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The Relationship between Depressive Symptoms and Obstructive Sleep Apnea in Pediatric Populations: A Meta-Analysis

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Background: A higher incidence of depressive disorders and symptoms has been suggested among children suffering from obstructive sleep apnea (OSA). Yet, the extent to which OSA is related to increased depression is unclear.

Objectives: To evaluate (a) the relationship between depressive symptoms and OSA in pediatric populations, and (b) the efficacy of adenotonsillectomy (AT) for decreasing depressive symptoms among children with OSA.

Methods: A meta-analysis was conducted to assess the relationship between depressive symptoms and OSA, and the efficacy of AT for decreasing depressive symptoms. Studies reporting depressive symptoms of children with OSA through January 2013 were included.

Results: Eleven studies assessed depressive symptoms in both children diagnosed with OSA (n = 894) and a comparison group (n = 1,096). A medium relationship was found between depressive symptoms and OSA (Hedges' g = 0.43, 95% CI: 0.22-0.64; p = 0.0005). Addressing the second question, 9 studies (n = 379 children) examined depressive symptoms pre- and post-AT. A medium improvement in depressive symptoms was found at follow-up (Hedge's g = 0.41, 95% CI: 0.20-0.62; p ≤ 0.001).

Conclusion: Our findings suggest that depressive symptoms are higher among children with OSA. Therefore, patients with depressive symptomatology should receive screening for sleep disordered breathing. Treatment of OSA with AT might decrease clinical symptoms of depression, reduce pharmacotherapy, improve sleep patterns, and promote better health.

Keywords: Sleep disordered breathing, obstructive sleep apnea, depression, depressive symptoms, meta-analysis

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Childhood depression is a significant problem that may lead to elevated psychosocial problems and physical disabilities.[1] Adolescents with depression have an added risk of suicide and substance abuse.[1] Subclinical depressive symptoms have also been associated with similar health problems including, poor quality of life, smoking and substance abuse, and future clinical depression.[2-4] Depression affects approximately 1% of preschoolers, 2% of school-aged children, and 5% to 8% of adolescents in community samples and is a risk factor for noncompliance with medical treatment.[5,6]

Sleep disordered breathing (SDB) in children represents a spectrum of disorders ranging in severity from primary snoring to more severe forms such as obstructive sleep apnea (OSA).[7] OSA, which is best assessed by full-night polysomnography, affects up to 2% of children, while subtle "subclinical" forms of SDB may affect many more.[7-9] Although OSA is thought to be equally prevalent among both genders in childhood, the incidence of OSA increases gradually during adolescence when it becomes more common among males.[10]

In the adult literature, inconsistencies about the relation between depression and OSA exist. For example, Guilleminault et al. reported a high rate of depressive and anxiety symptoms (24%) among adults with OSA.[11] In contrast, some studies did not find such a relation. Bardwell and colleagues, for example, reported that the relation between depressive symptoms and OSA was no longer significant after controlling for age, body mass index (BMI), and hypertension.[12] The child literature is similarly inconsistent. Differences in diagnostic methods and criteria to identify OSA and its severity, as well as differences in how depressive symptoms are assessed, may affect the magnitude of the effect size (ES) between depressive symptoms and OSA.

Due to the inconsistent relationship between depressive symptoms and OSA, further research is needed to address the extent to which these problems are related. Enhanced understanding of the relationship between depressive symptoms and OSA may have important clinical implications. The use of antidepressant medications in children is controversial as they have limited efficacy,[13] adverse events are common,[14] and as a result medications are often considered only for severe cases or in those with a partial or non-response to therapy. At least in a subpopulation of children and adolescents presenting with depressive symptoms, screening for OSA may suggest alternative causes and treatment of depressive symptoms, preventing significant distress, disability, and financial loss. As the most common cause of OSA in children is enlargement of adenoids

