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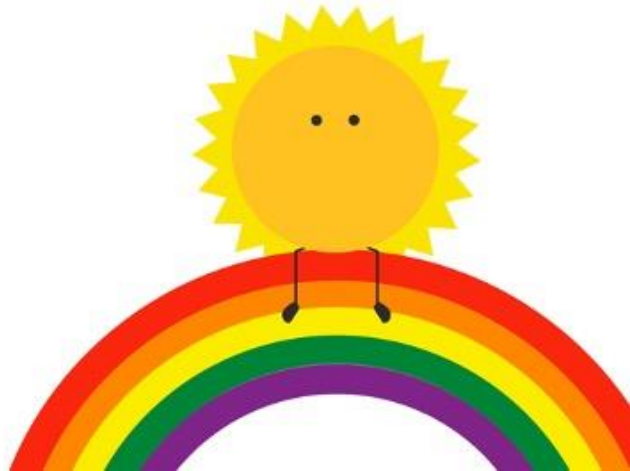
Assessing Sleep Disordered Breathing in Children with Obesity

Dr Surendran Thavagnanam
Royal London Children's Hospital,
United Kingdom

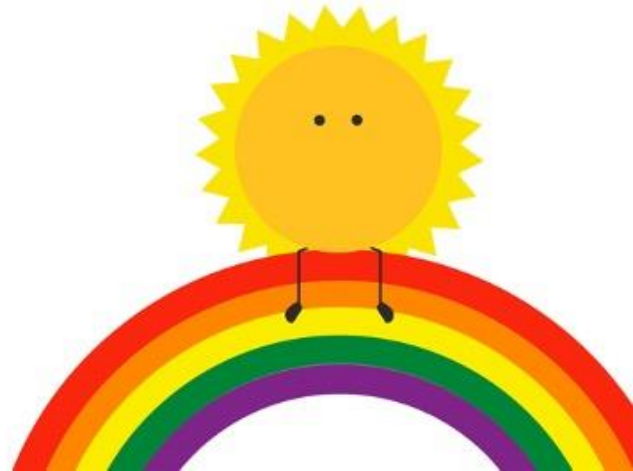
Overview

- Epidemiology of SDB in children with obesity
- Pathophysiology of SDB in children with obesity
- Diagnostics for SDB assessments
- Treatment strategies in managing SDB in children with obesity
- Personalised management approach



Case History

- 4y referred by ENT with a 1-year history of OSA symptoms, recurrent croup with a background history of obesity. O/E: Grade 2 tonsils with good bilateral nasal airflow.
- Weight: 35.5kg, Height: 107cm, BMI: 31kg/m2 and BMI SDS +4
- Endocrinology and CEW clinic:
  - Genetics testing: Obesity panel, PWS, microarray - negative
  - Cortisol, TFT, metabolic syndrome work up within normal limits

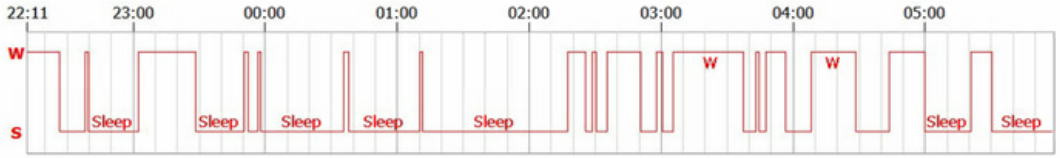


Sleep assessment

Date	Height (cm)	Weight (kg)	BMI (kg/m2)	BMI SDS
14/4/2022	112.6	46	36.3	5.6
6/1/2022	110.1	37.6	31.02	5.1
3/6/2021	104	36.7	33.9	5.8
14/5/2021	107	35.5	31.01	+4

22/08/2022 Dietetic Paed Metabolic

Sleep Stages



Total Sleep Time (TST)	05:00:17
Sleep Efficiency [%]	68.6
Sustained Sleep Eff. [%]	66.5
Sleep Latency [m]	15
Total Sleep Period (SPT)	07:31:21
Sleep Stage Change (Index)	32 (4.1)
# Wake (Index)	16 (3.2)

Sleep Stage	Duration	(%) TIB	(%) Sleep Time
Artefact	00:28:46	6.2	0 %
Wake	02:17:16	29.4	0 %
Sleep	05:00:17	64.4	100 %

Respiratory Analysis

	Number (Index)
Obstructive	11 (2.7)
Mixed	0 (0)
Central	1 (0.2)
Undef Ap.	0 (0)
Total Ap.	12 (2.9)
Hypopnea	136 (32.9)
A+H	148 (35.8)
Limitation	0 (0)
RDI	148 (35.8)

	Sleep
Apnea (Index)	12 (2.9)
Hypopnea (Index)	136 (32.9)
AHI/RDI [/h]	35.8 / 35.8
Flow Limitation (Index)	0 (0)
Max. Apnea Duration [s]	18
Max. Hypopnea Duration [s]	30
Average Apnea Dur. [s]	12
Average Hypopnea Dur. [s]	10.5
Artefact [min]	52.1 (17.4%)

Hypopnea-rules 1: Desaturation 4 %, Ratio 70 %.

Position	Supine	not Supine	Left	Right	Prone	Upright
Sleep Time Fraction [%]	9.7	90.3	15.6	32.4	42.3	0.0
RDI	22 (45.1)	126 (27.9)	52 (66.8)	12 (7.4)	62 (29.3)	0 (0)
Obstructive Apnea (Index)	0 (0)	11 (2.4)	0 (0)	0 (0)	11 (5.2)	0 (0)
Central Apnea (Index)	0 (0)	1 (0.2)	0 (0)	0 (0)	1 (0.5)	0 (0)
Mixed Apnea (Index)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Hypopnea (Index)	22 (45.1)	114 (25.2)	52 (66.8)	12 (7.4)	50 (23.6)	0 (0)
Flow Limitation (Index)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
RERAs (Index)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Number of Desaturations (Index)	33 (67.7)	132 (29.2)	49 (62.9)	15 (9.3)	68 (32.1)	0 (0)

Date of Study

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O2 Saturation

	Number (Index)	Time
Number of Desaturations (Index)	165 (35.4)	
Minimal SpO2 [%]	61	01:16:05
Baseline O2 Saturation	95	
Average SpO2 [%]	92	
Number desaturations < 90 %	109	13.9 %
Number desaturations < 80 %	51	7.1 %
SpO2 Time < 90 %	26.7 %	01:14:28
Biggest Desaturation [%]	28	01:20:33
Average Desaturation [%]	8.7	20.6 s
Longest Desaturation [s]	81.4	03:56:33
Average Min. Saturation [%]	84	
Deepest Desaturation [%]	61	01:16:05
Sum all desaturation	00:56:36	20.3 %
Average Circulatory delay [s]	22.5	
Artefact [min]	21.1 (7%)	

Heart Rate

	Number (Index)	Time
Acc. (Index)	15 (3.1)	
Dec. (Index)	21 (4.4)	
Arrhythmia (Index)	0 (0)	
Maximum HR [bpm]	139	03:46:02
Minimum HR [bpm]	34	05:34:05
Average HR [bpm]	112	
Std. deviation [bpm]	13.3	
Artefact [min]	12.8 (4.3%)	

Breathing Frequency

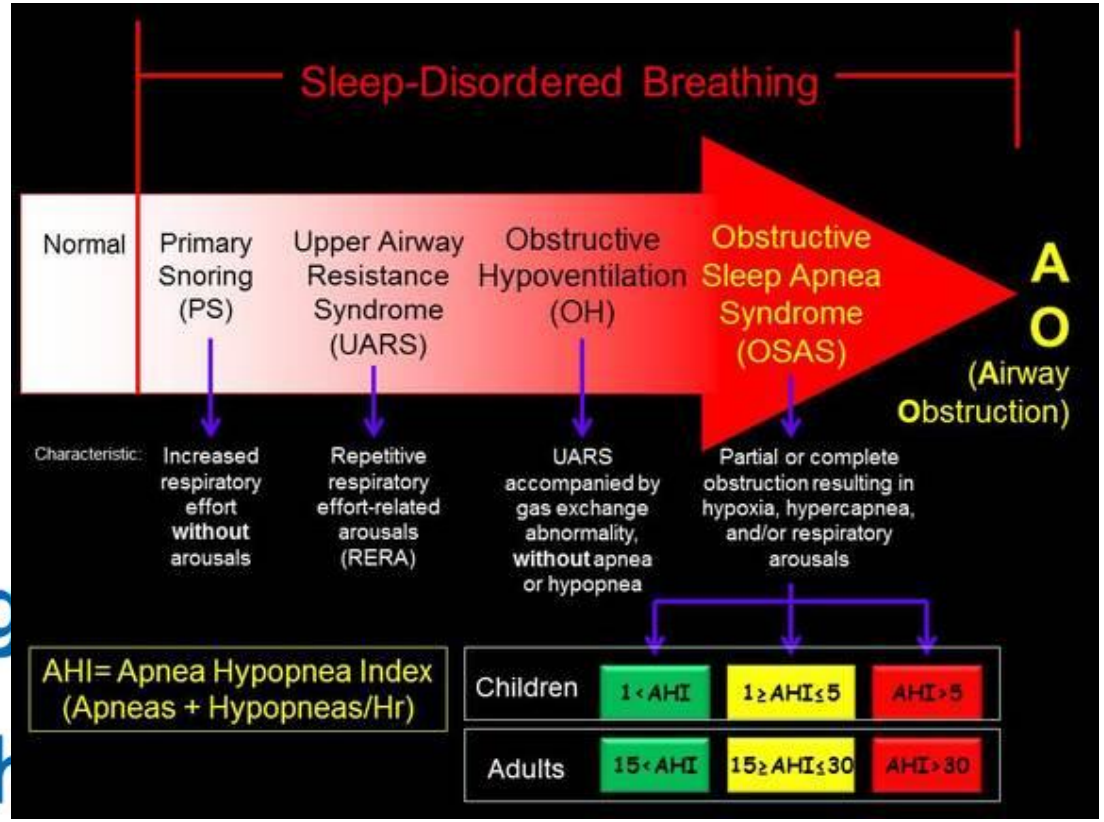
	REM	Non-REM	Sleep
Average BF [/min]	0	26	26
Maximum BF [/min]	0	68	68
Minimum BF [/min]	0	1	1
Duration < 5 /min	00:00	11:58	11:58 (4
Duration < 10 /min	00:00	31:36	31:36 (10.5
Duration < 15 /min	00:00	51:33	51:33 (17.2

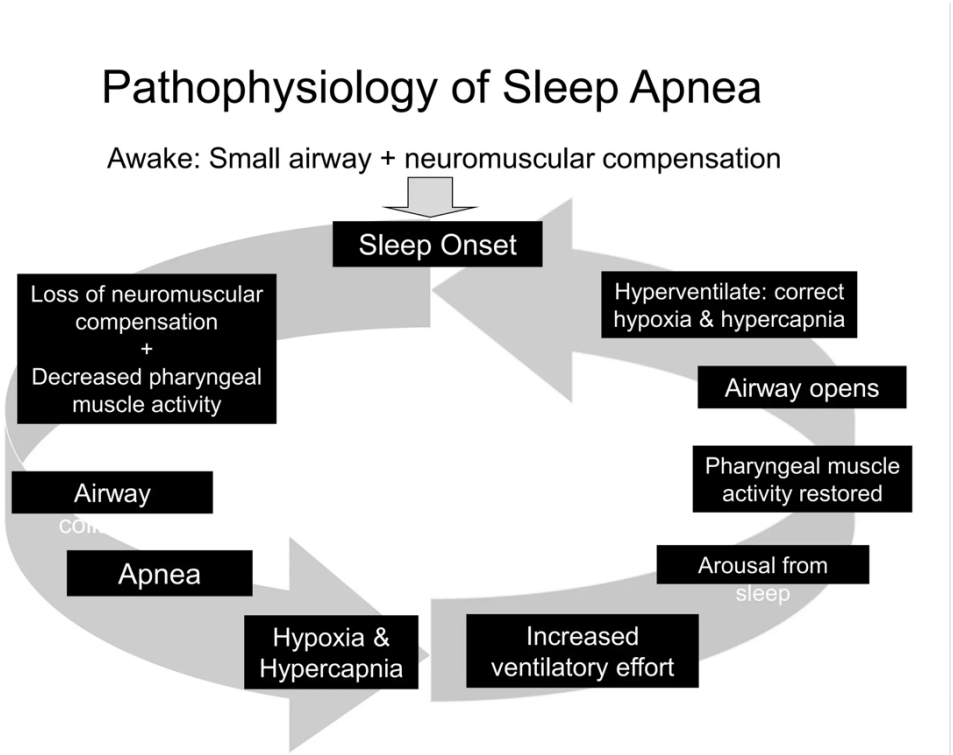
Arousal

Number (Index)	64 (17.5)

Sleep-Disordered Breathing (SDB) in children

- SDB is an umbrella term describing abnormal respiratory patterns and functions during sleep, including apnoea, hypopnoea, and hypoventilation.





