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# Adenotonsillectomy and the Development of Overweight

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## What's Known on This Subject

Accelerated weight gain after (adeno)tonsillectomy has been reported in previous studies.

## What This Study Adds

Children who undergo (adeno)tonsillectomy are at increased risk to develop overweight in the years after surgery.

## ABSTRACT

**OBJECTIVE.** Studies among patients have shown accelerated weight gain after (adeno)tonsillectomy.\* Whether (adeno)tonsillectomy is also a risk factor for the development of overweight is unknown. We investigated the association between (adeno)tonsillectomy and the subsequent development of overweight in the general population.

**METHODS.** The study population consisted of 3963 children participating in the Dutch Prevention and Incidence of Asthma and Mite Allergy birth cohort. Data on weight and height, adenoidectomy and tonsillectomy, and covariates (gender, birth weight, maternal education, maternal overweight, maternal smoking during pregnancy, breastfeeding, and smoking in the home) were obtained from annual questionnaires completed by the parents. In addition to the questionnaire data, weight and height were measured by the investigators when the children were 8 years old.

**RESULTS.** (Adeno)tonsillectomy between 0 and 7 years of age was significantly associated with overweight and obesity at age 8. Overweight at the age of 2 years was not associated with increased risk of (adeno)tonsillectomy in later years, indicating that the association between (adeno)tonsillectomy and overweight was not explained by preexisting overweight. Longitudinal data on weight and height in the years before and after surgery suggest that (adeno)tonsillectomy forms a turning point between a period of growth faltering and a period of catch-up growth, which might explain the increased risk to develop overweight after the operation.

**CONCLUSION.** Children who undergo (adeno)tonsillectomy are at increased risk to develop overweight in the years after surgery. *Pediatrics* 2009;123:1095–1101

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### Key Words

adenotonsillectomy, children, epidemiology, obesity

### Abbreviations

aOR—adjusted odds ratio  
CI—confidence interval

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**A**CCCELERATED WEIGHT GAIN after (adeno)tonsillectomy has been reported in a number of studies.<sup>1–10</sup> Historically, underweight used to be a common problem in children undergoing adenotonsillectomy and, in studies published up to the early 1990s, increased weight gain was invariably described as a beneficial effect.<sup>1–5</sup> Later publications suggested that underweight was no longer a typical characteristic of the children undergoing (adeno)tonsillectomy and that accelerated weight gain also occurred in children who were not underweight before surgery. A study published in 1997 reported that children undergoing tonsillectomy were heavier than their peers already at the time of surgery and that this discrepancy increased after surgery.<sup>6</sup> Later studies also showed that weight substantially increased after (adeno)tonsillectomy, not only in underweight children, but also in normal weight and overweight children.<sup>7–10</sup> In a recent article on pediatric sleep apnea, the authors expressed their concern that changes in energy balance after adenotonsillectomy might cause increased weight gain resulting in overweight.<sup>11</sup> The effects of adenotonsillectomy on growth and weight status have been studied in relatively small groups of (between 1 and 85) patients, but, to our knowledge, adenotonsillectomy has so far not been studied as a risk factor for overweight in the general population.

\*For an explanation of the distinction between (adeno)tonsillectomy and adenotonsillectomy, see Data Collection section on next page.

We investigated the association of adenoidectomy and tonsillectomy with overweight in a large ( $n = 3963$ ) prospective birth cohort of children, who were recruited from the general population and followed from 0 to 8 years of age. We hypothesized that adenoidectomy and tonsillectomy are independently associated with the subsequent development of overweight.

## MATERIALS AND METHODS

### Study Design and Study Population

The study population consisted of children who participated in the Dutch Prevention and Incidence of Asthma and Mite Allergy (PIAMA) birth cohort study. In this study, pregnant women were recruited from the general population in 3 different regions of the Netherlands ( $n = 4146$ ). Their children were born in 1996 or 1997 and were followed up to the age of 8 years. A detailed description of the study design was published previously.<sup>12</sup>

Data were collected mainly by annual postal questionnaires, which included questions on the child's weight and height, lifestyle, and different aspects of health and disease. At the age of 8 years, the children were invited for a medical examination, which included measurement of weight and height. The study protocol was approved by the medical ethics committees of the participating institutes and all parents gave written informed consent.

Of the baseline population of 4146 pregnant women, 183 (5%) were lost to follow-up before any data on the child had been collected. The study therefore started with 3963 newborns; 2214 children (63% of those invited) participated in the medical examination of 8-year-olds and had their weight and height measured.