Table 1—Demographic information by group and the scale used

Study Name	Scale Used	Rater	# Clinical Subjects	# Comparison Subjects	Mean/SD Age Clinical Group (Age Range)	Mean/SD Age Control Group (Age Range)	BMI Clinical	BMI Comparison	Male % Clinical Group	Male % Comparison Group
Beebe et al., 2010	BASC	P&T	100	37	13.74 ± 1.96	13.0 ± 2.0	39.62 ± 8.01	35.9 ± 6.5	47	18.9
Blunden et al., 2000*	CBCL (A&D)	P only	16	16	7.2 ± 1.6 (5.7-10.8)	7.7 ± 1.6 (5.4-10.7)			43.75	43.75
Bourke et al., 2011	CBCL (A&D)	P only	42	35	9.14 ± 1.40	9.5 ± 1.7			50.0	48.57
Carotenuto et al., 2012*	CDI	C-SR	94	107	10.15 ± 2.60	10.2 ± 2.44	18.93 ± 1.47	19.02 ± 1.33	52.13	40.19
Crabtree et al., 2004	CDI	C-SR	62	31	10.1 ± 1.45	9.56 ± 0.90	24.79 ± 4.67	17.50 ± 2.90	55.29	41.94
Huang et al., 2007	CBCL (A&D)	P&T	66	20	8.12 ± 4.31	8.85 ± 2.13	18.74 ± 2.83	18.84 ± 3.66	89.39	80
Kurnatowski et al, 2008	CDI	C-SR	121	104	(6-13)	(6-13)				
Landau et al., 2012	CBCL & C-TRF (A&D)	P&T	45	26	3.80 ± 0.77	4.05 ± 0.7	15.7 ± 2	16.4 ± 2	73.3	46.2
O'Brien et al., 2004*	CBCL (A&D)	P only	35	35	6.7 ± 0.6	6.7 ± 0.5	19.8 ± 4.3	17.7 ± 3.5	49	49
Rosen et al., 2004*	CBCL (A&D)	P only	162	667	9.3 ± 0.9	9.5 ± 0.8	19.0 ± 4.7	17.9 ± 3.5	42.5	50.2
Ting et al., 2011	CBCL ,TRF (A&D)	P&T	128	10	10.2 ± 1.03	10.1 ± 0.9	18.39 ± 3.24	7.1 ± 0.8	63.27	40

*Sleep disordered breathing group was included (which is OSA with primary snoring) not only the obstructive sleep apnea group. BASC, Behavior Assessment System for Children; CBCL, Child Behavior Checklist; A&D, Anxiety and Depression subscale; CDI, Children's Depression Inventory; C-TRF, Caregiver Teacher Report Form; P, parent; P&T, parent and teacher scale; C-SR, child self-reporting; SD, standard deviation; BMI, body mass index.

and/or tonsils, the first line of treatment involves adenotonsillectomy (AT),[15] which might lead to significant decreases in depressive symptoms for those with OSA.

Using meta-analysis, we sought to examine (a) the strength of the relationship between depressive symptoms and OSA in children and adolescents, and (b) the effectiveness of AT on reducing depressive symptoms for children and adolescents with OSA.

METHODS

Study Selection

The PubMed/Medline, PsychInfo, Cochrane library, and Google Scholar data bases were searched using the terms "adenotonsillectomy," "sleep disordered breathing," "SDB," "obstructive sleep apnea," "OSA" and "depression," "depressive symptoms," "mood," crossed by "child," "children," and "adolescents." English-language studies through January 2013 were examined.

Inclusion and Exclusion Criteria

Selection of the articles was conducted by the first author (EY) and revised by the second (KS). Coded information included: sample size, age, gender, BMI, and study quality using the Newcastle-Ottawa scale.[16] Studies of patients up to age 18 years were included in the meta-analysis (0-18 years old; no study was included if the oldest individual was older than 18).

Although there are several proposed methods to diagnose OSA, the gold standard diagnostic test remains polysomnography (PSG).[17] Thus, in addressing our first question (i.e., the extent of a relationship between depressive symptoms and OSA), studies needed to include both PSG and a depression assessment measure in both the OSA and comparison groups. Twenty-two published studies were initially identified: 11 were excluded: 4 due to lack of the use of PSG to detect OSA (one lacked PSG in the control group[18]),[19-22] 4 for the absence of a depression measure,[23-26] 1 lacked a comparison group,[27] and 1 was excluded due to division of groups into snorers versus non-snorers, without assessing for OSA.[28] Eleven studies satisfied the inclusion criteria.[1,29-38] To avoid publication bias, our team searched for unpublished data including dissertations. Two unpublished dissertations were found; one was excluded due to the lack of a depression measure,[39] and the other for the lack of PSG.[40] Of the 11 included studies, 8 were dependent on the parent/caregiver to complete the forms, of which 4 also included teacher ratings of depressive symptoms. Three studies used child reports of depressive symptoms (see **Table 1**). Examining specific measures, 7 studies used the Child Behavior Checklist (CBCL), 2 of which also used the Teacher Report Form (TRF). Three other studies used the Children's Depression Inventory (CDI), and one used the Behavior Assessment Scale for Children (BASC).

