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TONSILLECTOMY AND ADENOIDECTOMY: THE INFLUENCE IN CHILDREN´S SLEEP AND BEHAVIOUR

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Tonsillectomy and Adenoidectomy: The Influence in Children´s Sleep and Behaviour

Dissertação de candidatura ao grau de Mestre em Medicina, submetida ao Instituto de Ciências Biomédicas Abel Salazar – Universidade do Porto (ICBAS-UP)

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Porto, junho de 2025.

Maria Margarida Camanho

(Maria Margarida Albuquerque Ribeiro Ponces Camanho)

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Resumo

Introdução: A hipertrofia adenoamigdalina é uma condição frequente em idade pediátrica, podendo contribuir para consequências relevantes na prática clínica devido à sua potencial associação com distúrbios respiratórios do sono, incluindo a apneia obstrutiva do sono, condição essa associada a um impacto negativo na qualidade do sono, no comportamento diurno, no desenvolvimento neurocognitivo e, ainda, no crescimento normal da criança.

Objetivos: Perceber de que modo é que a amigdalectomia e adenoidectomia têm impacto nos hábitos de sono e comportamento das crianças ao longo do tempo. Pretende-se, também, explorar as diferenças entre as crianças submetidas a intervenção cirúrgica devido a infeções das vias aéreas superiores recorrentes e distúrbios respiratórios obstrutivos do sono.

Metodologia: Estudo longitudinal, prospetivo e observacional que incluiu crianças com idade entre os 2 e os 10 anos submetidas a adenoamigdalectomia entre dezembro de 2023 e dezembro de 2024 no Centro Materno-Infantil do Norte (CMIN). Os dados demográficos, clínicos e cirúrgicos foram extraídos através do Processo Clínico Eletrónico. A avaliação das alterações nos hábitos de sono e comportamento foi realizada com recurso a instrumentos validados: o *Children's Sleep Habits Questionnaire – versão portuguesa adaptada* (CSHQ-PT) e o *Strengths and Difficulties Questionnaire – versão portuguesa* (SDQ-Por). Foram usados testes t para amostras emparelhadas e modelos de regressão para comparar os resultados pré e pós-operatórios, bem como para explorar diferenças entre grupos conforme a indicação cirúrgica. Todas as análises estatísticas foram realizadas com recurso ao *software* IBM SPSS Statistics® versão 29.0 para Windows (SPSS Inc., Chicago, IL, EUA)

Resultados: O estudo incluiu 28 crianças com avaliações pré e pós-operatórias. Foram observadas melhorias significativas em vários parâmetros do sono, incluindo a duração do sono, parassónias, perturbações respiratórias relacionadas com o sono, sonolência diurna e o índice global de perturbação do sono ($p < 0,001$). No domínio comportamental, apesar de melhorias ligeiras em todas as subescalas, apenas a hiperatividade atingiu significância estatística ($p = 0,028$). A indicação cirúrgica não influenciou significativamente a maioria dos resultados, com exceção das perturbações respiratórias do sono, onde se verificou uma melhoria superior nas crianças com indicação obstrutiva.

Conclusão: A intervenção cirúrgica revelou um impacto positivo em diversas dimensões do sono, com especial destaque para a diminuição dos episódios de parassónias, bem como nos sintomas de hiperatividade, independentemente da indicação cirúrgica. Estes resultados reforçam a importância do reconhecimento e abordagem precoces dos distúrbios respiratórios do sono, não só para promover uma boa qualidade de sono e melhor desempenho funcional diurno, mas também promover um bom desenvolvimento psicossocial da criança a longo prazo.

Palavras-chave: Adenoidectomia; Amigdalectomia; Distúrbios Respiratórios do Sono; Apneia Obstrutiva do Sono; Infeções do Trato Respiratório Superior; Desenvolvimento infantil; Sono Infantil; Parassónias; Hiperatividade

Abstract

Introduction: Adenotonsillar hypertrophy is a common condition in pediatric population and may contribute to clinically significant consequences due to its potential association with sleep-disordered breathing, including obstructive sleep apnea syndrome, a condition known to impact negatively sleep quality, daytime behaviour, neurocognitive development, and normal child growth.

Objectives: Investigate how tonsillectomy and adenoidectomy affect children's sleeping habits and behaviour over time exploring the differences between children undergoing surgery due to recurrent Upper Respiratory Tract infections (URTIs) versus those with Obstructive Sleep-Disordered Breathing (OSDB).

Methodology: Prospective longitudinal and observational study involving children aged between 2 and 10 years who underwent adenotonsillectomy between December 2023 and December 2024 at the Centro Materno-Infantil do Norte (CMIN). Demographic, clinical, and surgical data were extracted from each patient's Electronic Health Record (EHRs). The evaluation of the changes in sleep behaviour and psychosocial adjustment over time was done through validated tools - Adapted Children's Sleep Habits Questionnaire (CSHQ-PT), based on the version developed by Professor Owens in 2000 and the Portuguese version of the Strengths and Difficulties Questionnaire (SDQ-Por). Paired sample t-tests and regression models were applied to compare pre- and postoperative scores, as well as explore any differences between the outcomes according to the surgical indication. All statistical analyses were performed using IBM SPSS Statistics® version 29.0 for Windows (SPSS Inc., Chicago, IL, USA).

Results: 28 children completed both pre- and postoperative assessments. Significant improvements were observed in several sleep parameters, including sleep duration, parasomnias, sleep-related breathing disorders, daytime sleepiness, and the total sleep disturbance index ($p < 0.001$). In the behaviour domain, despite slight improvements in all the subscales, hyperactivity was the only one reaching a statistical significance ($p = 0.028$). Surgical indication did not significantly influence most outcomes, except for sleep-related breathing disorders, where greater improvement was observed in children with obstructive indications.

Conclusion: Otolaryngologic intervention proved to have a positive impact in multiple dimensions of sleep, with a special relevance in the reduction of parasomnia´s episodes, as well as on symptoms of hyperactivity, regardless of clinical indication. These findings highlight the importance of the early recognition and management of sleep-disordered breathing, not

only to promote sleep quality and improved daytime functioning, but also to support a healthy psychosocial development in children.

Keywords: Adenoidectomy; Tonsillectomy; Sleep-Disordered Breathing; Obstructive Sleep Apnea Syndrome; Superior Respiratory Tract Infections; Pediatric Sleep; Child Development; Parasomnias; Hyperactivity

Acronyms

ADHD - Attention Deficit Hyperactivity Disorder

ADT – Adenotonsillectomy

APCs – Antigen Presenting Cells

CMIN – Centro Materno-Infantil Do Norte

CSHQ-PT - Adapted Children's Sleep Habits Questionnaire, based on the version developed by Professor Owens in 2000

DS - Daytime Sleepiness

EHRs - Electronic Health Record

GABA - Gamma-AminoButyric Acid

GH - Growth Hormone

GLM – General Linear Model

IGF-I – Insulin-like Growth Factor I

IGFBP-3 - Insulin-like Growth Factor Binding Protein 3

MALT - Mucosa-Associated Lymphoid Tissue

ORL – Otorhinolaryngology

OSAS – Obstructive Sleep Apnea Syndrome

OSDB - Obstructive Sleep-Disordered Breathing

PFAPA - Periodic Fever, Aphthous stomatitis, Pharyngitis, and cervical Adenitis

PSG – Polysomnography

SD – Sleep Duration

SDB – Sleep-Disordered Breathing

SDQ-Por - Portuguese version of the Strengths and Difficulties Questionnaire (SDQ-Por).

SRBD - Sleep Related Breathing Disorders

TSDI - Total Sleep Disturbance Index

Tfh - T follicular helper

URTIs –Upper Respiratory Tract Infections

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Context and Importance of the Study

Adenoid and tonsil hypertrophy are among the most prevalent conditions in the pediatric population and constitute a major concern in pediatric otolaryngology due to their potential significant impact on children's overall health and development. The lymphoid tissues that make up Waldeyer's ring, particularly the palatine and pharyngeal tonsils, play an essential role in the immune defense of the upper respiratory tract. However, in some children, these structures undergo abnormal growth, which may lead to upper airway obstruction and consequent complications affecting multiple physiological functions, especially during sleep.

One of the most important consequences of this hypertrophy is its association with Sleep-Disordered Breathing (SDB), including Obstructive Sleep Apnea Syndrome (OSAS), a condition with a range of adverse effects on sleep quality, daytime behaviour, neurocognitive development, and even physical growth. The obstruction caused by enlarged adenoids and tonsils can lead to fragmented sleep and intermittent hypoxemia, which are believed to be responsible for a number of behavioural and cognitive impairments observed in affected children. For this reason, adenotonsillar hypertrophy and its impact on sleep and behaviour represent a significant area of interest for clinical research and intervention.

This study aims to investigate how tonsillectomy and adenoidectomy affect children's sleep habits and behaviour over time, exploring the differences between children undergoing surgery due to recurrent Upper Respiratory Tract Infections (URTIs) versus those with Obstructive Sleep-Disordered Breathing (OSDB). By assessing these outcomes before and after surgery, the research seeks to provide deeper insight into the benefits of these common procedures, and ultimately, to contribute to better-informed clinical decision-making and improved quality of life for pediatric patients.