### Data Collection

Based on the annual questionnaire data, we defined 3 exposure groups: (1) the reference group no adenoidectomy and no tonsillectomy (children who had neither tonsillectomy nor adenoidectomy); (2) adenoidectomy only (children who had only adenoidectomy); and (3) (adeno)tonsillectomy (children who had tonsillectomy with or without adenoidectomy). Within the last group, we identified a subgroup called "adenotonsillectomy," consisting of children who had both adenoidectomy and tonsillectomy at the same age.

The following anthropometric outcomes were defined: weight status (normal weight, overweight, and obesity) at the age of 8 years; and relative height, weight, and BMI from age 0 to age 8.

The variable "weight status at 8 years" was based on weight and height measurements taken during the medical examination of the 8-year-olds. BMI (weight/height squared [ $\text{kg}/\text{m}^2$ ]) was calculated, and "overweight" and "obesity" were defined according to age- and gender-specific international standards, that use cutoff points equivalent to the  $25 \text{ kg}/\text{m}^2$  and  $30 \text{ kg}/\text{m}^2$  cutoffs that are commonly used for adults.<sup>13</sup> The term overweight is used for the total group of children who were overweight, including those who were obese.

"Relative weight, height, and BMI" were defined to

be able to compare children's weight, height, and BMI at different points in time (ie, before and after surgery), independent of the child's age at that moment. SD scores for weight for age, height for age, and BMI for age ( $\text{weight}_{\text{SDS}}$ ,  $\text{height}_{\text{SDS}}$  and  $\text{BMI}_{\text{SDS}}$ ) relative to the Dutch reference population<sup>14</sup> were calculated using the weight and height data reported by the parents in the annual (ages 0–8 years) questionnaires and these were used as measures of relative weight, height, and BMI.

### Data Analysis

The associations between adenoidectomy only and (adeno)tonsillectomy and weight status at the age of 8 years were analyzed by logistic regression. The regression models were adjusted for gender, birth weight, maternal education (low, intermediate, high), maternal overweight (maternal BMI  $> 25 \text{ kg}/\text{m}^2$  when the child was 1 year old, yes or no), maternal smoking during pregnancy (any smoking after the fourth week of pregnancy), breastfeeding (never, 1–16 weeks, or  $> 16$  weeks), and smoking in the home at least once a week in the child's first year of life (yes or no). Region of birth, parental atopy, maternal age, the presence of older siblings, and day care attendance in the first year of life were also considered as potential confounders, but not included in the final analyses, because they did not influence the associations studied.

In the subgroup of children who underwent adenotonsillectomy, relative weight, height, and BMI before and after adenotonsillectomy were assessed. For this purpose, we used  $\text{weight}_{\text{SDS}}$ ,  $\text{height}_{\text{SDS}}$  and  $\text{BMI}_{\text{SDS}}$  obtained during the following time periods: 2 years before surgery; 1 year before surgery; the year in which surgery took place; the year after surgery; the second year after surgery; and the third year after surgery.

Complete data on adenoidectomy and tonsillectomy as well as measured weight and height at 8 years were available for 2100 children. If data are not missing completely at random, complete case analysis may lead to biased results.<sup>15,16</sup> We therefore used multiple imputation, which we considered the best available method to deal with missing data in our study. Missing data were multiple times imputed, using the multivariate imputation by chained equations procedure,<sup>17,18</sup> that runs under the statistical program R version 2.5.0.<sup>19</sup> After 100 iterations, convergence was achieved resulting in 5 imputed data sets. Each imputed data set was analyzed by standard complete data procedures, which ignore the distinction between real and imputed values. The results of the analyses were combined using PROC MIANALYZE in SAS (SAS Institute, Cary, NC). All analyses were performed on the complete case data and on the imputed data. The results shown are those from the analyses in the imputed data set, unless indicated otherwise.