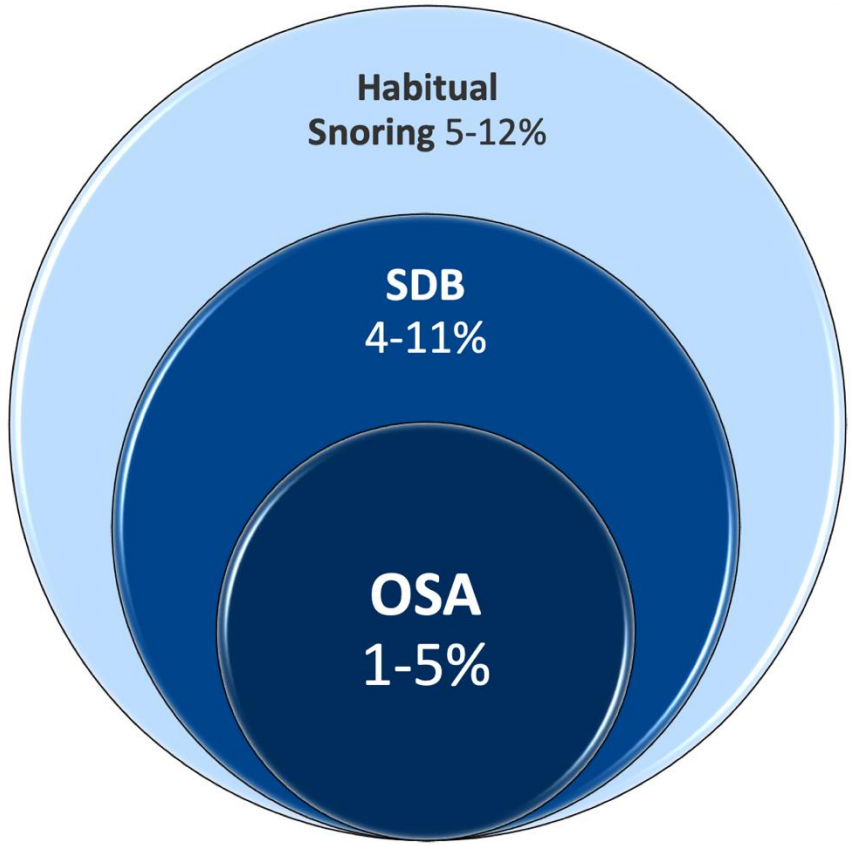
Sleep-Disordered Breathing (SDB) in children

pOSA epidemiology

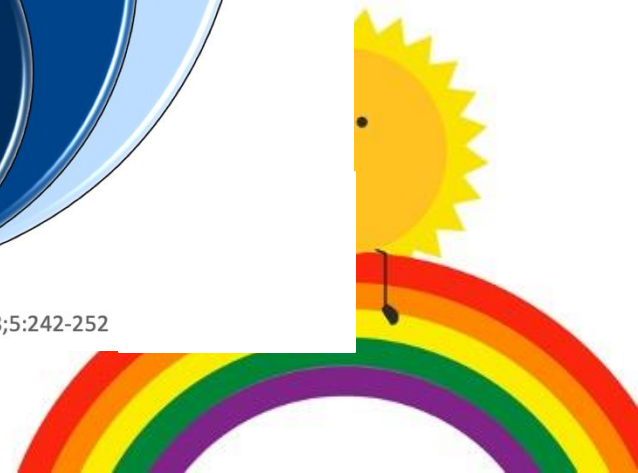
- Snoring occurs in 12 to 26% of infants, 5-12% of children
  OSA in approx. 1-5% of children*
- Peak prevalence between 2 to 8 years old

*Prevalence rates vary on definitions used (PSG vs parental report)

- Rates ↑ with changing anthropomorphic distribution of children



Lumeng JC *Proc Am Thorac Soc* 2008;5:242-252



What does pOSA look like?

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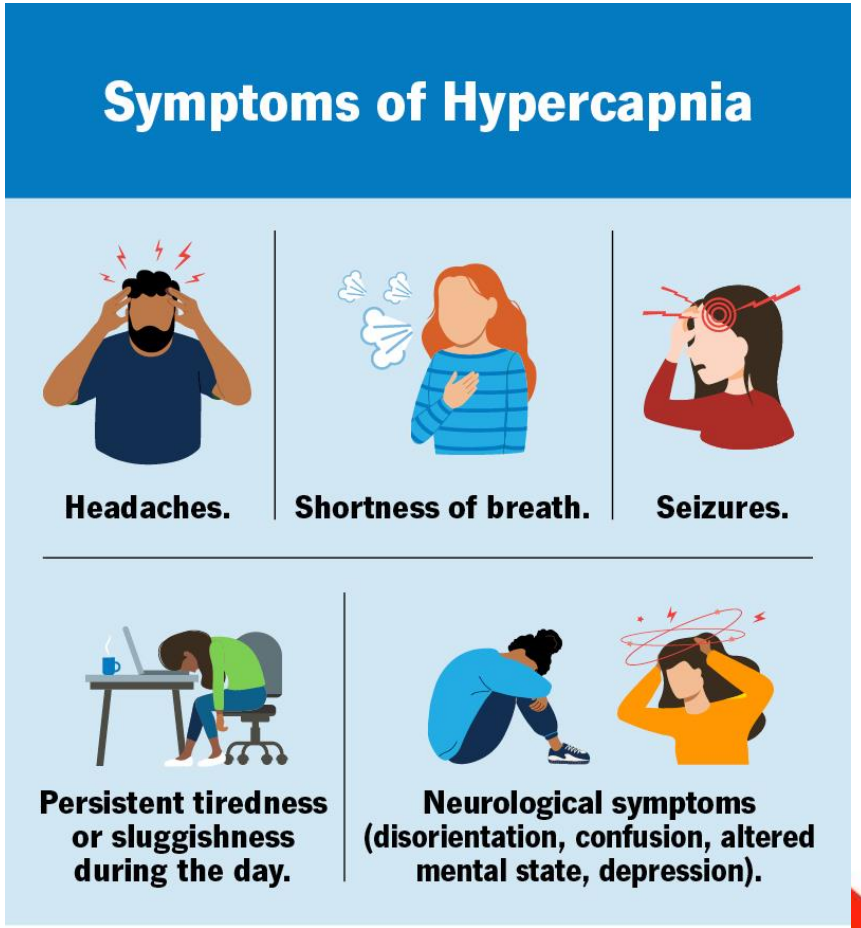
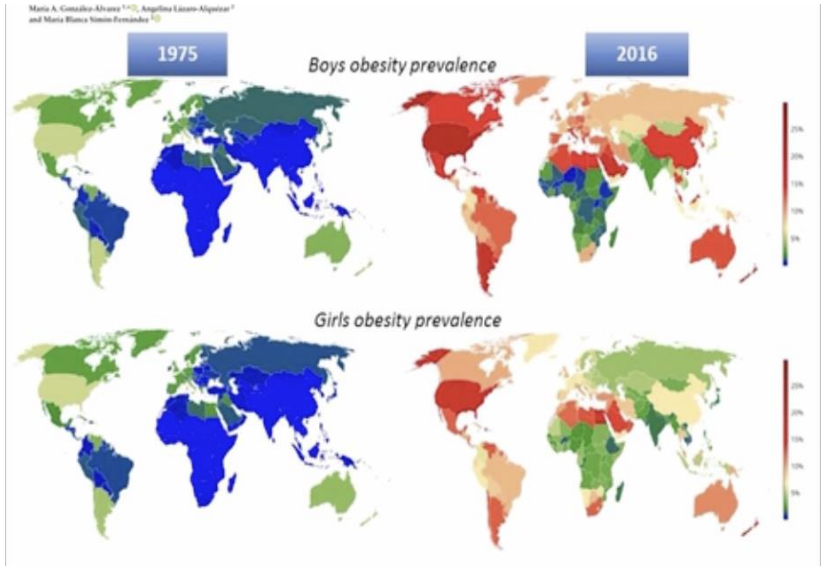


Obesity and OSA



Refs.	Subject characteristics	Obesity	OSAS	Prevalence of OSAS (%)
Mallory et al.[21]	45 subjects, mean age of 10.3 years (SD=4.4), average ideal body weight was 208% (SD=42.2); all had a history suggesting abnormal breathing during sleep, referred to a sleep clinic	Ideal body weight >150%	AHI>5	24
Silvestri et al.[22]	32 subjects, mean age of 8.6 years (SD=3.3), average ideal body weight was 196% (SD=45%); all had a history suggesting abnormal breathing during sleep	Weight >95th percentile or ideal body weight >120% or BMI >90th percentile	Occurrence of ≥1 obstructive apnea	59
Marcus et al.[24]	22 subjects, mean age of 10 years (SD=5), average ideal body weight was 184% (SD=36%); none presented with sleep or respiratory complaints, referred to routine patient care	Ideal body weight >120%	OAI>1, and/or desaturation and/or hypercapnia	36
Chay et al.[23]	60 subjects; recruited from a pediatric obesity clinic	Ideal body weight ≥180%	AHI>5	13
Wing et al.[26]	46 subjects; mean age of 10.8 years (SD=2.3), average BMI was 27.4 kg/m^2 (SD=5.1); recruited from a pediatric obesity clinic	Ideal body weight ≥120%	OAI≥1	26.1
Verhulst et al.[25]	64 subjects; mean age of 11.2 years (SD=2.6), average BMI z-score was 2.3 (SD=0.5); recruited from a pediatric obesity clinic	International Obesity Task[28]	OAI≥1 and/or obstructive AHI≥2	19

Verhulst et al., Sleep Medicine Reviews, 2008.

- Obesity is a chronic disease and OSA is only one of the complications of obesity. Has OSA in paediatric obesity **NOW BECOME** a chronic disease?

Risk Factors for Sleep-disordered Breathing in Children

Associations with Obesity, Race, and Respiratory Problems

SUSAN REDLINE, PETER V. TISHLER, MARK SCHLUCHTER, JOAN AYLOR, KATHRYN CLARK, and GREGORY GRAHAM

Department of Pediatrics, Case Western Reserve University, Rainbow Babies and Childrens Hospital, Cleveland, Ohio; and Harvard Medical School and Brockton-West Roxbury Veterans Affairs Medical Center, Boston, Massachusetts

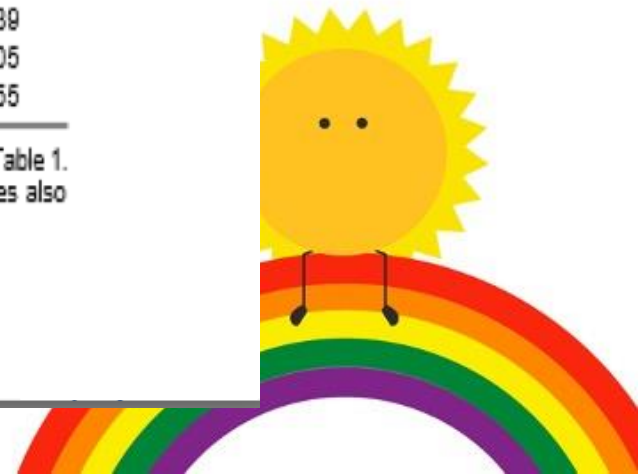
- Cleveland Family Epi study
- 399 children with sleep studies
- Obesity one of the highest independent odds for OSA

ODDS RATIOS, RELATING DEMOGRAPHIC FACTORS AND UPPER AND LOWER RESPIRATORY PROBLEMS TO SLEEP-DISORDERED BREATHING*

	Unadjusted		Adjusted for Race and Obesity	
	Odds Ratio	95% CI	Odds Ratio	95% CI
Obesity (BMI > 28)	4.59	1.58–13.33	4.69†	1.59–14.15
African American	3.49	1.56–8.32	3.59†	1.50–8.58
Sinus problems	3.41	1.32–9.68	5.10	1.78–15.18
Occasional wheeze	3.64	1.51–8.79	3.29	1.24–8.94
Persistent wheeze	4.71	1.30–16.76	7.45	2.03–27.39
Cough	10.52	3.28–33.68	8.83	2.29–34.05
History of asthma	3.22	1.39–7.54	3.83	1.39–10.55

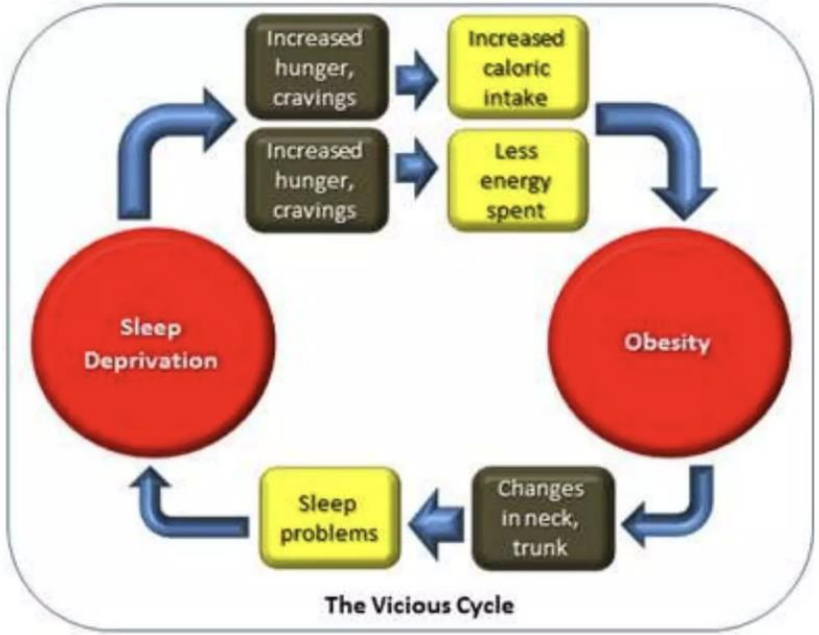
Definition of abbreviations: CI = confidence interval. For other definitions, see Table 1.
* All values adjusted for recruitment source (control or index family). Analyses also account for clustered family data (see STATISTICAL METHODS).
† Values adjusted for obesity or African American race.