Introduction

1. Waldeyer´s Ring

The Waldeyer´s ring consists of a collection of lymphoid tissue that forms part of the mucosa-associated lymphoid tissue (MALT) and plays an important role in local and systemic immunity. This structure, strategically arranged in a circumferential configuration in the nasopharynx and oropharynx, at the common entry of both respiratory and alimentary tracts, is formed by four main structures, each positioned to monitor and protect different entry routes for pathogens (see Figure 1). Firstly, the palatine tonsils are located between the lateral oropharyngeal wall's anterior and posterior tonsillar pillars. Secondly, the pharyngeal tonsil, commonly referred to as the adenoid, lies in the midline of the nasopharynx lined with its roof and posterior wall, positioned posterosuperiorly to the posterior nasal opening (choanae). Laterally to the pharyngeal tonsil, there is the third lymphoid structure, the tubal tonsils, also known as Gerlach tonsils, found at the lateral walls of the nasopharynx immediately posterior to the opening of the Eustachian tube and in close association with the torus tubarius. The last structure of the Waldeyer´s ring is the lingual tonsil, which is located along the posterior third of the base of the tongue adjacent to the palatine tonsils at the glossotonsillar sulcus (1–3).

As a MALT component, Waldeyer´s ring is the primary immunological barrier formed by specialized surface epithelium, including M cells, that line the deep crypts, allowing and increasing the direct contact with inhaled and ingested pathogens, as well as the uptake and transport of these antigens into the underlying, not fully encapsulated, lymphoid tissue, therefore, priming the whole upper-airway immune system (1,3,4).

1.1. Hypertrophy of Palatine and Pharyngeal Tonsils in the Pediatric Population

During the first years of life, due to its immunologic role, a rapid tonsillar growth is observed. Although the mechanism remains unclear, it may be explained by exogenous antigen presentation that promotes the formation of germinal centers, proliferation of lymphoid tissue, and expansion of the tonsillar parenchyma (1,2).

Generally, the dimensions of pharyngeal and palatine tonsils are expected to peak around the age of 6 and puberty, respectively. Thereafter, the tonsils begin to shrink through the increased production of fibrous tissue and fatty degeneration, usually, around the age of 8-10 for the pharyngeal tonsils and in adulthood for the palatine tonsils (1). Due to this initial rapid tonsillar growth phase, it can be noted that some individuals develop pathologic immune-related processes, such as recurrent URTIs, tonsillar hypertrophy and allergic diseases (1,2).

Palatine and pharyngeal hypertrophy is a highly prevalent condition in the pediatric population, that affects children predominantly between the ages of 3 and 6. It represents a common underlying cause of mechanical obstruction and chronic inflammation, often reflecting a wide range of clinical signs and symptoms. These alterations can significantly impair quality of life, disrupt sleep patterns, and negatively influence overall child development (5). Although the underlying cause for this condition is not yet fully understood, it may depend on various factors, such as recurrent URTIs.

Chronic tonsillitis relies on a history of tonsillitis and odynophagia relapsing 3 to 4 times per year or not responding completely to antibiotic therapy. As a result, hypertrophy develops because of parenchymal hyperplasia or fibrinoid degeneration, leading to obstruction of the crypts (6). Studies suggest that tonsillitis and adenoiditis result from antigens' evasion from immune defenses, becoming trapped in tonsillar crypts and proliferating before an adequate immune response is established. During a recurrent infection, there is a change in the reticulated epithelium that may reduce the efficiency of the antigen uptake and, in combination with immature antigen-presenting cells, may impair the activation of a proper immune response, leading to local immunosuppression, perpetuating the inflammation. It is also important to note that some studies identified senescent macrophages and T cells in the epithelium and interfollicular area, respectively. This finding suggests an impaired immune response that affects both phagocytosis and pathogen killing, leading to the overgrowth of follicles through lymphoid cell accumulation (1,6–8). Furthermore, the formation of biofilms must be considered, since they enhance pathogen survival and further compromise the immune response (9,10).

Other factors described as potential causes of tonsillar hypertrophy include exposure to allergens and environmental pollutants, such as exposure to cigarette smoke, gastroesophageal reflux, which leads to chronic inflammation of the upper respiratory tract, and genetic predisposition (9,10).

Therefore, multiple factors may contribute to the hypertrophy of the palatine and pharyngeal tonsils, which may be caused by either chronic infectious processes or by non-infectious causes.

Palatine and pharyngeal hypertrophy can be the underlying cause for several pathological conditions due to a relative mismatch between enlarged tonsils and a small nasopharynx and oropharynx in the pediatric population, leading to choanal and oropharynx obstruction, therefore, resulting in restricted air flow as a consequence of partial obstruction of the airway (11). These children, especially the ones with pharyngeal tonsil hypertrophy, will have predominantly oral breathing that dries mucous membranes, perpetuating the susceptibility to chronic upper respiratory tract infections, particularly recurrent tonsillitis, as well as dental caries, halitosis, and dysgeusia (12,13). The prevalence of pharyngeal hypertrophy in the pediatric population is estimated to be 34% (2).

Cardoso et al. (2020) showed that approximately 70% of children between 2 and 7 years old with adenoid hypertrophy had chronic rhinosinusitis and 60% otitis media with effusion (14). In fact, hypertrophied adenoids will cause the obstruction of the Eustachian tube orifice, resulting in the impairment of the secretion drainage and the creation of a favorable environment for the proliferation of infectious agents. For these reasons, a biofilm is thought to be implicated in the pathogenesis of otitis media with effusion (11). Prolonged persistence can then result in impaired or delayed speech and language development. Furthermore, the dysfunction of Eustachian tube can be implicated in other symptoms such as aural fullness, muffled hearing, otalgia, tinnitus, and a sensation of ear popping or clicking, particularly during changes in atmospheric pressure. In the long term, dysfunction of Eustachian tube can cause a variety of complications including tympanic retraction, conductive hearing loss, and even cholesteatoma (5). If the choanal obstruction is significant, the patient can suffer from chronic sinusitis as a result and may complain of facial pain or pressure (9).

On physical exam, the patient with adenoid hypertrophy will often breathe through the mouth and, therefore, have a characteristic nasal speech, and may have facial characteristics known as adenoid facies (9). In fact, craniofacial growth is complex and depends on a myriad of factors, such as surrounding soft tissues and physiological processes like biting, chewing, swallowing, breathing and speech. Therefore, breathing plays a rather important role in the shaping of the face and the normal means of breathing in humans that maintains a functional balance is through the nasal respiratory tract. For this reason, children with pharyngeal tonsil hypertrophy, because of the shift from nasal to oral breathing, will have a lifting of the soft palate and the lowering of the tongue, in order to allow the airflow through the mouth. Over the years, in severe cases and if left untreated, the child will develop a permanent “adenoid facies” which include an open-mouth posture with recessed lower jaw and lower dental arch, high arched soft palate and narrow upper dental arch, shorter upper lip and elongated face. Additionally, the tongue´s position is different, particularly its resting position that, instead of being on the palate, it is at the bottom of the mouth, resulting in elongated mandible. Children often present with dental malocclusion, such as an oversized bite, open bite or crossbite (2,9,11,12). It is, also, important to note that the dental malocclusion described, in association with poor tongue positioning, can result in the impairment of speech, namely, difficulties with the articulation of words (15). Furthermore, the adenoidal face, as well as the impaired mobility of tongue and even a hearing impairment, due to the dysfunction of Eustachian tube and accumulation of fluid in tympanic cavity, contributes, all together, for the characteristic nasal speech of these children (12,13).

It has also been described that children with palatine and pharyngeal hypertrophy often manifest eating and swallowing disorders, namely dysphagia typically for solids with failure to thrive associated (12,16).

It is of high importance to note that other individuals develop complications associated with anatomic obstruction of the oropharynx and nasopharynx, in particular (1). Indeed, adenotonsillar hypertrophy is the most common cause of pediatric OSDB, with several short- and long- term consequences affecting various aspects of a child´s development and quality of life (12).

2. Obstructive Sleep-Disordered Breathing (OSDB)

OSDB in children is a clinical spectrum of conditions characterized by the collapse and narrowing of the upper respiratory tract, leading to episodes of partial or complete obstruction of its patency during sleep and, consequently, disorders of the blood-gas exchange as well as atypical sleep patterns (2,17,18). Indeed, it includes simple snoring, increased upper airway resistance syndrome, obstructive hypoventilation, characterized by the decrease in the airflow, and, also, OSAS, the most severe sleep respiratory disorder (18). OSDB occurs in 1.2% to 5.7% of children, and its prevalence is increasing over time due to the rising trend of childhood obesity (2,16) and, typically, symptoms peak between the ages of 2 and 8 (2). The pathophysiology of pediatric OSDB is multifactorial, however, the main cause is the hypertrophy of the pharyngeal and palatine tonsils, leading to upper airway restriction during sleep (12,14,16,17). Other potential etiologies include craniofacial anomalies, Down's syndrome, obesity, neuromuscular disorders and laxity (2,16). The combined volume of adenotonsillar hypertrophy, craniofacial anatomy and neuromuscular tone correlates closely with OSDB severity (16,19).

Simple snoring, characterized by vibratory noises of the soft palate during inspiration, reflects a partial upper airway obstruction and it is often associated with OSAS or increased upper airway resistance syndrome. It affects 3-12% of children and 47% during upper respiratory tract infections (18,20). Common causes include adenotonsillar hypertrophy, obesity, nasal obstruction, and respiratory infections. Furthermore, children may present with symptoms of forced oral breathing, dry lips, halitosis and speech difficulties (2).

Increased upper airway resistance syndrome, on the other hand, involves increased respiratory muscle effort during sleep due to excessive resistance of the upper respiratory tract.

Obstructive hypoventilation is marked by prolonged hypoventilation with hypoxia and hypercapnia, without complete airway collapse, and minimal sleep disruption.

Lastly, OSAS affects 2% of children and involves episodes of prolonged partial upper airway obstruction that are interrupted by a total obstruction with consequent hypoxemia. It is important to note that habitual (3 or more nights per week) or loud snoring is present in most children with obstructive sleep apnea, but it is insufficient to make a diagnosis (21). In pediatrics, any respiratory pause, regardless of its duration, is considered apnea (18,20).

Therefore, OSDB is a clinical diagnosis that encompasses the conditions mentioned above, which have the common characteristic of the potential decrease in oxygen saturation and hypoventilation (17).

