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Increases in Overweight After Adenotonsillectomy in Overweight Children With Obstructive Sleep-Disordered Breathing Are Associated With Decreases in Motor Activity and Hyperactivity

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ABSTRACT

OBJECTIVE. To examine the effect of adenotonsillectomy (T&A) in children with obstructive sleep-disordered breathing on growth, hyperactivity, and sleep and waking motor activity.

METHODS. We studied 54 children who were aged 6 to 12 years and had adenotonsillar hypertrophy and an obstructive apnea-hypopnea index of ≥1 before and 12 months after they all received adenotonsillectomy (T&A). We measured their height, weight, percentage overweight (patient BMI − BMI at 50th percentile)/BMI at 50th percentile * 100) and obtained a hyperactivity score from parent report on a standardized behavior questionnaire scale. A subset of 21 of these children were also studied for motor activity by wrist actigraphy for 7 consecutive days and nights before and 12 months after T&A.

RESULTS. After T&A, mean obstructive apnea-hypopnea index decreased from 7.6 to 0.6. Height percentile did not change, but weight percentile increased; as a consequence, percentage overweight increased from 32.0% to 36.3%. Hyperactivity scores and total daily motor activity were reduced after T&A. From linear regression, the reduction in hyperactivity scores predicted an increase in percentage overweight. Reduced motor activity was correlated with increased percentage overweight.

CONCLUSIONS. An increase in percentage overweight after T&A in children with obstructive sleep-disordered breathing is correlated to decreased child hyperactivity scores and to decreased measured motor activity in the subset studied. These associations suggest that the increase in overweight may be attributable to reductions in physical activity and fidgeting energy expenditure.

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Key Words
sleep apnea, growth, height, weight, obesity, physical activity, hyperactivity, nonexercise activity thermogenesis

Abbreviations
OSDB—obstructive sleep-disordered breathing
T&A—adenotonsillectomy
OAHI—obstructive apnea-hypopnea index

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OBSTRUCTIVE SLEEP-DISORDERED BREATHING (OSDB) occurs in ~3% of children.[1–3] Adenotonsillar hypertrophy is the most common cause of OSDB in young children, and adenotonsillectomy (T&A) is the primary treatment of obstructive sleep apnea in children.[4–6] OSDB in children has been associated with a variety of comorbidities, including hypertension, enuresis, poor scholastic performance, hyperactivity, and attention-deficit/hyperactivity disorder, and these conditions are also ameliorated with successful treatment of OSDB via T&A.[7,8]

OSDB has also been reported to influence somatic growth. Several studies have shown that OSDB is associated with reduced growth in height and weight[5,6,9–12] and failure to thrive in infants.[13] These growth alterations have been related to a number of factors, including reduced secretion of growth hormone and insulin-like growth factor-I,[11,14,15] low energy intake as a result of difficulty swallowing,[16] and increased energy expenditure during sleep.[5,16] All of these factors are reported to improve after T&A.[6,11,14–16] Other studies, however, have reported that growth in children with adenotonsillar hypertrophy and OSDB is normal or that these children are actually overweight before treatment.[4,17,18]

After T&A, normal-weight and overweight children with or without OSDB rapidly gain weight.[17,18] Thus, although T&A has a beneficial effect on OSDB symptoms[4] and improves the other comorbidities listed above, the procedure may also lead to weight gain, even in youths who are already overweight. Weight gain in already overweight children can cause recurrent or persistent OSDB,[19,20] as well as contribute to insulin resistance,[21,22] hypertension,[23] and other chronic diseases.[19,20,24,25]

The reasons for the excessive weight gain after T&A are unclear. Body weight changes are a function of dietary energy intake and energy expenditure through basal metabolism, dietary-induced thermogenesis, and motor (physical) activity. The most modifiable of these components are dietary energy intake and motor activity energy expenditure. A single study investigated the role of both diet and energy expenditure on gains in body weight after T&A and found that T&A reduced sleeping energy expenditure by ~5 kcal/kg body weight per night[5]; however, there was little effect on dietary intake. OSDB has also been linked to hyperactivity disorders in children,[26–28] and T&A reduces hyperactive behavior.[29] If T&A reduces motor activity or hyperactivity, then the corresponding reduction in energy expenditure may lead to excessive positive energy balance and weight gain despite minimal changes in energy intake. The purpose of this study was to examine the effects of T&A in children with OSDB on weight gain, motor activity, and hyperactivity.

