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Research Article

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Scholastic and Cognitive Achievement Following Adenotonsillectomy in Children with Obstructive Sleep Apnea

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Abstract

Objective: *To evaluate the effect of adenotonsillectomy (AT), in children with Obstructive Sleep Apnea (OSA), on the cognitive and scholastic achievement.*

Study Design: *Prospective study*

Sitting: *Tertiary care hospital (Minia university hospital)*

Subjects and Methods: *50 children were selected, complaining of symptoms of (OSA) and seeking adenotonsillectomy compared to another control group of 50 children without symptoms of OSA. The study sample were subjected to clinical evaluation where hypertrophied palatine tonsils and Adenoid were the cause of OSA. Polysomnography, audiological evaluation were done and All 50 children underwent a battery of neurocognitive tests including process-oriented intelligence scales (Stanford Binet Intelligence scale and Illinois Test of psycholinguistic ability) pre and post adenotonsillectomy to reveal the effect of (AT) on the cognitive and scholastic achievement of those children.*

Results: *Children with OSA had lower scores in neurocognitive tests (Illinois test and Stanford Binet intelligent scale), as well as. In Academic performance in comparison to the control group. After 8 months from AT, the children with OSA demonstrated highly significant improvement in IQ, Mental age, auditory perceptual assessment (APA), PLA of VSM (Visual sequential memory), AA (Auditory association) VA (Visual association), AC (Auditory closure), VC (Visual closure), GC (Grammatic closure) and SB (Sound Blending).*

Conclusions: *School performance and Neurocognitive functions are worsened in children with Adenotonsillar hypertrophy, this effect is reversible as improvement occurred after their removal.*

Keywords: OSA, Cognitive Disorders, Adenotonsillectomy.

Introduction

Obstructive sleep apnea (OSA) in children is a disorder characterized by repeated and/or prolonged airway obstructions during sleep, in the form of apneas and hypopneas throughout the night [1]. The peak incidence for pediatric OSA is during early childhood [2]. In particular, the period between 2 and 8 years of age [3]. In children, OSA affects 1 to 3% of the population and appears to affect males and females equally [4]. The most commonly cause for the childhood obstructive sleep apnea syndrome is adenotonsillar hypertrophy. Thus, the primary treatment is adenotonsillectomy, which accounts for more than 500,000 procedures annually in the United States alone [5]. OSA is known as sleep-disordered breathing (SDB). This spectrum ranges in severity from OSA to upper airway resistance syndrome (UARS) to habitual primary snoring. As OSA affects an estimated 1 to 3% of the pediatric population [6]. It has been associated with many of psychological problems, of which neurocognitive and depression, difficulties particularly in memory, attention, learning and executive function, are the most widely reported. The neurocognitive impairment seen in OSA is due to the adverse effects of sleep fragmentation and/or intermittent hypoxia [7]. Some studies have extensively documented the presence of significantly reduced IQ scores compared with control children [8]. School problems have been reported in studies of children with OSA, and such findings may underscore more extensive behavioral disturbances such as restlessness, aggressive behavior, excessive daytime sleepiness and poor test performances [9]. While Marcus et al. stated that the surgical treatment for the OSA in school-age children did not significantly improve attention or executive function as measured by neuropsychological testing but did reduce symptoms and improve secondary outcomes of behavior, quality of life, and polysomnographic findings, thus providing evidence of beneficial effects of early adenotonsillectomy [10].

The purpose of the present study is to evaluate the effect of adenotonsillectomy (AT) on the scholastic and cognitive achievement of children with Obstructive Sleep Apnea (OSA) in order to establish a plan for proper management of those children.

Subjects and Methods

Subjects

The current study is a prospective one that done at the Department of Otorhinolaryngology from October 2016 to July 2019. It was approved by the Research ethics committee of the Faculty of Medicine, Minia university and signed informed consent was obtained from parents/ guardian of the children. One hundred Fifty children suffering from recurrent attacks of tonsillitis with or without chronic nasal obstruction were selected as pool for the present study. They were 73 males (48 %) and 77females (52%), with a mean age 101.5±15.6 of and a range of (72-120) months.

Methods: All one hundred fifty children were subjected to the following protocol to classify the study and control groups

1-Personal history was obtained from parents/ Guardian of the children, with special attention to sleep history including snoring.