2.1. Symptoms of OSDB

The symptoms described in this spectrum can be divided into nocturnal and daytime symptoms. Indeed, the hypoxia observed, due to the significant airflow reduction or complete cessation of breathing, results in restless or agitated sleep and frequent nocturnal arousals, causing sleep fragmentation. In fact, parents usually describe frequent snoring, not necessarily loud, and the sensation of pauses in breathing followed by brief arousals and gasping of the child. Normally, children can be observed sleeping in unusual positions such as with an extended neck and may have a labored breathing and paradoxical abdominal movements (22). Furthermore, it is also known that OSDB is associated with the increased frequency of parasomnias, including night terrors, confusional arousals and sleepwalking. The reason for this association is likely due to increased arousals from sleep and disruption of sleep architecture (23). Studies have, also, suggested an association between OSDB and the prevalence of bruxism in children. Indeed, frequent nocturnal micro-arousals may lead to increased parafunctional activity, including activation of mastigatory muscles, thereby triggering bruxism. Additionally, airway obstruction prompts anterior positioning of the mandible to improve airway patency, stimulating receptors that increase upper airway muscle tone. Oral breathing may also disrupt sleep architecture and impair cerebral oxygenation, resulting in involuntary contractions of facial muscles (24).

On the other hand, daytime symptoms may include frequent complaints of headaches, sleepiness during the day that, despite being less obvious in children than in adults, it can be manifested by age-inappropriate daytime napping or falling asleep during school or short car rides (25,26). Also, OSDB can be suspected in children presenting with mouth breathing, consequent dry mouth, halitosis and hyponasal speech. (2,22). Importantly, it impacts organ dysfunction and may be the underlying cause of altered behaviour and neurocognitive performance due to the frequent arousals and intermittent hypoxemia during sleep. Hence, OSDB in children has a strong association with inattention as well as memory impairment, resulting in learning disabilities and poor school performance. Behavioural problems are, also, extremely relevant in these pediatric patients, due to the fact that OSDB is strongly correlated with hyperactivity, impulsivity and aggressivity (2,13,16,22). This fact can be explained by altered neurotransmitter regulation with lower levels of Gamma-Aminobutyric Acid (GABA), an inhibitory neurotransmitter and higher levels of glutamate, an excitatory neurotransmitter in the insular cortex as well as brain structural changes, since intermittent hypoxia and hypercapnia may contribute to brain oxidative stress, with consequent neuronal injury and vascular inflammation, leading to reduced cortical thickness, particularly in the prefrontal cortex and hippocampus, critical areas in the regulation of behaviour, executive function and memory (27,28). In fact, children may be particularly vulnerable to these neurocognitive impairments, as the insult occurs during a critical window of brain development, potentially resulting in long-lasting consequences (2). It is also important to mention that OSDB, in some cases, can lead to the diagnosis of Attention Deficit Hyperactivity Disorder (ADHD), revealing an overlap between both diagnoses. This can be explained by several mechanisms. Indeed, sleep fragmentation can exacerbate ADHD symptoms, as well as disrupt the regulation of dopamine and norepinephrine, both neurotransmitters with important roles in attention and focus (27–30).

In the long term, if not treated accordingly, OSDB may lead to several cardiovascular consequences. In fact, studies concluded that these children have increased heart rate and heart rate variability, a non-dipping blood pressure and elevated mean blood pressure when compared with healthy individuals (31,32). Over time, these changes can lead to hypertension. Other cardiovascular morbidity that may be associated with OSDB includes *cor pulmonale*, pulmonary hypertension, right and left ventricular dysfunction as well as endothelial dysfunction (12,31,33–35).

Additionally, studies showed a relation between OSDB and secondary enuresis in up to 50% of the children (5,19,27,36,37). This can be explained by hormonal contribution, in particular, the increased release of natriuretic peptides due to the hypoxia and altered cardiac load. Also, breathing forcefully against a blocked airway causes direct mechanical pressure on the bladder, contributing, also, to the nocturnal enuresis.

Lastly, an extremely important consequence of OSDB in childhood is the potential growth impairment (12,13,16). In fact, there are several theories that explain this growth retardation. Severe OSDB can be associated with decreased caloric intake due to anorexia or dysphagia commonly seen in children with tonsillar hypertrophy. On the other hand, studies suggest an increased energy expenditure resulting from the elevated respiratory effort required during sleep. Furthermore, Growth Hormone (GH) secretion may be decreased in children with OSDB. GH is primarily secreted during the deep stages of sleep. Thus, it is hypothesized that children with OSDB experience a reduction in nocturnal GH secretion due to the frequent arousals and consequent failure to reach those stages of sleep. Supporting this, serum levels of Insulin-like Growth Factor I (IGF-I), as well as Insulin-like Growth Factor Binding Protein 3 (IGFBP-3), are found to be lower in children with OSDB compared to healthy children (19,38,39).

2.2. Diagnosis of OSDB

A screening for OSDB may be done during routine health care visits, as well as visits where the airway is evaluated due to upper respiratory symptoms by asking caregivers about snoring, recurrent URTIs or other symptoms or risk factors associated such as sleepiness, behavioural or learning problems. The diagnostic evaluation of OSDB in children is based on a clinical history comprehending all the risk factors, nocturnal and daytime symptoms (17,18). Some questionnaires have been developed and validated, for clinical research, to assess signs and symptoms associated with OSDB, despite that, in some cases, it can be a useful screening tool and can be a good support during clinical history. Sleep-Related Breathing Disorder scale from the Pediatric Sleep, as well as *Children's Sleep Habits Questionnaire, Prof. Owens, 2000* are two examples of validated questionnaires used for clinical research (40–42).

Physical examination is crucial for the diagnosis of OSDB, as several abnormalities may be observed. It is important to do an ear, nose and throat examination to evaluate not only the presence or absence of tonsillar hypertrophy and the determination of its relationship with the oropharynx, but also the presence of the adenoid facies as described above and any other feature that can be related to OSDB. Tonsil size is graded using the Brodsky score (see Figure 2). Head and neck examination is, also, essential to determine other clues to the source of the airway obstruction (17,18). The child´s height and weight should also be assessed and, finally, it is also essential to measure arterial pressure and rule out signs of pulmonary hypertension (18).

The gold standard that, in combination with the clinical criteria, makes the definite diagnosis of OSDB, in particular, OSAS is the overnight Polysomnography (PSG) and is the only diagnostic tool that can correctly identify obstructive events and assess its severity (16–19,43). However, the use of PSG is not recommended in all cases of suspected OSAS due to its lack of availability and costs. Current American Academy of Otolaryngology – Head and Neck Surgery guidelines recommend PSG in high-risk children, namely, below the age of 2 years or if they have obesity, Down syndrome, craniofacial abnormalities, neuromuscular disorder, sickle-cell disease, or mucopolysaccharidoses (19), if the need for definite treatment is uncertain or there is any discordance between history of OSDB and tonsillar size observed on physical exam. Other diagnostic tests that may be useful in some cases if PSG is not available include home sleep apnea tests, nap PSG, overnight continuous pulse oximetry, audiotapes and videotapes (16–19)

3. Tonsillectomy and Adenoidectomy

Tonsillectomy, with or without adenoidectomy, is one of the most commonly performed surgical procedures in children under the age of 15. Tonsillectomy can involve completely removing both palatine tonsils, including the surrounding capsule, through dissection of the space between the capsule and the muscular wall. Adenoidectomy, on the other hand, refers to the excision of the pharyngeal tonsil. Studies estimate that in the United States, 5 to 8 tonsillectomies/adenotonsillectomies are performed per 1000 children per year (44,45).

The primary indications for these procedures are infectious and obstructive conditions, such as recurrent or chronic infection that may involve the tonsils, peritonsillar tissues, pharynx, recurrent otitis media, sinusitis, mastoiditis, chronic infection of cervical lymph nodes and OSDB, which includes OSAS (7,46). It is noteworthy that OSDB and recurrent tonsillitis are, by far, the most common indications for adenotonsillectomy in children and this surgical procedure constitutes the first-line treatment for pediatric OSAS in otherwise healthy children presenting with hypertrophy of the tonsils and adenoids—a highly prevalent clinical scenario (7,17,43).

3.1. Indications for tonsillectomy and adenoidectomy

According to the American Academy of Otolaryngology – Head and Neck Surgery, adenoidectomy is advised in various clinical contexts, particularly among pediatric patients. It is typically indicated in children under 12 years of age who present with four or more episodes of recurrent purulent nasal discharge over the course of a year, with at least one episode confirmed through intranasal examination or imaging studies. Surgical intervention is also justified when symptoms of adenoiditis persist despite two distinct courses of antibiotic treatment, provided that at least one regimen includes a beta-lactam antibiotic administered for a minimum of 14 days. Other indications encompass sleep-related disturbances due to nasal obstruction lasting three months or longer, hyponasal speech patterns, persistent otitis media with effusion exceeding a three-month duration, and evidence of malocclusion or abnormal orofacial development documented by dental or orthodontic evaluation. Cardiopulmonary sequelae, such as *cor pulmonale*, elevated pulmonary arterial pressure, or right ventricular hypertrophy arising from chronic upper airway obstruction, also represent valid justifications for adenoidectomy. In some cases, the presence of persistent otitis media with effusion alone may warrant surgical consideration (46).