Am J Respir Crit Care Med Vol 159. pp 1527–1532, 1999



Obesity and OSA

- High prevalence of OSA in up to 60% of obese children
- Total body weight, BMI and fat distribution all correlates with odds of having OSA.
- Higher BMI associated with higher prevalence
  - BMI > 30: 26% with AHI > 15, 60% with AHI > 5
  - BMI > 40: 33% with AHI > 15, 98% with AHI > 5 (Valencia-flores 2000)
- Every increase in waist or hip circumference by 13 to 15cm increases OSA risk by x4
  - Waist-hip ratio > 0.9 in 🚹 and ≧ 0.85 in 🚺.



Obesity, Ethnicity and OSA

- Beyond a normal BMI adjusted for age and gender, increases of 1 kg/m^2 of the BMI increases risk for OSAS by 12% and increase the number of apnoea and hypopneas per hour of sleep by 3%.
- In the Cleveland Children Sleep and Health Study including 850 children from 8 to 11 years of age, black American ethnicity is an additional risk for OSAS of 4-6 times in obese children.
- Asian children have an increased OSA risk due to more restrictive facial structures.

Craniofacial Risk Factors for OSA

Soft Tissue

Tongue

- Enlarged in African Americans with OSA

Skeletal

Brachycephaly

- Predictor of OSA among Caucasians, not among African Americans

Midface length

- Shorter in Asians with OSA

Cranial base

- Shorter and extended angle in Asians with OSA

Maxilla

- Shorter length predicts OSA in Asians
- Retro-position may be associated with OSA in Hispanics and Asians

Mandible

- Length and position predict OSA in Asians

Hyoid

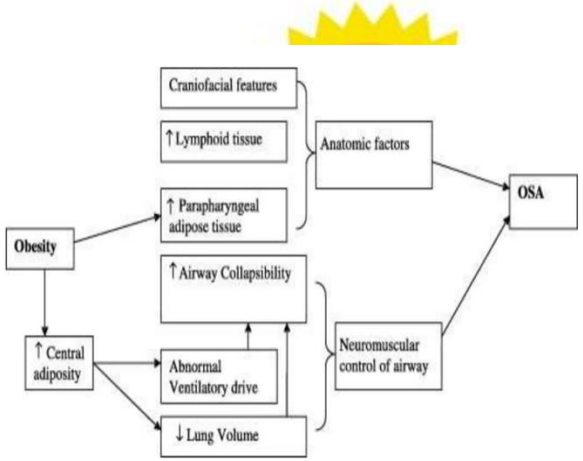
- Inferiorly positioned in Asians and Caucasians with OSA

Anatomical imbalance (tongue area relative to intermaxillary length)

- Large tongue area relative to intermaxillary length associated with OSA in Caucasians but not African Americans or Asians

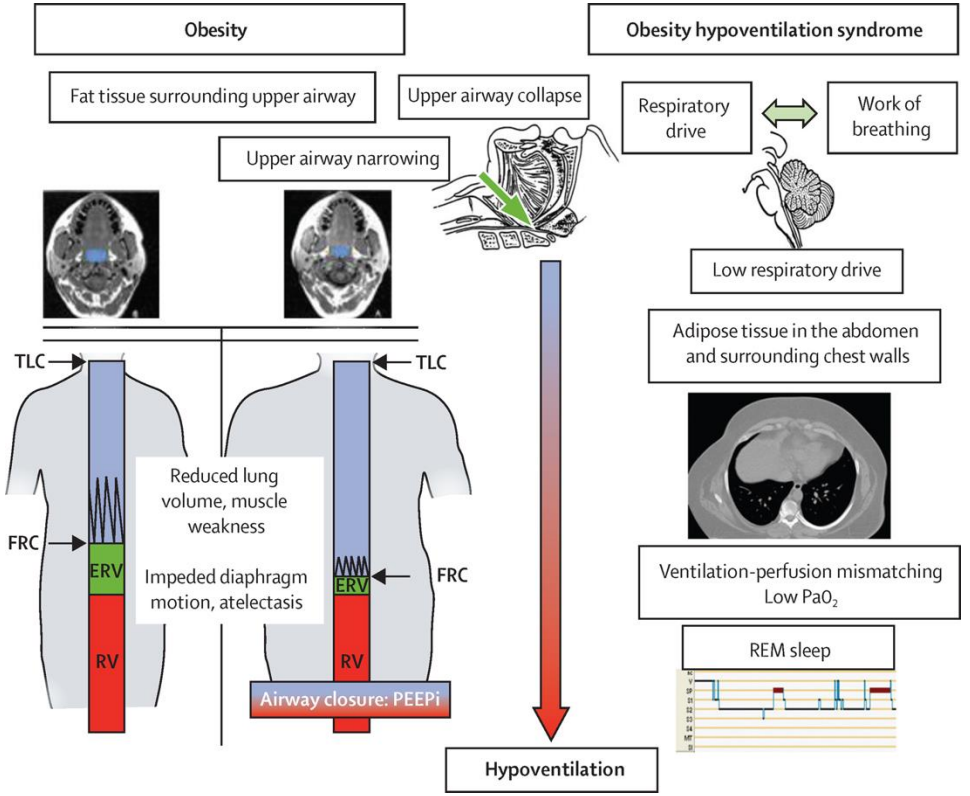
Pathophysiology of OSA in children with obesity

- Altered upper airway mechanics during sleep
  - ✓ Increased parapharyngeal fat deposition →narrowed pharyngeal cross-sectional area → smaller upper airway → increased collapsibility of the pharyngeal airway
  - ✓ Neck circumference : ≧ 17” in 🚹 and ≧ 16” in 🚺
- 45% of obese children with OSAS have evidence of adenotonsillar hypertrophy
  - ✓ Could be due to overgrowth from hormonal changes associated with somatic growth
  - ✓ Local or systemic inflammatory changes noted with childhood obesity (Gozal 2008)



Pathophysiology of OSA in children with obesity

- Chest wall mechanics and reduction in functional residual capacity (FRC) increases risk for SDB by mechanics of hypoventilation, atelectasis and ventilation perfusion mismatch, increases the work of breathing and fatigue.
- Hypoventilation may reduce upper airway motor tone
- Reduced lung volumes decreases airway stiffness by reducing the tracheal tethering effect and may further increase risk of airway collapse and OSA (Van de Graaff 1988)



Abstract

Introduction: Overweight and obese children are at risk of obstructive sleep apnoea (OSA) and abnormal pulmonary function (PF).

Aim: Investigate the relationship between body mass index (BMI), OSA on PF in children.

Materials & Method: Seventy-four children were recruited. Mixed obstructive apnoea-hypopnea index (MOAHI), BMI, oxygen saturation (SpO_2), forced expiratory volume one second (FEV_1), forced vital capacity (FVC) and fractionated exhaled nitric oxide (FeNO) were measured.

Results: Twenty-four and thirty children had mild OSA and moderate-to-severe OSA respectively. BMI correlated negatively with SpO_2 nadir ($r = -.363$, $p = .001$). FVC, FEV_1 and nadir SpO_2 values decreased with OSA severity ($p < .001$). The odds of a child with OSA having an abnormal spirometry was 3.16 (95% CI: 1.08, 9.22). There was significant association between FeNO and AHI ($r = .497$, $<.001$).

Discussion: Overweight and obese children with OSA have significant abnormalities in pulmonary function independent of BMI. OSA severity and elevated FeNO also correlated with diminishing lung function.

KEYWORDS

children, cytokines, obesity, obstructive sleep apnoea, overweight, pulmonary function

Health

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RESEARCH ARTICLE

Endocrinology, Diabetes & Metabolism Open Access WILEY

Pulmonary dysfunction in overweight and obese children with obstructive sleep apnoea

Aina Salwa Kasim[1] | Shahram Golbabapour[2] | Azriyanti Anuar Zaini[1,3] | Eg Kah Peng[1,3] | Muhammad Yazid Jalaludin[1,3] | Anna Marie Nathan[1,3] | Karuthan Chinna[4] | Surendran Thavagnanam[1,3]

	oAHI ≤ 1 *n* = 20	1.5 > oAHI ≤ 5 *n* = 24	oAHI ≥ 5 *n* = 30	*p*-value
Male/Female	17/3	21/3	19/11	.072
Age (years) (Min, Max)	10.3 ± 2.3 (5, 13)	8.9 ± 2.8 (4, 13)	8.7 ± 2.6 (5, 13)	.054
Height (cm)	146.2 ± 16.5	147.3 ± 18.2	143.8 ± 18.2	.763
Weight (kg)	62.3 ± 19.5	63.6 ± 23.1	69.9 ± 29.7	.521
BMI z-score	2.26 ± 0.45	2.33 ± 0.47	2.46 ± 0.41	.265
BFM (%)	40.1 ± 10.8	41.3 ± 9.3	44.5 ± 9.2	.542
Asthma (%)	7 (35%)	14 (58%)	11 (37%)	.191
Nocturnal respiratory parameters				
Baseline SpO_2	99 (2)	98 (3)	98 (3)	.052
Nadir SpO_2*	93 (4)	90 (8)	84 (13)	<.001
Awake pulmonary function				
FVC*	91.8 ± 15.1	82.2 ± 11.7	76.4 ± 11.4	<.001
FEV_1*	92.6 ± 16.0	83.3 ± 12.3	74.9 ± 14.5	<.001
FEV_1/FVC	90.0 ± 7.2	87.7 ± 8.7	85.8 ± 7.5	.193
$FEF_{25\%-75\%}$	95.9 ± 30.1	84.5 ± 30.0	80.5 ± 28.8	.182

Abbreviations: BFM, body fat mass; BMI, body mass index; FEF, forced expiratory flow 25%–75%; FEV1, forced expiratory volume at 1 s; FVC, forced vital capacity; Mean ± SD; Median (IQR); oAHI, obstructive apnoea-hypopnoea index.

*Significant result, $p < .05$.

Sleep-Disordered Breathing (SDB) in children

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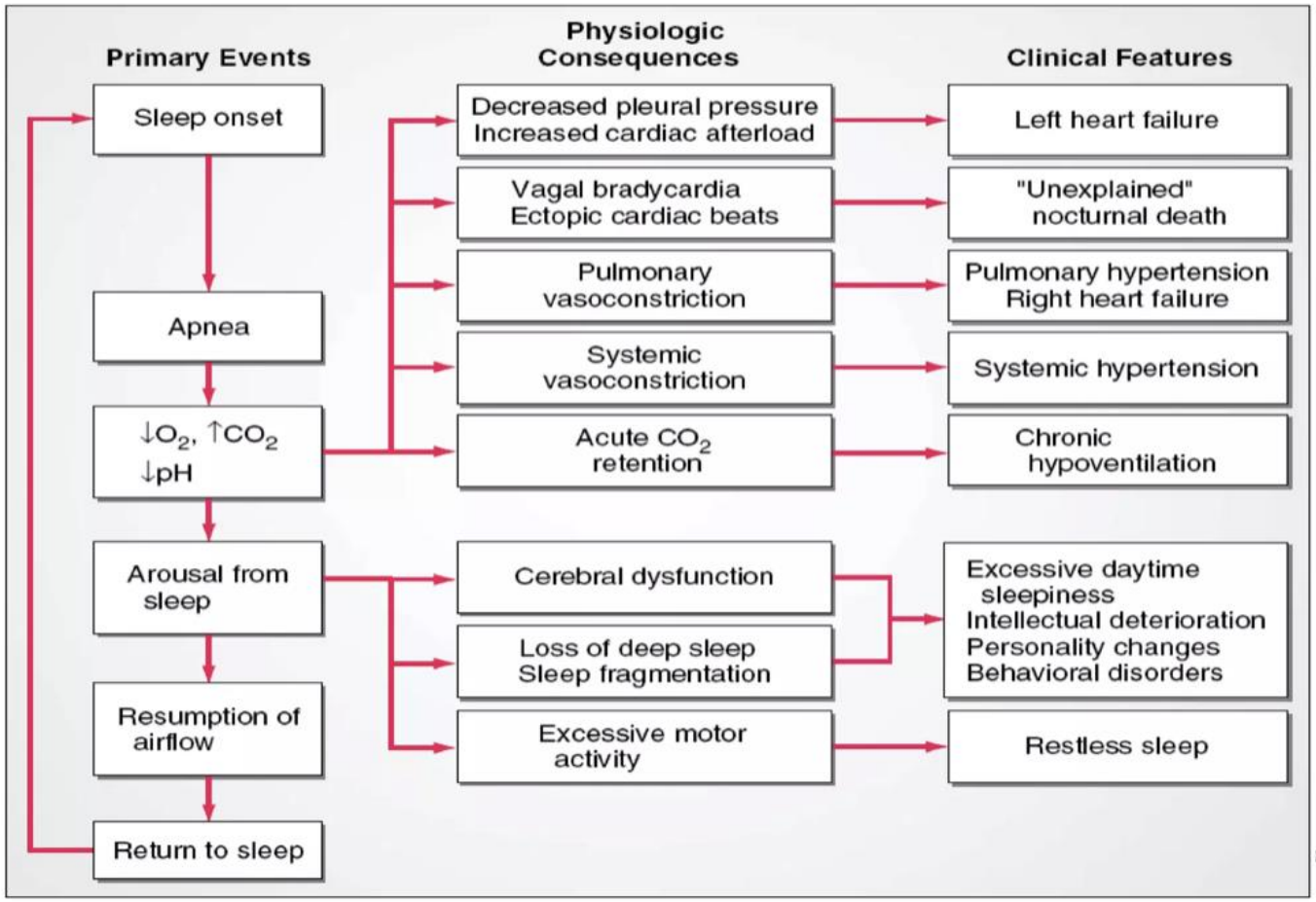
Sequences