METHODS

Participants

All participants were volunteers who signed informed assent and whose parents signed written informed consent for the study. The University of Virginia Human Investigation Committee approved these studies. We studied 54 children who were 6 to 12 years of age (mean ± SD: 7.8 ± 1.7 years) and had adenotonsillar hypertrophy and >1 episode of apnea or hypopnea per hour of sleep (obstructive apnea-hypopnea index [OAHI]). These children were consecutive participants in a study on the effect of OSDB as a result of adenotonsillar hypertrophy on behavior, cognitive performance, and anthropometric measures of growth. Children were excluded from the study when they had underlying cardiac, pulmonary, neurologic, or auditory disease or were taking medication that alters sleep, breathing, or behavior. A subset of these children that consisted of 8 boys and 13 girls (mean ± SD: 7.8 ± 1.7 years) were also investigated for sleeping and waking motor activity. This subset included the final 21 children who entered the study and had T&A, when actigraphy data collection was initiated.

Protocol

Children were admitted to the University of Virginia General Clinical Research Center, where they had anthropometric studies and overnight polysomnography. A parent filled out questionnaires about his or her child's clinical symptoms and behavior. All children studied received T&A surgery; the decision to perform the surgery was made by the children's physician. Assessments were repeated on all children on average of 12.6 months after surgery (range: 6.2–27.4 months). The subset of children who were studied for motor activity was monitored at home with actigraphy for 7 consecutive days and nights before admission to the General Clinical Research Center.

Anthropometrics

Height was measured to the nearest millimeter using a Harpenden stadiometer (Cambridge, MD), and weight was measured to the nearest 0.1 kg using a medical balance beam scale (Healthometer, Bridgeview, IL) calibrated daily. Percentiles for height, weight, and BMI (weight in kg/height in [cm]^2) were obtained using Epi Info public domain software (version 3.2.2; Centers for Disease Control and Prevention, Atlanta, GA), which uses data obtained from the National Center for Health Statistics.[30] We calculated percentage overweight as (patient's BMI − BMI at 50th percentile)/BMI at 50th percentile * 100). For this calculation, the BMI at the 50th percentile was based on the gender and the age of each child using pages 178 to 186 of Kuczmarski et al.[30]

Polysomnography

Children had overnight polysomnography from 9:00 PM until awakening using conventional techniques, including electroencephalograms (C3A2, C4A1), bilateral electro-oculograms, submental electromyograms, nasal airflow measured with a nasal cannula attached to a pressure transducer (DP 45, Validyne Engineering Inc, Northridge, CA), oral airflow measured with a thermistor, pulse oximetry, and chest and abdominal movement detected by respiratory inductance plethysmography (NonInvasive Monitoring Systems, Inc, North Bay Village, FL). Data were recorded on a Sandman sleep system (Sandman Sleep Diagnostics, Kanata, Ontario, Canada). Polysomnographic data were obtained in a dark room at a constant temperature. Children refrained from caffeine on the day of the study. A sleep technician who was blinded to the results of the questionnaire and all other studies analyzed the study by scoring sleep with conventional methods for children and scoring apneas and hypopneas. Sleep staging was performed using Rechtschaffen and Kales criteria.[31] Apneas were characterized by reductions in air flow to <20% of normal for 6 or more seconds or 2 respiratory cycles, and hypopneas were characterized by reductions in air flow to <60% of normal for 6 or more seconds or 2 respiratory cycles. Apneas and hypopneas were reported to be obstructive when the chest and abdomen moved and central when chest and abdominal movements were absent. Polysomnography data reported in this study include sleep time, percentage of time in stages 1 through 4 of sleep, percentage of time in rapid eye movement sleep, and OAHI.

Snoring Questionnaire

A sleep questionnaire was administered to all parents to solicit a score that ranged from 1 to 5 regarding their child's snoring frequency.[32] Parents were asked to score their child's snoring frequency as occurring (1) never, (2) rarely (less than once month), (3) occasionally (1–4 times a month), (4) frequently (more than once a week), or (5) most nights.[32] The change in snoring frequency score was calculated as postsurgery snoring frequency score minus presurgery snoring frequency score.