Tonsillectomy is likewise indicated under specific clinical conditions. Recurrent acute tonsillitis serves as a primary criterion, particularly when there are seven or more documented episodes within a single year, five episodes annually for two consecutive years, or three episodes per year over a span of three years. Additionally, if a child has missed more than two weeks of school in one academic year due to tonsillitis—characterized by fever exceeding 38.3 °C, tender or enlarged (>2 cm) cervical lymph nodes, tonsillar exudates, or a confirmed Group A beta-hemolytic Streptococcus infection—surgical removal of the tonsils may be considered. Further indications include tonsillar enlargement leading to airway obstruction, such as in obstructive sleep apnea, difficulties in swallowing or articulation, the occurrence of peritonsillar abscesses, acute tonsillitis accompanied by febrile seizures, syndrome of periodic fever, aphthous stomatitis, pharyngitis, and cervical adenitis (PFAPA) who have not responded to conservative treatment, halitosis refractory to other measures or clinical suspicion of malignancy (19,46,47).

It is important to note that most tonsil-related problems in children tend to decline naturally as the child grows, although not predictably. Therefore, the decision to pursue elective tonsillectomy or adenoidectomy should be made individually. This decision-making process should take into account a range of considerations, including a careful evaluation of the potential advantages and risks associated with surgical intervention. The severity of the child’s condition, such as the frequency and intensity of recurrent tonsillitis or the degree of airway obstruction, should be weighed alongside the expected clinical course of the underlying issue.

In situations where there is no clear and definitive indication for surgery, the presence of certain modifying factors, such as intolerance or allergy to multiple antibiotics, or associated comorbidities, like significant academic difficulties, may influence the decision in favor of proceeding with tonsillectomy (19).

3.2. Benefits of surgery

These surgical procedures have been shown to improve these symptoms and enhance quality of life, with cure rates of 70% to 90% in appropriate cases (47). Indeed, growing evidence demonstrates that tonsillectomy and adenoidectomy have significant and lasting benefits, including improvements in behaviour, neurocognitive performance, school outcomes, and overall quality of life. These procedures also contribute to the resolution of enuresis, better growth parameters, and reduced asthma severity (19). Additionally, they have been linked to a decreased incidence of upper respiratory infections, lower healthcare utilization, reduced school absenteeism, and enhanced sleep and cognitive function (12,16,38).

3.3. Alternative Approaches

An alternative surgical approach is partial tonsillectomy, which involves reducing the volume of the tonsils rather than complete removal. This technique offers certain advantages in terms of intraoperative and postoperative complications. Evidence suggests a lower risk of postoperative bleeding, reduced pain, decreased need for analgesics, and earlier return to a normal diet. However, there is a potential for tonsillar regrowth and recurrence of symptoms, though the underlying pathophysiological mechanism remains unclear (48–50).

Objectives

This study, primarily aims to investigate the evolution of children's sleeping habits and behavioural patterns, as reported by their caregivers, at baseline (preoperative period) and three to six months after adenotonsillectomy performed due to recurrent URTIs, OSDB or both.

Furthermore, it also seeks to explore the differences in this evolution between children undergoing surgery for recurrent URTIs and those undergoing surgery due to OSDB.

The relevance of this research lies in its potential to provide insights into the impact of these surgical interventions on children's sleep quality and behaviour, thereby contributing to the development of more effective clinical management strategies.

Methods

1. Study Design

Prospective longitudinal and observational study involving children aged between 2 and 10 years who underwent adenotonsillectomy between December 2023 and December 2024 at the Centro Materno-Infantil do Norte (CMIN).

Demographic, clinical, and surgical data were extracted from each patient's Electronic Health Record (EHRs). Specifically, the following data were gathered: the child's name, sex, contact information and email of one or both parents, when available, date of surgery, and surgical indication—recurrent URTIs, OSDB or both. All data were pseudonymized and stored in a secure database to ensure confidentiality.

Caregivers were contacted via telephone or email at two different time points: before the surgical intervention (baseline), and between three and six months postoperatively. At each time point, they were asked to complete two validated instruments: the Adapted Children's Sleep Habits Questionnaire, based on the version developed by Professor Owens in 2000 (CSHQ-PT) and the Portuguese version of the Strengths and Difficulties Questionnaire (SDQ-Por). These are two validated tools used to assess changes in sleep behaviours and psychosocial adjustment over time.

Informed consent was obtained from all caregivers prior to their participation in the study. Completion of the questionnaires was preceded by the signing of a written consent form, through which participants confirmed their voluntary involvement and authorized the use of anonymized data for research purposes in accordance with ethical standards.

This study was approved by the Ethics Committee, the Department of Education, Training and Research, and, finally, by the Department Responsible for Information Access (RAI) – 2023-321 (248-CAC/293-CE).

2. Patient Selection

The inclusion criteria were: patients aged between 2 and 10 years who underwent outpatient otorhinolaryngology (ORL) procedures; scheduled for primary ORL surgery involving adenoidectomy, tonsillectomy, or both, potentially including additional procedures such as myringotomy or turbinectomy; and surgical indication based on OSDB and/or recurrent URTIs.

The exclusion criteria included were: patients who had previously undergone otorhinolaryngological procedures, including prior tonsillectomy, adenoidectomy, or other surgeries involving the upper airway; any case in which the surgical indication was not related to recurrent URTIs or OSDB; presence of congenital craniofacial anomalies—such as cleft palate or Pierre Robin sequence—that could potentially alter the anatomy of the upper airway or influence the surgical approach, as well as the presence of known genetic syndromes, including Down syndrome and Prader-Willi syndrome; incomplete or missing clinical information in their electronic health records; questionnaire responses after the 6-month follow-up period.

Participants were selected consecutively based on surgical scheduling. Families were contacted by telephone or email by the research team.

3. Assessment Instruments and Scoring

3.1. Adapted Children's Sleep Habits Questionnaire (CSHQ-PT)

The CSHQ-PT comprises 33 items covering multiple domains of sleep behaviour in children over the previous week. The items are grouped into eight subscales: Bedtime resistance, Sleep Onset Delay, Sleep Duration, Sleep Anxiety, Night Wakings, Parasomnias, Sleep-Disordered Breathing and Daytime Sleepiness. Responses are scored on a three-point frequency scale, *Habitualmente* (5-7 times per week) that is equivalent to 3 points, *Às Vezes* (2-4 times per week), equivalent to 2 points and, lastly, *Raramente* (0-1 time per week) that represents 1 point. In order to maintain the scoring consistency, i.e., higher scores reflect more serious sleep behaviours, six items with positively formulated content (called *Positive Items* or "PI"), namely items 1, 2, 3, 10, 11 and 26 are reverse-coded. In other words, in these six items, *Raramente* represents 3 points, *Às Vezes* maintains as equivalent to 2 points and *Habitualmente* represents 1 point. In turn, for items 32 and 33, which assess sleepiness during passive activities, a specific scale is used: 3 points for *Adormeceu*, 2 points for *Ficou muito sonolento* and 1 point for *Não ficou sonolento* (see Figure 5).

Each subscale is calculated by the sum of the scores of its respective items. The total sleep disturbance score (CSHQ Total Score) is derived by summing all 33 item scores. It is important to note that items 5 and 8 are included in more than one subscale, meaning that the total score is not equal to the simple sum of all subscales score. Overall, higher scores indicate greater severity of sleep disturbance.

3.2. Portuguese version of the Strengths and Difficulties Questionnaire (SDQ-Por)

The SDQ-PT consists of 25 items, grouped into five subscales – Emotional Symptoms, Conduct Problems, Hyperactivity or Inattention, Peer Relationship Problems and Prosocial

Behaviour. Each item is rated on a three-point scale, *Não é verdade* representing 0 points, *É um pouco verdade* representing 1 point and, lastly, *É muito verdade* corresponding to 2 points.

Each subscale ranges from 0 to 10 points and the total difficulties score is calculated by the sum of the first four subscales (excluding Prosocial Behaviour), ranging from 0 to 40 points. Higher scores reflect more severe psychological or behavioural difficulties (see Figure 6).

4. Statistical Analysis

Data obtained from the assessment tools were analyzed using IBM SPSS Statistics (version 29.0). To compare the scores before and after the surgery, paired-samples t-tests were conducted for each subscale and for the total scores of both questionnaires. Normality assumptions were evaluated prior to analysis.

Furthermore, a general linear model (GLM) was used with a within-subject factor (time—preoperatively vs. postoperatively) and a between-subject factor (type of surgical indication—OSAS, recurrent URTIs, or both) to explore possible interactions between surgical indication and clinical outcomes over time.

All analyses used a significance threshold of $p < 0.05$. Cohen's d effect sizes were also calculated to estimate the magnitude of the observed changes.

Results

1. Participant Flow and Characteristics

1.1. Sample selection

Out of 92 patients initially screened for the study, 35 were excluded due to not meeting the inclusion criteria, and an additional 29 were lost to follow-up, yielding a final cohort of 28 participants with both pre and post operative data (see Figure 3).

1.2. Follow-up period

Within the follow-up period (3 to 6 months postoperatively), the mean response time of the caregivers to the questionnaires was 4 months following surgery (4.41 ± 1.52 months).

1.3. Age and sex

The mean age of participants at surgery was 5.36 ± 3.25 years, with 17 males (60.7%) and 11 females (39.3%). No statistically significant difference in age at the time of surgery between males and females was noted (males: 5.35 ± 2.42 vs females: 5.36 ± 4.36 years, $p = 0.994$).

1.4. Surgical Indication

All patients underwent adenotonsillectomy. Most patients (n=20, 71.4%) were indicated for surgery due to OSDB. A history of recurrent URTIs was documented in 8 children (28.6%).

1.5. Sleep Schedule

Pre-operatively, the mean bedtime during the week was 21:24 (± 34 minutes), shifting later to 22:07 (± 39 minutes) on weekends. The mean awakening time before surgery was 07:30 (± 46 minutes) on weekdays and 08:41 (± 68 minutes) on weekends. The average duration of during-night awakenings before the surgical intervention was 10 minutes and 12 seconds (± 2 minutes).