In the second part of the study, we examined whether depressive symptoms improved following AT. The follow-ups were conducted between 1.5 and 6 months post-surgery. Seventeen articles were identified, of which 9 were included in the meta-analysis.[18,34,41-47] Of the 8 excluded studies, 2 were excluded due to lack of PSG,[48,49] one for the use of respiratory sinus arrhythmia rather than PSG,[50] and 5 due to lack of a depression measure.[51-55] In all 9 included studies, parents/caregivers were the source of children's depressive symptom ratings, with one also including teacher ratings. Four studies used the CBCL and 5 used the BASC.

Data Analysis

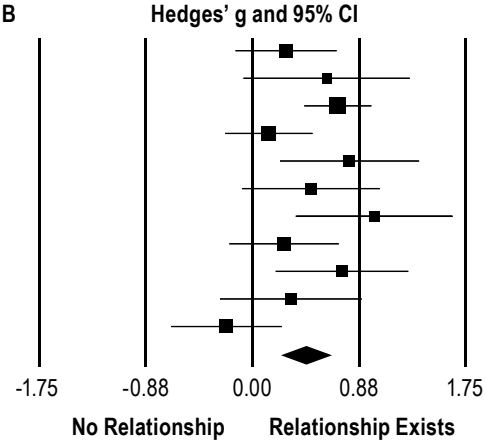
All statistics included mean values with their standard deviation (SD). Data were analyzed using the Comprehensive Meta-Analysis, version 2.0 (Biostat, Englewood, NJ) software program. ES was calculated using Hedges' g and a random effects model, as is appropriate when there is heterogeneity in methodology among analyzed studies. Depressive symptom scores were compared between OSA and comparison groups in the first part, while pre- and post-adenotonsillectomy depressive symptom levels were compared in the second part of the study.

RESULTS

In the first part of the study, 11 studies were included; a total of 894 children in the OSA group and 1,096 in the

Figure 1—The relationship between OSA and depression

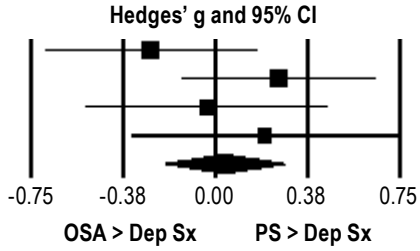
Study name	Statistics for each study					Sample size	
	Hedges' g	Variance	LL	UL	p-value	Group A	Group B
Beebe et al., 2010	0.27	0.05	-0.15	0.70	0.2054	100	37
Blunden et al., 2000*	0.61	0.12	-0.08	1.30	0.0855	16	16
Carotenuto et al.,2012*	0.70	0.02	0.41	0.98	0.0000	94	107
Kurnatowski et al., 2008	0.13	0.04	-0.23	0.50	0.4785	121	104
Crabtree et al., 2004	0.80	0.09	0.22	1.37	0.0072	62	31
Landau et al.,2012	0.48	0.09	-0.10	1.05	0.1022	68	36
Huang et al., 2006	1.00	0.11	0.35	1.65	0.0026	66	20
Rosen et al., 2012*	0.26	0.05	-0.20	0.72	0.2700	162	667
Bourke et al., 2011ExcludeWD	0.73	0.08	0.18	1.29	0.0093	42	35
Ting et al., 2011	0.31	0.09	-0.28	0.90	0.2967	128	10
O'Brien et al., 2004*	-0.21	0.06	-0.68	0.25	0.3658	35	35
	0.43	0.01	0.22	0.64	0.0001		



Group A represents the OSA group, while group B represents the depression group. *Groups having sleep disordered breathing (which is OSA with primary snoring) not only OSA. OSA, obstructive sleep apnea; LL, lower limit; UL, upper limit.

