

# Pediatric Obstructive Sleep Apnea, Obesity and The Role of Nutrition

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Best Evidence ENT



# Overview

- Overview of pediatric obstructive sleep apnea (OSA)
- Surgical management of pediatric OSA
- Pediatric OSA and obesity
- Non-surgical treatment
- Obesity and Nutrition
- Nutrition & lifestyle interventions outcomes for obesity
  - Implications for pediatric OSA

# Epidemiology of Pediatric Obstructive Sleep Apnea

- The prevalence of sleep disordered breathing ranges from 0.1% to 13.0%, but most studies suggest a prevalence of 1% to 4%
- The peak incidence of pediatric OSA is between 2 and 6 years of age
  - A second peak occurs during adolescence with the development of the adult body habitus and craniofacial structure
- Boys are affected at rates that are 50% to 100% higher than girls
- African American children have been reported to be at increased risk (3.5 times) for developing OSA and to be at increased risk for the morbidity associated with OSA

# Clinical Features of OSA and SDB

- Snoring is the most common symptom of SDB and OSA
- Other nighttime symptoms include apneic pauses, snorting, mouth breathing, gasping, restless sleep, frequent arousals, frequent awakening
- Daytime obstructive symptoms can include mouth breathing, hypo-nasality, chronic rhinorrhea, nasal obstruction, and dysphagia

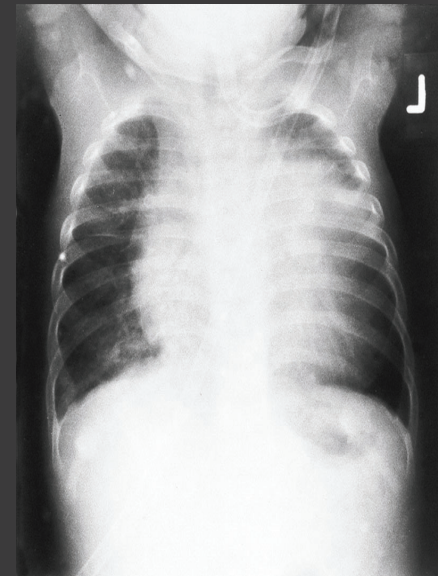
# Behavioral and Neurocognitive Difficulties

- Behavioral and neurocognitive difficulties have been found in 8.5% to 63% of children with SDB
- Behavioral problems include attention problems, hyperactivity, aggression, emotional distress, irritability, somatic complaints, and difficulties with peers
- Neurocognitive skills affected include memory, recall, vigilance and attention, mental flexibility, and visuospatial tasks
- Studies that used standardized behavioral and neurocognitive assessments have documented significant improvements in test scores after adenotonsillectomy in children

# Cardiovascular Sequelae of OSA and SDB

- Higher risk of hypertension in children with more severe SDB/OSA
- Ventricular hypertrophy, reduced ejection fraction, wall motion abnormalities, ventricular dysfunction and cor pulmonale have been demonstrated in children with SDB and severe OSA

