



**Cochrane**  
**Library**

Cochrane Database of Systematic Reviews

## Oral appliances and functional orthopaedic appliances for obstructive sleep apnoea in children (Review)

Carvalho FR, Lentini-Oliveira DA, Prado LBF, Prado GF, Carvalho LBC

Carvalho FR, Lentini-Oliveira DA, Prado LBF, Prado GF, Carvalho LBC.

Oral appliances and functional orthopaedic appliances for obstructive sleep apnoea in children.

*Cochrane Database of Systematic Reviews* 2016, Issue 10. Art. No.: CD005520.

DOI: 10.1002/14651858.CD005520.pub3.

[www.cochranelibrary.com](http://www.cochranelibrary.com)

## TABLE OF CONTENTS

HEADER . . . . .	1
ABSTRACT . . . . .	1
PLAIN LANGUAGE SUMMARY . . . . .	2
SUMMARY OF FINDINGS FOR THE MAIN COMPARISON . . . . .	3
BACKGROUND . . . . .	6
OBJECTIVES . . . . .	7
METHODS . . . . .	7
Figure 1. . . . .	9
RESULTS . . . . .	10
Figure 2. . . . .	12
DISCUSSION . . . . .	15
AUTHORS' CONCLUSIONS . . . . .	16
ACKNOWLEDGEMENTS . . . . .	17
REFERENCES . . . . .	17
CHARACTERISTICS OF STUDIES . . . . .	19
DATA AND ANALYSES . . . . .	22
ADDITIONAL TABLES . . . . .	22
WHAT'S NEW . . . . .	24
HISTORY . . . . .	24
CONTRIBUTIONS OF AUTHORS . . . . .	25
DECLARATIONS OF INTEREST . . . . .	25
SOURCES OF SUPPORT . . . . .	25
DIFFERENCES BETWEEN PROTOCOL AND REVIEW . . . . .	26
NOTES . . . . .	26
INDEX TERMS . . . . .	26

[Intervention Review]

# Oral appliances and functional orthopaedic appliances for obstructive sleep apnoea in children

Fernando R Carvalho<sup>1</sup>, Débora A Lentini-Oliveira<sup>1</sup>, Lucila BF Prado<sup>2</sup>, Gilmar F Prado<sup>3</sup>, Luciane BC Carvalho<sup>2</sup>

<sup>1</sup>Neuro-Sono Sleep Center, Department of Neurology, Universidade Federal de São Paulo, São Paulo, Brazil. <sup>2</sup>Department of Neurology, Universidade Federal de São Paulo, São Paulo, Brazil. <sup>3</sup>Department of Neurology, Escola Paulista de Medicina, Universidade Federal de São Paulo, São Paulo, Brazil

Contact address: Fernando R Carvalho, Neuro-Sono Sleep Center, Department of Neurology, Universidade Federal de São Paulo, Rua Americo Salvador Novelli 508, São Paulo, São Paulo, 08210-090, Brazil. [odontofernandocarvalho@gmail.com](mailto:odontofernandocarvalho@gmail.com).

**Editorial group:** Cochrane Oral Health Group.

**Publication status and date:** Stable (no update expected for reasons given in 'What's new'), published in Issue 11, 2016.

**Review content assessed as up-to-date:** 7 April 2016.

**Citation:** Carvalho FR, Lentini-Oliveira DA, Prado LBF, Prado GF, Carvalho LBC. Oral appliances and functional orthopaedic appliances for obstructive sleep apnoea in children. *Cochrane Database of Systematic Reviews* 2016, Issue 10. Art. No.: CD005520. DOI: 10.1002/14651858.CD005520.pub3.

Copyright © 2016 The Cochrane Collaboration. Published by John Wiley & Sons, Ltd.

## ABSTRACT

### Background

Apnoea is a breathing disorder marked by the absence of airflow at the nose or mouth. In children, risk factors include adenotonsillar hypertrophy, obesity, neuromuscular disorders and craniofacial anomalies. The most common treatment for obstructive sleep apnoea syndrome (OSAS) in childhood is adeno-tonsillectomy. This approach is limited by its surgical risks, mostly in children with comorbidities and, in some patients, by recurrence that can be associated with craniofacial problems. Oral appliances and functional orthopaedic appliances have been used for patients who have OSAS and craniofacial anomalies because they hold the lower jaw (mandible) forwards which potentially enlarges the upper airway and increases the upper airspace, improving the respiratory function.

### Objectives

To assess the effects of oral appliances or functional orthopaedic appliances for obstructive sleep apnoea in children.

### Search methods

We searched the following electronic databases: Cochrane Oral Health's Trials Register (to 7 April 2016); Cochrane Central Register of Controlled Trials (CENTRAL; 2016, Issue 3) in the Cochrane Library (searched 7 April 2016); MEDLINE Ovid (1946 to 7 April 2016); Embase Ovid (1980 to 7 April 2016); LILACS BIREME (from 1982 to 7 April 2016); BBO BIREME (from 1986 to 7 April 2016) and SciELO Web of Science (from 1997 to 7 April 2016). We searched ClinicalTrials.gov and the World Health Organization International Clinical Trials Registry Platform for ongoing trials on 7 April 2016. We placed no restrictions on the language or date of publication when searching the electronic databases.

### Selection criteria

All randomised or quasi-randomised controlled trials comparing all types of oral and functional orthopaedic appliances with placebo or no treatment, in children 15 years old or younger. Primary outcome: reduction of apnoea to less than one episode per hour. Secondary outcomes: dental and skeletal relationship, sleep parameters improvement, cognitive and phonoaudiological function, behavioural problems, quality of life, side effects (tolerability) and economic evaluation.