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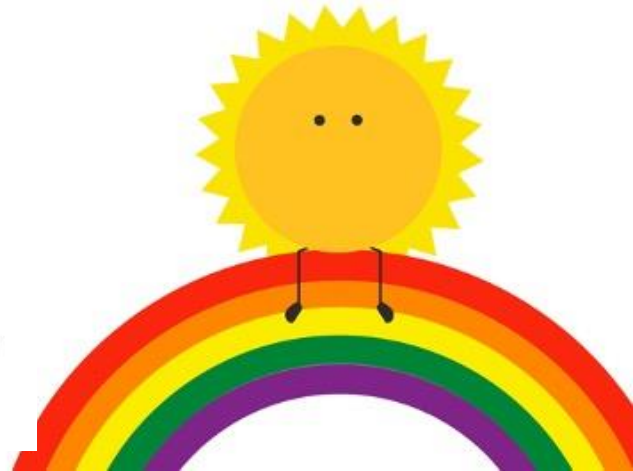

Obesity and the associated co-morbidities

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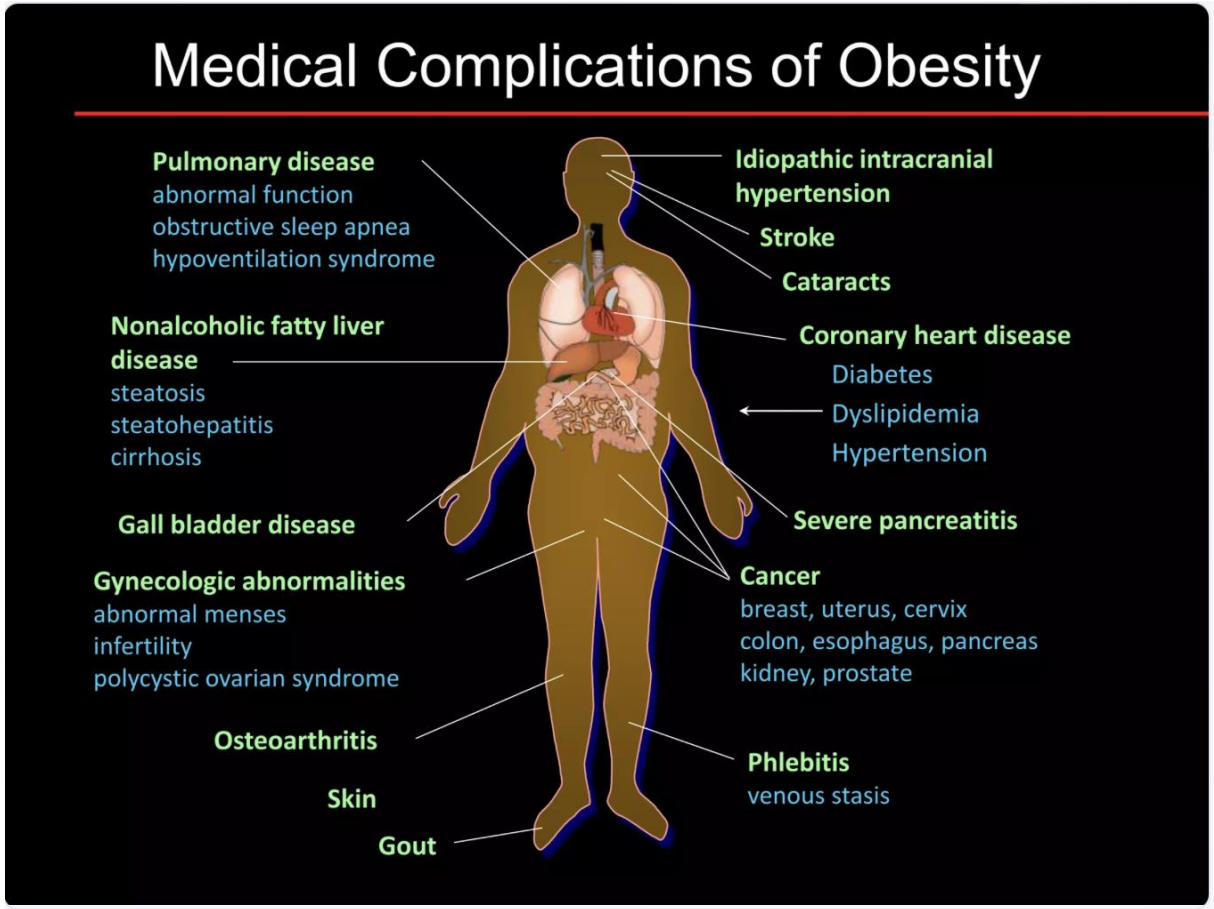
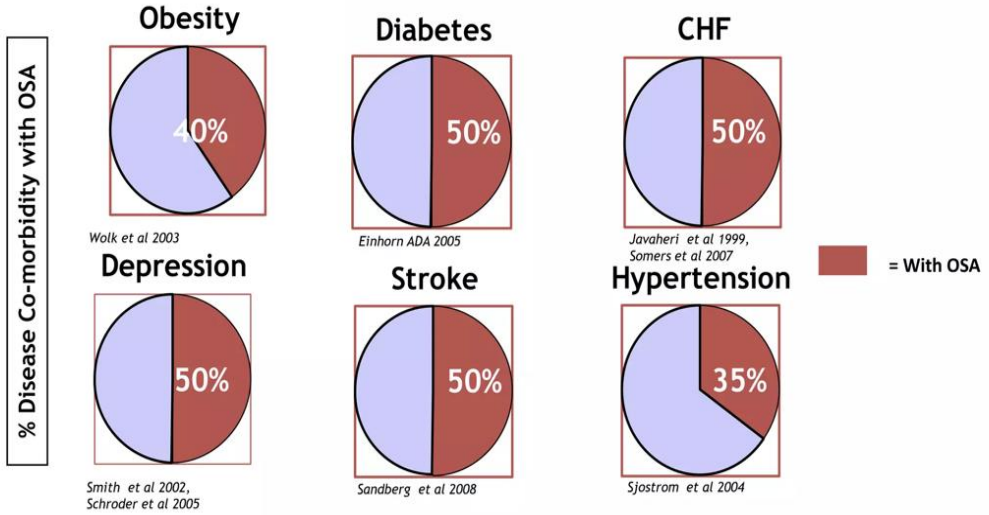


OSA Increases Co-Morbid Health Risks

- OSA is an independent risk factor for HTN & Type II DM



- Left undiagnosed, OSA increases risk of stroke by 2X, risk of fatal cardiovascular events by 5X, and risk of serious vehicular accidents

Sources: Yaggi et al, NEJM 2005; Young et al, Sleep 2008; Teran-Santos, NEJM 1999

Bone metabolism and OSA

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PMID: 33542317

Obstructive sleep apnoea syndrome (OSAS) as a risk factor for secondary osteoporosis in children

Nur Syazwin Sies,[1] Azriyanti Anuar Zaini,[1,2] Jessie Anne de Bruyne,[1,2] Muhammad Yazid Jalaludin,[1,2] Anna Marie Nathan,[1,2] Ng Yit Han,[3] and Surendran Thavagnanam[1,2,4]

Associated Data

Data Availability Statement

Abstract

Go to:

Repetitive hypoxia seen in obstructive sleep apnoea syndrome (OSAS) may affect bone metabolism increasing the risk for secondary osteoporosis. This study investigates the association between OSAS in children and secondary osteoporosis. This cross-sectional study included 150 children aged 10–17 years: 86 with OSAS and 64 with no OSAS. OSAS was confirmed by polysomnography. Quantitative ultrasound (QUS) of calcaneum measuring speed of sound (SoS) and broadband ultrasound attenuation (BUA) were collected. Other parameters collected including bone profile, vitamin D levels, physical activity scoring and dietary calcium intake. Majority were male and Malay ethnicity. OSAS children were mostly obese (84%) and 57% had moderate to severe OSAS. Most had lower physical activities scores. Mean (SD) phosphate and Alkaline phosphatase were lower in OSA children compared to controls: PO_4, $p = 0.039$ and ALP, $p < 0.001$. Using both single and multivariate analysis, children with OSAS had a lower mean SoS value, $p < 0.001$ and $p = 0.004$ respectively after adjusting for age, BMI and bone profile. Children with OSAS had lower SoS suggesting risk for secondary osteoporosis. QUS calcaneus is a non-invasive, feasible tool and can be used to screen risk of osteoporosis in children. Further bone mineral density assessment is needed in these groups of children to confirm diagnosis of osteoporosis.

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Of 150 children, 86 had OSAS

Ultrasound of calcaneum (QUS) to assess bone density by measuring SoS and BUA.

Results:

- OSAS seen mainly in obese children (84%)
- 57% had mod-severe OSA
- Lower physical activities scores
- Mean PO4 and Alk Phosp was low in OSAS
- Lower SoS in OSAS → increasing the risk of secondary osteoporosis

Conclusion: QUS is a non-invasive tool to screen osteoporosis risks.

Screening tools (Questionnaires)

- A number of clinical scoring instruments have been developed including the OSA score (Brouilette 1984) , paediatric sleep questionnaire (PSQ) (Chervin 2007), and OSA-18 (Franco 2000), among others (Patel 2019)
- The diagnostic accuracy varies depending on the cutoff score and study population but is generally too low to be considered an alternative diagnostic method.
  - While they cannot accurately identify OSAS, questionnaires do have clinical utility in assessing the impact of OSAS on quality of life.
  - For example, the PSQ showed stronger correlation to behaviour, sleepiness, and quality of life metrics than polysomnogram parameters, leading the authors to suggest that PSQ score is a useful adjunct to polysomnography (Rosen 2015)

Pulse oximetry

McGill Oximetry Score (MOS):

- The McGill Oximetry Score (MOS) has been validated as a diagnostic tool for Obstructive Sleep Apnoea (OSA) in TD children.
- However, its accuracy may be reduced in children with comorbidities. This is due to the higher likelihood of desaturations that arise from non obstructive causes, which can lead to false positive results .
- Although intermittent oxygen desaturations on overnight continuous pulse oximetry is highly suggestive of OSAS, not all children with OSAS exhibit nocturnal hypoxemia (Owen 1996) and therefore children with negative studies require follow-up polysomnography to rule out OSAS.

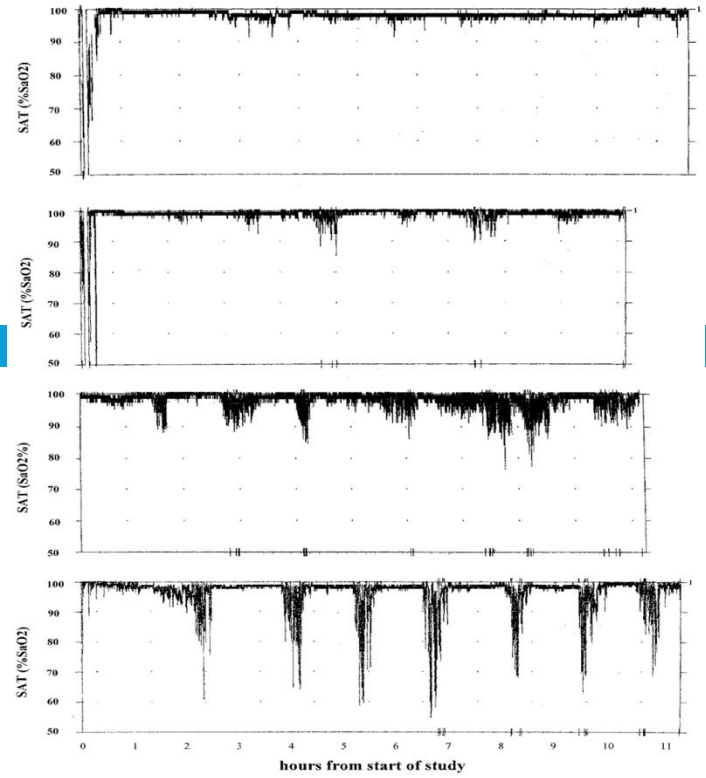


Table 5 McGill oximetry score (MOS).[32,33]

Score	Implication	Standard			
		No. of Drops in SaO_2 <0.90	No. of Drops in SaO2 <0.85	No. of Drops in SaO_2 <0.80	Other
MOS 1	Normal study/ inconclusive	<3	0	0	Baseline: stable (<3 clusters of desaturation) and >0.95
MOS 2	Mild	≥3	≤3	0	Three or more clusters of desaturation events
MOS 3	Moderate	≥3	>3	≤3	Three or more clusters of desaturation events
MOS 4	Severe	≥3	>3	>3	Three or more clusters of desaturation events

A cluster of desaturations was defined as ≥ 5 desaturations in a 10—30 min period.[33] Each score was required to meet the criteria for "No. of drops in SaO_2 " and "Others".