Cor-pulmonale



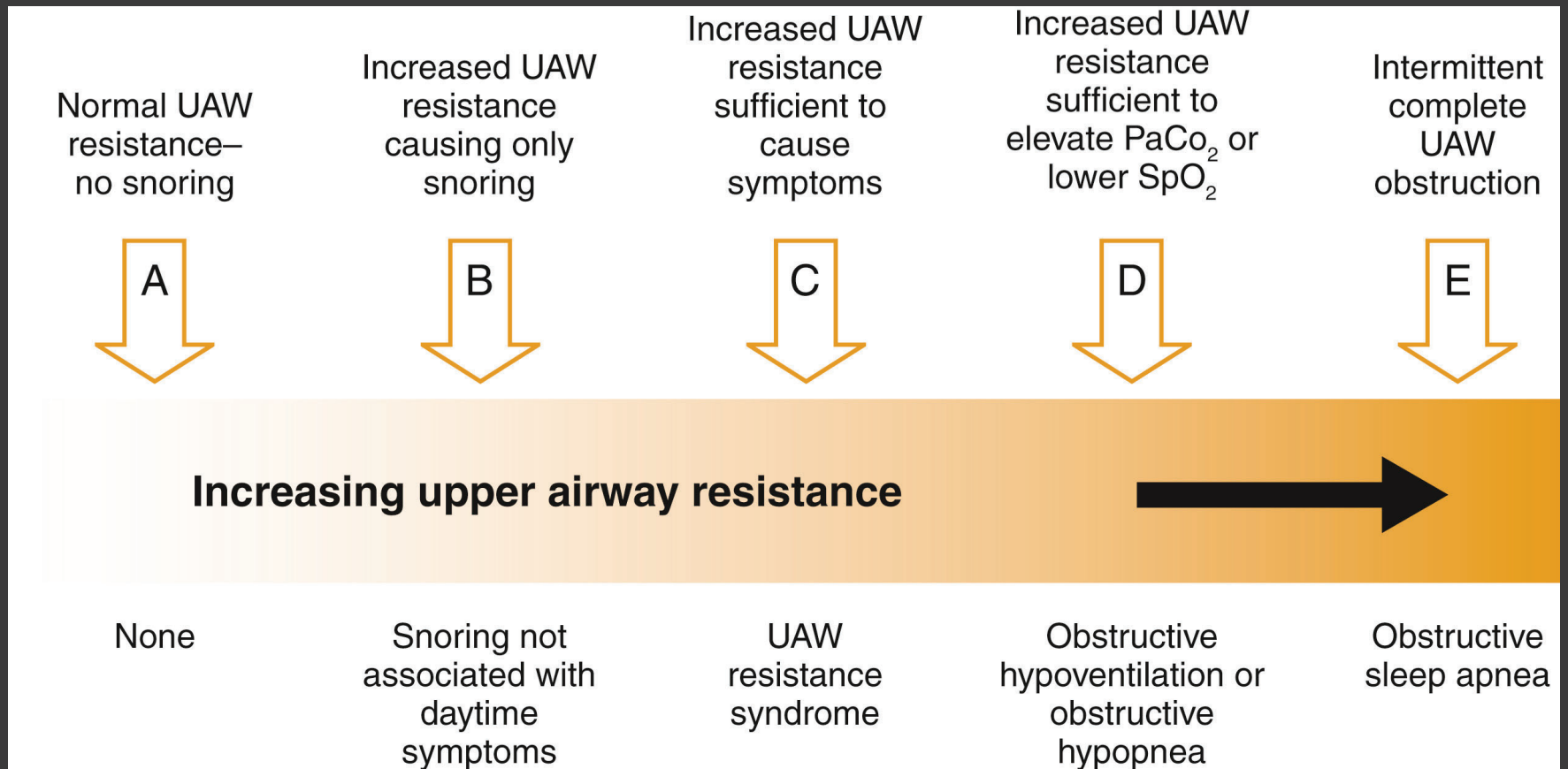
Chest radiograph of a child with cor pulmonale secondary to obstructive sleep apnea

# Obesity and Pediatric OSA

- Obese children are significantly more likely to have OSA
- The prevalence of persistent OSA in children with obesity ranges from 33% to 76%, while in patients who are not obese, the rate of persistent OSA is only 25%-37%
- Higher rates of persistent OSA are reported in overweight or obese children compared to their normal-weight counterparts following adenotonsillectomy
- Quality of life OSA scores are also expected to be lower in children with obesity following AT

Xu Z, Jiaqing A, Yuchuan L, Shen K. A case-control study of obstructive sleep apnea-hypopnea syndrome in obese and nonobese chinese children. Chest. 2008 Mar;133(3):684-9. doi: 10.1378/chest.07-1611. Epub 2008 Jan 15. PMID: 18198258.