Motor Activity

Activity was measured with a Mini Motion Logger Actigraph (Ambulatory Monitoring Inc, Ardsley, NY) that was worn on the nondominant wrist for 7 consecutive days and nights, including the night of polysomnography. The Actigraph measures motor activity by acceleration changes of the limb. The Actigraph was set to operate in "zero crossing mode" to record the number of movements within a 1-minute interval. Calculations were performed with Action-W software version 2.0. Activity values during sleep and wakefulness were determined by multiplying the counts per minute by the number of minutes the patient was asleep or awake, respectively. Sleep and awake counts were distinguished using the Sadeh[33] algorithms in the analysis software package. We calculated counts during sleep periods, awake periods, and per 24-hour period (daily counts). The change in daily motor activity was calculated as postsurgery counts per 24-hour period minus presurgery counts per 24-hour period. The Actigraph has been used in studies of sleep[34,35] and hyperactivity in youths.[36]

Hyperactivity

Hyperactivity was accessed with the Conners' Parent Rating Scale.[37] Each child's age adjusted T-score was used for analyses of the hyperactivity data. The Conners' Parent Rating Scale consists of 9 questions answered on a scale of 0 to 3: 0, "not true at all (never, seldom)"; 1, "just a little true (occasionally)"; 2, "pretty much true (often, quite a bit)"; and 3, "very much true (very often, very frequent)." The 9 specific questions are as follows: (1) is always on the go or acts as if driven by a motor, (2) hard to control in malls or while grocery shopping, (3) runs about or climbs excessively in situations in which it is inappropriate, (4) excitable and impulsive, (5) restless in the squirmy sense, (6) has difficulty waiting in lines or awaiting turn in games or group situations, (7) will run around between mouthfuls at meals, (8) has difficulty playing or engaging in leisure activities quietly, and (9) blurts out answers to questions before the questions have been completed. The change in hyperactivity was calculated as postsurgery hyperactivity T score minus presurgery hyperactivity T score.

Statistics

Differences in sleep time; percentage of time in stages 1 through 4 of sleep; percentage of time in rapid eye movement sleep; OAHI; age; height; weight; BMI; percentage overweight; and percentiles for height, weight, and BMI before and after T&A were compared with separate mixed 2-way analyses of variance with gender (boy and girl) as a between factor and time (before and after T&A) as a within factor. Snoring frequency before and after T&A was analyzed with a Wilcoxon signed ranks test for matched pairs. Differences in polysomnography variables and in physical characteristics of the whole group and patients who were enrolled after initiation of the actigraphy measures were tested with separate 1-way analyses of variance. Linear regression was used to determine whether the changes in child hyperactivity score predicted the changes in percentage overweight after T&A when adjusting for baseline hyperactivity scores. Spearman correlation was used in all 54 patients to determine whether the changes in snoring frequency or OAHI predicted changes in hyperactive behavior. Spearman correlation was also used in the subset of 21 children who were studied with actigraphy to determine whether the changes in motor activity predicted the changes in percentage overweight after T&A.

RESULTS

Polysomnography data before and after T&A are shown in Table 1. There were no gender differences or gender by time interactions for any polysomnography variable ($P \leq .25$), so the data are displayed for the whole group. Sleep time did not differ before or after surgery ($P \leq .73$). The percentage time in stage 1 sleep was reduced from 3.0% before T&A to 2.3% after T&A, a 23% reduction ($P \leq .001$). OAHI decreased from 7.6 (range: 1.2–37.8) to 0.6 (range: 0.0–3.1) episodes per hour ($P \leq .001$), and snoring frequency score also decreased ($P \leq .001$) before to after T&A. There were no significant differences between the entire group and the subset of 21 children who were investigated for sleeping and waking motor activity for their pre-T&A polysomnography data (Table 1)

Anthropometric data are shown in Table 2. No statistically significant main effects of gender emerged for any anthropometric variable ($P \leq .23$), so the data are presented for the whole group. With regard to time (before vs after T&A), there was a main effect for height ($P \leq .001$), but height percentile was not changed ($P = .96$). There were significant increases in both body weight ($P \leq .001$) and weight percentile ($P \leq .01$) after surgery. These differential rates of change in height and weight percentile resulted in increases in BMI ($P \leq .001$), BMI percentile ($P = .04$), and percentage overweight ($P \leq .003$) after T&A. Individual presurgery and postsurgery percentage overweight data are plotted in Fig 1. There were no significant gender by time interaction effects for the anthropometric variables. There were no significant differences between the entire group and the subset of 21 children who were investigated for sleeping and waking motor activity for their pre-T&A anthropometric data (Table 2).