## RESULTS

### Characteristics of the Study Population

In Table 1 characteristics of the study population are shown for the children with complete data on adenoidectomy, tonsillectomy, and measured weight and height

**TABLE 1** Characteristics of the Study Population for Children With Complete Data on Adenoidectomy, Tonsillectomy, and Measured Weight and Height at 8 Years of Age, the Imputed Data Set, Children Who had Adenoidectomy Only or (Adeno)tonsillectomy, and Children Who Had No Adenoidectomy and No (Adeno)tonsillectomy

Characteristics	Children With Complete Data	Imputed Data Set		
		All (N = 3963)	With Adenoidectomy Only or (Adeno)tonsillectomy (N = 1085)	No Adenoidectomy or (Adeno)tonsillectomy (N = 2878)
Gender, N	2100			
Male, %	50.0	51.8	56.7	49.6
Birth weight, N	2093			
Mean (SD), g	3523 (535)	3508 (545)	3472 (588)	3521 (528)
Siblings, N	2100			
Older, %	50.9	50.7	49.2	51.3
Region, N	2100			
North, %	31.6	31.1	29.6	31.6
Central, %	41.5	40.0	37.8	40.9
West, %	26.9	28.9	32.6	27.5
Maternal education, N	2094			
Low, %	20.2	23.9	30.8	21.3
Intermediate, %	42.1	41.6	44.2	40.7
High, %	37.7	34.5	25.1	38.1
Maternal weight status, N	1975			
Overweight, %	25.1	25.5	29.3	24.1
Maternal smoking during pregnancy, N	2079			
Yes, %	15.9	17.8	22.9	15.9
Breastfeeding, N	2085			
Never, %	16.1	17.9	22.8	16.1
0–16 wk, %	43.7	47.0	50.3	45.7
>16 wk, %	40.2	35.1	26.9	38.2
Day care ( $\geq 4$ h/wk) at 1 y of age, N	2082			
Yes, %	66.2	65.0	61.9	66.1
Smoking in the home at 1 y of age, N	2095			
Yes, %	25.3	28.1	33.0	26.3
Adenoidectomy, N	2100			
Yes, %	10.6	12.1	44.0	0
(Adeno)tonsillectomy, N	2100			
Yes, %	13.7	15.3	56.0	0
Weight status at 8 y of age, N	2100			
Normal weight, %	85.5	86.7	83.0	88.1
Overweight, %	14.5	13.3	17.1	11.9
Obesity, %	2.8	2.7	4.7	1.9

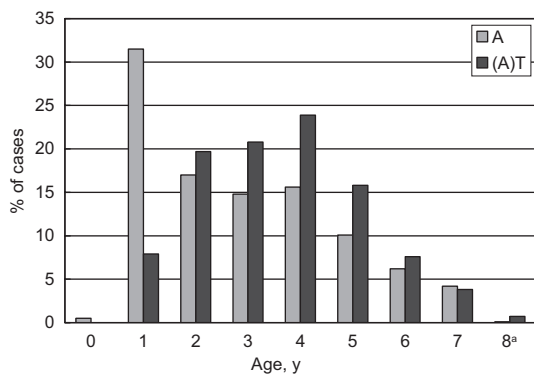
at 8 years of age and for the imputed data set. In addition, the characteristics are shown separately for the children who underwent adenoidectomy only or (adeno)tonsillectomy and for the children who did not.

Children with incomplete data on either adenoidectomy and tonsillectomy or on measured weight and height at 8 years old (data not shown) were compared with the children with complete data, with respect to a number of characteristics on which information was collected during the first year of the study. In the group of children with incomplete data, there was a relatively high prevalence of low maternal education (27.5%), of no breastfeeding (19.9%), and of smoking in the home at the age of 1 year (30.7%). In the imputed data set the cumulative incidence of adenoidectomy only and (adeno)tonsillectomy was slightly higher than in the group

with complete data. Differences in prevalences of characteristics between children who did and who did not undergo adenoidectomy only or (adeno)tonsillectomy were similar in the imputed data set and in the data set with complete cases (data not shown).

#### Incidence of Adenoidectomy Only and (Adeno)tonsillectomy

In this study population, recruited from the general population, the cumulative incidence up to the age of 8 years was 12% for adenoidectomy only and 15% for (adeno)tonsillectomy. In the latter group, 70% had adenoidectomy, 26% had both adenoidectomy and tonsillectomy but at different ages, and 4% had only tonsillectomy. (Adeno)tonsillectomy took place between the ages of 2 and 5 years in most cases, whereas adenoidectomy only was also common under the age of 2



**FIGURE 1** Age distribution of adenoidectomy only (A) and (adeno)tonsillectomy [(A)T] cases. If adenoidectomy and tonsillectomy did not take place at the same age, the age of tonsillectomy was counted. <sup>a</sup> This was not a complete year, because most parents returned the questionnaire in the first few months after the child's eighth birthday.