# Spectrum of Pediatric SDB and OSA Severity





# Predisposing Conditions

- adenotonsillar hypertrophy
- **Obesity**
- Down syndrome
- Craniofacial syndromes
  - • Craniosynostoses (Apert, Crouzon, Pfeiffer, and Saethre-Chotzen syndromes)
  - • Pierre Robin sequence
  - • Stickler syndrome
  - • CHARGE syndrome
  - Treacher Collins syndrome
  - • Craniofacial microsomia
  - • Fragile X syndrome
- Mucopolysaccharidoses
- Achondroplasia
- Neuromuscular disease
- Cerebral palsy
- Beckwith-Wiedemann syndrome
- Klippel-Feil syndrome
- Prader-Willi syndrome
- Arnold-Chiari malformation
- Sickle cell disease
- Post pharyngoplasty patients

# Defining Pediatric OSA

## Abnormal Values of Pediatric Polysomnography

Obstructive sleep apnea:

Obstructive apnea index (AI)  $>1/h$

Apnea-hypopnea index (AHI)  $>1/h$

AHI 1 to 4 = mild

AHI 5 to 10 = moderate

AHI greater than 10 = severe

Minimum oxyhemoglobin saturation ( $SpO_2$ ) less than 92%

Hypoventilation:

Peak end-tidal  $CO_2$  greater than 53 mm Hg

End-tidal  $CO_2$  greater than 50 mm Hg for more than 10% of total sleep time

Upper airway resistance syndrome (UARS): esophageal pressure between  $-10$  and  $-20$  cm  $H_2O$

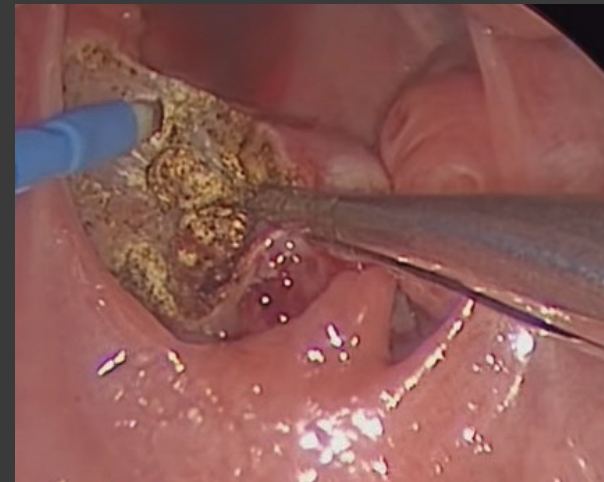
# Indications for Polysomnography

- Clinical Practice Guidelines of the American Academy of Otolaryngology–Head and Neck Surgery (AAO-HNS) recommend PSG prior to tonsillectomy only for selected children
- Children <2 years of age, **obesity**, Down syndrome, craniofacial abnormalities, neuromuscular disorders, sickle cell disease, or mucopolysaccharidoses, or when there is discordance between the physical examination and the reported severity of symptoms

Mitchell RB, Archer SM, Ishman SL, Rosenfeld RM, Coles S, Finestone SA, Friedman NR, Giordano T, Hildrew DM, Kim TW, Lloyd RM, Parikh SR, Shulman ST, Walner DL, Walsh SA, Nnacheta LC. Clinical Practice Guideline: Tonsillectomy in Children (Update). Otolaryngol Head Neck Surg. 2019 Feb;160(1\_suppl):S1-S42. doi: 10.1177/0194599818801757. PMID: 30798778.

# Surgical Treatment of SDB/OSA

- First-line therapy for the treatment of SDB/OSA is adenotonsillectomy
- Most studies find that adenotonsillectomy significantly improves respiratory indices
- Published OSA “cure rates” vary widely, from 25% to 100%
- In otherwise healthy, non obese children rates of success are as high as 80%



# Non-Surgical Treatment of SDB/OSA

## Pharmacotherapy

- Nasal steroids
- Montelukast
- Novel pharmacotherapeutics

## CPAP or BiPAP

### Optimisation of PAP usage

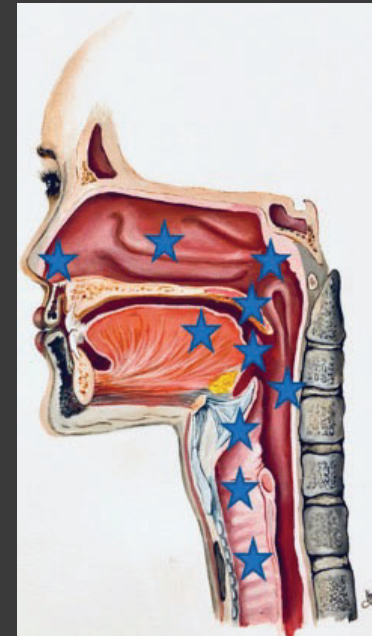
- Caregiver support
- PAP education
- Customised mask
- Behavioural therapy
- Rewards