2-Auditory perceptual assessment (APA) of speech (degree of closed nasality). The speech of each case were assessed from two expert phoniatricians for the degree of closed nasality (From I to IV) after recording of the patient's speech for a nasal sentence (Mama betniim manal).

3- (ENT) Examination: Oral and oropharyngeal examination (lips, teeth, tongue, hard and soft palates, uvula, tonsillar pillars, tonsils, lateral and posterior pharyngeal walls) was examined with a tongue blade and a good light. Then tonsillar hypertrophied were graded by Brodsky scale (From zero to 4) [5]. Examination of the nasopharynx through nasopharyngoscopy, for evaluation of the velopharyngeal area (velar mobility, lateral pharyngeal wall mobility, presence of adenoid and degree of narrowing the air column, type of closure, presence or absence of passivent's ridge).

4- PSG was performed using a digital polygraph system (Grass-Tele factor Twin version 2.6; Astro-Med Inc., West Warwick, RI, USA). The data were manually scored according to the American Academy of Sleep Medicine, Version 2.0 Berry et al., [11]. Polysomnography (PSG) study using standard clinical pediatric techniques and a commercially available sleep system for diagnosis of OSA. The current gold standard for the diagnosis of OSA, as recommended by the American Academy of Pediatrics (AAP), is a PSG study. Polysomnographic diagnostic criteria for OSA depends on the following parameters Apnea-Hypoapnea index (AHI) (represents the average number of obstructive or partially obstructive events per hour of sleep and considered abnormal if greater than 1 in children), a minimum oxygen saturation (less than 92 percent (average: 96 percent ± 2 percent) is considered abnormal in children). According to the inclusion criteria in table-2 we classified the patient to study group and control group.

We selected one hundred patients, fifty children as study group with OSA that documented by PSG and fifty child suffer from chronic tonsillitis without OSA as a control group. Both groups were subjected to protocol of evaluation the psycholinguistic abilities and IQ preoperatively as follow:

1-Parents interview and history including complaint, personal data, personal history, in addition to the clinical findings of prolonged upper airway obstructive symptoms, including OSA (recur¬rent episodes of apnea and hypopnea, secondary to collapse of the upper airways during sleep), snor¬ing, mouth breathing, adenoid fancies, enuresis, and restlessness during sleep (if accompanied by snoring at night). History of arousal or awakening, and distrust sleep continuity.

2-Auditory perceptual assessment of speech (degree of closed nasality). The speech of each case were assessed from two experts for the degree of closed nasality after recording of the patient's speech for a nasal sentence.

3-Audiological evaluation included middle ear assessment through immitancemetry (Tympanometry and Acoustic Reflex threshold recording) and hearing assessment. According to the age of child. Hearing assessment was performed through one of the following methods: Free field Audiometry and Behavioral Observational Audiomety (BOA). Pure tone audiometry (Conditioned play or conventional audiometry).

4-Psychometric evaluation by Intelligence Quotient "IQ" using Stanford Binet Intelligence Scale (4th edition). The Stanford-Binet scale tests intelligence across four areas: verbal reasoning, quantitative reasoning, abstract /visual reasoning, and short-term memory. The areas are covered by 15 subtests. Raw scores were based on the number of items answered, and were converted into a standard age score corresponding to age group. Mental age was determined for each child: I.Q = Mental age chronological age ×100 Gary [12].

5-Illinois test of psycholinguistic abilities (ITPA):
It is an individually administered battery of tests designed to measure the spoken and written language abilities of children aged 5-12. It may be used for determining specific strengths and weakness among language abilities, for early identification of children at-risk for school failure. It consists of twelve subtests Adel Aziz A et al., [12].

6-Percentage of the child's scores of his subjects (Academic performance) in two academic terms, which were obtained from academic reports taken from the school.

All patients (study and control groups) underwent Adenotonsillectomy (AT) under general Anaesthesia. Then Finally after eight months of adenotonsillectomy all the patients were followed by:

- APA of speech.
- IQ test and mental age.
- Tympanogram
- Ilinois test.
- Academic performance of the child

The data was collected from every battery of evaluation and subjected to I.B.M. compatible computer using software SPSS (Statistical Package for social science) for windows version 13 for statistical evaluation. Graphics were done by Excel. Quantitative data were presented by mean and standard deviation, while qualitative data were presented by frequency distribution. Wilcoxon signed-rank test for ordinal qualitative data between the two times: Significant level at P-value < 0.05. Paired samples T-test for parametric quantitative data between the two times: Significant level at P-value < 0.05. Pearson's correlation: Significant level at P-value < 0.05. Spearman's rho correlation. Significant level at P-value < 0.05 P-value was considered statistically significant (S) if <0.05 and highly significant (HS), if <0.001 and no significant (NS) if >0.05.