### **Data collection and analysis**

Two review authors screened studies and extracted data independently. Authors were contacted for additional information. We calculated risk ratios with 95% confidence intervals for all important dichotomous outcomes. We assessed the quality of the evidence of included studies using GRADEpro software.

### **Main results**

The initial search identified 686 trials. Only one trial, reporting the results from a total of 23 children and comparing an oral appliance to no treatment, was suitable for inclusion in the review. The trial assessed apnoea-hypopnoea, daytime symptoms (sleepiness, irritability, tiredness, school problems, morning headache, thirstiness in the morning, oral breathing and nasal stuffiness) and night-time symptoms (habitual snoring, restless sleep and nightmares measured by questionnaire). Results were inconsistent across outcomes measures and time points. The evidence was considered very low quality.

### **Authors' conclusions**

There is insufficient evidence to support or refute the effectiveness of oral appliances and functional orthopaedic appliances for the treatment of obstructive sleep apnoea in children. Oral appliances or functional orthopaedic appliances may be considered in specified cases as an auxiliary in the treatment of children who have craniofacial anomalies which are risk factors for apnoea.

## **PLAIN LANGUAGE SUMMARY**

### **Oral appliances and functional orthopaedic appliances for obstructive sleep apnoea in children**

#### **Review question**

Are oral appliances and functional orthopaedic appliances effective and safe for treating children with obstructive sleep apnoea syndrome?

#### **Background**

Obstructive sleep apnoea in children is a breathing disorder characterized by episodes of partial or complete upper airway obstruction that occur during sleep. There are various risk factors and is associated with daytime and night-time symptoms including among others sleepiness, irritability, tiredness, morning headaches, nasal stuffiness, habitual snoring, nightmares, etc. The common treatment for obstructive sleep apnoea in childhood is adeno-tonsillectomy, the removal of the adenoids and tonsils. This approach is limited by recurrence that can be associated with craniofacial problems. Oral/functional orthopaedic appliances have been used for patients who have obstructive sleep apnoea and craniofacial anomalies because they hold the lower jaw (mandible) forwards which potentially enlarges the upper airway and increases the upper airspace, improving the respiratory function.

#### **Study characteristics**

The evidence on which this review is based was current as of 7 April 2016. It included only one study in which 32 children were randomised to receive an oral appliance or no treatment. Twenty-three participants finished the study.

#### **Key results**

Treatment of obstructive sleep apnoea syndrome in children appears to be possible with oral appliances or functional orthopaedic appliances. However, this is only based on data from one small study.

#### **Quality of the evidence**

This was a study with a small number of participants and the quality of the evidence for the different outcomes was rated as very low. At present there is insufficient evidence to conclude that oral or functional orthopaedic appliances are effective in the treatment of obstructive sleep apnoea in children.

## SUMMARY OF FINDINGS FOR THE MAIN COMPARISON *[Explanation]*

Oral appliance compared with no treatment for obstructive sleep apnoea in children						
<b>Patient or population:</b> Children (age range 4 to 10 years old) <b>Setting:</b> <b>Intervention:</b> Oral appliance <b>Comparison:</b> No treatment						
Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	No. of participants (studies)	Quality of the evidence (GRADE)	Comments
	Risk with no treatment	Risk with oral appliance				
Apnoea-hypopnoea index (AHI) assessed with polysomnography Follow-up: 6 months	Study population		RR 0.39 (0.20 to 0.76)	23 (1 RCT)	⊕○○○ VERY LOW <sup>123</sup>	
	1.000 per 1.000	390 per 1.000 (200 to 760)				
Daytime symptoms: Sleepiness assessed with Brouillette questionnaire (considered improvement a fall of at least 2 points in the score) Follow-up: 6 months	Study population		RR 0.64 (0.11 to 3.78)	23 (1 RCT)	⊕○○○ VERY LOW <sup>123</sup>	Change measured with a subjective questionnaire answered by parents
	222 per 1.000	142 per 1.000 (24 to 840)				
Daytime symptoms: Irritability assessed with Brouillette questionnaire (considered improvement a fall of at least 2 points in	Study population		RR 0.32 (0.07 to 1.41)	23 (1 RCT)	⊕○○○ VERY LOW <sup>123</sup>	Change measured with a subjective questionnaire answered by parents

the score) Follow-up: 6 months						
	444 per 1.000	142 per 1.000 (31 to 627)				
Daytime symptoms: Tiredness as- sessed with Brouillette questionnaire (consid- ered improvement a fall of at least 2 points in the score) Follow-up: 6 months	Study population		RR 0.26 (0.06 to 1.05)	23 (1 RCT)	⊕○○○ VERY LOW <sup>123</sup>	Change measured with a subjective question- naire answered by par- ents
	556 per 1.000	144 per 1.000 (33 to 583)				
Daytime symptoms: School problems as- sessed with Brouillette questionnaire (consid- ered improvement a fall of at least 2 points in the score) Follow-up: 6 months	Study population		RR 0.64 (0.11 to 3.78)	23 (1 RCT)	⊕○○○ VERY LOW <sup>123</sup>	Change measured with a subjective question- naire answered by par- ents
	222 per 1.000	142 per 1.000 (24 to 840)				
Daytime symptoms: Morning headache as- sessed with Brouillette questionnaire (consid- ered improvement a fall of at least 2 points in the score) Follow-up: 6 months	Study population		RR 0.39 (0.12 to 1.23)	23 (1 RCT)	⊕○○○ VERY LOW <sup>123</sup>	Change measured with a subjective question- naire answered by par- ents