Figure 2—Difference in effect size between children with OSA and children with PS

Study name	Statistics for each study					Sample size	
	Hedges' g	Variance	LL	UL	p-value	OSA group	PS group
Beebe et al., 2010	-0.26	0.05	-0.69	0.17	0.23	100	26
Bourke et al., 2011	0.26	0.04	-0.14	0.65	0.21	42	57
Crabtree et al., 2004	-0.04	0.06	-0.53	0.46	0.89	31	31
Tripuraneni et al., 2012	0.20	0.08	-0.34	0.74	0.47	56	17
	0.04	0.02	-0.21	0.28	0.76	229	131



OSA group are patients diagnosed with OSA, while PS group are children with primary snoring. OSA, obstructive sleep apnea; PS, primary snoring; LL, lower limit; UL, upper limit; Dep Sx, depressive symptoms.

comparison group. After excluding one study in each group that did not report gender data, the overall percentage of males was 57.83% (447/773) in the OSA group and 47.98% (476/992) in the comparison group. The mean unweighted age for the 10 studies in the OSA group was 8.85 ± 2.63 years, compared to 8.92 ± 2.38 for the comparison group.

Question 1: Is there an elevated rate of depressive symptoms in children with OSA compared to those without?

A significant relationship between depressive symptoms and OSA was found. Hedges' g was 0.43 (95% CI = 0.22-0.64; p = 0.00005; see **Figure 1**), indicating a medium relationship.[56] Testing for heterogeneity, the *Q* value with 10 d.f. was 20.46, signifying mild heterogeneity across studies, while I^2 was 51.13, p = 0.03, indicating moderate inconsistency among studies. When excluding one study that included children previously diagnosed with attention deficit hyperactivity disorder,[34] the overall ES remained similar; 0.39 (95% CI = 0.18-0.60; p = 0.0002; see **Figure 1**). Testing for heterogeneity, the *Q* value with 9 d.f. was 17.39, again signifying mild heterogeneity across studies, while I^2 was 48.24, p = 0.04. In addition, Kendall's tau = 0.05; this suggests that the standard errors of the means and the effect sizes were independent, indicating that there was not significant publication bias. To examine the ES of depressive symptoms separately in children with OSA versus those with primary snoring (PS), 4 studies were identified that included both OSA and primary snoring groups.[29,32,37,57] While 3 of these studies used as criteria the presence of snoring and an AHI < 1 to diagnose PS, Crabtree and colleagues used a criteria of "mild OSA" for their snoring group. A nonsignificant ES was found in comparing children with OSA to those with PS (Hedges' g = 0.04, p = 0.76, **Figure 2**), indicating that depressive symptoms are similarly elevated among children with PS as well as OSA. This was consistent after including only the 3 studies that satisfied the strict criteria of PS (Hedges' g = 0.06, p = 0.73).

While the relatively small number of studies limited our ability to identify significant moderators of the relation between depressive symptoms and OSA, we did explore several potential moderators using the mean weighted ESs. Gender was found to be a significant moderator as studies having a higher percentage of males had higher ESs (beta = 0.66, p = 0.03). Thus, the relationship between depressive symptoms and OSA appears to be stronger for boys than for girls. None of the other potential moderators were significant: average group age

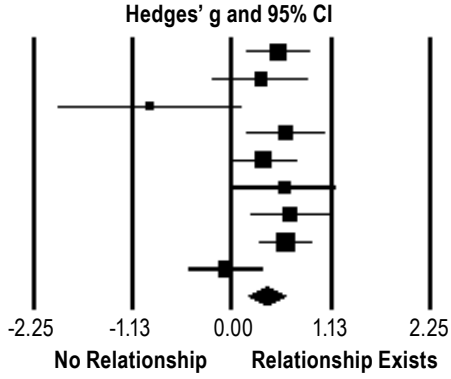
Table 2—Demographic information of the clinical group undergoing adenotonsillectomy (AT) pre- and post-surgery

Study Name	Scale Used	Rater	# Clinical Subjects	AHI Before AT	Mean/SD Age Clinical Group	Male Percentage	BMI Clinical	AHI Cutoff	Post-AT Duration	Post-AT AHI
Galland et al., 2006	CBCL (D&W)	P only	61	3.0 ± 2.60	7.0 ± 2.0 (4-11)	57.38 (35/61)	18.1 ± 4.0	1.5	3 months	
Huang et al., 2007	CBCL	P&T	25	3.32 ± 1.11	8.08 ± 1.28	92 (23/25)	18.51 ± 1.28	1-5		
Lewin et al, 2002	CBCL (A&D)	P only	28	9.51 ± 5.50	7.17	50 (14/28)	18.44 ± 4.8	0.5	6-18 months	
Li et al., 2006	BASC (A&D)	P only	40	10.6 ± 11.1	8.4 ± 1.6	90 (36/40)	18.6 ± 4.2	1	6 months	1.7 ± 2.1
Mitchell et al., 2005	BASC (D&W)	P only	52	16.2 (5.0-88)	7.1 (2.5-14.9)	55.77 (29/52)		5	6 months	
Mitchell et al., 2006	BASC (D)	P only	23	14.1 (5.2-88.0)	7.2 (2.5-14.8)	65 (15/23)		5	6 months	
Mitchell et al., 2007	BASC (D)	P only	40	15.87 (1.7-48)	7.07 (3.1-14.9)	55 (22/40)	22.58 (12-46)	1	6 months	
Mitchell et al., 2009	BASC (D)	P only	89	16.30 (3.0-88.0)	7.78	60.67 (54/89)	20.39	2	3-6 months	4.67
Tran et al., 2005	CBCL (A&D&W)	P only	42		5.8 ± 2.5 (2-11.5)	59.52 (25/42)		5	3 months	