Pulse oximetry

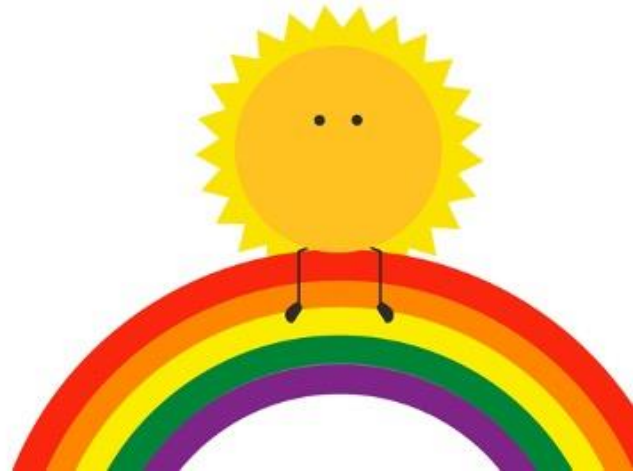
The role of nocturnal pulse oximetry in the screening for obstructive sleep apnea in obese children and adolescents

Annelies Van Eyck [a,*,1], Chinouk Lambrechts [a,1], Liesbeth Vanheeswijck [a], Kim Van Hoorenbeeck [a,b], Dominique Haentjens [c], An Boudewyns [d], Benedicte Y. De Winter [a], Luc Van Gaal [a,e], Wilfried De Backer [a,f], Stijn L. Verhulst [a,b]

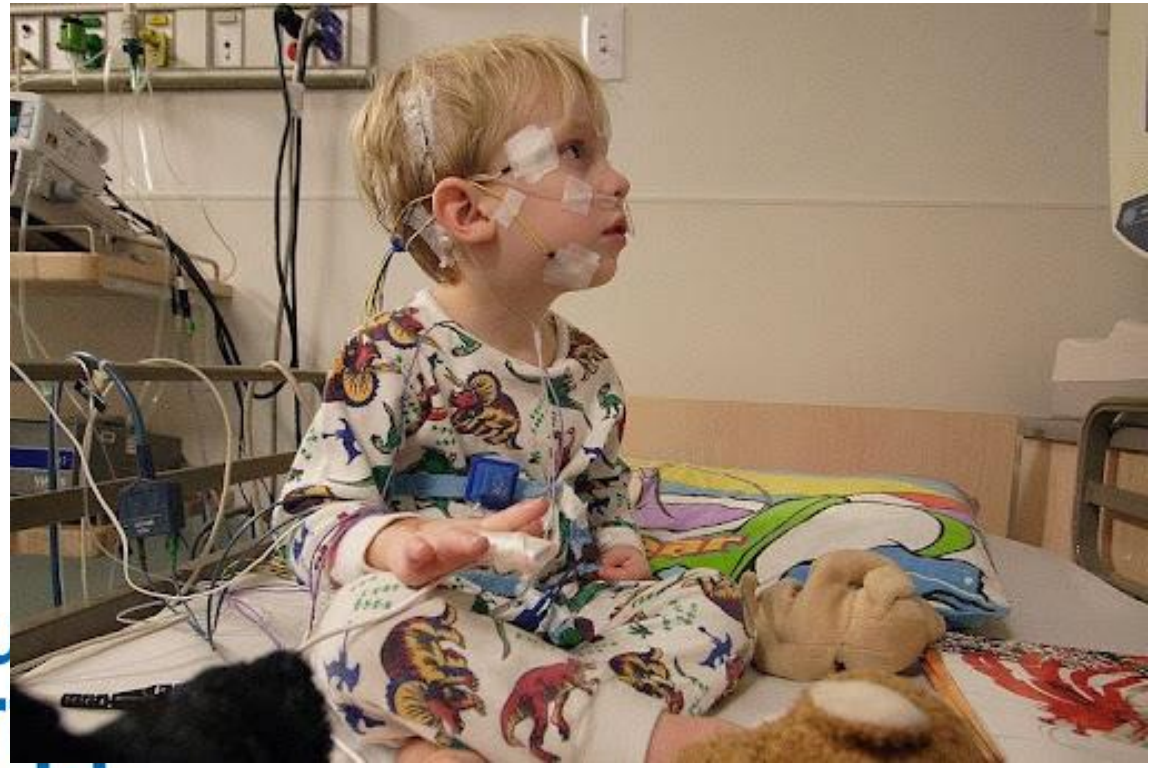
	Brouillete et al. (1)	Velaso Suárez et al. (2)	ODI >4.31	ODI >2
Sensitivity (%)	58	69	57	71
Specificity (%)	88	66	73	56
Negative predictive value (%)	81	81	77	79
Positive predictive value (%)	69	50	52	45

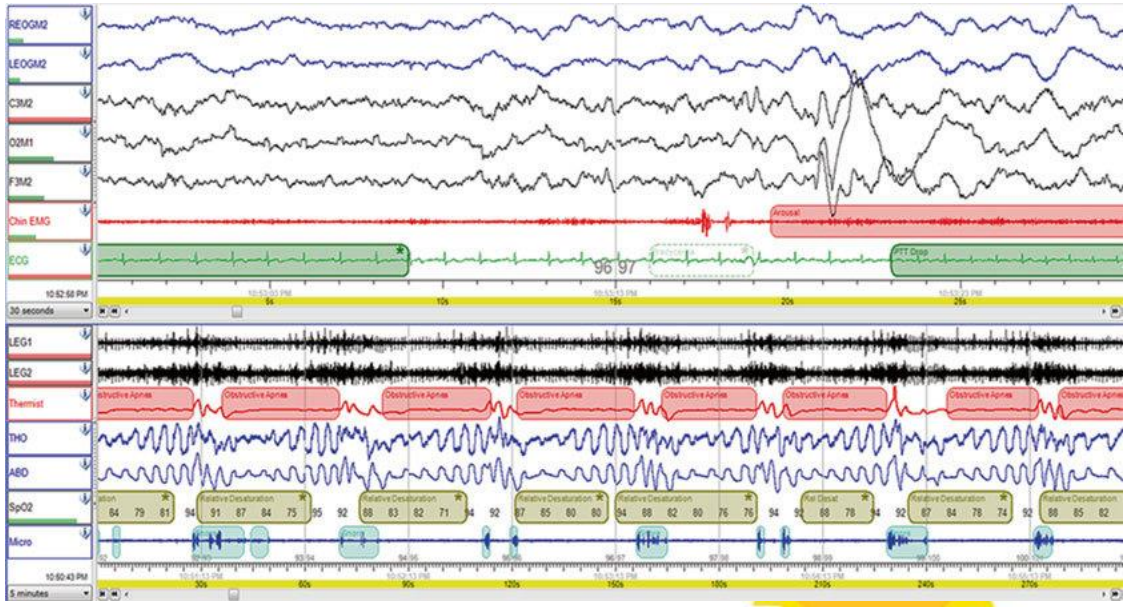
(1) Brouillette, R. T., et al. (2000). "Nocturnal pulse oximetry as an abbreviated testing modality for pediatric obstructive sleep apnea." Pediatrics **105**(2): 405-412.

(2) Velasco Suárez, C. (2013). "Pulse oximetry recording in children with adenotonsillar hypertrophy: usefulness in the diagnosis of obstructive sleep apnea syndrome." Archivos Argentinos de Pediatria **111**(3): 196-201.

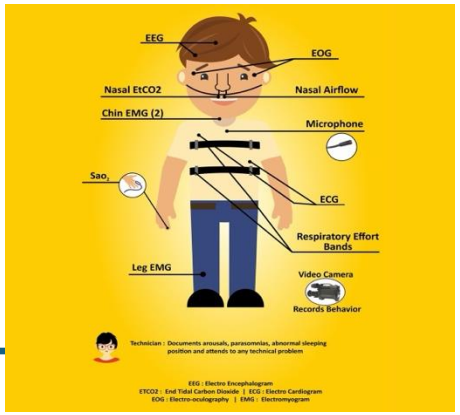


Diagnosis of SDB



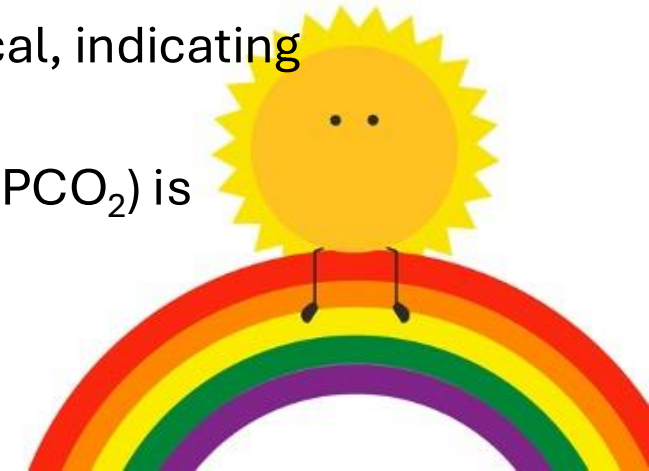


Diagnosis of SDB



- **Polysomnography (PSG) as the Gold Standard**:
- The American Academy of Sleep Medicine (AASM) scoring criteria are used for apnoeas and hypopnoeas, with the Apnoea-Hypopnoea Index (AHI) quantifying the severity of sleep apnoea.
- Severity classifications for children under 16 years include:
  - Mild OSA: OAHI $\geqslant$1 and <5 events·h^{-1}
  - Moderate OSA: OAHI $\geqslant$5 and <10 events·h^{-1}
  - Severe OSA: OAHI $\geqslant$10 events·h^{-1}
- Central AHI (CAHI) $\geqslant$5 events·h^{-1} is generally considered pathological, indicating central sleep apnoea (CSA) in children > 2 years.
- Nocturnal hypoventilation when partial pressure of carbon dioxide (PCO_2) is >50 mmHg for >25% of total sleep time.

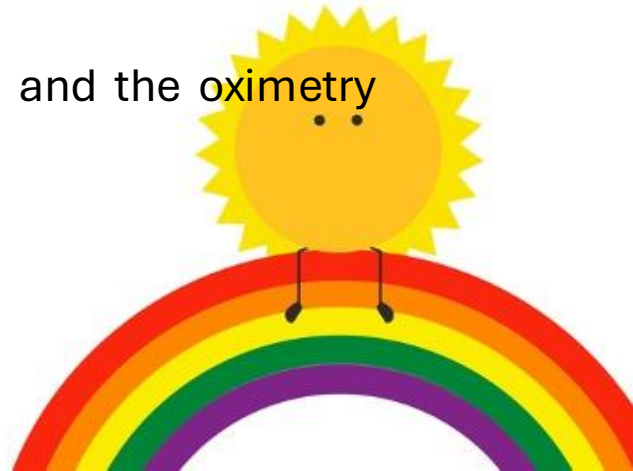
Young Barts Health



Berry RB, Version 2.6. Darien, American Academy of Sleep Medicine, 2020.

Home Sleep Apnoea Test (HSAT)

- Home studies better reflects the child's usual sleep patterns compared to the unfamiliar setting
  - Advantageous for children with Autism, complex medical needs, adolescents
  - More consolidated sleep, makes it easier to obtain accurate and reliable data.
  - Most patients found home PSG to be acceptable, with only 8% of participants retrospectively expressing a preference for a hospital-based study.
- The technical acceptability for unmonitored home SS is reported to be around 81% improving to 87% in experienced settings.
  - Failures in home SS due to poor tolerance of the nasal flow sensors and the oximetry probe.



Ioan I J clin sleep Med 2020, Russo K Sleep Med 2021.