	556 per 1.000	217 per 1.000 (67 to 683)				
Daytime symptoms: Oral breathing assessed with Brouillette questionnaire (considered improvement a fall of at least 2 points in the score) Follow-up: 6 months	Study population		RR 0.16 (0.04 to 0.59)	23 (1 RCT)	⊕○○○ VERY LOW <sup>123</sup>	Change measured with a subjective questionnaire answered by parents
	889 per 1.000	142 per 1.000 (36 to 524)				

\* **The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI)

CI: Confidence interval; RR: Risk ratio; RCT: Randomised controlled trial

**GRADE Working Group grades of evidence**

**High quality:** We are very confident that the true effect lies close to that of the estimate of the effect

**Moderate quality:** We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different

**Low quality:** Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect

**Very low quality:** We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

<sup>1</sup> Quasi-randomised study, no allocation concealment, no blinding, attrition bias (overall high risk of bias).

<sup>2</sup> Low sample size and wide confidence interval (imprecision).

<sup>3</sup> Single, small study (may lack generalisability).

## BACKGROUND

### Description of the condition

Apnoea is a breathing disorder marked by the absence of airflow through the nose or mouth. It is divided into central, obstructive and mixed apnoea. In central apnoea, airflow is absent due to the lack of respiratory efforts. In obstructive apnoea, airflow is absent, in spite of continuing respiratory efforts, due to the obstruction of the upper airway. In mixed apnoea, central and obstructive apnoea occurs sequentially with no normal breathing between the two events (Carroll 1995a).

Sleep disordered breathing is common in childhood (Nixon 2005; Schechter 2002). It occurs in children of all ages, from neonates to adolescents (Marcus 2001). It is estimated that 0.8% to 24% of children are habitual snorers and that 1% to 5% have obstructive sleep apnoea syndrome (OSAS) (Marcus 2012). OSAS in children is characterized by episodes of partial or complete upper airway obstruction that occur during sleep, usually associated with a reduction in oxyhaemoglobin saturation or hypercarbia or both (Carroll 1995a).

The aetiology is multifactorial. OSAS arises when the balance between the factors maintaining airway patency and those promoting airway collapse is perturbed. This balance is determined by the interactions of central ventilatory responses to hypoxia, hypercapnia and airway occlusion, upper-airway neuromuscular tone, the effects of sleep state and arousal, and the anatomic size and resistance of the upper airway (Ward 1996).

In children, risk factors include obesity, adenotonsillar hypertrophy, neuromuscular disorders and craniofacial anomalies (AAP Guideline 2002; Kohler 2008; Shintani 1998). These factors can reduce the volume of the oronasopharyngeal cavity and can result in the tongue falling into the oropharynx (Viva 1992). There are many malocclusions associated with obstructive sleep apnoea, e.g. retrognathism/micrognathias, unilateral or bilateral cross bite, and open bite (Carvalho 2014; Defabjanis 2003).

OSAS in children is associated with a series of daytime and nighttime signs and symptoms. The daytime symptoms include excessive daytime sleepiness and abnormal daytime behaviour ranging from aggressiveness and hyperactivity to pathological shyness and social withdrawal, morning headaches and frequent upper airway infections. Nocturnal symptoms include difficult breathing whilst asleep, heavy snoring, apnoeic episodes, restless sleep, heavy sweating, nightmares, night terrors and enuresis (Guilleminault 1990). Untreated obstructive sleep apnoea syndrome can result in serious morbidity. Early reports documented such complications as failure to thrive (Bell 2001), cor pulmonale and neurological dysfunction (Brouillette 1982), and other reports have suggested that children with OSAS have neurocognitive deficits (Goldstein 2000), such as poor learning, behavioural problems (Bell 2001), attention deficit hyperactivity disorder (AAP Guideline 2002; Chervin 1997) and

systemic inflammation (Kheirandish-Gozal 2006). However, the symptoms can be very varied and difficult to detect (Carroll 2003). Diagnosis of OSAS may be based on information obtained by clinical history, physical examination and laboratory studies (Carroll 1995b). The 'gold standard' for the diagnosis of OSAS is polysomnography (AAP Guideline 2002; Schechter 2002), which is made up of channels for electrocardiography (ECG), electroencephalography (EEG), electroculography (EOG), electromyography (EMG), nasal and oral airflow, chest and abdominal movements, pulse oximetry arterial oxygen saturation (SpO<sub>2</sub>) and end tidal carbon dioxide tension (PETCO<sub>2</sub>) (Uliel 2004). Polysomnography provides information on a number of sleep-related parameters: number and duration of complete or partial obstructions per hour of sleep, lowest oxygen saturation during each event, time spent below a given level of oxygen saturation during the night, presence and type of cardiac arrhythmias, and presence and severity of respiratory disturbances and their impact on the cardiovascular system. It also provides information on the severity of sleep disruption (Guilleminault 1990).

Treatment for OSAS must be based on the assessment, duration and severity of symptoms and the anatomic structural and physiological abnormalities and their associated severity (Carroll 1995b). There are several treatments for OSAS in childhood, like alteration of the sleeping position, continuous positive airways pressure (CPAP), weight loss (AAP Guideline 2002), tracheostomy, maxillomandibular advancement (Bell 2001), uvulopalatopharyngoplasty, oral appliances and adeno-tonsillectomy (AAP Guideline 2002; Schechter 2002).