All values are in standard deviation (SD) values; BASC, Behavior Assessment System for children; CBCL, Child Behavior Checklist; P, parent; P&T, parent and teacher; A&D, anxiety and depression subscale; D&W, depression and withdrawal; SD, standard deviation; BMI, body mass index; AHI, apnea-hypopnea index.

Figure 3—Pre- and post-adenotonsillectomy depression/anxiety

Study name	Statistics for each study: Hedges' g	Variance	LL	UL	p-value	Sample size
Galland et al., 2006	0.53	0.03	0.17	0.89	0.0038	61
Huang et al., 2007	0.33	0.08	-0.22	0.88	0.2377	25
Lewin et al, 2002	-0.94	0.28	-1.98	0.10	0.0771	7
Li et al., 2006	0.62	0.05	0.17	1.06	0.0066	40
Mitchell et al., 2005	0.36	0.04	-0.03	0.74	0.0673	52
Mitchell et al., 2006	0.60	0.09	0.02	1.19	0.0415	23
Mitchell et al., 2007	0.67	0.05	0.22	1.12	0.0033	40
Mitchell et al., 2009	0.61	0.02	0.31	0.91	0.0001	89
Tran et al., 2005	-0.07	0.05	-0.50	0.35	0.7380	42
	0.41	0.01	0.20	0.62	0.0002	379



LL, lower limit; UL, upper limit.

(beta = 0.07, p = 0.83), BMI (beta = -0.31, p = 0.43), or study quality (beta = 0.47; p = 0.13).

Question 2: Do depressive symptoms decrease following adenotonsillectomy?

In the second part of the study, 379 children across nine studies were assessed for depressive symptoms both pre- and post-surgery. Demographics of this group are presented in **Table 2**. The overall ES change between pre- versus post-surgery was 0.41 (95% CI = 0.20-0.62; p ≤ 0.001; see **Figure 3**), indicating a medium improvement[56] occurred in depressive symptoms after AT. Testing for heterogeneity, the *Q* value with 8 d.f. was 16.11, again signifying mild heterogeneity across studies, while I^2 was 50.34, p = 0.04, indicating moderate inconsistencies between studies. Of the 9 studies, 7 studies found ESs greater in the post-AT period compared to pre-surgery (ES = 0.54; p ≤ 0.001). One study found a negative effect size (ES = -0.94, 99% CI = -1.98-0.10; p = 0.08), while another found essentially no improvement following surgery (ES = -0.07; **Figure 3**). Of note, the largest ESs tended to be observed in studies that did not have a comparison group. Among the 3 studies that did have a comparison group, one showed mild improvement in the AT group compared to controls, the second showed no change, while the third showed worsening of symptoms after AT.

DISCUSSION AND CONCLUSION

This study found a medium relation between depressive symptoms in children with OSA, with an ES of 0.45. This relationship was moderated by gender, as males showed a stronger relationship between depressive symptoms and OSA. In addition, children were found to exhibit fewer depressive symptoms after AT compared to pre-surgery, with an ES of 0.41. In the TuCASA study, 63 children suffering from RDI in the

higher 15% were compared to 340 children suffering from the other 85% gradient.[58] Higher anxious/depressed values were observed as assessed by CBCL in children suffering the severe form of OSA (55.3 ± 7.9 vs 54.4 ± 7.7), with an ES of 0.12 and variance = 0.02.