2. Exploring the primary outcome: The impact of surgery on sleep and behaviour

2.1. Sleep

Scores were obtained from the responses to CSHQ-PT. Table 1 describes the main results. Statistically significant improvements ($p < 0.05$) were observed post-operatively in several sleep parameters. Specifically, there was a significant reduction in Sleep Duration (meaning less fragmentation and longer periods of sleep after surgery), Parasomnias, Sleep-Related Breathing Disorder, Daytime Sleepiness, and the Total Sleep Disturbance Index.

Conversely, no statistically significant changes were found in Resistance to Going to Bed, Sleep Onset, Sleep-Related Anxiety, and Night Wakings following the surgical intervention.

2.2. Behaviour

Regarding behaviour, as assessed by the SDQ-Por, only Hyperactivity showed a statistically significant reduction post-operatively. No significant changes were observed in Emotional Symptoms, Behavioural Problems, Peer Relationship Problems, Total Difficulties Score, or Prosocial Behaviour after surgery (see Table 1).

3. Exploring the secondary outcome: Influence of Surgical Indication on Sleep and Behaviour Changes

Following the identification of significant pre- to post-operative changes in several sleep and behaviour parameters (Sleep Duration, Parasomnias, Sleep-Related Breathing Disorder, Daytime Sleepiness, Total Sleep Disturbance Index, and Hyperactivity), a more detailed analysis was conducted to explore the impact of surgical indication (OSDB vs recurrent URTIs) on these outcomes. A mixed-design repeated measures ANOVA was employed, with surgical indication as the between-subjects factor and the pre- and post-operative measurements as the within-subjects factor (see Figure 4). For the majority of sleep and behavioural outcomes examined in the multivariate analysis, surgical indication (OSDB vs. recurrent URTIs) did not significantly influence the extent of pre- to post-operative changes. However, a notable contrast was observed for the Sleep-Related Breathing Disorder score. Patients with an OSDB indication for surgery experienced significantly greater improvements in this domain following the intervention compared to those with recurrent URTIs. The detailed results for all parameters are presented in the following subsections.

3.1. Sleep Duration

Concerning Sleep Duration (SD), there was a significant main effect of adenotonsillectomy on SD values, $F(1,25) = 19.01$, $p < 0.001$. SD score was significantly lower after ($M = 3.464$, $SE = 0.414$, 95 % CI [3.221,3.207]) than before surgery ($M = 5.27$, $SE= 0.118$, 95% CI [4.416, 6.123]).

Nevertheless, the main effect of surgical indication was not significant ($F(1,25) = 3.98$, $p = 0.057$) and no interaction was observed between surgery effects on outcome and surgical indication $F(1,25) = 0.028$, $p = 0.869$.

3.2. Parasomnias

Regarding Parasomnias, there was a significant main effect of adenotonsillectomy on Parasomnias score, $F(1,26) = 20.083$, $p < 0.001$. Parasomnias score was significantly lower after ($M = 8.137$, $SE = 0.431$, 95 % CI [7.251,9.024]) than before surgery ($M = 10.537$, $SE= 0.597$, 95% CI [9.310, 11.765]).

Nevertheless, the main effect of surgical indication was not significant ($F(1,26) = 1.729$, $p = 0.2$) and no interaction was observed between surgery effects on outcome and surgical indication $F(1,26) = 0.078$, $p = 0.782$.

3.3. Sleep-Related Breathing Disorder

Concerning Sleep Related Breathing Disorders (SRBD), there was a significant main effect of adenotonsillectomy on SRDB score, $F(1,25) = 70.707$, $p < 0.001$. SRBD score was significantly lower after ($M = 3.243$, $SE = 0.109$, 95 % CI [3.019,3.468]) than before surgery ($M = 7.036$, $SE= 0.597$, 95% CI [6.160, 7.912]).

The main effect of surgical indication was significant ($F(1,25) = 4.495$, $p = 0.044$) and a nearly significant interaction was observed between surgery effects on SRBD and surgical indication $F(1,25) = 4.140$, $p = 0.053$.

3.4. Daytime Sleepiness

Regarding daytime sleepiness (DS), there was a significant main effect of adenotonsillectomy on DS score, $F(1,26) = 7.729$, $p = 0.010$. DS score was significantly lower after ($M = 13.788$, $SE = 0.606$, 95 % CI [12.542,15.033]) than before surgery ($M = 15.400$, $SE= 0.609$, 95% CI [14.149, 16.651]).

The main effect of surgical indication was significant ($F_{(1,26)} = 5.215$, $p = 0.031$) but no significant interaction was observed between surgery effects on DS and surgical indication $F_{(1,26)} = 0.168$, $p = 0.686$.

3.5. Total Sleep Disturbance Index

Concerning Total Sleep Disturbance Index (TSDI), there was a significant main effect of adenotonsillectomy, $F_{(1,23)} = 33.196$, $p < 0.001$. TSDI score was significantly lower after ($M = 47.948$, $SE = 1.397$, 95 % CI [45.058,50.839]) than before surgery ($M = 58.647$, $SE= 2.231$, 95% CI [54.032, 63.261]).

The main effect of surgical indication was not significant ($F_{(1,23)} = 0.492$, $p = 0.490$) and no significant interaction was observed between surgery effects on TSDI and surgical indication $F_{(1,26)} = 0.168$, $p = 0.686$.

3.6. Hyperactivity

Concerning Hyperactivity, no significant main effect of adenotonsillectomy was observed on Hyperactivity score, $F_{(1,27)} = 2.144$, $p = 0.155$. Hyperactivity score was lower after ($M = 4.411$, $SE = 0.527$, 95 % CI [3.330,5.492]) than before surgery ($M = 5.077$, $SE= 0.547$, 95% CI [3.955, 6.200]).

The main effect of surgical indication was not significant ($F_{(1,27)} = 1.082$, $p = 0.308$) and no significant interaction was observed between surgery effects on Hyperactivity and surgical indication $F_{(1,27)} = 2.144$, $p = 0.155$.

Discussion

1. Exploring the primary outcome: The impact of surgery on sleep and behaviour

As a primary objective, the present study aimed to evaluate the impact of adenotonsillectomy in sleep quality, behaviour, as well as emotional functioning in a pediatric population aged 2 to 10 years in 2 different timepoints: before and 3-6 months after the surgical intervention. To make this possible, two previously validated questionnaires, with recognized scientific reliability, were applied – the CSHQ-PT (based on the version developed by Professor Owens in 2000) and the SDQ-Por. These tools evaluate different aspects of children´s sleep quality and behavioural parameters and, therefore, allow a detailed evaluation of the changes observed following surgical intervention, performed, as mentioned, due to OSDB, recurrent URTIs, or both.

The results showed important improvements following surgery, mainly in the sleep dimensions, reflecting significant impact in sleep quality of the children evaluated. These changes were statistically significant and associated with moderate to large effect sizes, indicating clinical relevance. On the other hand, changes in behaviour and emotional functioning were more variable, except for hyperactivity, the only domain with a statistically significant change.

A more detailed analysis of sleep-related outcomes revealed significant improvements across multiple dimensions of sleep quality following surgery. More specifically, significant changes were found mainly in SRBD, parasomnia´s subscale, SD, and DS.

These results are consistent with the existing literature demonstrating that adenotonsillectomy significantly reduces obstructive symptoms and improves sleep architecture in children with OSDB or chronic upper airway obstruction (20,51). In particular, the reduction in SRBD was one of the most striking improvements, confirming the surgery's ability to eliminate upper airway obstruction, one of the main causes of sleep fragmentation in children. Furthermore, SD and daytime alertness improvements are also consistent with polysomnographic studies that demonstrate increased total sleep time and fewer arousals post-surgery (43,52). The changes observed in these 2 subscales suggest that the surgery was able to increase the total sleep time, leading to the recovery of a continuous and restorative sleep pattern with positive impact in daytime functioning and in the reduction of fatigue and somnolence during the day.

One particularly notable outcome of this study was the significant decrease in parasomnia symptoms after surgery. The spectrum of parasomnias includes night terrors, sleepwalking, confusional arousals, and abnormal motor behaviour during sleep. These nocturnal events often lead to sleep fragmentation, abrupt transitions between deep stages of sleep, and episodes of micro-arousals, and are further exacerbated by obstructive respiratory events, such as those observed in children with OSDB. By removing the anatomical obstruction of the upper airway, adenotonsillectomy contributes to the stabilization of deep stages of sleep and, therefore, to the reduction of autonomic nervous system activation, which, in turn, may explain the significant decrease observed in parasomnia scores. These results are consistent with previous studies demonstrating a strong correlation between OSDB and parasomnias, highlighting substantial improvements following surgical intervention (22,23,53).

Furthermore, it is important to consider that the improvement in the parasomnia´s subscale occurred regardless of the surgical indication (OSDB versus URTIs). This may reflect a broad positive effect of the surgery, improving not only respiratory patterns and sleep stability, but also being responsible for the reduction of local inflammation. Thus, because of the disruptive nature of parasomnias for both the child and the family with impact in psychological well-being and nighttime quality, this outcome holds relevant clinical implications.

Overall, the TSDI showed statistically significant improvement, reflecting a consistent global change in overall sleep quality following surgical intervention.

However, despite the improvements mentioned above, some CSHQ-PT subscales, such as bedtime resistance, sleep onset, sleep-related anxiety and sleep arousals did not reach statistical significance between the 2 timepoints evaluated. These findings may be explained by the fact that the parameters assessed in these subscales may also depend on behavioural, emotional, and environmental factors, such as family routines, parental stress, or sleep hygiene practices, which are not directly affected and modified by the surgical intervention. Therefore, in certain cases, surgery may need to be accompained by additional patient-specific behavioural interventions.

Nevertheless, globally, these findings reflect a clinically relevant enhancement in sleep quality that may be explained by the resolution of the enlarged tonsils and inflammatory factors that affect nocturnal breathing, hence, contributing to an improved sleep architecture. Moreover, this may even reflect additional benefits related to daytime functioning of the child and overall quality of life.