(see Fig 1). Among boys the cumulative incidence of adenoidectomy only and (adeno)tonsillectomy was higher (13.3% and 16.7%, respectively) than among girls (10.7% and 13.9%, respectively). Children who underwent adenoidectomy only or (adeno)tonsillectomy came from families with a relatively high prevalence of low maternal education, maternal overweight, smoking, and no breastfeeding.

#### Association Between Adenoidectomy Only, (Adeno)tonsillectomy, and Overweight

Children who underwent adenoidectomy only or (adeno)tonsillectomy had a higher prevalence of overweight and obesity at the age of 8 years than children who did not (see Table 1). We hypothesized that adenoidectomy and (adeno)tonsillectomy increase the risk of subsequent development of overweight. As a consequence, we assumed a certain time lag between surgery and the presence of overweight. We therefore assessed the association between adenoidectomy and (adeno)tonsillectomy between the ages of 0 to 7 years and overweight at the age of 8 years. Children who had ade-

noidectomy or (adeno)tonsillectomy after their 7th birthday ( $n = 49$ ) were excluded from the analysis. Logistic regression analysis showed that (adeno)tonsillectomy was significantly associated with overweight and with obesity at the age of 8 years, also after adjustment for confounders (see Table 2). Adenoidectomy only was also associated with increased risk of obesity, but the association was weaker and the association with overweight was not statistically significant. To assess the possibility that children were already overweight at the time they underwent adenoidectomy only or (adeno)tonsillectomy, we analyzed the association between weight status at the age of 2 years and the incidence of adenoidectomy only and (adeno)tonsillectomy in the years thereafter. This analysis showed that overweight at the age of 2 was not associated with increased risk of adenoidectomy only or (adeno)tonsillectomy in later years (adjusted odds ratio [aOR]: 0.98 [95% confidence interval (CI): 0.68–1.41]).

The possibility of effect modification was assessed for gender, maternal education, and weight status at the age of 2 years, but no significant interaction was observed for any of these factors.

Results of the analyses in the group of 2100 children with complete data (data not shown) were compared with the results of the analyses in the imputed data set. Results were similar in the 2 analyses, but in the complete case data set, the associations among (adeno)tonsillectomy and overweight and obesity were stronger (aOR: 1.99 [95% CI: 1.40–2.84] for overweight and 2.77 [95% CI: 1.42–5.41] for obesity) than in the imputed data set, indicating that a complete case analysis would have resulted in overestimation of the strength of the associations.

#### Longitudinal Development of Weight, Height, and BMI in Adenotonsillectomy Patients

To gain more insight in the development of BMI after (adeno)tonsillectomy, we graphically assessed the development of relative weight, height, and BMI in the period

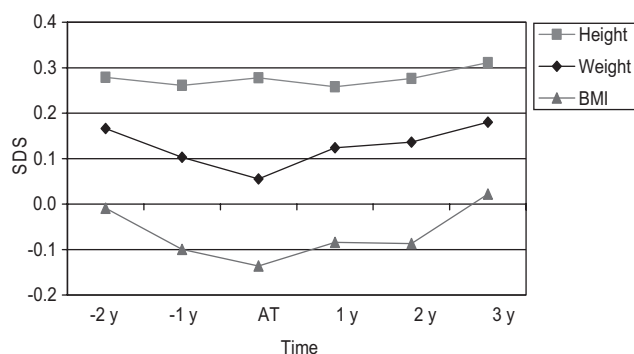
**TABLE 2** Association of Adenoidectomy Only and (Adeno)tonsillectomy Between the Ages of 0 and 7 Years With Overweight and Obesity at 8 Years: Prevalences and Crude and Adjusted Odds Ratios With 95% CIs (N = 3914)

	No Adenoidectomy or Tonsillectomy (N = 2878)	Adenoidectomy Only (N = 457)	(Adeno)tonsillectomy (N = 579)
<b>Overweight</b>			
%	11.9	14.8	19.0
Odds ratio (95% CI)	1.0	1.29 (0.95–1.76)	1.74 (1.35–2.25) <sup>b</sup>
aOR (95% CI)	1.0	1.26 (0.91–1.74)	1.61 (1.23–2.10) <sup>b</sup>
<b>Obese</b>			
%	1.9	4.5	5.8
Odds ratio (95% CI)	1.0	2.19 (1.17–4.11) <sup>c</sup>	2.89 (1.74–4.79) <sup>b</sup>
aOR (95% CI)	1.0	1.94 (1.02–3.70) <sup>c</sup>	2.36 (1.41–3.97) <sup>b</sup>

<sup>a</sup> ORs were Adjusted for gender, birth weight, maternal education, maternal overweight, maternal smoking during pregnancy, breast feeding, and smoking in the home.