The underlying etiological mechanisms for the relationship between depressive symptoms and OSA remains poorly understood, although there are several possible explanations. OSA is associated with blood oxygen desaturation, which may cause micro-awakenings at night, decrease the slow wave stage, and cause restless sleep, thus leading to daytime fatigue and depressive symptoms.[59,60] Hypoxia from desaturation might also lead to structural changes in the brain that in turn lead to depressive symptoms.[61] In one study, lower blood oxygen desaturation gradients correlated with more profound depressive symptoms among patients with OSA.[62] It is also possible that hormonal changes associated with OSA can lead to depressive symptoms. For example, among children with metabolic syndrome, those with OSA were found to exhibit higher leptin levels than those without OSA, suggesting leptin insensitivity in this population (i.e., with leptin insensitivity and relatively lower levels, this leads to increased appetite and weight gain).[63] Given that leptin is involved in regulating food intake, leptin insensitivity may lead to obesity. Due to low self-esteem associated with body image and obesity, children and adolescents (especially females) might develop depression.[64] Leptin levels normalized after 3 months of continuous positive airway pressure (CPAP).

Alternatively, obesity may contribute to both depressive symptoms and OSA. Obesity is a risk factor for both OSA[10] and depression, although the effect of obesity on depression may be greater among adults.[65] Obese children are often bullied and can have associated decreased mobility, thus, presenting with higher levels of internalizing symptoms secondary to their appearance (each of which can lead to the other).[66,67] More severe OSA was found among obese children than normal-weight children with OSA and those with PS.[57,68] Depressive symptoms were also significantly higher in the obese group than the other 2 groups. Likewise, obese patients can have fat deposition around the neck, hypotonia of airway muscles, and limited lung volumes leading to OSA,[10] so it is possible that the associations between depressive symptoms and obesity with OSA may be caused by distinct mechanisms.

The effect of depression leading to obesity and worsening OSA has also been reported. Some depressed children have a higher tendency to overeat, have less energy leading to a sedentary lifestyle, and are socially isolated, possibly leading to weight gain and worsening of OSA.[69] In addition, OSA has been linked to low serotonin levels, which is associated with depression, to sleep cycle irregularity, a known risk factor for depression, and to upper airway tone dyscontrol, also a risk factor for OSA.[61]

We found the relation between depressive symptoms and OSA to be greatest in studies with a higher proportion of males. The incidence of both OSA and depression occur equally in preschool children.[70] However a higher incidence of depression in females is observed in the post-pubertal period compared to males. OSA, on the other hand, occurs at a higher prevalence and more severe level in males than females after puberty, possibly suggesting a role of anthropometric face bony structure and female hormones as a protective factor to OSA.[71] Usually males have coarse bony structures with possibly narrower airway. A dramatic increase in OSA risk occurs in postmenopausal women; this risk was decreased with hormone replacement therapy.[71] Of note, some research has found obesity to be more strongly associated with depression in males than females during adolescence.[72] This raises the possibility that while the BMI itself did not predict the ES between depressive symptoms and OSA in the current study, obesity and gender may interact such that obese boys with OSA are at greatest risk for increased depressive symptoms. Of note, however, most studies had similar proportions of males and females with the exception of Huang et al., who had a high proportion of males and a high ES. Thus, given that the significant moderator effect of gender on the relation between depressive symptoms and OSA was largely due to this one study, replication of this finding is needed.

Adenotonsillectomy, the main treatment for OSA in children, was associated with decreased depressive symptoms compared to pre-surgery levels. The effect size was fairly consistent across studies, with the exception of a large negative effect size found in one study of only 7 patients.[18] Also of note, the ESs appeared to be lower among the 3 that had a comparison group, raising the possibility that some of the observed decrease in depressive symptoms could be related to regression to the mean or due to the effects of administering a measure of depressive symptoms over multiple time points,[73] highlighting the need for future studies to include comparison groups of children who did not receive adenotonsillectomy. Although the exact mechanism for this improvement is unclear, improved oxygenation and nighttime sleep might explain children's improvement in depressive symptoms. It is not clear if hormonal normalization (e.g., leptin) might contribute to long-term improvements in children's depressive symptoms. However, weight gain is not an uncommon outcome post-AT surgery in the short term (i.e., within a 6-month period).[74] Accordingly, it is possible that such weight gain (usually a change of more than 10%-15% of the baseline weight) would actually contribute to the worsening of OSA and depression in the post-surgery period. It remains unclear whether this weight gain would contribute to the worsening of OSA and relapse and/or worsening of the depressive symptoms later on. Of importance to note, although AT improves the severity of the OSA in most children, it might not cure it in many cases, necessitating reevaluation of possible residual OSA.[75] Another treatment option in this population is continuous positive airway pressure (CPAP). Although there are limited studies relating CPAP to depressive symptoms in children, controversies exists in adults. In a study involving 51 patients with OSA treated with CPAP, depressive and anxiety symptoms decreased after 1 and 3 months of treatment.[76] However, in a double-blind, placebo control study, CPAP treatment dramatically decreased AHI but had no effect on depressed mood.[77] A limitation of these studies included small sample sizes and assessment of depression shortly after treatment duration possibly affecting the outcome.