Management of OSA in children with obesity

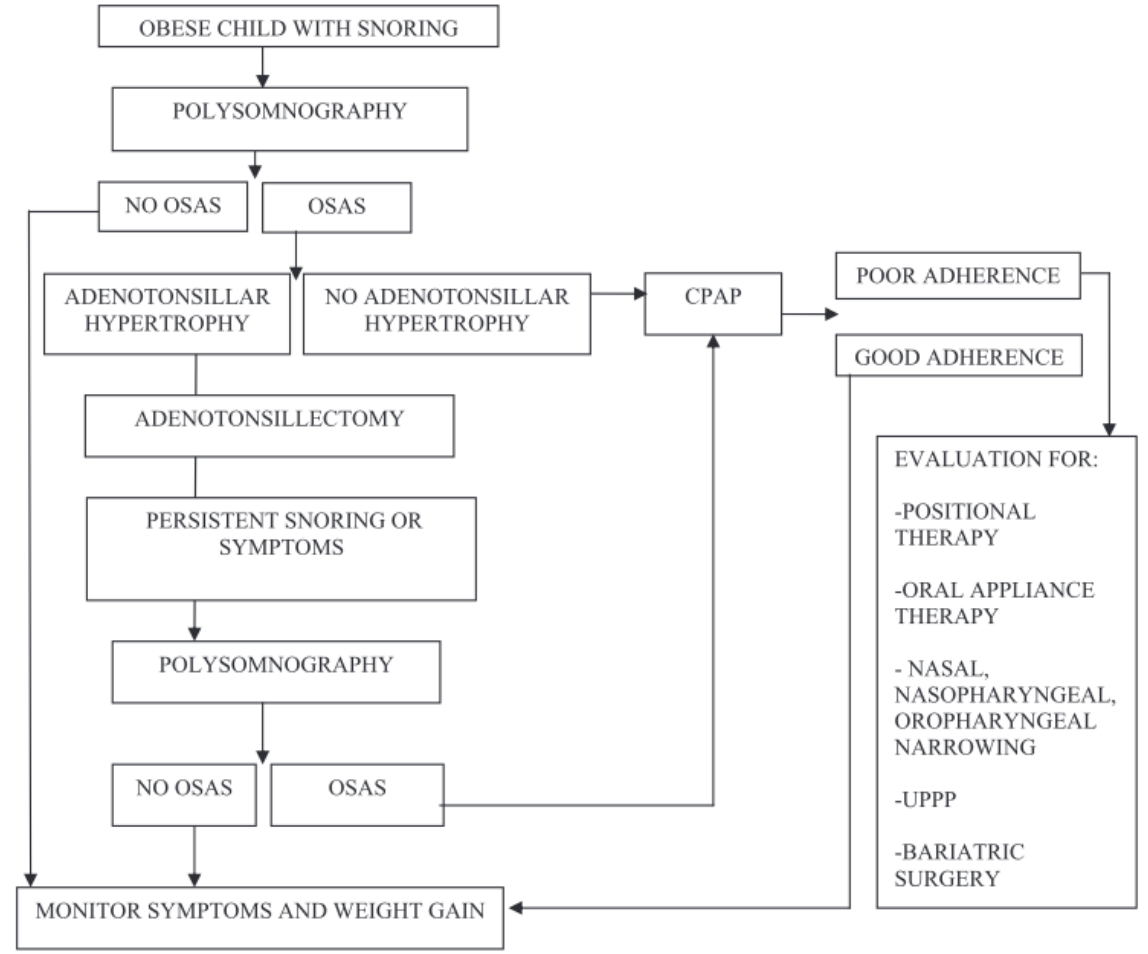


Fig. 2. Suggested approaches to the treatment of the obese child with snoring. Note that dietary modification, exercise, and lifestyle changes to achieve weight loss are essential for all children with obesity. CPAP, continuous positive airway pressure; UPPP, uvulopalatopharynoplasty.

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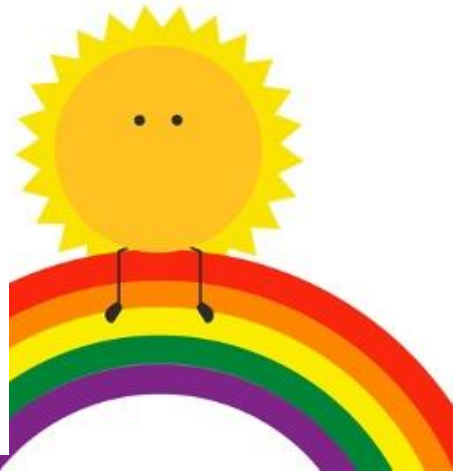
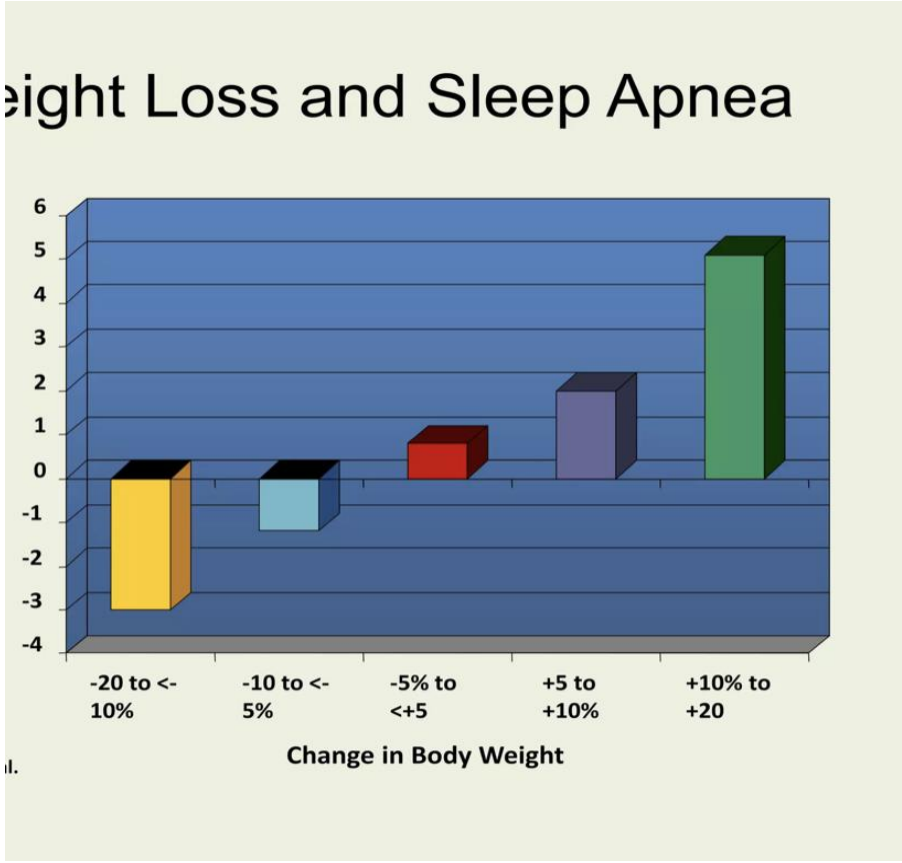


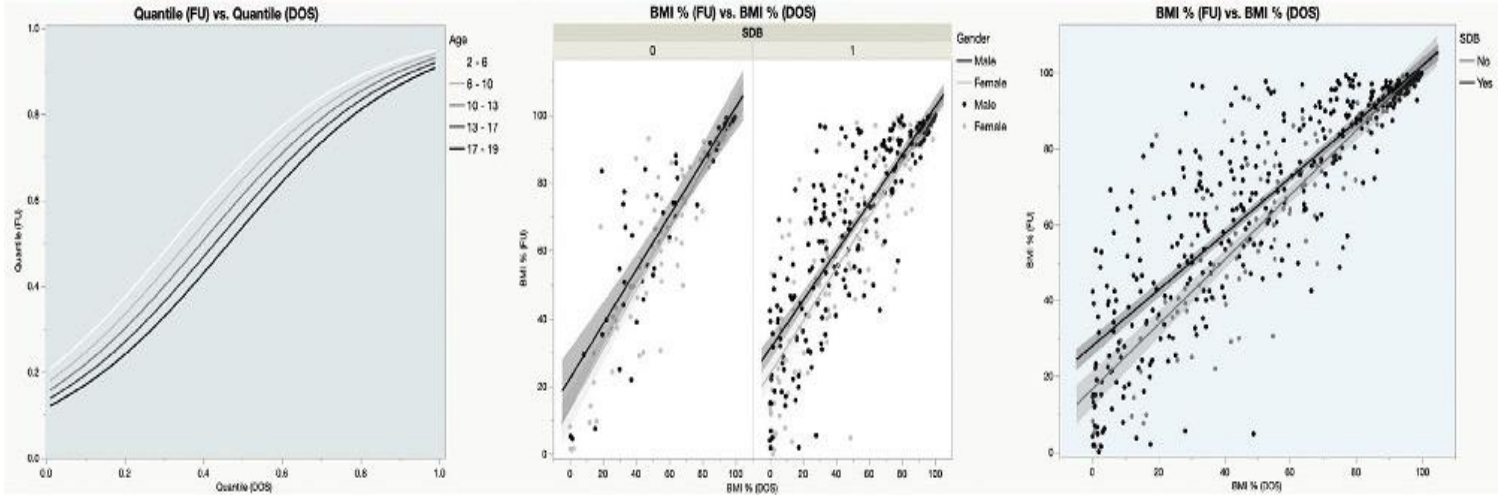
Dietary weight loss can improve OSA

- Reduces upper airway collapse by modifying anatomy and function
- 13% weight loss decreased nasopharyngeal airway collapsibility in obese patients with OSA resulting in reduced AHI
- Improved pharyngeal and glottic function and significant decrease in AHI after 26kg weight loss in obese patients with OSA
- Weight loss may be helped by CPAP in obese with OSA in compliant vs non-compliant (> 4 hour).
- Losing 10% of weight will decrease the AHI (Apnoea Hypopnea Index) by 26%.
- 6 month of CPAP could reduce intra-abdominal visceral fat and serum leptin even in absence of weight loss



Management of OSA in children with obesity

- If adenotonsillar hypertrophy is present, AT is first-line treatment and significantly improves OSAS symptoms and polysomnogram parameters
  - persistent OSAS is identified in 33–76% of obese children compared to 15–37% of non-obese children (Anderson 2016).



Adenotonsillectomy outcomes in obese adolescents with obstructive sleep apnea

Timothy C. Kearney, MS[1]; Turaj Vazifedan, DHSc[2]; Cristina M. Baldassari, MD, FACS, FAAP[3]

ble 2—Pre-AT and Post-AT PSG Parameters for obese and normal weight adolescents.

		Non-Obese Adolescents (BMI < 95%)	Obese Adolescents (BMI ≥ 95%)	Total Group (All Adolescents)
-I (pre-AT)	Mean (SD)	26.8 (28.0)	33.9 (28.5)	31.8 (28.4)
	Median [IQR]	18.4 [10.2, 29.8]	27.5 [9.2, 51.1]	23.9 [9.7, 46.1]
-I (post-AT)	Mean (SD)	2.5 (2.8)	9.9 (16.3)	7.6 (14.1)
	Median [IQR]	1.8 [0.5, 3.6]	5.3 [1.8, 10.8]	3.5 [1.3, 8.8]

Table 3—Pre-AT and post-AT OSA severity.

	Obese Adolescents (n = 70)	Nonobese Adolescents (n = 30)	*P*
Baseline Severity	n (%)	n (%)	
Mild OSA	8 (11.4)	3 (10.0)	.97
Moderate OSA	10 (14.3)	4 (13.3)	
Severe OSA	52 (74.3)	23 (46.7)	
Post-AT Severity			
AHI < 1 events/h	6 (8.7)	9 (30.0)	n/a
Mild OSA	27 (39.1)	17 (56.7)	.014
Moderate OSA	17 (24.6)	3 (10.0)	< .001
Severe OSA	19 (27.52)	1 (3.3)	.003

AHI = apnea-hypopnea index, Mild OSA = AHI > 1 events/h and < 5 events/h, Moderate OSA = AHI ≥ 5 events/h and < 10 events/h, OSA = obstructive sleep apnea, Severe OSA = AHI ≥ 10 events/h.