<sup>b</sup>  $P < .01$ .

<sup>c</sup>  $.01 \leq P < .05$ .



**FIGURE 2**  
Longitudinal development of mean relative weight, height, and BMI in children who underwent adenotonsillectomy between the ages of 2 and 5 years ( $n = 336$ ), from 2 years before surgery until 3 years after surgery (time = AT).

from 2 years before surgery until 3 years thereafter in children who underwent adenotonsillectomy (ie, the subgroup of children who underwent adenoidectomy and tonsillectomy at the same age; see Fig 2). If, on average, the adenotonsillectomy patients would stay on their own initial growth curves during these 6 years, mean relative weight, height, and BMI would graphically follow horizontal lines. This was indeed the case for relative height, but not for relative weight and relative BMI. Figure 2 reveals that adenotonsillectomy was a turning point between a period in which patients, on average, experienced a decrease in relative weight and BMI and a period in which their weight and BMI steadily increased relative to the reference population.

## DISCUSSION

The cumulative incidence up to the age of 8 years of adenoidectomy only and (adeno)tonsillectomy was 12% and 15%, respectively in our study population. These rates are in agreement with national data on adenoidectomy and tonsillectomy, which are considerably higher in the Netherlands than in most other European countries and in the United States.<sup>20,21</sup> Our results showed that (adeno)tonsillectomy between the ages of 0 and 7 years was associated with an increased risk of overweight and obesity at the age of 8 years, also after adjustment for confounders.

### Strengths and Limitations of the Study

Important strengths of the study were the prospective design, the large study population, the availability of annually collected data on weight, height, adenoidectomy and tonsillectomy, and the availability of data on a number of important confounders. In our general population sample of nearly 4000 children we were able to assess the association between adenoidectomy and tonsillectomy and the development of overweight. In addition, we had the possibility to describe the development of relative weight, height, and BMI from 2 years before until 3 years after surgery in the group of 336 children, who underwent adenotonsillectomy between the ages of 2 and 5 years.

However, a number of limitations have to be consid-

ered. Whereas loss-to-follow-up was low in this study and response rates were high for the yearly questionnaires, the response on the medical examination, where weight and height were measured, was lower. To avoid bias because of selective missingness, we used multiple imputation, which we considered the best available method to deal with missing data in our study. Results of the complete case analysis and the analyses in the imputed data sets were similar, but using multiple imputation of missing data helped to avoid overestimation of the strengths of the associations and has provided us with better estimates of the associations studied.

Another limitation of our study is that most of the data were parental reported. It is unlikely however, that parents would fail to recall that their child had an operation during the last 12 months. Data on weight and height were measured by the investigators when the children were 8 years old and were reported by the parents in the annual questionnaires for the ages 0 to 8 years. Although parents were asked to either copy the values from medical charts or to weigh and measure the child themselves, a validation study conducted at the age of 4 years showed that, on average, BMI was underreported by 0.7 kg/m<sup>2</sup> in children in the highest BMI quartile, whereas BMI was overreported by 0.4 kg/m<sup>2</sup> in children in the lowest BMI quartile.<sup>22</sup> This means that the higher mean BMI values shown in Figure 2 may have been influenced by underreporting and the lower mean BMI values by overreporting. The actual change in mean BMI between the time of surgery and 3 years later may therefore have been larger than the change shown.

### Findings of Other Studies

Our findings are in agreement with the findings of studies in (adeno)tonsillectomy patients. Nearly all the studies that investigated weight and height gain after (adeno)tonsillectomy have observed accelerated growth. This was reported from different parts of the world: in infants and preschool children<sup>2,5</sup> as well as in school children<sup>3,8,10,23</sup>; in children who mainly suffered from recurrent tonsillitis;<sup>1,6</sup> in children with obstructive symptoms or adenotonsillar hypertrophy;<sup>2,3,9,10,24-26</sup> in children who had obstructive sleep apnea syndrome<sup>4,8,27</sup>; and both in underweight and normal weight children.<sup>1-10</sup> Accelerated weight gain after surgery was reported in all these studies, but increased height velocity was not always observed. Some studies reported no increase in relative height or height velocity,<sup>5,10,23</sup> 1 reported a stronger increase in weight velocity than in height velocity<sup>2</sup> and 2 reported an increase in weight for height or in BMI after surgery,<sup>4,7</sup> which means that weight increased more strongly than height. Most of the studies conducted in patients had follow-up times between 6 and 18 months, they included numbers ranging from a single patient<sup>28,29</sup> up to 85 patients,<sup>3</sup> and only a minority of studies included a control group of healthy children.<sup>1,9,27</sup>