Results

The study group had Age range between (7-10 years) and mean 8.8±14.6. They were 29 males and 21 females. All patients in study group suffer from Moderate to severe closed nasality according to auditory perceptual assessment, Grade III to IV with tonsillar hypertrophied as measured by Brodsky scale, positive signs of Adenoid faces, Symptoms of OSA, the adenoid occupied 50-100 % of the choanal area. PSG of the study group revealed that Apnea-Hypopnea index (AHI) > 1 and oxygen saturation less than 92 percent. The control group (children without OSA) included 50 children, they have mild closed nasality according to auditory perceptual assessment, Grade 0 to I of tonsillar hypertrophied with by Brodsky scale, negative signs of Adenoid faces, no Symptoms of OSA, the adenoid occupied less than 25 % choanal area and with the PSG the had Apnea-Hypopnea index (AHI) <1 and oxygen saturation more than ≥ 96 percent. The age of control group between (7-9 years) and mean 7.9±14.6. They were 26 males and 24 females (Table 1 & 2).

Table (1): Distribution of age and sex of study and control group.

		Study(50)	Control (50)	P value
Age	Range	(7-10 years)	(7-9 years)	0.1
	Mean ± SD	8.8±14.6	7.9±14.6	
Sex	Male	29(58%)	26(52%)	0.3
	Female	21(42%)	24(48%)	

Non- significant (p>0.05), significant (p<0.05), -highly significant (p<0.001).

Table (2): Distribution of both group according to APA, Brodsky grade Tonsils enlargement and adenoid faces and PSG.

		Study(50)	Control (50)	P value
APA	No Closed	0(0%)	23(46%)	<0.001*
	Mild	0(0%)	27(54%)	
	Moderate	32(64%)	0(0%)	
	Severe	18(36%)	0(0%)	
Brodsky grade of tonsils	0	0	28	<0.001*
	I	0	22	
	II	0	0	
	III	32	0	
	IV	18	0	
Adenoid faces	Positive	50	0	<0.001*
	negative	0	50	
Endoscopic grading of adenoid.	occupied more than 50-100 % choanal area	50	0	<0.001*
	occupied less than 25 % of the choanal area	0	50	
PSG:AHI	> 1	50	0	<0.001*
	<1	0	50	
PSG:O2 saturation	< 92	50	0	<0.001*
	≥ 96	0	50	

Non- significant (p>0.05), significant (p<0.05), -highly significant (p<0.001).

Preoperative assessment of both groups regarding psycholinguistic abilities, Academic performance, and middle ear function. The results revealed a highly statistically significant difference were obtained between the two groups as study group showed marked closed nasality (Table-3), also symptoms of OSA were more apparent in the study group compared to control group (Table-4). Also, we found 30% of the children in the study group had type B tympanogram in comparison to 6% in the control group (Table-5). The children in the study group had low IQ and low mental age in comparison to the control group (Table-6). The children in the study group had low score in all subtest of Illinois test of psycholinguistic abilities (Table-7) and had low percentile of academic performance in comparison to the control group (Table-8).

Table (3): preoperative and postoperative Comparison between the study and control group regards to APA.

APA		Study N=50	control N=50	P value
Preoperative	No Closed	0(0%)	23(46%)	<0.001*
	Mild	0(0%)	27(54%)	
	Moderate	32(64%)	0(0%)	
	Severe	18(36%)	0(0%)	
Postoperative	No Closed	22(44%)	23(46%)	0.08
	Mild	26(52%)	27(54%)	
	Moderate	2(4%)	0(0%)	
	Severe	0(0%)	0(0%)	

Non- significant (p>0.05), significant (p<0.05), -highly significant (p<0.001).

Table (4): Comparison between study and control group regards to symptoms of OSA.