## Therapies beyond PAP and surgery

- HFNC therapy
- Positional devices
- Orthodontic treatments
- Myofunctional therapy
- Watchful waiting

# Refractory Obstructive Sleep Apnea

- About 20 percent of children who have obstructive sleep apnea are refractory to adenotonsillectomy
- Rates of resolution of OSA are much lower in children with **obesity**, severe OSA, Down syndrome, and those with craniofacial anomalies
- If adenotonsillectomy alone is not curative other anatomical sites or multi-level obstruction may be contributing to refractory OSA
  - nasal, nasopharyngeal, retropalatal, retroglottal, and hypopharyngeal, and supraglottic regions



# Evaluation of Residual Obstruction

- The two main techniques for identifying residual obstruction are drug induced sleep endoscopy (DISE) and Cine MRI
- DISE is now routinely used to assess for sites of upper airway obstruction after T&A in children
- Cine MRI is less commonly utilized imaging modality used to identify the sites of obstruction
- Both techniques can help tailor surgical treatment

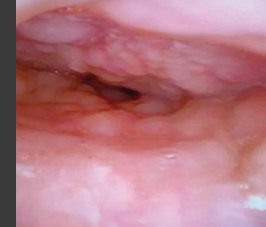
DISE Video



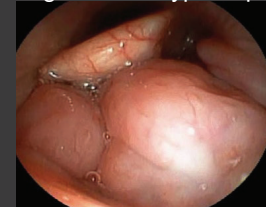
# Obstruction in Refractory OSA

- DISE/Cine MRI findings in studies of pediatric refractory OSA reveal that the base of tongue often the leading site of obstruction
- Surgical management of tongue base obstruction may include a variety of procedures
  - lingual tonsillectomy, posterior midline glossectomy, epiglottopexy, hyoid suspension, tongue base suspension, hypoglossal nerve stimulator