### Interpretation of the Results

Our prospective general population study and the studies that have been conducted in patients show consistent

evidence that (adeno)tonsillectomy tends to be followed by accelerated weight gain. A number of effects of (adeno)tonsillectomy may be responsible for this, including improved appetite<sup>30,31</sup> and increased energy intake,<sup>24</sup> a reduction of energy expenditure<sup>4,10</sup>, and increased levels of insulin-like growth factor 1 or insulin-like growth factor binding protein-3 after surgery.<sup>8,9,23–25</sup>

Even if (adeno)tonsillectomy is followed by catch-up growth, the question remains whether it is also causally related to the subsequent development of overweight. It could be that the children who develop overweight, were predisposed to develop overweight anyway, either genetically or by their environment, and had only temporarily deviated from their track to overweight when (adeno)tonsillectomy restored their health and helped them back on their original track. Our data showed a higher prevalence of overweight at age 8 in the group of children who underwent (adeno)tonsillectomy, but also a relatively high prevalence of indicators of an unhealthy and possibly obesogenic lifestyle, such as maternal overweight, smoking, and no breastfeeding. Adjustment for these factors did indeed attenuate the association between (adeno)tonsillectomy and subsequent overweight, but the results suggest that (adeno)tonsillectomy is also associated with subsequent overweight, independent of these factors. We also showed that the prevalence of overweight at the age of 2 years was not higher in the children who underwent (adeno)tonsillectomy at later ages than in the children who had no surgery, which indicates that the association between (adeno)tonsillectomy and overweight was not explained by preexisting overweight.

How could (adeno)tonsillectomy and the development of overweight be related? We hypothesize that the period preceding surgery may be characterized by metabolic adaptation to a situation in which—because of frequent respiratory infections, poor appetite, poor sleep quality, or difficult breathing—the balance between energy intake and energy expenditure is insufficient to maintain healthy growth. When health is restored, owing to (adeno)tonsillectomy, this metabolic adaptation to catabolic conditions, may make healthy catch-up growth turn into the development of overweight. Parental inclination to overfeed a child who has recovered after a period of ill health and poor appetite, might also play a role and interact with this hypothesized metabolic mechanism.

## CONCLUSIONS AND IMPLICATIONS

We conclude that children who undergo (adeno)tonsillectomy are at increased risk to develop overweight in the years after surgery. Dietary and lifestyle advice at the time of surgery and growth monitoring thereafter might help parents to keep their child's catch-up growth within healthy limits.

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## OCTOPUSES GIVEN RUBIK'S CUBES TO FIND OUT IF THEY HAVE A FAVORITE TENTACLE

“Marine experts have given 25 octopuses a Rubik’s Cube each in a study aimed at easing their stress levels in captivity. Scientists believe the intelligent sea creatures have a preferred arm out of 8 that they use to feed and investigate with. They are now testing this theory with a month-long observation project in which the octopuses will be given food and toys to play with. Experts have launched a study at sea life centres across Europe to find out if octopuses have a favourite tentacle. They will then record whether the creatures use a specific limb to pick up the object or if they are octidextrous. It is hoped the results of the Sea Life Centre study will shed light on ‘handiness’ in the animal kingdom. Claire Little, marine expert at the Sea Life Centre in Weymouth, Dorset, said the study could eventually help to reduce stress among octopuses. She said: ‘It will be very interesting to see the results. Uniquely, octopuses have more than half their nerves in their arms and have even been shown to partially think with their arms. We hope the study will help the overall well-being of octopuses. They are very susceptible to stress so if they do have a favorite side to be fed on, it could reduce risk to them.’”

A Daily Mail Reporter. *MailOnline*. July 7, 2008

Noted by MG, MD

## Adenotonsillectomy and the Development of Overweight

Alet H. Wijga, Salome Scholtens, Marjan H. Wieringa, Marjan Kerkhof, Jorrit Gerritsen, Bert Brunekreef and Henriette A. Smit

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