Symptoms of OSA		Study N=50	control N=50	P value
Snoring	Yes	50(100%)	5(10%)	<0.001*
	No	0(0%)	45(90%)	
Mouth Breathing	Yes	50(100%)	3(6%)	<0.001*
	No	0(0%)	47(94%)	
Nasal Obstruction	Yes	50(100%)	8(16%)	<0.001*
	No	0(0%)	42(84%)	
Excessive Daytime Somnolence	Yes	30(60%)	7(14%)	<0.001*
	No	20(40)	43(86%)	
Nighttime Awakening	Yes	40(80%)	5(10%)	<0.001*
	No	10(20)	45(90%)	

Non- significant (p>0.05), significant (p<0.05), -highly significant (p<0.001).

Table (5): preoperative and postoperative Comparison between the study and control group regards to tympanogram.

Tympanogram		Study N=50	control N=50	P value
Preoperative	Type A	16(32%)	40(80%)	<0.001*
	Type B	15(50%)	3(6%)	
	Type C	19(38%)	7(14%)	
Postoperative	Type A	43(86%)	46(92%)	0.9
	Type B	4(8%)	2(4%)	
	Type C	3(6%)	2(4%)	

Non- significant (p>0.05), significant (p<0.05), -highly significant (p<0.001).

Table (6): preoperative and postoperative Comparison between the study and control group regards to the IQ and mental age.

Preoperative		study N=50	control N=50	P value
IQ	Range	(70-91)	(78-99)	<0.001*
	Mean ± SD	80.9±5.9	89.1±4.3	
Mental age (months)	Range	(54-132)	(68-121)	<0.001*
	Mean ± SD	87.3±20.1	95.9±22-3	

Non- significant (p>0.05), significant (p<0.05), -highly significant (p<0.001).

Table (7): preoperative Comparison between study and control state in the study group as regard the psycholinguistic age (PLA) of Illinois test.

		study N=50	control N=50	P value
PLA of AR	Range	(40-106)	(51-119)	<0.001*
	Mean ± SD	68.9±14.5	79.8±16.5	
PLA of VR	Range	(37-126)	(53-131)	0.008*
	Mean ± SD	81.5±23	92.8±21.5	
PLA of ASM	Range	(45-124)	(55-136)	<0.001*
	Mean ± SD	72±19.8	87.3±18.8	
PLA of VSM	Range	(37-123)	(60-138)	<0.001*
	Mean ± SD	67.9±16.8	81.1±28.4	
PLA of AA	Range	(43-124)	(49-139)	<0.001*
	Mean ± SD	71.3±21	86.5±11.4	
PLA of VA	Range	(37-124)	(48-139)	<0.001*
	Mean ± SD	76.9±18.6	86.6±22.3	
PLA of AC	Range	(36-126)	(41-137)	<0.001*
	Mean ± SD	59.5±22.2	71.5±31.6	
PLA of VC	Range	(37-122)	(49-138)	<0.001*
	Mean ± SD	64.2±18.4	78.5±25.1	
PLA of ME	Range	(36-123)	(44-1382)	<0.032*
	Mean ± SD	57.2±17.6	69.1±10.6	
PLA of VE	Range	(39-94)	(51-132)	<0.002*
	Mean ± SD	57.4±13	71.8±19.3	
PLA of GC	Range	(34-96)	(55-138)	<0.001*
	Mean ± SD	55.7±13.7	69.3±21.2	
PLA of SB	Range	(38-97)	(48-132)	<0.001*
	Mean ± SD	62.3±11.2	77±14.5	
Total PLA	Range	(50-98)	(53-112)	<0.001*
	Mean ± SD	72.6±12.1	93.1±12	

Non- significant (p>0.05), significant (p<0.05), -highly significant (p<0.001).

Table (8): preoperative Comparison between the study and control group regards to Academic performance.

Academic performance		study	control	P value
		N=50	N=50	
Preoperative	Range	(46-94)	(52-99)	<0.001*
	Mean ± SD	66.6±12.1	86.3±77	

Non- significant (p>0.05), significant (p<0.05), -highly significant (p<0.001).

After eight months of adenotonsillectomy, the children in the study group had improvement in nasal tone of speech as 2% only has marked closed nasality (Table-9) and most symptoms of OSA disappeared (Table-10), only 8% had type B tympanogram (Table-11). The results revealed no statistically significant difference were obtained between the two groups regarding the mental age, IQ (Table-12), as well as subtest of Illinois test of psycholinguistic abilities (Table-13). Also, our data showed improvement in percentile of academic performances of the study group in comparison to the control group (Table-14).