Management of OSA in children with obesity

Table 2. Comparison of obesity and OSA indices before and after bariatric surgery

	Baseline	After weight loss	*p*
Weight (kg)	173.1 ± 27.8	118.3 ± 21.7	<0.01†
BMI	60.8 ± 11.07	41.6 ± 9.5	<0.01†
AHI	9.1*	0.65*	<0.01‡
Arousal index	11.36 ± 4.64	8.13 ± 3.7	0.22†
Mean O_2 saturation	94.5 ± 1.65	95.5 ± 1.4	0.06†
Minimum O_2 saturation	82.9 ± 5.7	91.7 ± 3.6	<0.01†

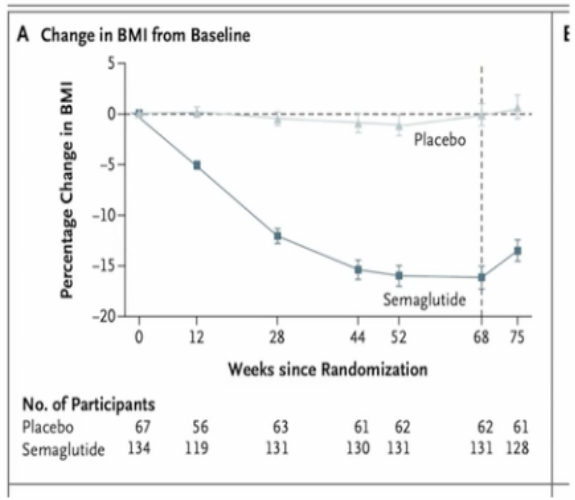
Kalra et al., Obesity Research, 2005

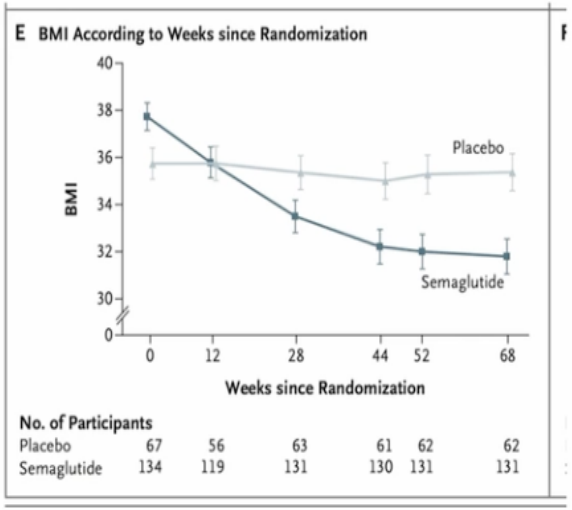
The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Once-Weekly Semaglutide in Adolescents with Obesity

Daniel Weghuber, M.D., Timothy Barrett, Ph.D., Margarita Barrientos-Pérez, M.D., Inge Gies, Ph.D., Dan Hesse, Ph.D., Ole K. Jeppesen, M.Sc., Aaron S. Kelly, Ph.D., Lucy D. Mastrandrea, M.D., Rasmus Sørrig, Ph.D., and Silva Arslanian, M.D., for the STEP TEENS Investigators*





Medical therapy

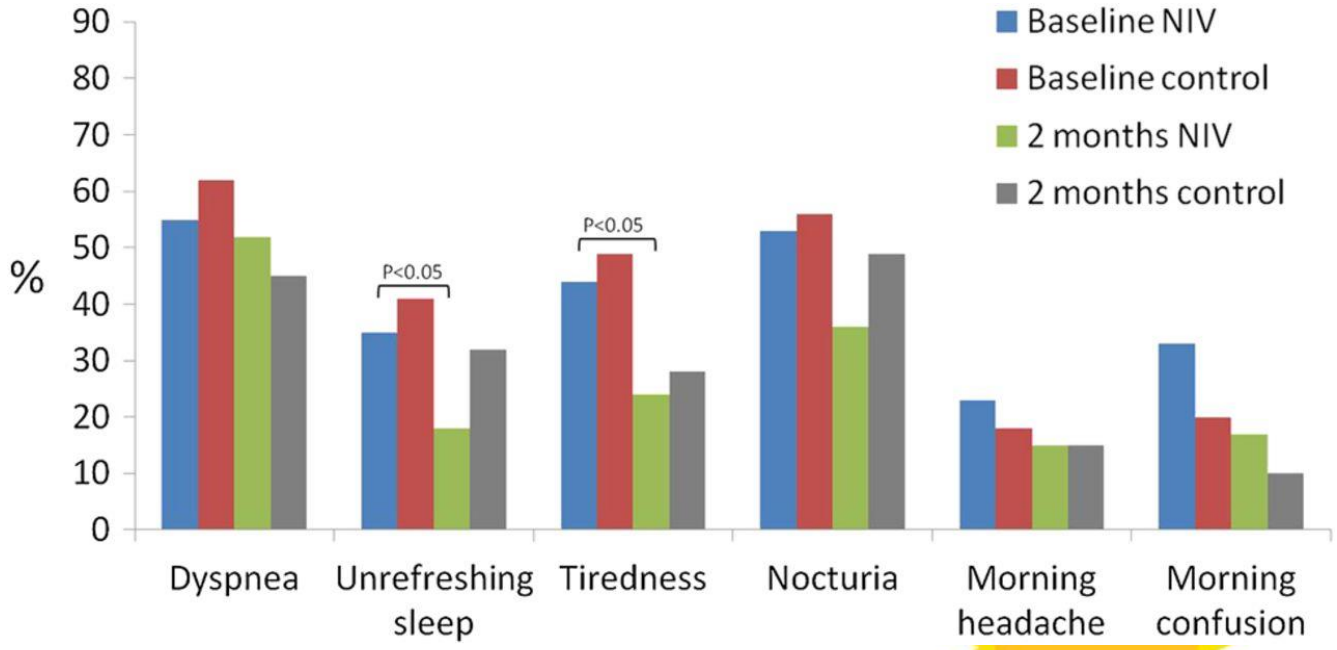
- OSA being associated with increased inflammatory markers and pro-inflammatory cytokines, reasonable to hypothesize that local and system corticosteroids may be helpful.
- Tapia *et al* investigated role of Intranasal Corticosteroids (INCS) in a RDBCT.
  - The AHI between group was not different at 3 and 12 months
  - Symptomatology and neurobehavioral results were not significant different between groups.
  - ICNS had a drop in AHI from 7.2ev/hr to 3.7 ev/hr, $p<0.01$
  - ICNS improved PSQ-SRDB and OSA-18 score
  - Recommended in mild OSA for symptomatic improvement
- Evangelisti *et al* found systemic corticosteroid and INCS could be used to bridge treatment in children with severe OSA and awaiting AT.

Tapia Chest 2022; Evangelisti Sleep Breathing 2022

PAP therapy in OSA

Table 1: Respiratory criteria during sleep that have been used for continuous positive pressure or non-invasive ventilation initiation[5].	
1	Minimum SpO_2 < 90%
2	Maximal $PtcCO_2$ > 50 mmHg
3	Time spent with a SpO_2 < 90% ≥ 2% of recording time
4	Time spent with a $PtcCO_2$ > 50 mmHg ≥ 2% of recording time
5	3% oxygen desaturation index > 1.4 events/h
6	AHI > 10 events/hour

SpO_2: pulse oximetry, $PtcCO_2$: transcutaneous carbon dioxide pressure, AHI: apnea-hypopnea index.



You
Barts
Health

Kaditis AG Eur Respir J 2017; Fauroux B Eur Respir J 2022; Cielo CM Chest 2021, Juan F Masa et al. Thorax 2016;71:899-906

Cardiovascular changes in children with obstructive sleep apnea and obesity after treatment with noninvasive ventilation

Valerie G. Kirk, MD[1]; Heather Edgell, PhD[2]; Hitesh Joshi[2]; Evelyn Constantin, MDCM, MSc[3]; Sherri L. Katz, MDCM, MSc[4]; Joanna E. MacLean, MD, PhD[5]

[1]Alberta Children's Hospital, University of Calgary, Calgary, Alberta, Canada; [2]York University, Toronto, Ontario, Canada; [3]Montreal Children's Hospital, McGill University, Montreal, Quebec, Canada; [4]Children's Hospital of Eastern Ontario, University of Ottawa, Ottawa, Ontario, Canada; [5]Stollery Children's Hospital, University of Alberta, Edmonton, Alberta, Canada

Study Objectives: Adults with obesity and obstructive sleep apnea (OSA) are at risk for cardiometabolic disease, and this risk likely extends to children with both conditions. Noninvasive ventilation (NIV; including continuous and bilevel positive airway pressure) is often used to treat OSA in children with obesity. The aim of this study was to examine the impact of NIV treatment on heart rate variability (HRV), as a marker of cardiovascular risk, in children with obesity and newly diagnosed OSA.
Methods: A prospective multicenter cohort study was conducted in children with obesity prescribed NIV therapy for newly diagnosed moderate-severe OSA. Measurements of HRV were derived from polysomnography recordings at baseline and after 12 months of treatment. HRV parameters were examined by sleep stage, before and after arousal and oxygen desaturation events. HRV parameters were compared between time points using pair *t* tests as well as mixed model analysis.
Results: Twelve children had appropriate data for analysis at baseline and 12 months. Heart rate decreased by 4.5 beats/min after NIV treatment, with no change in HRV parameters. HRV parameters differed by sleep stage and showed an increase in arousal-related sympathetic-parasympathetic balance after 12 months of NIV treatment. HRV parameters did not differ before and after oxygen desaturation events.
Conclusions: NIV for the treatment in children with obesity and OSA resulted in a small decrease in heart rate and an increase in arousal-related sympathetic-parasympathetic balance. These findings suggest small, potentially positive impacts of NIV on cardiovascular risk in children with concurrent obesity and OSA.

Keywords: adolescent, youth, continuous positive airway pressure, bilevel positive airway pressure
Citation: Kirk VG, Edgell H, Joshi H, et al. Cardiovascular changes in children with obstructive sleep apnea and obesity after treatment with noninvasive ventilation. *J Clin Sleep Med*. 2020;16(12):2063–2071.

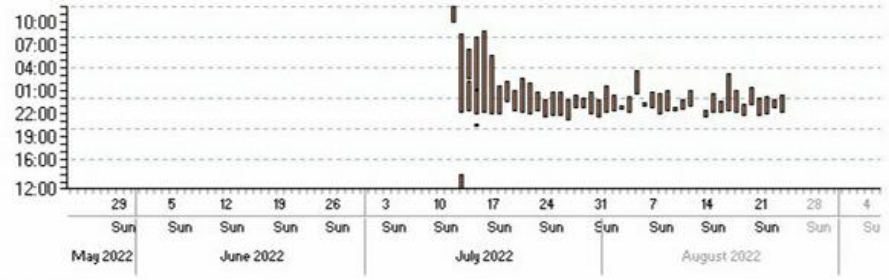
Our case continued....

Date	Height (cm)	Weight (kg)	BMI (kg/m2)	BMI SDS
14/4/2022	112.6	46	36.3	5.6
6/1/2022	110.1	37.6	31.02	5.1
3/6/2021	104	36.7	33.9	5.8
14/5/2021	107	35.5	31.01	+4

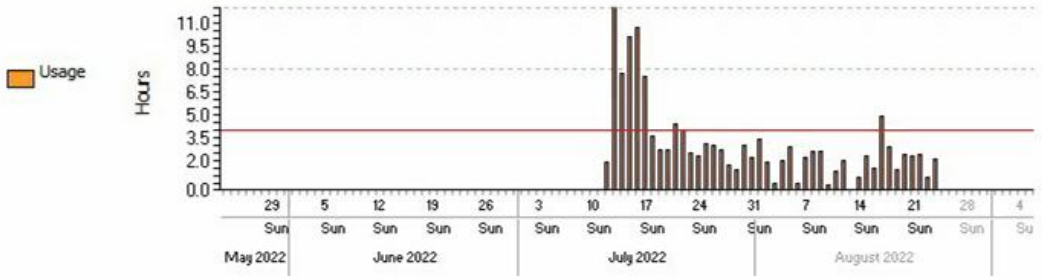
Summary Graphs

27/05/2022 - 24/08/2022 **Device: Stellar 150 (S/N: 000000022211133213)**

Usage



Total Usage



Statistics

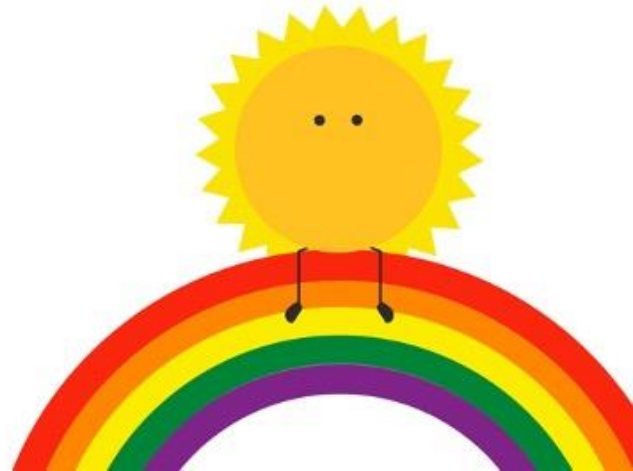
27/05/2022 - 24/08/2022 **Device: Stellar 150 (S/N: 000000022211133213)**

Device Settings

Therapy Mode: **iVAPS**
Rise Time: **300.0**
Cycle Sensitivity: **MED**
Max PS: **6.0 cmH2O**
Height: **115.0 cm**
Expiration Pressure: **8.0 cmH2O**
Fall Time: **200.0**
Ti Max: **1.6 sec**
Min PS: **4.0 cmH2O**
Auto EPAP: **OFF**
Target Patient Rate: **24.0 per min**
Trigger Sensitivity: **MED**
Ti Min: **0.8 sec**
Target Alveolar Ventilation: **4.9 L/min**