Base of tongue prolapse



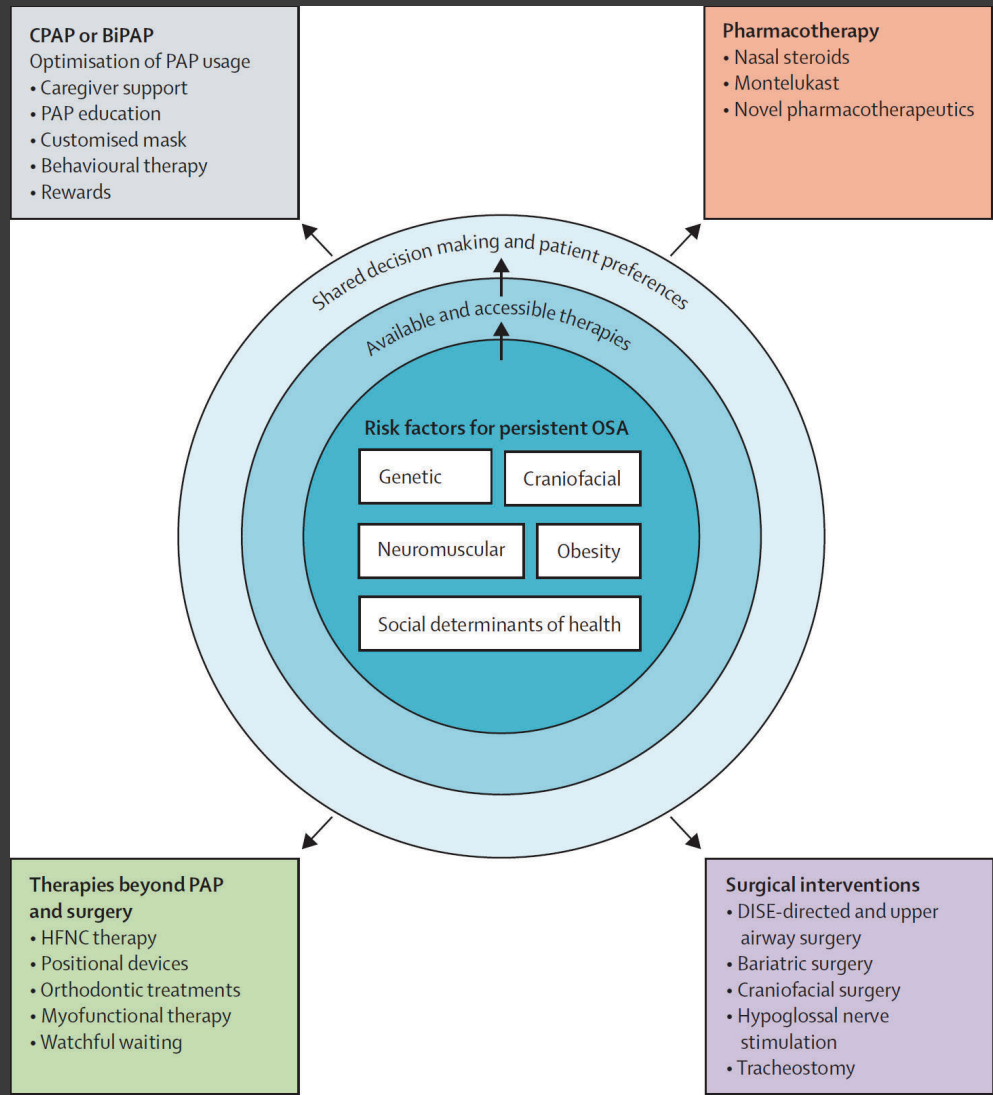
Lingual tonsil hypertrophy



Retroflexion of epiglottis







Ersu R, Chen ML, Ehsan Z, Ishman SL, Redline S, Narang I. Persistent obstructive sleep apnoea in children: treatment options and management considerations. *Lancet Respir Med.* 2023 Mar;11(3):283-296. doi: 10.1016/S2213-2600(22)00262-4. Epub 2022 Sep 23. PMID: 36162413.

# Brief Summary of Pediatric OSA

- Untreated SDB/OSA can lead to long-term health consequences in children
- Surgical outcome for primary adenotonsillectomy have a high success rates in ~ 80% of pediatric patients
- Refractory obstructive sleep apnea secondary to residual obstruction impacts ~20% of pediatric patients particularly those with obesity, Trisomy 21, and craniofacial disorders
- DISE and Cine MRI are helpful techniques in identifying residual obstruction and to help target surgical treatment
- The base of tongue is a common area of obstruction in refractory OSA

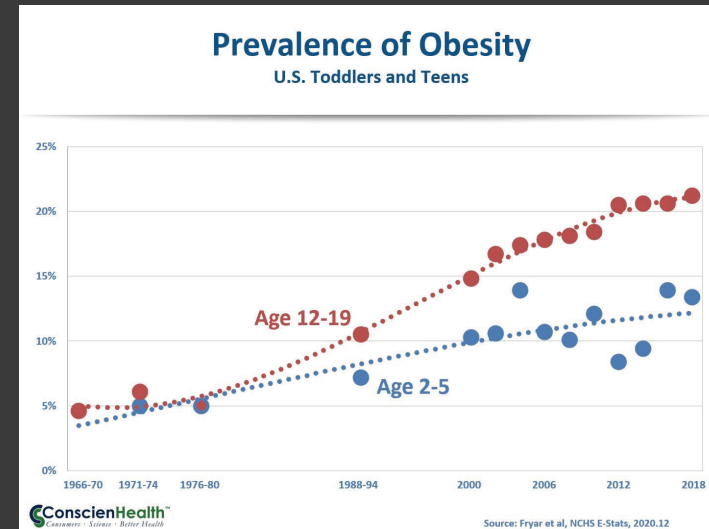
# Obesity and Nutrition

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- Limited data looking specifically at nutritional strategies that impact pediatric OSA in patients with obesity
- Majority of research focuses on impact of nutrition, diet, and physical activity on weight loss & obesity
- The indirect impact on obesity has implications for pediatric OSA as obesity is a significant risk factor for OSA and refractory OSA

# Pediatric Obesity

- The childhood obesity epidemic has reached 124 million individuals, and nearly one in five children and adolescents are overweight or obese
- The worldwide trend in childhood obesity shows a steadily increasing body mass index (BMI) in children and adolescents across four decades.