Table (9): Comparison between preoperative and postoperative state of the study group regards to APA.

APA	Preoperative	Postoperative	P value
	N=50	N=50	
No Closed	0(0%)	22(44%)	<0.001*
Mild	0(0%)	26(52%)	
Moderate	32(64%)	2(4%)	
Severe	18(36%)	0(0%)	

Non- significant (p>0.05), significant (p<0.05), -highly significant (p<0.001).

Table (10): Comparison between preoperative and postoperative state of the study group regards to symptoms of OSA.

Symptoms of OSA		Preoperative	Postoperative	P value
		N=50	N=50	
Snoring	Yes	50(100%)	50(100%)	<0.001*
	No	0(0%)	0(0%)	
Mouth Breathing	Yes	50(100%)	3(6%)	<0.001*
	No	0(0%)	47(94%)	
Nasal Obstruction	Yes	50(100%)	8(16%)	<0.001*
	No	0(0%)	42(84%)	
Excessive Daytime Somnolence	Yes	30(60%)	7(14%)	<0.001*
	No	20(40)	43(86%)	
Nighttime Awakening	Yes	40(80%)	5(10%)	<0.001*
	No	10(20)	45(90%)	

Non- significant (p>0.05), significant (p<0.05), -highly significant (p<0.001).

Table (11): Comparison between preoperative and postoperative state of the study group regards to tympanogram.

Tympanogram	Preoperative	Postoperative	P value
	N=50	N=50	
Type A	16(32%)	43(86%)	<0.001*
Type B	15(50%)	4(8%)	
Type C	19(38%)	3(6%)	

Non- significant (p>0.05), significant (p<0.05), -highly significant (p<0.001).

Table (12): postoperative Comparison between the study and control group regards to the IQ and mental age.

Postoperative		study	control	P value
		N=50	N=50	
IQ	Range	(78-95)	(78-99)	0.72
	Mean ± SD	84.1±5.6	89.1±4.3	
Mental age (Months)	Range	(61-133)	68-121)	0.6
	Mean ± SD	94.9±19.6	95.9±22-3	

Non- significant (p>0.05), significant (p<0.05), -highly significant (p<0.001).

Table (13):post operative Comparison between study and control state in the study group as regard the psycholinguistic age (PLA) of Illinois test.

psycholinguistic age (PLA)		study	control	P value
		N=50	N=50	
PLA of AR	Range	(47-118)	(51-119)	0.4
	Mean ± SD	77.8±16.5	79.8±16.5	
PLA of VR	Range	(49-132)	(53-131)	0.083
	Mean ± SD	90.8±22.5	92.8±21.5	
PLA of ASM	Range	(51-138)	(55-136)	0.09
	Mean ± SD	85.3±20.6	87.3±18.8	
PLA of VSM	Range	(58-135)	(60-138)	0.63
	Mean ± SD	75.1±18.5	81.1±28.4	
PLA of AA	Range	(48-138)	(49-139)	0.43
	Mean ± SD	80.5±21.8	86.5±11.4	
PLA of VA	Range	(43-132)	(48-139)	0.073
	Mean ± SD	82.6±19.6	86.6±22.3	
PLA of AC	Range	(43-138)	(41-137)	0.5
	Mean ± SD	68.5±25.2	71.5±31.6	
PLA of VC	Range	(44-133)	(49-138)	0.064
	Mean ± SD	71.5±20.9	78.5±25.1	
PLA of ME	Range	(36-132)	(44-1382)	0.77
	Mean ± SD	63.1±20.7	69.1±10.6	
PLA of VE	Range	(40-124)	(51-132)	0.8
	Mean ± SD	64.8±17.3	71.8±19.3	
PLA of GC	Range	(48-144)	(55-138)	0.93
	Mean ± SD	66.3±21.2	69.3±21.2	
PLA of SB	Range	(46-127)	(48-132)	0.66
	Mean ± SD	72±15.5	77±14.5	
Total PLA	Range	(50-98)	(53-112)	0.8
	Mean ± SD	83.1±12	93.1±12	

Non- significant (p>0.05), significant (p<0.05), -highly significant (p<0.001).

Table (14): postoperative Comparison between the study and control group regards to Academic performance.

Academic performance		study	control	P value
		N=50	N=50	
Postoperative	Range	(50-98)	(52-99)	0.8
	Mean ± SD	83.1±12	86.3±77	

Non- significant (p>0.05), significant (p<0.05), -highly significant (p<0.001).