In contrast to the significant sleep-related outcomes, changes in behaviour and emotional functioning were more variable. Indeed, the hyperactivity subscale of the SDQ-Por questionnaire was the only one revealing a statistically significant decrease, suggesting a considerable and meaningful improvement in attention and behaviour regulation in the studied population. This finding is particularly relevant given the high prevalence of hyperactive symptoms in children with sleep fragmentation, reflecting a phenotypic overlap between OSDB and ADHD. The literature consistently suggests that poor sleep quality, especially when associated with hypoxemia and frequent nocturnal micro-arousals, may be the underlying cause of the origin or exacerbation of symptoms of hyperactivity, impulsivity and attention deficits (28). Thus, the recovery of a healthy sleep pattern following surgery, may enhance greater neurobehavioural regulation, leading to the reduction of hyperactive symptoms and, consequently, the recovery of executive function and behavioural self-regulation (28,29,54,55). Indeed, this significant improvement in hyperactive symptoms is particularly relevant, as it suggests that adenotonsillectomy may act as an indirect modulator of behaviour. Therefore, given the fact that childhood hyperactivity is often managed pharmacologically, the surgical intervention may be a potential non-pharmacological alternative, especially in cases where underlying OSDB and/or enlarged adenoids and tonsils are present.

It is also important to consider that, despite the slight improvement observed, the lack of statistically significant changes in the remaining behavioural subscales - emotional symptoms, conduct problems, peer relationship difficulties, prosocial behaviour and, globally, total difficulties score - may reflect the multifactorial nature of child behaviour. In fact, behavioural development is shaped by a wide range of factors, including familial and environmental contexts, school-related factors and individual temperamental traits. Additionally, it can also be speculated that the average 4-month time interval in which the study took place may have been insufficient to allow for deeper or more sustained behavioural changes to emerge.

2. Exploring the secondary outcome: Influence of Surgical Indication on Sleep and Behaviour Changes

One particularly relevant finding of this study was the lack of a statistically significant influence of the type of surgical indication on the degree of sleep improvement in most variables. This is suggestive of sleep benefits after adenotonsillectomy, even in children whose surgical indication is not directly related to nocturnal respiratory symptoms, although the magnitude of these benefits may vary.

However, the SRDB subscale was the only exception, where a significant main effect of surgical indication was found. The OSDB and recurrent URTIs groups showed statistically significant differences, suggesting that children with OSDB had higher respiratory symptom values on average. Additionally, a near-significant interaction between the surgical indication and the post-intervention outcome was reported, indicating a potential trend toward SRBD symptom improvement in the OSDB group of children. Although this interaction did not reach conventional statistical significance, the proximity of the p-value ($p=0.053$) reinforces the clinical hypothesis that surgery is particularly effective in children with well-established respiratory obstruction.

A significant difference was also observed in DS according to surgical indication, although there was no statistically significant interaction between the surgical indication and the post-intervention outcome, indicating that both groups benefited from the intervention.

The absence of interaction effects, depending on surgical indication, for the remaining subscales may also suggest that, even in children with recurrent URTIs, the improvement in baseline respiratory function and the reduction of inflammatory episodes may have indirect positive effects on sleep consolidation. However, such effects appear to be less pronounced than those observed in children with OSDB, in whom anatomical obstruction is the main cause of sleep fragmentation.

Overall, these findings reinforce the broad therapeutic benefits of otolaryngologic interventions across different clinical subgroups and may have relevant implications for clinical practice, as it supports a symptom-oriented rather than diagnosis-oriented approaches to surgical decision-making in children with disrupted sleep.

3. Limitations

It is important to recognize some limitations of the present study. Firstly, the rather small final sample size of 28 participants may have limited the generalizability and statistical power to identify minor effects, especially in behavioural domains. Furthermore, due to the high dropout rate (approximately 32%), a selection bias may have been introduced, particularly if the participants who were lost differ systematically from those who completed the trial. It is also important to mention that the lack of a control group restricts the ability to draw strong conclusions about causality, as physiological changes or placebo effects cannot be ruled out. Lastly, despite the use of validated tools, all measures relied on parental report, which, in conjugation with the absence of objective sleep measures, such as PSG, limiting the physiological characterization of the observed events, may introduce a perception bias

4. Future Perspectives

Combining all this data, it can be concluded that it is critical to identify and treat accordingly sleep disorders in pediatric populations. It has been demonstrated that adenotonsillectomy results in significant improvements in respiratory function during sleep, sleep architecture, and alertness during the day, all of which have a positive impact on children´s global development, academic performance, and quality of life. Additionally, the reduction in hyperactivity symptoms following the surgical intervention reflects that its benefits may extend beyond sleep itself, reinforcing the possible need for routinely screening for sleep disorders in clinical practice, especially in children who exhibit behavioural or academic challenges.

In many cases, surgical correction of anatomical obstructions may serve as a primary intervention with advantages that extend well beyond the night-time period. The lack of significant differences between surgical indications also suggests that otolaryngologic surgery should be regarded as a feasible treatment for a wide spectrum of pediatric sleep-related disorders.

Future research should be able to increase the validity of sleep-related outcomes by including multiple informants - teachers or medical professionals - as well as objective sleep measures, such as PSG. Furthermore, these findings should be replicated in larger samples using, preferably, randomized controlled designs. A comprehensive understanding of the broader impact of surgical intervention should be taken into consideration through the evaluation of the quality of life, family well-being, executive functioning, and academic success.

Conclusion

This investigation reflects the multidimensional benefits of adenotonsillectomy in pediatric population, particularly in patients with OSDB and recurrent URTIs. Regardless of the surgical indication, many improvements were reported across many sleep parameters, particularly the parasomnia's subscale, reflecting the importance of adenotonsillectomy in the reestablishment of deeper and more stable sleep cycles, improving overall sleep architecture and, even, the child's quality of life. In the behavioural domain, hyperactivity symptoms were the only subscale to reach statistical significance postoperatively, reinforcing the critical role of sleep for executive functioning in children. Despite the lack of statistical significance of the other behavioural domains, the global enhancement of sleep architecture, allows us to hypothesize long term neurobehavioural gains.

Therefore, adenotonsillectomy is a safe and effective surgical procedure with benefits extending well beyond respiratory improvement, suggesting the importance of the early recognition and symptom-oriented approach of sleep disordered breathing in pediatric population.

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Appendices

Figures and Tables

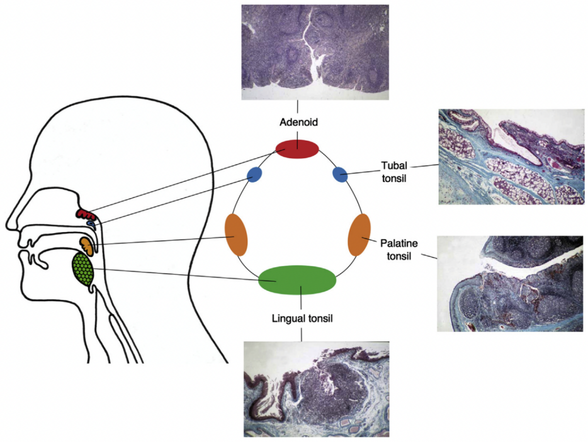

Figure 1 - Diagrammatic representation of Waldeyer's ring and histological sections of the adenoid, tubal, palatine, and lingual tonsils (56).

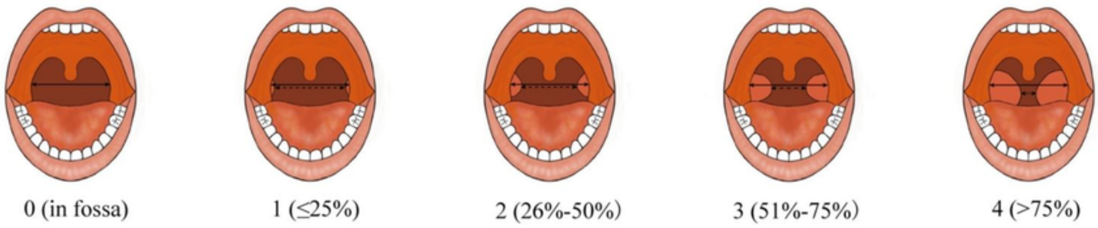

Figure 2 - Brodsky grading scale for tonsil size classification. The Brodsky grading scale of tonsil size. Grade 0 (tonsils in the fossa), grade 1 (tonsils outside of the fossa and occupy ≤25% of the oropharyngeal width), grade 2 (tonsils occupy 26–50% of the oropharyngeal width), grade 3 (tonsils occupy 51–75% of the oropharyngeal width), and grade 4 (tonsils occupy > 75% of the oropharyngeal width). (57)