The most common treatment for obstructive sleep apnoea syndrome in childhood is adeno-tonsillectomy, but this approach is limited by its surgical risks (Chan 2004). In some patients there is recurrence of the OSA especially in those with underlying skeletal deformities e.g. retrognathic mandible or constricted maxilla or both (Guilleminault 1989). Children who do not improve after adeno-tonsillectomy tend to have a narrower epipharyngeal air space, a more poorly developed maxilla and mandibular retrusion (Shintani 1998).

### Description of the intervention

Functional orthopaedic appliances are usually removable intraoral devices which alter the muscle forces against the teeth and facial skeleton i.e. maxilla and mandible. These are dynamic appliances which depend on altered neuromuscular action to affect bony growth and occlusal development.

### How the intervention might work

Functional orthopaedic appliances have been used for patients who have OSAS and craniofacial anomalies because functional orthopaedic appliances posture the mandible forwards and poten-



tially enlarge the upper airway and increase the upper airspace, improving the respiratory function (Defabjanis 2003; Viva 1992).

### Why it is important to do this review

OSAS in children has been shown to be a prevalent condition and also a disease that can cause a number of other medical and/or social problems if left untreated. Many adults' OSAS started in childhood or adolescence so the importance of recognizing OSAS in childhood and the need for appropriate treatment should be emphasized to avoid potential long-term complications in adulthood. If the problem is recognized and treated early, there is a potential to reduce the economic costs to the health system (Tarasiuk 2007) and improve the quality of life for sufferers (Nixon 2005). This review updates the previous version published in 2007 (Carvalho 2007).

## OBJECTIVES

To assess the effects of oral appliances or functional orthopaedic appliances for obstructive sleep apnoea in children.

## METHODS

### Criteria for considering studies for this review

#### Types of studies

We aimed to identify all randomised controlled trials (RCTs). Trials using quasi-random methods of allocation (such as alternation, date of birth, record number) were included and would have been subjected to a sensitivity analysis.

#### Types of participants

Children and adolescents. We included trials in which over 80% of included participants were 15 years old or younger, receiving oral appliances or functional orthopaedic appliances to treat obstructive sleep apnoea. Criteria for abnormal values for obstructive apnoea in children considered as one or more apnoea, of any length, per hour of sleep, measured by standard polysomnography (Marcus 1992). Trials including patients with a cleft lip or palate or both were excluded. There was no gender restriction.

#### Types of interventions

Intervention group: All types of oral and functional appliances used to treat obstructive sleep apnoea were compared to placebo or no treatment. Several types of appliances are used for this situation including: Bimler appliance, Frankel appliance, Harvold appliance, Andresen appliance, Bionator, bite block, Herbst appliance, Herren activator and Woodside activator.

Control group: Placebo or no treatment.

We excluded trials including other interventions like continuous positive airways pressure (CPAP), weight loss (dietary intervention), lifestyle modification, tracheostomy, maxillomandibular surgery, uvulopalatopharyngoplasty and adeno-tonsillectomy.

#### Types of outcome measures

##### Primary outcomes

1. Reduction to less than one episode of apnoea per hour measured by standard polysomnography.

##### Secondary outcomes

1. Reduction of apnoea episodes measured by standard polysomnography.
2. Reduction of upper airway resistance syndrome (UARS) measured by standard polysomnography and body-weight development curve compared by graphic of body mass index for age percentiles.
3. Reduction of snoring measured by standard polysomnography.
4. Signs and symptoms of respiratory disease: mouth breathing, nasal airway resistance measured by clinical assessment or rhinomanometry or fibroscopy.
5. Signs and symptoms of atypical swallowing, and speech production disturbance measured by validated tests for speech production or videofluoroscopy or clinical assessment.
6. Daytime and nocturnal symptoms e.g. daytime sleepiness, behavioural problems, nightmares.
7. Change of mandibular length measured by cephalometric data.
8. Improvement on sagittal relationship between the maxilla-mandible measured by cephalometric data.
9. Changes of the width between cuspids and first molars measured by plaster models.
10. Change of the arch perimeter measured by plaster models.
11. Improvement of the overbite and overjet measured by plaster models.
12. Alteration of growth pattern measured in cephalometric data or facial analysis.
13. Quality of life measured by validated scale.
14. Side effects - tolerability - measured by patient's self report.
15. Economic evaluation - costs.

16. Educational outcomes: cognitive function measured by validated scale.

## Search methods for identification of studies

To identify studies for this review, we developed detailed search strategies for each database searched. These were based on the search strategy developed for MEDLINE (Ovid) but revised appropriately for each database. The search strategy used a combination of controlled vocabulary and free text terms and was linked with the Cochrane Highly Sensitive Search Strategy (CHSS) for identifying randomised trials (RCTs) in MEDLINE: sensitivity maximising version (2008 revision) as referenced in Chapter 6.4.11.1 and detailed in box 6.4.c of the *Cochrane Handbook for Systematic Reviews of Interventions* Version 5.1.0 (updated March 2011) (Higgins 2011). Details of the MEDLINE search are provided in Appendix 1. The Embase subject search was linked to an adapted version of the Cochrane Embase Project filter for identifying RCTs in Embase via Ovid (see <http://www.cochranelibrary.com/help/central-creation-details.html> for information). Searches of LILACs and BBO were linked to the Brazilian Cochrane Center filter for identifying RCTs.