Statistical highly significant differences were obtained between preoperative and postoperative results of the children in the study group as regards the PLA of AR (auditory reception), VR (visual reception), (auditory sequential memory), VE (Visual Expression), ME (Mental Expression), (p<0.05). Statistical highly significant differences were obtained between the preoperative and postoperative examination of the study group as regard the PLA of VSM (Visual sequential memory), AA (Auditory association) VA (Visual association), AC (Auditory closure), VC (Visual closure), GC (Grammatical closure) and SB (Sound Blending) (p<0.001). Statistical highly significant differences were obtained between the preoperative and postoperative examination of the study group as regards the Total PLA. (p<0.001). The mean Total PLA in the preoperative examination of the study group were 72.6±12.1 with a range (50-98) months, and the mean Total PLA in the postoperative examination of the study group were 83.1±12 with a range (50-98) months (Table-15).

Table (15): Comparison between preoperative and postoperative state in the study group as regard the psycholinguistic age (PLA) of Illinois test.

psycholinguistic age (PLA)		Preoperative	Postoperative	P value
		N=50	N=50	
PLA of AR	Range	(40-106)	(47-118)	<0.001*
	Mean ± SD	68.9±14.5	77.8±16.5	
PLA of VR	Range	(37-126)	(49-132)	0.008*
	Mean ± SD	81.5±23	90.8±22.5	
PLA of ASM	Range	(45-124)	(51-138)	<0.001*
	Mean ± SD	72±19.8	85.3±20.6	
PLA of VSM	Range	(37-123)	(58-135)	<0.001*
	Mean ± SD	67.9±16.8	75.1±18.5	
PLA of AA	Range	(43-124)	(48-138)	<0.001*
	Mean ± SD	71.3±21	80.5±21.8	
PLA of VA	Range	(37-124)	(43-132)	<0.001*
	Mean ± SD	76.9±18.6	82.6±19.6	
PLA of AC	Range	(36-126)	(43-138)	<0.001*
	Mean ± SD	59.5±22.2	68.5±25.2	
PLA of VC	Range	(37-122)	(44-133)	<0.001*
	Mean ± SD	64.2±18.4	71.5±20.9	
PLA of ME	Range	(36-123)	(36-132)	<0.032*
	Mean ± SD	57.2±17.6	63.1±20.7	
PLA of VE	Range	(39-94)	(40-124)	<0.002*
	Mean ± SD	57.4±13	64.8±17.3	
PLA of GC	Range	(34-96)	(48-144)	<0.001*
	Mean ± SD	55.7±13.7	66.3±21.2	
PLA of SB	Range	(38-97)	(46-127)	<0.001*
	Mean ± SD	62.3±11.2	72±15.5	
Total PLA	Range	(50-98)	(50-98)	<0.001*
	Mean ± SD	72.6±12.1	83.1±12	

Non- significant (p>0.05), significant (p<0.05), -highly significant (p<0.001).

Statistical significant differences were obtained between the preoperative and postoperative examination of the study group as regard Academic performance. (p<0.05). The mean Academic performance in the preoperative examination of the study group were 66.6±12.1 with a range (46-70) percentage, and the mean Total row score in the postoperative examination of the study group were 83.1±12 with a range (60-98) percentage (Table-16).

Table 16: Comparison between preoperative and postoperative state as regard to Academic performance in the study group.

Academic performance	Preoperative	Postoperative	P value
	N=50	N=50	
Range	(46-94)	(50-98)	<0.001*
Mean ± SD	66.6±12.1	83.1±12	

Non- significant (p>0.05), significant (p<0.05), -highly significant (p<0.001).

Discussion

In children, obstructive sleep apnea (OSA) is a disorder characterized by repeated and/or prolonged airway obstructions during sleep, in the form of apneas and hypopneas throughout the night [1]. Obstructive sleep apnea syndrome (OSAS) exhibits specific cognitive dysfunctions that include deficits in memory, problem-solving, and behavioral functioning [13, 14]. This is problematic, as SDB with AHI < 1 can still impact children's academic performance and behavior [15, 16]. Friedman et al. reported that young children who snore frequently and loudly during sleep are at greater risk for poor academic performance in later years, even well after snoring has resolved, suggests that the neurocognitive deficits may be only partially reversible after treatment. AT results in significant improvement in clinical as well as polysomnography parameters. Improvement in learning and behavior has been reported following the treatment of OSAS in children. The purpose of our present study was to evaluate the effect of AT on the academic and cognitive achievement of children with OSA so proper management of those children can be established. The study group included 50 children well diagnosed as OSA due to adenotonsillar hypertrophy confirmed by polysomnography compared to another control group of 50 children without symptoms of OSA.