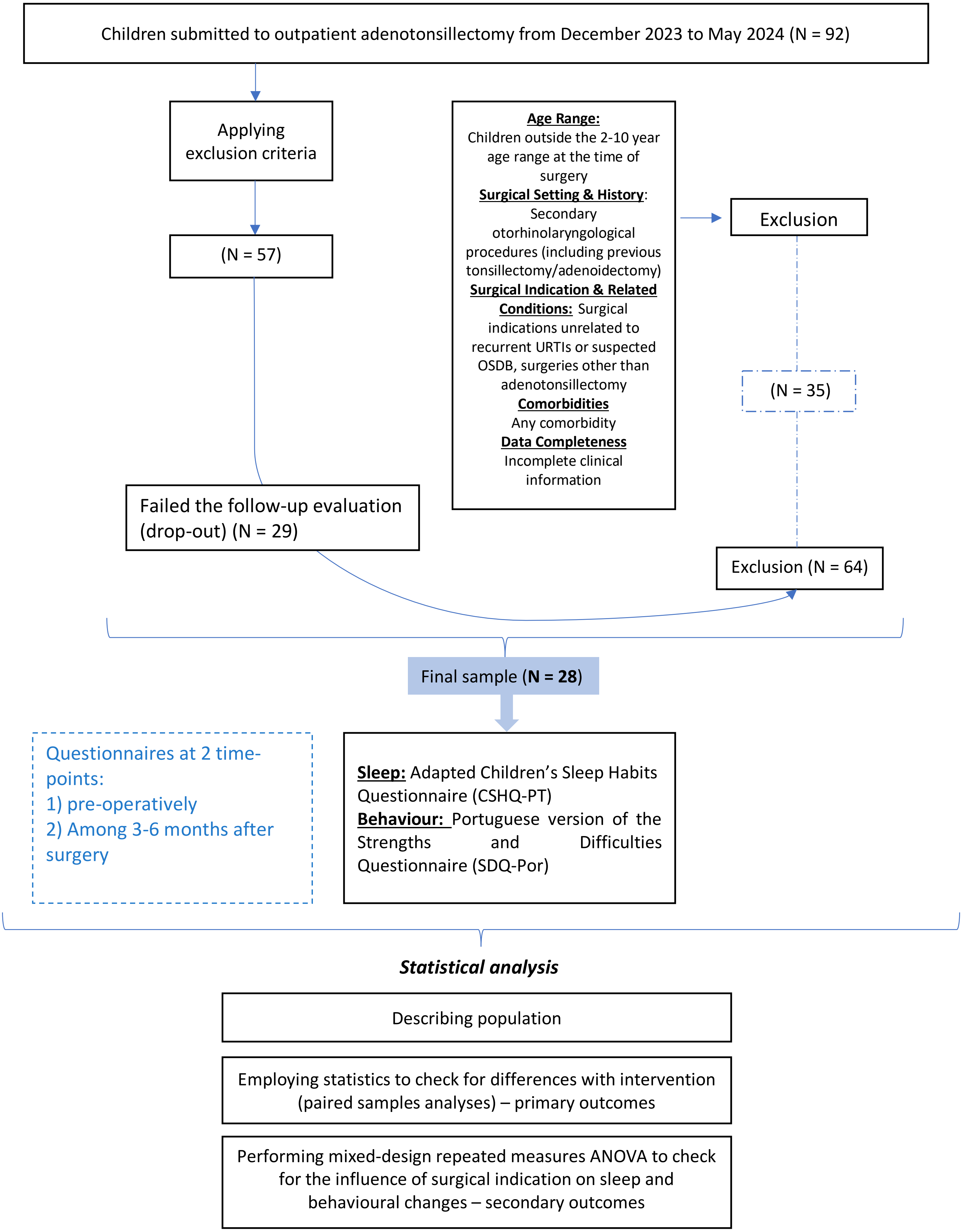

Figure 3 – Sample selection and statistical analysis design

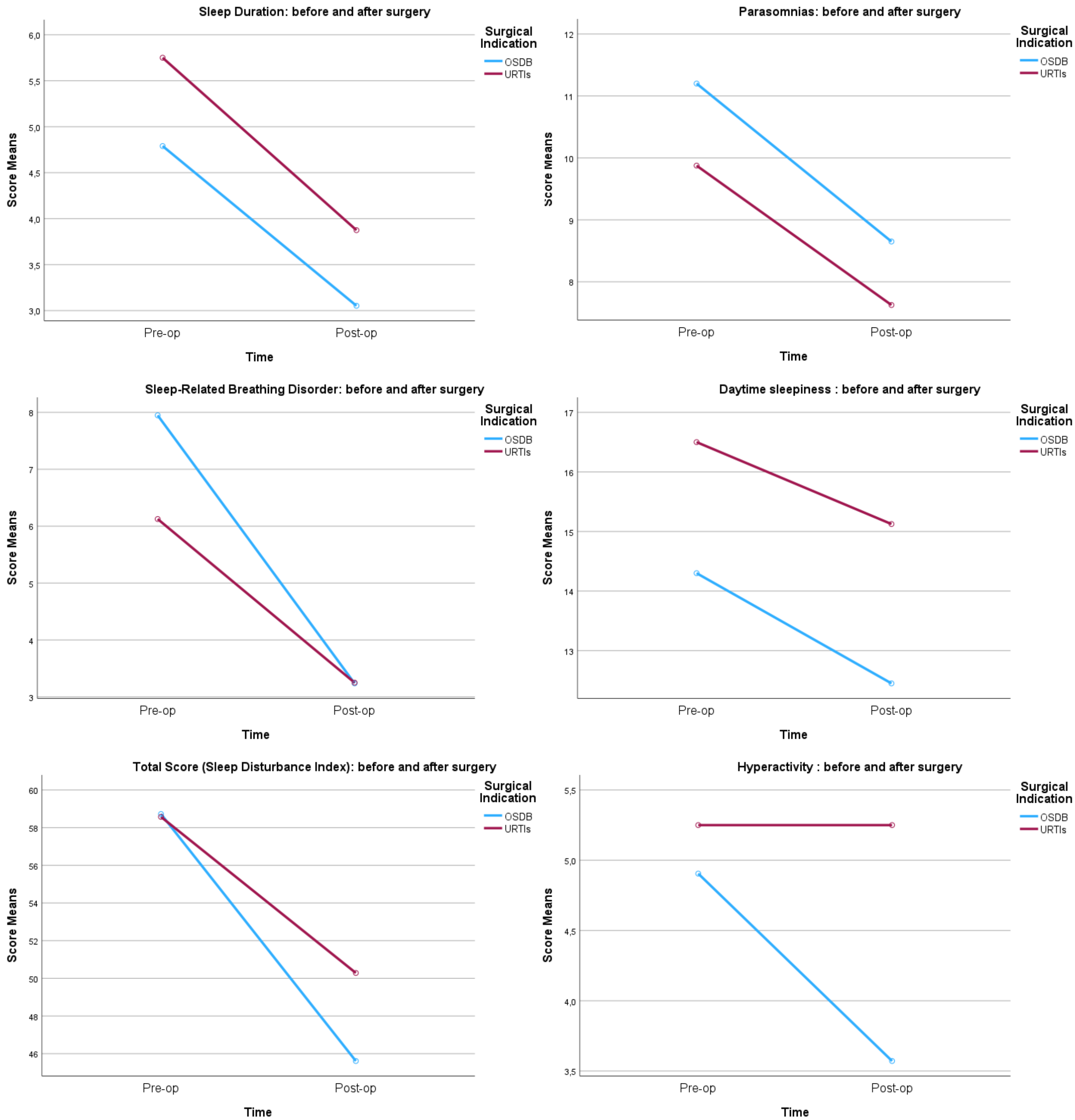

Figure 4 – Significant Pre- and Post-Operative Changes in sleep and behaviour (by surgical indication)

Questionário de Hábitos de Sono das Crianças

Adaptado do *Children's Sleep Habits Questionnaire*, Prof. Owens, 2000‡

Cotação

Itens incluídos na cotação total e nas subescalas

1. **Resistência em ir para a cama**
Deita-se sempre à mesma hora **(PI)(1)** *
Adormece sozinha na sua própria cama **(PI)(3)**
Adormece na cama dos pais ou dos irmãos **(4)**
Precisa dos pais no quarto para adormecer **(5)**
"Luta" na hora de deitar **(6)**
Tem medo de dormir sozinha **(8)**

2. **Início do sono**
Demora até 20 minutos a adormecer **(PI)(2)**

3. **Duração do sono**
Dorme pouco **(9)**
Dorme o que é necessário **(PI)(10)**
Dorme o mesmo número de horas **(PI)(11)**

4. **Ansiedade associada ao sono**
Precisa dos pais no quarto para adormecer **(5)**
Tem medo de dormir no escuro **(7)**
Tem medo de dormir sozinha **(8)**
Tem dificuldade em dormir fora de casa **(21)**

5. **Despertares noturnos**
Vai para a cama dos pais, irmãos **(16)**
Acorda uma vez durante noite **(24)**
Acorda mais de uma vez durante a noite **(25)**

6. **Parassónias**
Molha a cama à noite **(12)** **
Fala a dormir **(13)**
Tem sono agitado, mexe-se muito **(14)**
Anda a dormir, à noite (sonambulismo) **(15)**
Range os dentes durante o sono **(17)**
Acorda a gritar, a suar, inconsolável **(22)**
Acorda assustada com pesadelos **(23)**

7. **Perturbação respiratória do sono**
Ressona alto **(18)**
Parece parar de respirar durante o sono **(19)**
Ronca ou tem dificuldade em respirar **(20)**

8. **Sonolência diurna**
De manhã, acorda por si própria **(PI)(26)**
Acorda mal-humorada **(27)**
É acordada pelos pais ou irmãos **(28)**
Dificuldade em sair da cama de manhã **(29)**
Demora a ficar bem acordada **(30)**
Parece cansada **(31)**
Adormece a ver televisão **(32)**
Adormece a andar de carro **(33)**

Pontuação dos itens: A pontuação de itens é feita de forma a que valores mais elevados correspondam a comportamentos problemáticos mais frequentes. Assim, para a maior parte dos itens a pontuação é:
"Habitualmente" = 3 , "Às vezes" = 2 , "Raramente" = 1
* Os itens assinalados com (PI) - itens 1, 2, 3, 10, 11, 26 - têm uma pontuação inversa:
"Habitualmente" = 1 , "Às vezes" = 2 , "Raramente" = 3
Nos itens 32 e 33 (sonolência) a pontuação é: "Não ficou"=1, "Ficou muito"=2, "Adormeceu"=3

Cotação das subescalas: soma das pontuações dos itens da subescala.
**Em crianças de 2 e 3 anos, o item 12 não é aplicado e deve ser cotado com "Às vezes" = 2.
Um valor mais elevado corresponde a mais problemas.