# WHO on Obesity Trends

- In 2022, an estimated 37 million children under the age of 5 years were overweight
- Over 390 million children and adolescents aged 5–19 years were overweight in 2022
- The prevalence of overweight (including obesity) among children and adolescents aged 5–19 has risen dramatically from just 8% in 1990 to 20% in 2022
- The rise has occurred similarly among both boys and girls: in 2022 19% of girls and 21% of boys were overweight

# Health Impacts of Obesity

- It is a major risk factor directly correlated with childhood hypertension and other metabolic chronic conditions including stroke, prediabetes and type 2 diabetes mellitus , dyslipidemia , and non-alcoholic fatty liver disease
- Obese children are at risk for developing OSA, obesity hypoventilation syndrome, pulmonary thromboembolism, chronic obstructive pulmonary disease (COPD), and respiratory failure may occur later in life



# OSA and Obesity

- Prevalence of obstructive sleep apnea syndrome is estimated at 13–59%
- Childhood obesity is associated with obstructive and central sleep apnea
- Furthermore, SDB in overweight children and adolescents is independently associated with the metabolic syndrome
- SDB becomes a potential additional risk factor for the development of future cardiovascular morbidity.

Verhulst SL, Franckx H, Van Gaal L, De Backer W, Desager K. The effect of weight loss on sleep-disordered breathing in obese teenagers. *Obesity (Silver Spring)*. 2009 Jun;17(6):1178-83. doi: 10.1038/oby.2008.673. Epub 2009 Mar 5. PMID: 19265797.

# Diet and Obesity

- Dietary- and health-related behaviors and food preferences are established in early childhood and continue into adulthood
- Poor food choices and overconsumption are associated with a higher risk of developing obesity
- **Dietary factors are the most important factors associated with childhood obesity**



# Diet and Obesity

- Dietary intervention and multi-sectoral approach intervention studies have reported some positive changes in body composition and dietary factors for overweight and obese children and adolescents
- Dietary components such as energy-dense foods, sugars, sweetened beverages (SSBs) and patterns of processed food consumption are discussed among the modifiable risk factors

# Diet Related Risk Factors

- Numerous diet-related modifiable risk factors (nutrients, foods, dietary patterns, and eating behaviors) have been considered in previous clinical research studies and suggested in guidelines on childhood obesity
- Diet patterns that are rich in meat, soda, fried food, instant noodles, burgers, and pizza increased the risk of obesity by 30% compared to diet patterns rich in whole grains, legumes, potatoes, fish, mushrooms, seaweed, fruits, and vegetables

**Table 1.** Diet-related modifiable factors affecting childhood obesity

Factor	Harmful	Beneficial
Nutrient	- Excessive intake of total energy, proteins (from animal products), fat, saturated fat, sodium <sup>17,28</sup>	- Adequate intake of vitamins C and D, non-starch polysaccharides (fiber), calcium, folate, iron <sup>17,29,36</sup>
Food	- Excessive intake of energy-dense foods: pizza, fast food, discretionary food, soda, sugar-sweetened beverages, and ice cream <sup>23,27,34</sup>	- Adequate intake of whole grains <sup>30,31</sup> - Low daily consumption of milk, fruits, vegetables, fish <sup>37,38</sup>
Dietary pattern	- Westernized dietary patterns high in saturated fatty acids, dense in energy, and poor in micronutrients <sup>17,18,23</sup> - Processed food dietary patterns, including meat, soda, fried food, instant noodles, burgers, and pizza <sup>24</sup>	- Balanced diet based on five food groups <sup>17,28-31</sup> - Stop-light/traffic-light diet, with food divided into three categories: green (low-energy, high-nutrient foods), yellow (moderate-energy foods), and red (high-energy, low-nutrient foods) <sup>39,40</sup>
Dietary behaviors and eating habits	- Eating while watching TV <sup>19</sup> - Skipping breakfast <sup>26,27</sup> - Frequent snacking and eating <sup>19</sup>	- Family mealtimes, eating together <sup>19,32</sup> - Portion control <sup>29,33</sup> - Regular mealtimes <sup>19,32,33</sup>

Guidelines and recommendations<sup>17-19,23,24,26-34,36-40</sup> of diet-related modifiable factors for nutritional management in childhood obesity.