The study group reported nighttime symptoms, including mouth breathing, apneic episodes, frequent awakenings, and restlessness. Children also had enuresis, behavior problems, deficient attention span, and daytime somnolence. The study group improved most of OSAS symptoms post AT, and this attributed to the removal of the upper airway obstruction. 60% of patients in our study had a severe degree of hyponasal speech, and 40% had a moderate degree of hyponasal speech pre-AT, but 8 months' post AT only 4 % of the patients had moderate hyponasal speech, and 12 % had a mild degree of hyponasal speech. This improvement of the auditory perceptual assessment can be attributed to the removal of the obstructive effect of adenoid on the choana, i.e., get rid of the anatomic and physiological factors that constrict the space of nasopharynx and compromising the soft tissues surrounding the pharynx that predispose to upper airway collapse and change in normal resonance of the vocal tract.

Cognition is a mental act that includes perception, reasoning, awareness, and intuition. Executive function encompasses the mental processes that enable children to plan, focus, remember instructions, and juggle multiple tasks successfully.

Psycholinguistics evaluations were carried out before and after AT for our patients revealed a significant difference between children in the study and the control group. The mean IQ of children in our study was increasing from 80.9±5.9 (pre AT) to 84.1±5.6 (post AT). Our result revealed a negative significant correlation between AHI and IQ, of the study group (p<0.001). This improvement of IQ in our patients with OSA can be attributed to the improvement of the upper airway obstruction during sleep, disappearance of intermittent hypoxemia, improvement of ventilation, and enough hours of a deep sleep. Eight months' post AT considered enough duration to raise intellectual functions, so improvement in IQ was detected. These results match most of the published data about the improvement of IQ after AT in children with OSA. As Friedman et al., conducted a prospective study to evaluate neurocognitive functions of children with OSAS, before and after AT, he found that six to ten months after adenotonsillectomy, the children with OSAS demonstrated significant improvement in sleep characteristics, as well as in daytime behavior, and their neurocognitive performance improved considerably in most tests conducted [16]. However, on the other side Abd-Allatif et al. in their study stated that the intelligent quotient (IQ) as an indicative parameter of neurocognitive function in children with adenoid hypertrophy not improved with adenoidectomy and there is no relation between adenoid hypertrophy and IQ [17]. Taylor et al. stated that significant improvement in the NESPY Auditory attention and response set of children with OSA seven months after early AT Children with primary snoring, as well as those with OSA, are at higher risk for deficits in attention compared to control children when measured on parental report scales, and that such deficits are substantially improved following treatment with AT [18, 9].

The current study revealed that, the mean PLA of Auditory association, visual association, auditory closure, visual closure, and manual expression, were raised 8 months after AT. This wide improvement in neurocognitive functions was attributed to the correction of the obstructive symptoms, improvement of sleep disruption, intermittent hypoxemia and inattention after AT, and in turn the improvement of the neurocognitive function as well as the intellectual functions demonstrated from the results of the IQ. We think that normal language development in children is such an important factor in acquisition of reading and writing skills. Most children with OSA had a history of delayed language development during their early life. Phonetic sounds are acquired between ages 3–7 years, which is also the peak age for hypertrophy of the tonsils and childhood OSA. Correa et al., stated that the late diagnosis and treatment of OSA is associated with a delay in verbal skill acquisition [19].