Finally, OSA in children and in adults has been associated with poor concentration and negative effects on behavior and mood.[78,79] A recent meta-analysis[80] found a slightly greater

relation between sleep disordered breathing and attention deficit hyperactivity disorder symptoms (Hedges' g = 0.57) than was found between OSA and depressive symptoms in the current meta-analysis, indicating that OSA may be related to a variety of psychiatric symptoms. As such, this highlights the importance of screening for emotional and behavioral adjustment among children with OSA.

Several limitations to this study exist. First, several studies included children with PS in the OSA group, possibly lowering the ES for the relationship between depressive symptoms and OSA.[1,30,35,36,81] However, when the 4 studies including children with PS were compared to OSA children as measured by depressive symptoms, the ES was almost zero (Hedges' g = 0.04, p = 0.76),[29,32,37,57] indicating that the inclusion of children with PS likely did not lower the strength of relationship between OSA and depressive symptoms. This was maintained when incorporating only the 3 studies that used the strict criteria for PS. Second, all of the included studies used either the BASC or CBCL depression scales, which are not necessarily the most comprehensive measures of depressive symptoms in children. The CBCL "anxious/depressed" subscale, for example, includes anxiety as well as depressive symptoms. Moreover, studies of depressive symptoms and OSA have largely relied on parent ratings of depressive symptoms, but self-reports may be more valid for depressive symptom assessment, particularly among adolescents.[82] Some depression scales might have better validity than those previously used in this literature. For example, the Center for Epidemiological Studies Depression Scale for Children (CES-DC)[83] and the Beck Depression Inventory for adolescents might be preferred.[84] On a related note, none of the included studies used a diagnostic interview, which would be the best measure of a diagnosis of depression.[85] Inclusion of a diagnostic interview that included the assessment of other psychiatric problems (e.g., anxiety and disruptive behavior disorders) that may be comorbid to depression[86] would be helpful to both assess the relation of OSA to clinical depression as well as the extent to which OSA is specific to depression versus other psychiatric problems. A recent meta-analysis, for example, found SDB to have a similar, medium relation to ADHD symptoms as the current meta-analysis found for depressive symptoms.[78] Third, the relatively modest number of studies included in the current meta-analysis limits our ability to identify moderators of the relationship between depressive symptoms and OSA. Finally, the definition of OSA varied across studies as some used 1/h as the cutoff, while others used 5/hour. This might suggest that children with milder forms of OSA (AHI between 1-5/h) have the strongest relationship to depressive symptoms. Thus, using a cutoff of AHI of 5/h or more might bias the relationship outcome.

Overall, the current study indicates that there is a medium relationship between depressive symptoms and OSA among children and adolescents. Treatment of depression includes primarily psychotherapy in mild to moderate cases, while psychopharmacological agents (e.g., antidepressant medications) can be used in more severe or therapy unresponsive cases.[87] However, medication side effects, especially the debated risk of elevated rates of suicide in child populations, may limit the viability of medication as a treatment option.[87] This meta-analysis suggests that depressive symptoms might improve in children having comorbid OSA, without the need for directly treating the depressive symptoms.

This meta-analysis also highlights the importance of screening for depressive symptoms in children presenting with OSA. Yet, well-controlled research is needed. Ideally, children from multiple clinics should be involved, with standardization of diagnostic criteria for OSA and exclusion of those with PS, given that the relationship with PS and depressive symptoms are not well delineated. Close monitoring of the AHI, as well as depressive symptoms before and after AT, and comparison of depressive symptoms in those with cured OSA versus those with residual symptoms will address more accurately whether a decrease in depressive symptoms directly coincides with a decrease in OSA. Despite the need for more research, this meta-analysis suggests that treating OSA may improve children's depressive symptoms, possibly avoiding the need for psychopharmacological treatment.

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