Kim J, Lim H. Nutritional Management in Childhood Obesity. *J Obes Metab Syndr*. 2019 Dec;28(4):225-235. doi: 10.7570/jomes.2019.28.4.225. Epub 2019 Dec 30. PMID: 31909365; PMCID: PMC6939706.

# Nutrition and Weight Loss Initiatives

- A multilevel approach that focuses on diet and health-related activities have provided the most sustainable and beneficial effects on childhood obesity
- Social support such as individualized coaching, text messaging, face-to-face communication, and Internet-based approaches have been adapted to change obesity-related dietary behaviors in children and adolescents
- The most promising approaches for childhood obesity management are intervening with support at levels ranging from individual to community via sustainable and multisectoral strategies.

Kim J, Lim H. Nutritional Management in Childhood Obesity. J Obes Metab Syndr. 2019 Dec;28(4):225-235. doi: 10.7570/jomes.2019.28.4.225. Epub 2019 Dec 30. PMID: 31909365; PMCID: PMC6939706.

# Nutritional Intervention Studies

Study	Subject	Duration	Intervention	Nutritional component	Outcome*
Amini et al. (2016) <sup>45</sup>	(n=334) Fourth to sixth grades, overweight or obese, based on World Health Organization standards	18 wk	Nutrition education and increased PA for the pupils, lifestyle modification for the parents, and changes in food items sold at the schools' cafeterias.	(1) Provided face-to-face training, the book <i>General Knowledge of Nutrition</i> whenever necessary, and a guide for health instructors; 15 to 45 minutes, once a week; 12 weekly sessions; concepts of overweight and obesity, food groups and energy, and obesogenic situations and strategies to overcome them (2) No nutrition education	Only the intervention reduced BMI z-score
Smith et al. (2015) <sup>46</sup>	(n=69) Aged 11–16 years, a BMI for age and sex above the 85th percentile	8 wk (follow-up 12 mo)	Twice-weekly group sessions at local community site (CAFAP) targeting the PA, sedentary behavior, and healthy eating behaviors of overweight adolescents	12 Group education sessions with parents and adolescents together regarding general nutrition, energy balance, food labeling, diet variety, fast food, lunchbox food, portion size, and recipe modification, with the key messages reinforced in each session; cooking classes focusing on the preparation of healthy foods containing fruits and vegetables	Energy intake (kJ)↑, protein (g)↑, fat (g)↑, saturated fat (g)↓, carbohydrate (g)↓, sugar (g)↓, fiber (g)↑ Self-reported eating behaviors↑ Frequency of breakfast↓, frequency of fast food↓, frequency of sweetened beverages↓, perceived daily fruit servings↑, perceived daily Vegetable servings↑
Ojeda-Rodríguez et al. (2018) <sup>47</sup>	(n=107) Aged 7–16 years, waist circumference above the 90th percentile according to national data	8 wk (follow-up 22 mo, ongoing); data present only for 8 wk	(1) Moderate hypocaloric Mediterranean diet and received nutritional education (2) A 30-min individual session with the dietitian and five monitoring visits to assess anthropometric parameters	(1) Children were taught several topics such as food preparation, portion control, eating behavior, food composition. Intensive care participants followed a Mediterranean-style diet based on high consumption of fruit, vegetables, whole grains, legumes, nuts, seeds, and olive oil, minimally processed foods; moderate consumption of dairy products, fish, and poultry; and low consumption of red meat.	(1) Energy (kcal/day)↓, Carbohydrate (g/day)↓, Fiber (g/day)↑, Protein (g/day)↓, Total Fat (g/day)↓ Fruits (g/day)↑, vegetables (g/day)↑, dairy products↑, meat (g/day)↓, fish (g/day)↑, sweets (g/day)↓ (2) Energy (kcal/day)↓, carbohydrate (g/day)↓, fiber (g/day)↑, protein (g/day)↓, total fat (g/day)↓ Fruits (g/day)↑, vegetables (g/day)↑, dairy products↑, meat (g/day)↓, fish (g/day)↑, sweets (g/day)↓ Significant reduction in BMI standard deviation score in both groups