Marcus et al., conducted a multicenter, single-blind, randomized, controlled trial evaluating the risks and benefits of adenotonsillectomy, as compared with waiting, for the management of the OSAS, cogntive, Polysomnographic, behavioral patterns, thes parameters were assessed at baseline and at 7 months post AT, they found that As compared with a strategy of watchful waiting, surgical treatment for OSAS in school-age children did not significantly improve attention or executive function as measured by neuropsychological testing but did reduce symptoms and improve secondary outcomes of behaviour, quality of life, and polysomnographic findings, thus providing evidence of beneficial effects of early AT [10].

we found that children with OSA due to adenotonsillar hypertrophy had poor academic achievement owing to obstructive symptoms of upper respiratory tract but eight months' post adenotonsillectomy there were improvement of 12 points of Illinois test in the Mental Processing and increasing in the academic performance also Parents of our children noticed that their children became more attentive and slept better without snoring, less impulsive and hyperactive. We agreed with Marcus et al in the improvement of the OSA symptoms as 60% of patients in our study had severe degree of hyponasal speech and 40% had moderate degree of hyponasal speech pre adenotonsillectomy but 8 months' post AT only 4 % of the patients had moderate hyponasal speech and 12 % had mild degree of hyponasal speech.

The early diagnosis and treatment of OSA should be emphasized, not only because of the possible implications for oral language, as demonstrated in the reviewed studies, which tend to worsen as the chronological age increases but also for the benefits in neurocognitive performance and quality of life [20]. Weber et al. stated that OSA children show a higher frequency of disorders of receptive and expressive language skills, mostly underdiagnosed and thus not treated. A more multi-disciplinary investigation of OSA children is needed to foster the evidence. In current study, there were increase in the score of PLA of VE (Verbal Expression) and grammatical closure. This improvement can be attributed to children with OSA due to adenotonsillar hypertrophy and Eustachian tube dysfunction, positive middle ear pressure, middle ear fluid accumulation, conductive hearing loss, all these causes impaired language acquisition, causing impairment in language development (semantic, syntactic, phonological and pragmatic development).

Ikedia et al reported that to assess whether tonsillectomy and AT surgeries would bring benefits as far as school performance is concerned in children with OSA, psychological evaluations were carried out before and after the surgery [21]. Gozal & Pope investigated 300 children with the worst grades in a school, 18.1% of them had gas-exchange (O_2 and CO_2) disorders during sleep [22]. Of those with obstructive sleep disorders, half were submitted to adenoidectomy. They noticed that the group submitted to adenoidectomy had a significant increase in school performance. The other half, without disorders, kept their mean scores. AT is effective in treating breathing problems in most children with OSAS and also appears to help improve their academic and intellectual performance and general behavior [16].

In our study, eight months' post AT, the mean Academic performance was increasing from 66.6±12.1 (pre AT) to 83.1±12 (post AT) in comparison to the control group. This improvement was demonstrated from increasing in the scores of the children' school subjects also from the results of the tests carried out (Stanford Binet Intelligence Scale and Illinois tests). Parents of our children noticed that their children became more attentive and slept better without snoring, less impulsive, and hyperactive, which benefitted not only the children but also the entire family. First, this improvement can be attributed to correction of the following parameters, sleep disruption, Intermittent nocturnal hypoxia, frequent arousals during sleep, inattentive behaviors, impulsivity, anxiety, aggression, hyperactivity, deficits in emotional regulation, alertness, and attention to tasks after AT; this correction leads to improvement in the memory and IQ, resulting in an increase in academic performance. Secondly, to the improvement of language expression after AT, which was impaired in the Illinois subtests; this was demonstrated from increasing in the mean age of the verbal expression, grammatical closure and sound blending subtests of Illinois test 8 months' post AT than pre AT.

Since language is a very important factor for good academic achievement so this important finding can help in the prediction of poor academic achievement or learning disabilities through appreciation of language impairment; also we raise attention to the importance of early detection or screening for language impairment in children in the hope of preventing possible late severe learning disabilities. This study (up to our knowledge) is the first study to use Illinois test to determine specific strengths and weaknesses among language abilities, for early identification of children at-risk for school failure. An improvement of 12 points of Illinois' test in the Mental Processing following AT is a very substantial improvement. This change enables the children to reach their original abilities and fulfill their cognitive potential. Cognitive factors such as memory, attention, intellectual and school performance improved significantly after AT. Visual and auditory short-term memory, as well as the ability to solve problems and to think analytically improved. These findings suggest that OSAS is a reversible disruptive factor to the neurocognitive function and school performance of children, at least in the short term (8 months after therapy).

From our study, we conclude that children with OSA due to adenotonsillar hypertrophy had poor academic achievement owing to obstructive symptoms of upper respiratory tract leading to nocturnal hypoxemia, interruptive sleep, Eustachian tube dysfunction also due to language impairment but eight months after AT there was an increase in academic achievement as a result of improvement of all previously mentioned factors.

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