Parent ratings of child hyperactivity were lower after T&A ($P \leq .01$; Fig 2). Children who had the greatest reductions in snoring frequency also had the greatest reductions in hyperactivity scores ($\rho = 0.28$, $P \leq .05$). The change in OAHI score did not predict the change in hyperactivity score ($\rho = 0.02$, $P > .89$). The change in child hyperactivity score significantly predicted the change in percentage overweight when controlling for initial hyperactivity (Table 3).

The motor activity data for the subset of children are shown in Table 4. The motor activity counts during sleep did not differ between boys and girls ($P \leq .17$), but the awake and total daily counts were greater in boys than in girls ($P \leq .05$). The total daily, awake, and sleep counts all decreased after T&A ($P \leq .05$). There was an inverse correlation for change scores of total daily motor activity counts and percentage overweight ($\rho = -0.54$, $P \leq .01$; Fig 3). The change in total daily motor activity from actigraphy did not predict the change in hyperactivity score ($\rho = 0.05$, $P > .83$)

DISCUSSION

This study demonstrates that children who have OSDB and are treated with T&A have an increase in weight, BMI percentile, and percentage overweight. They also had a decrease in hyperactivity and in sleep, waking, and total daily motor activity. The increase in percentage overweight correlated inversely with the changes in hyperactivity and total daily motor activity.

The OAHI range of our patients seems to be typical of OSDB. For example, Kaeminigk et al[38] reported that in 6- to 12-year-old children, the AHI was <5 in 72 subjects and >5 in 77. O'Brien et al[39] reported 35 children with sleep disordered breathing and a mean age of 6.7 had a mean AHI of 9.8. These findings are similar to the mean AHI of 6.7 in our male subjects and 8.0 in our female subjects.

Although the OAHI range was similar to previous studies, the weight status of the youths in the present study was greater than that in previous studies of children with OSDB of similar age. Before T&A, the participants' weight was at the 73rd percentile, which corresponds to an average overweight of 32%. Barr et al[17] reported the median weight of 8.5-year-old children

TABLE 1 **Polysomnography Data (Mean ± SE) Before and After T&A for All Patients and Presurgery Data for the Subset of Patients Who Were Enrolled After the Initiation of Actigraphy Measures**

	All Patients (n = 54)		Actigraphy Subset (n = 21)
	Presurgery	Postsurgery	Presurgery
Sleep time, h	7.1 ± 0.1	7.1 ± 0.1	7.0 ± 0.2
Stage 1 sleep time, %[a]	3.0 ± 0.2	2.3 ± 0.2	2.6 ± 0.3
Stage 2 sleep time, %	29.3 ± 1.0	28.8 ± 1.0	27.8 ± 1.5
Stage 3 sleep time, %	9.2 ± 0.3	9.2 ± 0.3	8.6 ± 0.5
Stage 4 sleep time, %	36.0 ± 0.9	38.3 ± 1.1	38.9 ± 1.2
REM sleep time, %	21.0 ± 0.7	20.9 ± 0.6	21.3 ± 1.2
Apneas and hypopneas per h[a]	7.4 ± 1.0	0.5 ± 0.1	8.3 ± 1.5
Snoring frequency score[a]	4.9 ± 0.1	0.6 ± 0.1	4.7 ± 0.2

REM indicates rapid eye movement.

[a] $P \leq .001$ presurgery to postsurgery for all patients (boys and girls) combined.

TABLE 2 **Anthropometric Data (Mean ± SE) Before and After T&A for All Patients and Presurgery Data for the Subset of Patients Who Were Enrolled After the Initiation of Actigraphy Measures**

	All Patients (n = 54)		Actigraphy Subset (n = 21)
	Presurgery	Postsurgery	Presurgery
Age, y[a]	7.7 ± 0.3	8.7 ± 0.3	7.8 ± 0.4
Height, cm[a]	130.3 ± 2.5	137.0 ± 2.6	131.1 ± 2.7
Height percentile	69.2 ± 4.8	67.8 ± 4.7	69.3 ± 5.8
Weight, kg[a]	34.9 ± 3.1	40.9 ± 3.8	38.1 ± 3.9
Weight percentile[a]	74.4 ± 5.4	76.9 ± 5.4	73.0 ± 7.5
BMI, kg/m^2[a]	19.9 ± 1.1	21.0 ± 1.2	21.3 ± 1.5
BMI percentile[a]	74.0 ± 5.4	75.9 ± 5.8	74.0 ± 7.5
Percentage overweight[a]	25.4 ± 6.4	30.2 ± 7.2	33.5 ± 8.6

[a] $P \leq .001$ presurgery to postsurgery for all patients (boys and girls) combined.