# Nutritional Intervention Studies

Kustiani et al. (2015) <sup>49</sup>	(n=90) Aged 10–15 years, obese	5 wk	(1) Nutrition education and PA intervention (2) Nutrition education and fruit intervention (3) Nutrition education, PA and fruit intervention	Nutrition education intervention was conducted for 30 minutes every week. Intervention of fruit was conducted on every school day (5 times/wk) with 1–2 servings of fruit.	(1) Fiber intake↑ (2) Fiber intake↑ (3) Fiber intake↑ Body weight decreased in (1, 3) exception of (2)
Serra-Paya et al. (2015) <sup>49</sup>	(n= 113) Aged 6–12 years, overweight or obese	8 mo	(1) Family-based multicomponent behavioral intervention (2) Usual advice from their pediatrician on healthy eating and PA	Three behavior strategy sessions were designed to reinforce the acquisition of healthier PA and eating habits within the family.	(1) Fruits (pieces/day)↑, processed meats (servings/day)↓, fish (servings/day)↑, vegetables (servings/day)↑, legumes/pulses (servings/day)↑, superfluous foods (servings/day)↓, sugar-sweetened juices and soft drinks (servings/day)↓ (2) Fruits (pieces/day)↑, processed meats (servings/day)↓, fish (servings/day)↓, vegetables (servings/day)↑, legumes/pulses (servings/day)↑, superfluous foods (servings/day)↓, sugar-sweetened juices and soft drinks (servings/day)↓ No significant difference of BMI between the two groups at post intervention
Llauradó et al. (2018) <sup>50</sup>	(n= 349) 13- to 15-year-old adolescents with childhood obesity	4-yr follow-up	Twelve educational intervention activities that focused on eight lifestyle topics selected based on scientific evidence to improve nutritional food selection, healthy habits, and overall adoption of behaviors that encourage PA	(1) To encourage the intake of healthy drinks (and the avoidance of unhealthy carbonated sweetened beverages) (2) To increase the consumption of vegetables and legumes (3) To decrease the consumption of candies and pastries while increasing the intake of fresh fruits and nuts (second year) (4) To increase fruit intake (5) To improve dairy product consumption and to increase fish consumption	Only the intervention girls showed reduced BMI z-scores.

# Outcomes

- Energy and nutrient intake:
  - Two studies reported higher energy, protein, and fat intake after the intervention compared to baseline
  - Despite the lack of positive changes in macronutrient intake, lower levels of saturated fat and sugar consumption were presented in the CAFAP cohort study
  - In another multidisciplinary intervention study, lower energy intake and macronutrient intake were reported after the dietary intervention (at 8 weeks) in both the usual care group and the intensive care group.<sup>47</sup>



# Outcomes

- Consumption of fruits, vegetables, and dairy products:
  - Improvements in consumption of fruits and vegetables among the children and adolescents were reported in three of the multicomponent-approach intervention studies.
  - OjedaRodríguez et al. and Serra-Paya et al. presented higher levels of dairy product consumption as well as fruit and vegetable consumption after the intervention in both groups.
  - Meanwhile, a 4-year follow-up study showed decreased consumption of dairy products, fruits, and fish among children and adolescents



# Outcomes

- Unhealthy dietary behaviors:
  - Lower consumption levels of sugar-sweetened juices and soft drinks and sweet, superfluous foods (cookies, pastries, dairy-based desserts, and French fries, which contain high levels of lipids and/ or simple sugars) were shown after the dietary intervention in three of the preceding studies.

# Outcomes

- Body composition:
  - Most of the studies showed decreased BMI z-scores of obese children and adolescents after 6 weeks to 6 months for each of the intervention studies.

# What's Missing

- Though there are some promising results in improving nutrition and weight loss, there is limited data on the direct impact on SDB/OSA in the pediatric population

# Conclusions:

- Pediatric SDB and OSA are frequently encountered
- First line treatment of SDB/OSA is surgical management
- Obesity is a significant risk factor for OSA and refractory OSA
- Treatment options include surgical and non surgical options
- Obesity is linked to nutrition/diet and strategies to for comprehensive treatment of OSA in obese children should include nutrition/diet planning to improve long term health outcomes