Cotação total (Índice de Perturbação do Sono): soma das pontuações dos 33 itens.
Um valor mais elevado corresponde a mais problemas.
Nota: este índice não é equivalente à soma das cotações das subescalas, uma vez que 2 itens aparecem em 2 subescalas (itens 5 e 8).

‡ Tradução e adaptação por Filipe Silva. Validado para crianças dos 2 aos 10 anos. dormirecrescer.blogspot.com

CSHQ-PT cotação 30-7-2012

Figure 5 - CSHQ-PT Scoring System

Cotação do Questionário de Capacidades e Dificuldades – Versão de Pais / Professores

Os 25 itens que constituem o SDQ estão organizados em 5 escalas, cada uma composta por 5 itens. Geralmente, é mais fácil cotar as 5 escalas antes de calcular a pontuação total de dificuldades. Cada item tem três opções de resposta: *Não é verdade*, *É um pouco verdade*, *É muito verdade*. A opção *É um pouco verdade* é sempre cotada com 1. Cada uma das outras duas opções pode ser cotada com 0 ou 2 pontos, conforme o item, tal como é apresentado em baixo, escala por escala. A pontuação total de cada uma das 5 escalas pode variar entre 0 e 10 se os 5 itens tiverem sido respondidos. O resultado de cada escala pode ser considerado desde que pelo menos 3 itens tenham sido respondidos.

Escala de Sintomas Emocionais	Não é verdade	É um pouco verdade	É muito verdade
Queixa-se frequentemente de dores de cabeça ...	0	1	2
Tem muitas preocupações, parece sempre preocupado/a	0	1	2
Anda muitas vezes triste, desanimado/a ou choroso/a	0	1	2
Em situações novas é receoso/a, muito agarrado/a	0	1	2
Tem muitos medos, assusta-se com facilidade	0	1	2

Escala de Problemas de Comportamento	Não é verdade	E um pouco verdade	É muito verdade
Enerva-se muito facilmente e faz muitas birras	0	1	2
Obedece com facilidade ...	2	1	0
Luta frequentemente com as outras crianças ...	0	1	2
Mente frequentemente ou engana	0	1	2
Rouba em casa, na escola ou em outros sítios	0	1	2

Escala de Hiperactividade	Não é verdade	É um pouco verdade	É muito verdade
É irrequieto/a, muito mexido/a, nunca pára quieto/a	0	1	2
Não sossega. Está sempre a mexer as pernas ou as mãos	0	1	2
Distrai-se com facilidade	0	1	2
Pensa nas coisas antes de as fazer	2	1	0
Geralmente acaba o que começa, tem uma boa atenção	2	1	0

Escala de Problemas de Relacionamento com os Colegas	Não é verdade	É um pouco verdade	É muito verdade
Tem tendência a isolar-se ...	0	1	2
Tem pelo menos um bom amigo/uma boa amiga	2	1	0
Em geral as outras crianças gostam dele/a	2	1	0
As outras crianças metem-se com ele/a ...	0	1	2
Dá-se melhor com adultos do que com outras crianças	0	1	2

Escala de Comportamento Pró-social	Não é verdade	É um pouco verdade	É muito verdade
É sensível aos sentimentos dos outros	0	1	2
Partilha facilmente com as outras crianças	0	1	2
Gosta de ajudar se alguém está magoado	0	1	2
É simpático/a e amável com crianças mais pequenas	0	1	2
Sempre pronto/a a ajudar os outros	0	1	2

Pontuação Total de Dificuldades
É obtida pela soma da pontuação total de todas as escalas com excepção da escala pró-social. Deste modo, a pontuação resultante pode variar entre 0 e 40 (e não pode ser computado caso a pontuação de alguma das escalas, exceto a pro-social, esteja ausente).

Figure 6 – SDQ-Por Scoring System

Interpretação da Pontuação dos Sintomas e Definição de "Caso"
Os intervalos provisórios, apresentados em baixo, foram estabelecidos de tal forma que aproximadamente 80 % das crianças na comunidade são normais, 10% são limítrofes e 10% são anormais. Em estudos com amostras de **alto risco**, onde os falsos positivos não sejam a maior preocupação, os possíveis **"casos"** podem ser identificados por uma **pontuação alta** ou **limítrofe** em uma das quatro escalas de dificuldades. Em estudos com amostras de **baixo risco**, onde é mais importante reduzir a taxa de falsos positivos, os possíveis **"casos"** podem ser identificados por uma **pontuação alta** em uma das quatro escalas de dificuldades.

	Normal	Limítrofe	Anormal
Preenchido pelos Pais			
Pontuação Total das Dificuldades	0 - 13	14 - 16	17 - 40
Pontuação dos Sintomas Emocionais	0 - 3	4	5 - 10
Pontuação de Problemas de Comportamento	0 - 2	3	4 - 10
Pontuação para Hiperactividade	0 - 5	6	7 - 10
Pontuação para Problemas com Colegas	0 - 2	3	4 - 10
Pontuação para Comportamento Pró-social	6 - 10	5	0 - 4
Prenchido pelo Professor			
Pontuação Total das Dificuldades	0 - 11	12 - 15	16 - 40
Pontuação dos Sintomas Emocionais	0 - 4	5	6 - 10
Pontuação de Problemas de Comportamento	0 - 2	3	4 - 10
Pontuação para Hiperactividade	0 - 5	6	7 - 10
Pontuação p/ Problemas com Colegas	0 - 3	4	5 - 10
Pontuação para Comportamento Pró-social	6 – 10	5	0 - 4

Pontuação e Interpretação do Impacto
Quando é usada a versão do SDQ que inclui o "Suplemento de Impacto", os itens relativos ao sofrimento global e às dificuldades sociais podem ser somados para se obter a pontuação do impacto, que pode variar entre 0 e 10 na versão para pais e entre 0 e 6 na versão para professores.

	Nada	Pouco	Muito	Muitíssimo
Avaliação dos pais				
As dificuldades incomodam/fazem sofrer a criança	0	0	1	2
Interferem em casa	0	0	1	2
Interferem com os amigos	0	0	1	2
Interferem na aprendizagem na escola	0	0	1	2
Interferem nas brincadeiras/tempos livres	0	0	1	2
Avaliação do professor				
As dificuldades incomodam/fazem sofrer a criança	0	0	1	2
Interferem nas relações com os colegas	0	0	1	2
Interferem na aprendizagem na escola	0	0	1	2

As respostas às questões sobre cronicidade e sobrecarga para os outros não são incluídas na cotação de impacto. Quando os entrevistados tiverem respondido "não" à primeira questão do suplemento de impacto (i.e. quando não se considerarem como tendo alguma dificuldade emocional ou de comportamento), não deverão responder às questões sobre sofrimento ou dificuldades e, nestas circunstâncias, a pontuação do impacto será automaticamente zero.

Uma pontuação total do impacto igual ou maior que 2 é anormal, uma pontuação de 1 é limítrofe e uma pontuação de 0 é normal.

Figure 6 - SDQ -Por Scoring System (cont.)

Table I - Comparative Analysis of Pre- and Post-operative Values of sleep and behaviour

	Subscale score ‡		Mean/Median (SD, P25-P75)		
			Pre-operative	**Post-operative**	**P value ***
SLEEP [Children's Sleep Habits Questionnaire]	Resistance to Going to Bed [A]		10.4 ± 3.1	9.4 ± 2.7	0.066
	Sleep Onset [B]		1.6 ± 0.8	1.4 ± 0.7	0.177
	Sleep Duration [C]		5.1 ± 2	3.3 ± 0.7	**< 0.001**
	Sleep-Related Anxiety [D]		7.7 ± 2.4	7.1 ± 2.5	0.132
	Night Wakings [E]		5.3 ± 1.5	4.8 ± 1.2	0.116
	Parasomnias [F]		10.8 ± 2.9	8.3 ± 3.1	**< 0.001**
	Sleep-Related Breathing Disorder [G]		7.4 ± 2.1	3.2 ± 0.5	**< 0.001**
	Daytime sleepiness [H]		14.9 ± 3	13.2 ± 3.1	**0.003**
	Total Score (Sleep Disturbance Index) [I]		58.7 ± 9.8	46.9 ± 6.5	**<0.001**
BEHAVIOUR [Portuguese version of the Strengths and Difficulties Questionnaire (SDQ-Por)]	Problems	Emotional Symptoms	3 ± 2.5	2.6 ± 2.4	0.405
		Behavioural problems	1.9 ± 2	1.7 ± 1.5	0.578
		Hyperactivity	5 ± 2.7	4 ± 2.6	**0.028**
		Peer relationship problems	1.2 ± 1.8	1 ± 1.6	0.246
		Total Difficulties Score [J]	11.1 ± 6.6	9.2 ± 6	0.406
	Prosocial behaviour		8.7 ± 1.8	8.9 ± 1.7	0.078

Table Legend

‡ Calculated as the sum of the scores of the items belonging to that specific subscale.

SLEEP: [A] Sum of items 1,3,4,5,6 and 8; [B] Item 2; [C] Sum of items 9,10 and 11; [D] Sum of items 5,7,8 and 21; [E] Sum of items 16,24 and 25; [F] Sum of the items 12,13,14,15,17,22,23; [G] Sum of items 18,19 and 20; [H] Sum of items 26,27,28,29,30,31,32,33; [I] Sum of the scores of the 33 items - a higher value corresponds to more problems. Note: this index is not equivalent to the sum of the subscale scores, as 2 items appear in 2 subscales (items 5 and 8).

BEHAVIOUR: Each score results from the sum of items in each scale (5 items per scale). [J] Total Difficulties Score - obtained by summing the total scores of all the scales with the exception of the prosocial scale. In this way, the resulting score can range between 0 and 40.

***** p-values describe the analysis by using paired samples T-test, **bold** for statistically significant changes

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