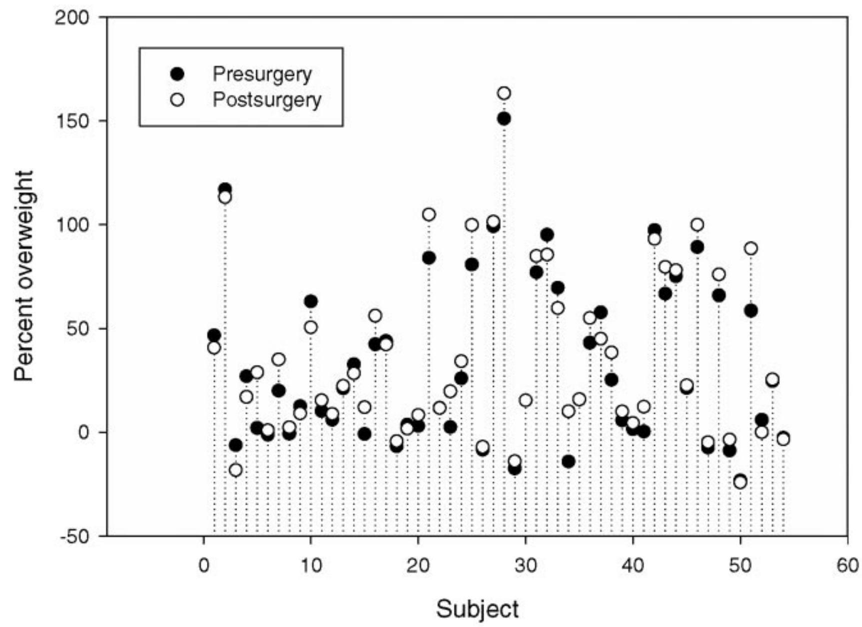


FIGURE 1
Vertical dot plot of the presurgery and postsurgery percentage overweight for each of the 54 children studied.

with OSDB was at the 55th percentile, whereas Conlon et al[40] reported that 7-year-old children with OSDB were 10% overweight. Studies have indicated that children with OSDB are overweight.[41,42] However, it is unclear why the children in the present study had greater overweight. They were not recruited on the basis of weight status and were screened for predisposing medical conditions related to overweight before entering the study. Perhaps the greater overweight of the present sample compared with studies that were completed 10 to 20 years previously is a function of the greater prevalence of pediatric overweight and the rightward shift in the magnitude of overweight in the general population.[43–45]

After surgery, the weight of the children in the present study increased further as indicated by a significant increase in weight percentile and a significant 12.5% increase in percentage overweight, whereas the rate of statural growth was maintained. Such excessive weight gain is a concern because obesity may be a primary cause of OSDB[19,20] and additional weight gain may lead to a future reoccurrence of OSDB in youths who are already overweight and particularly susceptible to developing OSDB. Weight gain after T&A has been noted previously in both normal or underweight[5,11,12] and overweight[4,18] children with OSDB.

The postsurgical increase in overweight has been attributed to fewer episodes of sore throat, which reduces dietary intake as a result of throat pain.[16,17] This explanation is unlikely in the present study because many of the children were overweight preoperatively. Moreover, the only investigation to study energy intake after T&A reported an excessive increase in weight with no change in energy intake.[5] If the increase in adiposity after T&A is not a result of increased energy intake, then it may result from a reduction in energy expenditure as a result of decreased motor activity.