## Electronic searches

We searched the following electronic databases:

- Cochrane Oral Health's Trials Register (searched 7 April 2016) (Appendix 2);
- Cochrane Central Register of Controlled Trials (CENTRAL; 2016, Issue 3) in the Cochrane Library (searched 7 April 2016) (Appendix 3);
- MEDLINE Ovid (1946 to 7 April 2016) (Appendix 1);
- Embase Ovid (1980 to 7 April 2016) (Appendix 4);
- LILACS BIREME Virtual Health Library (Latin American and Caribbean Health Science Information database; from 1982 to 7 April 2016) (Appendix 5);
- BBO BIREME Virtual Health Library (Bibliografia Brasileira de Odontologia; from 1986 to 7 April 2016) (Appendix 5);
- SciELO Web of Science (from 1997 to 7 April 2016) (Appendix 6).

No restrictions were placed on the language or date of publication when searching the electronic databases.

## Searching other resources

We searched the following trial registries for ongoing studies:

- US National Institutes of Health Ongoing Trials Register ClinicalTrials.gov ([www.clinicaltrials.gov](http://www.clinicaltrials.gov); searched 7 April 2016) (Appendix 7);
- World Health Organization International Clinical Trials Registry Platform ([apps.who.int/trialsearch](http://apps.who.int/trialsearch); searched 7 April 2016) (Appendix 8).

References from original papers and review articles were cross-checked to identify additional trials and no further randomised controlled trials were found.

We contacted first authors of randomised controlled trials and specialists to identify further information about unpublished studies.

## Data collection and analysis

### Selection of studies

Four review authors (Fernando Rodrigues Carvalho (FRC), Debora Lentini-Oliveira (DLO), Lucila Fernandes Prado (LFP), and Gilmar Fernandes Prado (GFP)) scanned the titles and abstracts of all reports identified through the searches. Full reports were obtained for trials appearing to meet the inclusion criteria or for which there was insufficient information in the title and abstract to make a clear decision. Full reports obtained were assessed independently, in duplicate, by two review authors (FRC and DLO) to establish whether the trials met the inclusion criteria or not. Disagreements were resolved by discussion with the main supervisor (Luciane Bizari Carvalho (LBC)).

### Data extraction and management

Two review authors (FRC and DLO) extracted data independently using specially designed data extraction forms. The date of the study, year of publication, setting and funding source of trials, sample size, age (mean or range, or both) and gender of participants, types of interventions, duration of study and tolerability were recorded.

The characteristics of the trial participants, interventions and outcomes for the included trial are presented in the [Characteristics of included studies](#) table.

We contacted study authors for clarification or for further information.

### Assessment of risk of bias in included studies

The quality assessment of the included trial was undertaken independently and in duplicate by two review authors (FRC and DLO) as part of the data extraction process. If there was uncertainty, the main supervisor (LBC) was consulted.

We used Cochrane's tool for assessing risk of bias as outlined in the *Cochrane Handbook for Systematic Reviews of Interventions* Version 5.1.0 (updated March 2011) (Higgins 2011).

We examined seven domains:

1. sequence generation,
2. allocation sequence concealment,
3. blinding of participants/personnel,
4. blinding of outcome assessment,
5. incomplete outcome data,
6. selective outcome reporting,

7. other bias (balance of baseline characteristics, free from co-intervention).

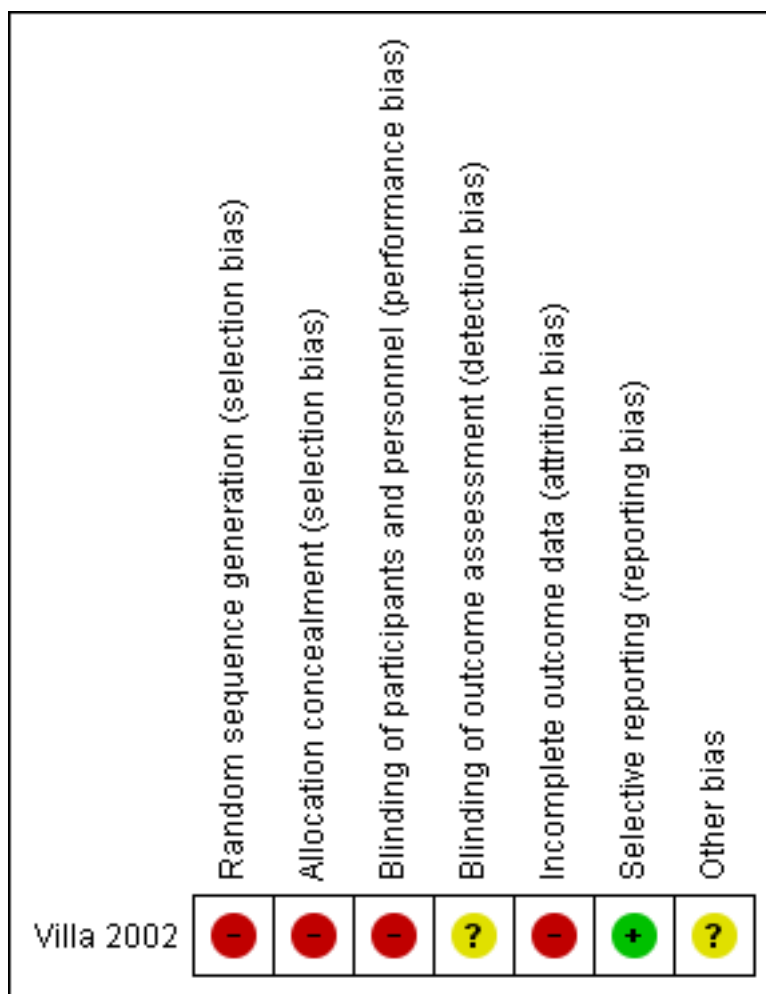
Each domain included one or more specific entries in a 'Risk of bias' table. Within each entry, we described information reported in the study and assigned a judgement relating to the risk of bias for that entry. Where the study clearly reported the methodology, we made a judgement of low risk of bias or high risk of bias. Where trial methodology was unclear, we judged a domain as at unclear risk of bias. We tried to get more information from the study authors. When we were provided with additional information, we re-assessed the overall risk of bias in included trials over all seven domains.