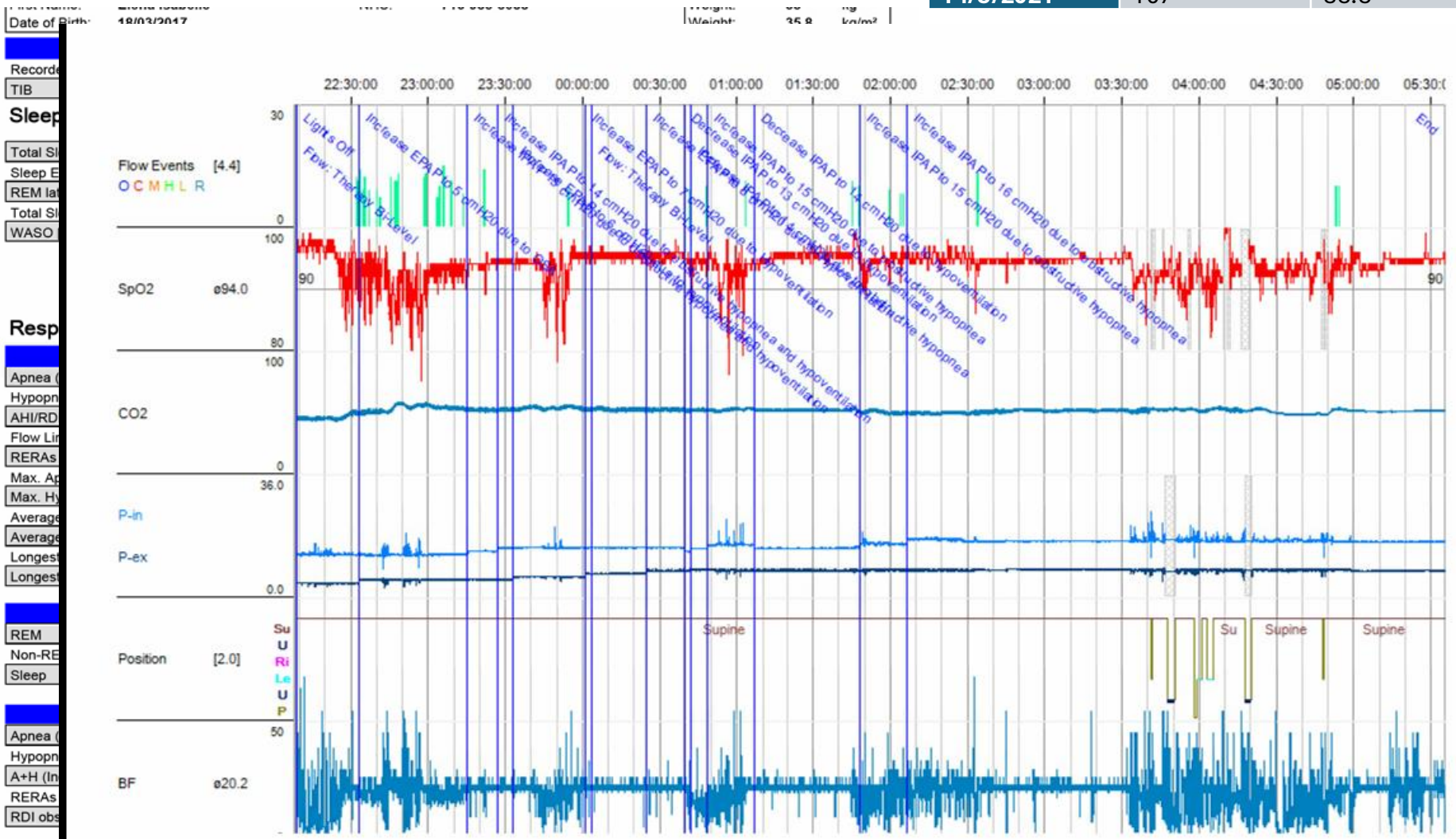
Total Usage

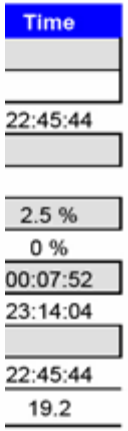
Used Days >= 4 hrs : **8**
Days not used: **47**
Median daily usage: **2:21**
Used Days < 4 hrs : **35**
Total days: **90**
Average daily usage: **1:29**
% Used Days >= 4 hrs : **8**
Total hours used: **134:31**

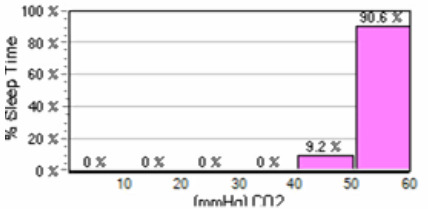


Our case continued...

Date	Height (cm)	Weight (kg)	BMI (kg/m2)	BMI SDS
16/11/2023	124.6	56	36.23	4.3
14/4/2022	112.6	46	36.3	5.6
6/1/2022	110.1	37.6	31.02	5.1
3/6/2021	104	36.7	33.9	5.8
14/5/2021	107	35.5	31.01	+4

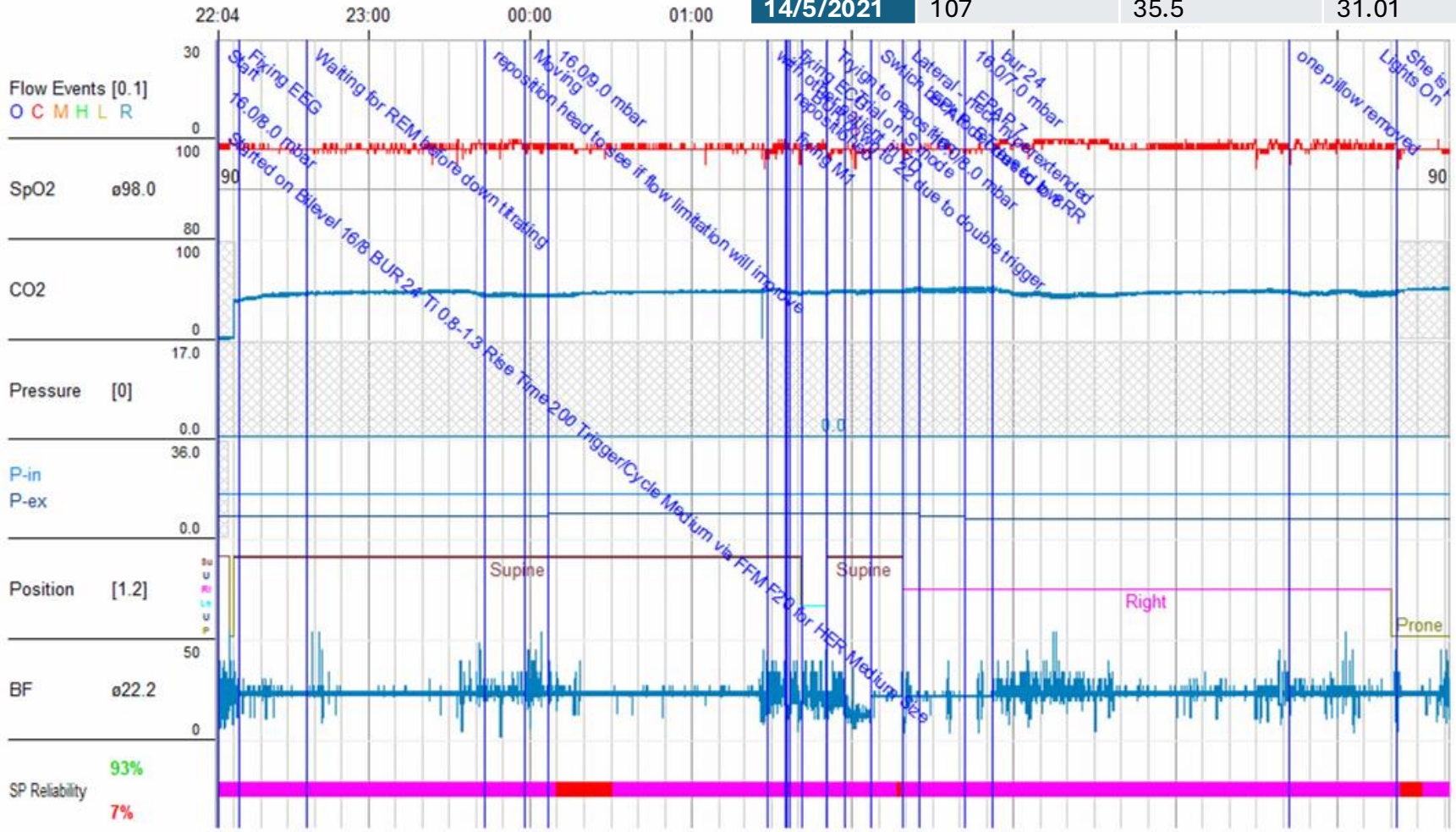






Our case continued...

Date	Height (cm)	Weight (kg)	BMI (kg/m2)	BMI SDS
6/11/2024	130	58	34.1	4.2
16/11/2023	124.6	56	36.23	4.3
14/4/2022	112.6	46	36.3	5.6
6/1/2022	110.1	37.6	31.02	5.1
3/6/2021	104	36.7	33.9	5.8
14/5/2021	107	35.5	31.01	+4



	Mean	Nadir	Duration
	0.7)	98.5	02:55:47
	(0)	97.9	00:20:49
	-	-	00:00:00
	0.8)	98.6	02:34:57
	0.5)	98.2	02:07:11
	-	-	00:00:00
	0.5)	98.2	01:49:58
	(0)	98	00:17:12
	0.4)	97.3	02:17:26
	(0)	14	00:00:08
	0.5)	97.3	02:01:38
	(0)	97.9	00:15:39

Recorded Time	06/11/
TIB	06/11/

Sleep Stages

Total Sleep Time (TST) [m]	
Sleep Efficiency [%]	
REM latency [m]	
Total Sleep Period (SPT) [m]	
WASO [m]	

Respiratory Analysis

Apnea (Index)	
Hypopnea (Index)	
AHI/RDI [/h]	
Flow Limitation (Index)	
RERAs (Index)	
Max. Apnea Duration [s]	
Max. Hypopnea Duration [s]	
Average Apnea Dur. [s]	
Average Hypopnea Dur. [s]	
Longest Obstructive Apnea [s]	
Longest Central Apena [s]	

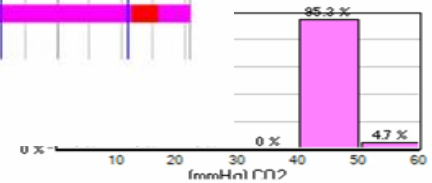
	Average OA [s
REM	-
Non-REM	-
Sleep	-

	Obstructive
Apnea (Index)	0 (0)
Hypopnea (Index)	0 (0)
A+H (Index)	0 (0)
RERAs	0 (0)
RDI obstructive	0 (0)

Spiridon Elena 10091041, Measurement date: 06/11/2024

Hypercapnia [min] | 00:26 (0.4%) | 04:18 (1.4%) | 04:45 (1.1%)

Hypocapny threshold: 35.0 mmHg, Hypercapny threshold: 50.0 mmHg



Age: 7 years

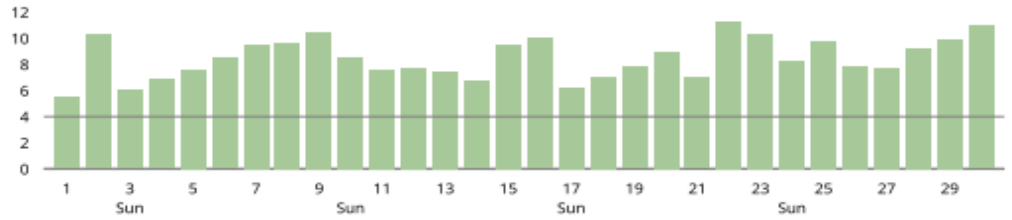
Compliance Report

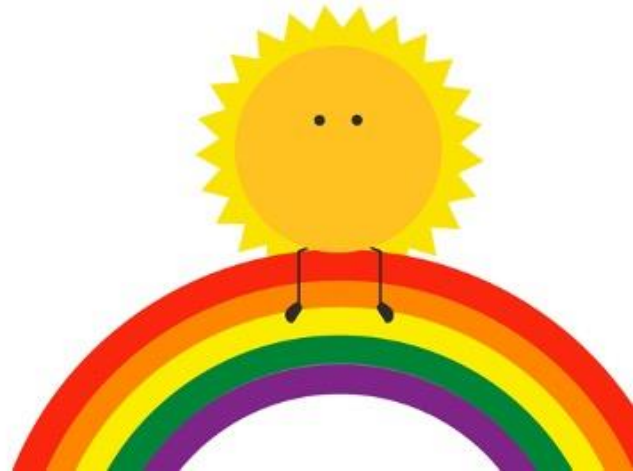
Usage	01/11/2024 - 30/11/2024
Usage days	**30/30 days (100%)**
>= 4 hours	**30 days (100%)**
< 4 hours	**0 days (0%)**
Usage hours	253 hours 50 minutes
Average usage (total days)	**8 hours 28 minutes**
Average usage (days used)	8 hours 28 minutes
Median usage (days used)	8 hours 21 minutes
Total used hours (value since last reset - 30/11/2024)	1,912 hours

Lumis VPAP 150 ST-A	
Serial number	22231642682
Mode	Spont Timed
IPAP	16 cmH2O
EPAP	7 cmH2O
iBR	Off
Respiratory rate	20 bpm

Therapy						
Leaks - L/min	Median:	**0.0**	95th percentile:	**2.5**	Maximum:	**11.2**
Events per hour	AI:	**0.6**	HI:	**1.2**	AHI:	**1.8**

Usage - hours





Conclusion

- Obesity: BMI, neck circumference, wait to hip ratio - associated with OSA risks
- OSA may lead to weight gain and weight gain leads to OSA → **CHRONIC DISEASE**
- Sleep studies are essential
- Losing weight can improve OSA/lessen symptoms but there's limited role for AT
- There are many promising techniques and treatment with emerging evidence base, which may allow more personalised management care for the complexities of paediatric OSA.