13.6 points in the 21st-40th percentiles, n = 107; and 11.9 points in the 41st-60th percentiles, n = 111). No significant changes in postoperative height percentile were observed among any of the subgroups. Analysis by BMI corroborated these findings. Larger increases in BMI percentile were found in the patients in the lower quintiles. Significant increases in BMI percentile for age were observed in all but the top quintile (Figure 3), with the largest increases observed in the children with the lowest BMI percentiles at the time of surgery. The BMI percentile did not increase.
postoperatively in the patients who had a preoperative BMI greater than the 80th percentile.

**Age at Surgery**
Children who were younger than 4 years at the time of surgery on average had larger increases in postoperative weight percentiles (Figure 2B). The mean increase in children younger than 4 years was 10.7 points, whereas children older than 8 years only gained 3.8 points. On multivariate analysis (Table 2), the younger children who were in the lower weight percentiles had the largest weight percentile gains.

**Sex**
The study population was approximately one-third female and two-thirds male. No significant difference was noted in weight gain between boys and girls in either the aggregate or subgroup analysis (Table 2).

**Ethnicity**
The ethnic composition of the study group was approximately 15% Asian, 3% African American, and 82% white or Hispanic as identified by parents in the electronic medical record. The preoperative weight percentiles differed significantly among the ethnic groups, with Asian children tending to be smaller (59.8% <60th percentile and 27.1% >80th percentile) and white and Hispanic children larger (44.3% <60th percentile and 37.1% >80th percentile). African American children were noted to have significantly more weight percentile increase than white or Hispanic and Asian children (mean of 13.7 percentile points). Height percentile changes were noted in African American children of all preoperative weights (mean of 13.1 points, n = 25), as well as in the less than the 1st percentile subgroup (n = 11). However, because of the small number of African American children in our study, these findings were not statistically significant.

**Discussion**
This study of growth patterns of a large population of children after adenotonsillectomy provides further support for the increasing body of evidence that children gain weight after adenotonsillectomy.
More weight than older children, with the greatest increases seen in children younger than 4 years. Use of advanced bioinformatics and data processing techniques allowed for extensive analysis of the electronic medical record. This process produced a rich database of weight and height growth curves that allowed us to demonstrate a few novel findings. Our study found that weight increase was significantly larger in children who were proportionally smaller at the time of surgery (1st-60th percentiles). This finding held true for children in all age groups, although the most notable differences were seen in children younger than 4 years. In addition, the children younger than 4 years who were larger at the time of surgery (81st-99th percentiles) did not gain weight like their smaller counterparts. In all analyzed subgroups, no statistically significant commensurate increase in height was observed in children who gained weight. This finding may suggest that weight gained after adenotonsillectomy is more fat than lean body mass. However, as in multiple other studies,9,10,17 we did not observe an increase in the overall rate of obesity before and after surgery. Although we found that most of the weight gain is seen in the 4½ to 6 months after adenotonsillectomy, it does not plateau until 1 year after surgery. In addition, an initial decrease in weight percentile is observed, possibly attributable to postoperative pain. These important time points must be kept in mind for future investigations of growth alterations induced by adenotonsillectomy.

We also noted significant differences among ethnic groups in our analysis. A higher proportion of Asian children were found in the lower weight percentiles than white, Hispanic, or African American children at the time of surgery. In addition, African American children increased in both weight and height.

Adenotonsillectomy.12–14 The overall rate of weight percentile change (6.3-percentile point increase) was comparable to that observed in earlier studies.12,15,16 In addition, this work corroborates prior studies9,10 that suggest that younger children gain more weight than older children, with the greatest increases seen in children younger than 4 years.

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Children in the 1st to 20th percentiles for BMI (calculated as weight in kilograms divided by height in meters squared) increased from a mean preoperative percentile of 14.2 to a postoperative mean percentile of 36.9 (P < .001), whereas those in the 81st to 99th percentiles had no significant increase in BMI percentile (P = .95).

*P < .001.
percentiles across all age and preoperative weight percentiles, including the heaviest children.

The study had several limitations. The ethnic makeup of our study population was underrepresentative of African American children. Furthermore, no distinction is made in the electronic medical record between white and Hispanic patients, and thus these subgroup analyses were not possible. Retrospective analysis resulted in the exclusion of many patients because of inadequate data at desired time points, and it is unclear whether any selection bias existed. Ideally, we could have prospectively analyzed growth, controlling for indication for surgery, partial vs total adenotonsillectomy, postoperative activity and diet, and medical comorbidities, and could have obtained more uniform time points for data collection. However, the sheer amount of data at different time points procured for most of the study population provided a more detailed depiction of the course of the postadenotonsillectomy weight gain than any previous study.

Conclusions
This retrospective analysis of 815 patients who underwent adenotonsillectomy corroborates the body of evidence demonstrating that many children gain more weight than expected after adenotonsillectomy. We observed that younger children gained more than older children; those younger than 4 years gained the most, and those older than 8 years gained the least. In addition, children with lower weight percentiles at the time of surgery gained the most weight: those in the 1st through 60th percentiles gained more than 10 percentile points, whereas those in the greater than 80th percentile had no significant increase in weight percentile. Similarly, BMI increase was proportional to preoperative BMI percentile: the smaller children had large increases in BMI percentile, whereas the larger children did not. Interestingly, although many gain weight after surgery, no group had any significant increase in height percentile. Why children gain weight but not height after adenotonsillectomy is an important area for further investigation. Despite the finding that many children gain weight and have higher BMIs after tonsillectomy, in our study, the proportion of children who were obese (BMI >95th percentile) before surgery (14.5%) remained statistically unchanged after surgery (16.3%) (P = .11). On the basis of this work, adenotonsillectomy does not correlate with increased rates of childhood obesity.

Table 2: Mean Weight Percentile Changes at 1½ Years After Adenotonsillectomy

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<th>Variable</th>
<th>1st-60th Preoperative Weight Percentile</th>
<th>61st-80th Preoperative Weight Percentile</th>
<th>81st-99th Preoperative Weight Percentile</th>
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ARTICLE INFORMATION

Submitted for Publication: November 11, 2013; final revision received January 30, 2014; accepted February 26, 2014.
Author Contributions: Drs Chang and Czechowicz had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: All authors. Acquisition, analysis, and interpretation of data: All authors. Drafting of the manuscript: All authors. Critical revision of the manuscript for important intellectual content: All authors. Statistical analysis: All authors. Obtained funding: Chang.

Conflict of Interest Disclosures: None reported.
Funding/Support: This study was supported by National Institutes of Health Clinical and Translational Science Award UL1 RR025744 and by funding from the Department of Otolaryngology–Head and Neck Surgery, Stanford University School of Medicine, Stanford, California (Dr Chang).
Role of the Sponsor: The funding sources had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Previous Presentation: This study was presented at the American Society of Pediatric Otolaryngology 28th Annual Meeting; April 26, 2013; Arlington, Virginia.
Additional Contributions: Gomathi Krishnan, PhD, Stanford University, assisted with data retrieval from STRIDE. Michael McCandless, PhD, consulting Python programmer, assisted with developing the Python code for formatting the data set.
REFERENCES