We categorised the overall risk of bias of individual studies according to the following criteria:

- low risk of bias (plausible bias unlikely to seriously alter the results; all seven domains assessed as at low risk of bias),
- high risk of bias (plausible bias that seriously weakens confidence in the results; at least one domain assessed as at high risk of bias),
- unclear risk of bias (plausible bias that raises some doubt about the results; at least one domain assessed as at unclear risk of bias, but none at high risk of bias).

We also presented the risk of bias summary graphically (Figure 1).

**Figure 1. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.**



### Measures of treatment effect

We calculated risk ratios, the number needed to treat and corresponding 95% confidence intervals for dichotomous data and expressed them by individual study. In cases where the included studies presented results as continuous data, we would have expressed the results as mean difference and 95% confidence intervals. For both continuous and dichotomous data we would have carried out a meta-analysis when possible and appropriate.

### Unit of analysis issues

Trials with multiple treatment arms: For trials with more than one intervention group and a common control group (placebo or no intervention) we would have tried to use the partial data, only data from relevant group and control group.

Cross-over studies were not felt to be an appropriate study design for this research question due to potential carry over effects of the first treatment.

### Dealing with missing data

We attempted to contact the author(s) of included studies, where feasible, for clarification, missing data, and details of any other outcomes that may have been measured but not reported.

### Assessment of heterogeneity

The significance of discrepancies in the estimates of treatment effects from the different trials would have been assessed by the  $I^2$  statistic and classified according to the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011). A guide to interpretation of the  $I^2$  statistic is as follows:

- 0% to 40% might not be important,
- 30% to 60% may represent moderate heterogeneity,
- 50% to 90% may represent substantial heterogeneity,
- 75% to 100% very substantial (considerable) heterogeneity.

### Assessment of reporting biases

Within-study reporting bias, it is one of the seven domains of the Risk of bias as 'selective outcome reporting'. It would ideally be assessed by comparing the outcomes in the paper published against the study protocol. As it is not possible in most cases, we compared the outcomes referred in the methods with the results showed. If the outcome were listed in the methods but not reported, we try to get more information from authors of the study, then we judge this as 'high risk' or 'low risk' of bias or 'unclear' (insufficient information to judge the risk of bias).

If possible, publication bias would have been assessed by plotting data onto a funnel graph (trial effect versus trial size) (Egger 1997). However, this was not feasible due to the inclusion of only one study.

### Data synthesis

For the included trial, risk ratios with 95% confidence intervals were calculated for all important dichotomous outcomes.

If further studies are included in future updates, we will carry out meta-analyses where there are studies of similar comparisons reporting the same outcomes. We would combine mean differences for continuous data, and risk ratios for dichotomous data. Our general approach would be to use a random-effects model. With this approach, the CIs for the average intervention effect would be wider than those that would be obtained using a fixed-effect approach, leading to a more conservative interpretation.

We would use additional tables to report the results from studies not suitable for inclusion in a meta-analysis.

### Subgroup analysis and investigation of heterogeneity

A subgroup analysis would have been carried out comparing studies that included different ranges of participants' age, but there were insufficient trials to undertake this.

### Sensitivity analysis

Sensitivity analyses would have been performed according to the risk of bias assessments of the included studies. If there had been an adequate number of studies, quasi-randomised studies would also have been analysed separately from the randomised ones in a sensitivity analysis. However, as there was only one study included in the review, no sensitivity analyses were carried out.

### Presentation of main results

We established a 'Summary of findings' table using the following outcomes listed according to priority.

1. Apnoea-hypopnoea index (AHI) (assessed with polysomnography).
2. Daytime symptoms: sleepiness (assessed with Brouillette questionnaire).
3. Daytime symptoms: irritability (assessed with Brouillette questionnaire).
4. Daytime symptoms: tiredness (assessed with Brouillette questionnaire).
5. Daytime symptoms: school problems (assessed with Brouillette questionnaire).
6. Daytime symptoms: morning headache (assessed with Brouillette questionnaire).
7. Daytime symptoms: oral breathing (assessed with Brouillette questionnaire).