Sleep energy expenditure in children with OSDB has been reported to decrease by 5 kcal/kg body weight after T&A, and this reduction was correlated with postsurgical weight gain.[5] The authors suggested that the reduction

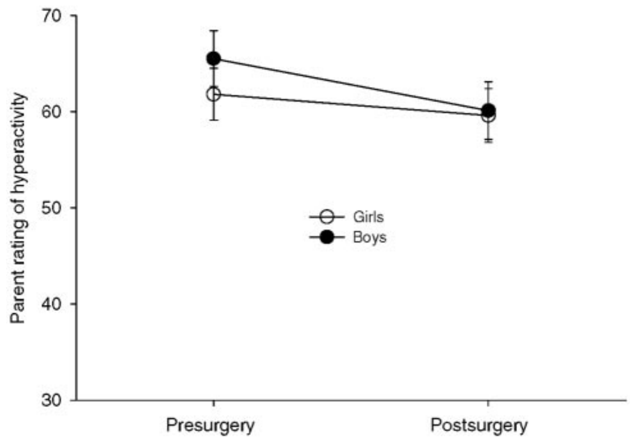


FIGURE 2
Parent ratings of child hyperactivity as scored using the Conners Parent Rating Scale. There was a significant reduction in hyperactivity for all subjects presurgery to postsurgery ($P \leq .01$).

in sleep energy expenditure was attributable to a decreased work of breathing.[5] In another study,[46] 7 children with OSDB were studied for polysomnography before and after T&A, and 3 had improvements in OAHI. Two of these children had small increases in energy expenditure, whereas the other had a small reduction in energy expenditure. However, the total energy expenditure of a group of 11 children did not differ from control subjects, suggesting that OSDB did not alter total energy expenditure. To our knowledge, the current study is the first to demonstrate a significant reduction in sleep, waking, and total daily motor activity of children with OSDB after T&A and the association of greater reductions in total daily motor activity with greater increases in the percentage of overweight in children.

The reduction in motor activity would lead to weight gain if energy intake is maintained at pre-T&A levels or indeed is increased as a result of fewer sore throats. Fidgeting and other forms of nonexercise activity that occur during sleep and throughout the day can protect against weight gain. For example, among adults who were overfed by 1000 kcal/day for 8 weeks, those who had the greatest increases in nonexercise activity thermogenesis gained the least body fat.[47] Thus, we hypothesize that postsurgery reductions in motor activity and energy expenditure lead to increased weight gain. T&A may also reduce the number and the severity of sore throats, resulting in increased energy intake, although there currently are no data to support this theory.

Similar to changes in motor activity, changes in hyperactivity scores were inversely correlated with the change in percentage overweight. Studies have shown that hyperactive children exhibit excessive movement while awake and during sleep,[6,48,49] suggesting that hyperactivity may be a portion of the motor activity measured by actigraphy. However, there was a very low correlation between the change in hyperactivity score and total daily motor activity in the present study, suggesting that actigraphy and the hyperactivity score are measuring different constructs that both are inversely related to changes in percentage overweight.

We observed that reductions in parent report of child hyperactivity were also correlated to reductions in snoring frequency. Previous studies have reported reductions in hyperactivity and snoring after T&A[6,28,29,50] and reported cross-sectional relationships between snoring frequency and hyperactivity in children,[26] but ours is the first study to report a direct correlation between changes in snoring and hyperactivity scores. The reduction in hyperactivity and snoring after T&A and the direct relationship between changes in snoring and hyperactivity scores after surgery suggest that high-resistance breathing may promote hyperactivity in children. However, these results are limited by their correlational nature,

TABLE 3 **Multiple Regression With the Change in Hyperactivity Score Predicting the Change in Percentage Overweight and Controlling for the Pre-T&A Hyperactivity Score**