## RESULTS

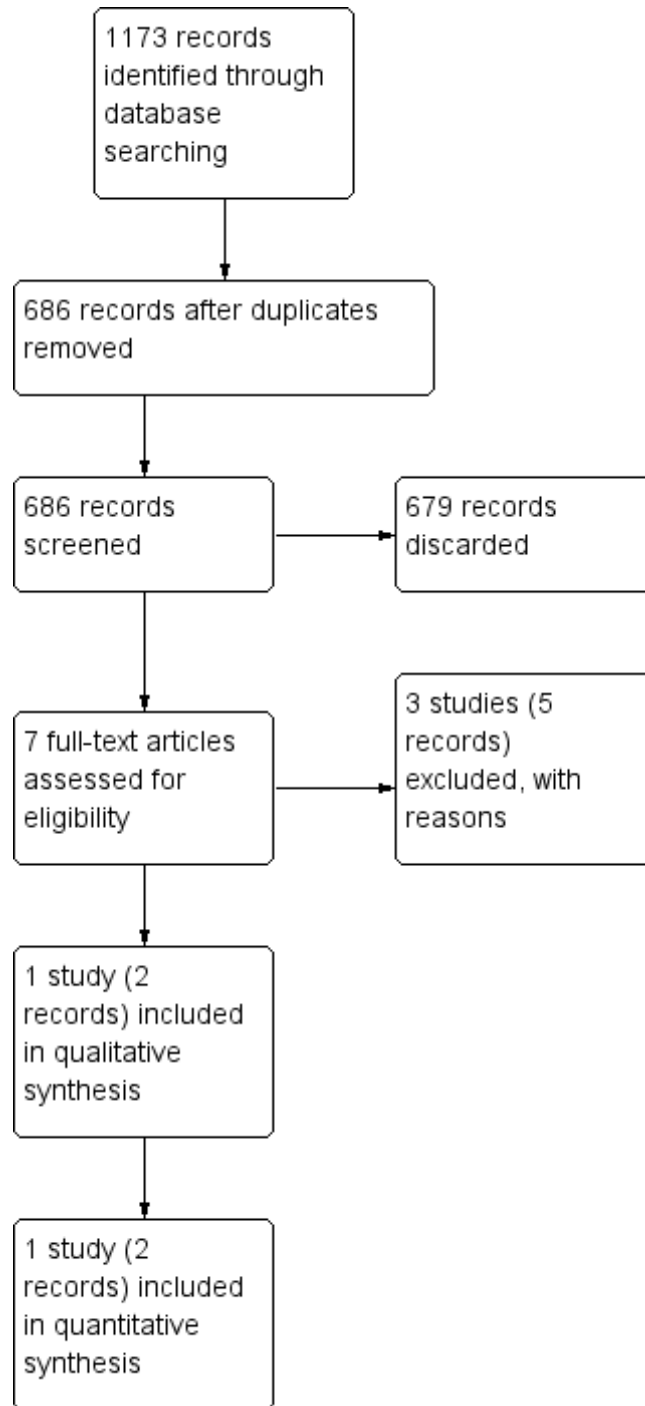
### Description of studies

## Results of the search

We identified a total of 686 potentially relevant records by electronic searching. Six hundred and seventy-nine records were discarded as not relevant for this review after assessment of the titles and abstracts. After obtaining the full texts, we excluded three studies (five records) ([Ghodke 2014](#); [Guilleminault 2011](#); [Nunes 2011](#)) and included one study (two records) ([Villa 2002](#)). We are not aware of any ongoing study.

We used the full search conducted as described in the [Search methods for identification of studies](#) section on 7 April 2016 to construct the PRISMA flow chart shown as [Figure 2](#).

**Figure 2. Study flow diagram, 2016 search.**



Summary details are given in the [Characteristics of included studies](#) and [Characteristics of excluded studies](#) tables.

### Included studies

[Villa 2002](#) is a quasi-randomised controlled trial conducted in Italy during six months. Randomisation was assigned alphabetically, by surname.

Thirty-two children, 20 male and 12 female, with an age range of 4 to 10 years (mean 7.1 +/- 2.6 years), with apnoea index (defined as the number of apnoeas per hour of total sleep time) of more than one event per hour diagnosed by polysomnography and who had evident clinical signs of dysgnathia participated in this study.

[Villa 2002](#) compared a personalised active oral appliance to no treatment. Email correspondence with the study authors confirmed that the participants were fitted the oral appliance at the time of the second polysomnography.

The parents of all participants completed a modified version of the Brouillette questionnaire on the daytime and night-time symptoms before the trial and after six months. The answers of the questionnaire range from 0 to 4 points and they were considered an improvement when the answers fell at least two points, after six months.

The outcomes measured included apnoea-hypopnoea index measured by polysomnography; daytime symptoms: sleepiness, irritability, tiredness, school problems, morning headache, thirstiness in the morning, oral breathing and nasal stuffiness measured by questionnaire; and night-time symptoms: habitual snoring, restless sleep and nightmares measured by questionnaire.

### Excluded studies

Three studies did not meet the inclusion criteria and they were excluded. The main reasons for exclusion were:

- polysomnography not used to evaluate sleep (two studies),
- study compared an oral appliance to surgery without placebo or no treatment group (one study).

### Risk of bias in included studies

#### Allocation

#### Sequence generation

The included trial ([Villa 2002](#)) used a quasi-random method of allocation, alphabetically by surname, and was assessed at high risk of selection bias.

#### Allocation concealment

[Villa 2002](#) did not report any information about allocation concealment, but the poor randomisation method used would have made adequate allocation concealment impossible in this trial. It was therefore assessed at high risk of bias for this domain.

#### Blinding

In [Villa 2002](#) it was impossible to blind the participants because the intervention group wore an oral appliance whilst the control or no treatment group wore nothing and could easily be distinguished from the active intervention. We assessed the study at high risk of performance bias.

Blinding of outcome assessment was not reported, therefore we assessed the study at unclear risk of detection bias.

#### Incomplete outcome data

We assessed [Villa 2002](#) at high risk of attrition bias due to the high percentage of participants lost to follow-up: five (26.3%) participants in the treatment group and four (30.8%) participants in the control group. The reasons for dropouts within the treatment group were described: one child found the oral appliance intolerable, two children lost their appliances three times and then refused to wear them again and two children found wearing the oral appliance at school embarrassing and discontinued therapy.

#### Selective reporting

Ideally we would have compared the outcomes listed in each study protocol with the outcomes reported in the papers, but since this was impossible, we then compared the results reported in the included study against those listed in the methods section. We assessed [Villa 2002](#) at low risk of reporting bias, because the outcomes reported in the results section were all those listed in the methods.