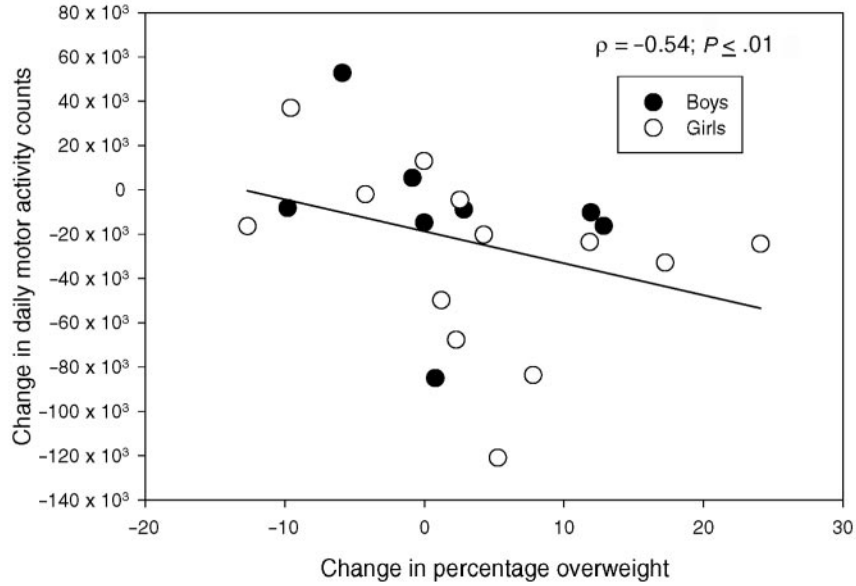
	Coefficient	SE	Standardized Coefficient	*P*	Model R^2
Constant	11.36	5.78	0.00	.06	
Baseline hyperactivity	−0.13	0.09	−0.19	.19	
Change in hyperactivity	−0.36	0.16	−0.33	.03	0.10

TABLE 4 **Motor Activity Data (Mean ± SE) of Patients Who Were Studied for Physical Activity Before and After T&A**

	Boys ($n = 8$)		Girls ($n = 13$)	
	Presurgery	Postsurgery	Presurgery	Postsurgery
Sleep, counts/d × 10^3[a]	8.9 ± 0.8	7.5 ± 0.4	8.1 ± 0.8	6.4 ± 0.4
Awake, counts/d × 10^3[a,b]	250.6 ± 10.4	241.4 ± 6.5	239.6 ± 7.4	210.8 ± 9.1
Total daily, counts/d × 10^3[a,b]	259.5 ± 11.1	248.8 ± 6.7	247.7 ± 7.8	217.2 ± 9.4

[a] $P \leq .05$ presurgery to postsurgery for all patients (boys and girls) combined.
[b] Boys had significantly ($P \leq .05$) greater motor activity than girls.

FIGURE 3
There was an inverse relationship between the pre-T&A to post-T&A changes in total daily motor activity (*y* axis) and percentage overweight (*x* axis). Children who reduced their activity after T&A tended to increase their percentage overweight, whereas children who increased their activity tended to reduce their percentage overweight.



which cannot prove cause–effect, and the use of subjective parental report of snoring frequency. Nonetheless, parental history of frequent snoring is a robust predictor of poor school performance[51] and cognitive impairment in children with sleep-disordered breathing.[39,51,52] This may be because children with OSDB have primarily high-resistance breathing without frequent apneas or hypopneas. The polysomnogram is not very sensitive to high-resistance breathing without apneas unless children swallow an esophageal catheter. High-resistance breathing is probably identified by parents as snoring.

As others have shown,[53–56] T&A reduced the number of apnea and hypopnea episodes during sleep (OAHI) in children with hypertrophied tonsils and adenoids. The reduction in OAHI was accompanied by improvements in sleep architecture, including a significant reduction in the percentage of time in stage 1 sleep from 3.0% to 2.3% (a 23% decrease). Although the clinical importance of this degree of change is not clear, improvements in sleep quality and reduced hyperactive behavior may improve children's ability to focus and be attentive during school and result in improved learning.

Another limitation of this study was that it did not include a control group of youths who had adenotonsillar hypertrophy and did not have T&A. It would be ethically difficult to randomly assign children who have adenotonsillar hypertrophy and have frequent snoring or are found to have OSDB by polysomnography to a control group that did not have T&A because these children have a higher-than-normal risk for impaired cognitive function or behavioral problems.[7,8] A nonrandomized control group of children who had OSDB as a result of adenotonsillar hypertrophy and whose parents chose for the child not to have T&A would not have been a proper control group because the decision to have T&A may be influenced by OSDB severity, parent concern regarding OSDB, and parental ability to pay for surgery.

CONCLUSIONS

Children who had OSDB and underwent T&A exhibited significant improvements in OSDB symptoms and increases in BMI percentile and percentage overweight. Furthermore, significant reductions in total daily motor activity and parent report of hyperactivity were correlated to significant increases in percentage overweight. Future studies that examine concomitant changes in OSDB, hyperactivity, physical activity, dietary intake, and growth in height and weight before and after T&A may provide a basis for developing exercise and dietary prescriptions for children who undergo T&A for the treatment of OSDB that may help to prevent excessive weight gain.

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