#### Other potential sources of bias

#### Balance of baseline characteristics and free from co-intervention

The study authors reported that there were no differences between groups at baseline but there is no analysis to support this. The study authors did not report any other interventions during the same treatment time. We therefore assessed the included study at unclear risk of other bias.

## Overall risk of bias

A summary of the risk of bias assessments for each domain is shown in [Figure 1](#). The included trial in this review was assessed at high risk of bias.

## Effects of interventions

See: [Summary of findings for the main comparison](#)

Meta-analyses were originally planned, but they were not possible since only one study was included ([Villa 2002](#)).

It has not been possible to fully achieve the objectives of this review as there is a lack of trials in this area. The included trial ([Villa 2002](#)) compared a personalised active oral appliance to no treatment and helped us to answer four secondary outcomes: reduction of apnoea episodes measured by standard polysomnography; daytime and nocturnal symptoms e.g. daytime sleepiness, behavioural problems, nightmares and side effects - tolerability - measured by patient's self report.

We calculated risk ratios (RRs) with 95% confidence intervals (CIs) for all dichotomous data as planned.

We found statistically significant differences in the following results: reduction of the apnoea-hypopnoea index measured by polysomnography; daytime symptoms measured by questionnaire: oral breathing and nasal stuffiness; and night-time symptoms measured by questionnaire: habitual snoring and restless sleep. All outcomes and results are described below.

## Primary outcomes

### Reduction to less than one episode of apnoea per hour measured by standard polysomnography

A decrease of at least 50% in the apnoea/hypopnoea index (AHI) was considered in this study ([Villa 2002](#)) as treatment success. In 9 of the 14 treated subjects (62.4%) the AHI fell 50%. [Villa 2002](#) showed the apnoea index only in the oral appliance group before (7.1 +/- 4.6) and after (2.6 +/- 2.2) the treatment as mean values and standard deviation. It proved impossible to know how many patients had apnoea index < 1 (primary outcome).

## Secondary outcomes

### (1) Reduction of apnoea episodes measured by standard polysomnography

Results from the paper can be found in [Additional Table 1](#).

Results from our analysis: RR = 0.39, 95% CI 0.20 to 0.76, P = 0.006, favouring treatment (Analysis 1.1), but result is from a study with very low quality of evidence for this outcome ([Summary of findings for the main comparison](#)).

### (2) Reduction of upper airway resistance syndrome (UARS) measured by standard polysomnography and body-weight development curve compared by graphic of body mass index for age percentiles

The included study did not assess this outcome.

### (3) Reduction of snoring measured by standard polysomnography

The included study did not assess this outcome.

### (4) Signs and symptoms of respiratory disease: mouth breathing, nasal airway resistance measured by clinical assessment or rhinomanometry or fibroscopy

The included study did not assess this outcome.

### (5) Signs and symptoms of atypical swallowing, and speech production disturbance measured by validated tests for speech production or videofluoroscopy or clinical assessment

The included study did not assess this outcome.

### (6) Daytime and nocturnal symptoms

#### Daytime symptoms (measured by questionnaire)

Results from the paper are presented in [Additional Table 2](#) and [Table 3](#).

Results from our analysis.

- Sleepiness: RR = 0.64, 95% CI 0.11 to 3.78 (Analysis 1.2), non-significant result ([Summary of findings for the main comparison](#)).

- Irritability: RR = 0.32, 95% CI 0.07 to 1.41 (Analysis 1.3), non-significant result ([Summary of findings for the main comparison](#)).

- Tiredness: RR = 0.26, 95% CI 0.06 to 1.05 (Analysis 1.4), non-significant result ([Summary of findings for the main comparison](#)).

- School problems: RR = 0.64, 95% CI 0.11 to 3.78 (Analysis 1.5), non-significant result ([Summary of findings for the main comparison](#)).

- Morning headache: RR = 0.39, 95% CI 0.12 to 1.23 (Analysis 1.6), non-significant result ([Summary of findings for the main comparison](#)).

- Thirsty in the morning: RR = 0.16, 95% CI 0.02 to 1.22 (Analysis 1.7), non-significant result.

- Oral breathing: RR = 0.16, 95% CI 0.04 to 0.59, P = 0.006 (Analysis 1.8), favouring treatment, but result is from a study with very low quality of evidence for this outcome ([Summary of findings for the main comparison](#)).



- Nasal stuffiness: RR = 0.18, 95% CI 0.05 to 0.69, P = 0.01 (Analysis 1.9), favouring treatment, but result is from a study with very low quality of evidence.

#### **Nocturnal symptoms (measured by questionnaire)**

Results from the paper are presented in Additional [Table 4](#) and [Table 5](#).

Results from our analysis.

- Habitual snoring: RR = 0.18, 95% CI 0.06 to 0.55, P = 0.003 (Analysis 1.10), favouring treatment, but result is from a study with very low quality of evidence.
- Restless sleep: RR = 0.21, 95% CI 0.05 to 0.84, P = 0.03 (Analysis 1.11), favouring treatment, but result is from a study with very low quality of evidence.
- Nightmares: RR = 0.22, 95% CI 0.01 to 4.93 (Analysis 1.12), non-significant result.

#### **(7) Change of mandibular length measured by cephalometric data**

The included study did not assess this outcome.

#### **(8) Improvement on sagittal relationship between the maxilla-mandible measured by cephalometric data**

The included study did not assess this outcome.

#### **(9) Changes of the width between cuspids and first molars measured by plaster models**

The included study did not assess this outcome.

#### **(10) Change of the arch perimeter measured by plaster models**

The included study did not assess this outcome.

#### **(11) Improvement of the overbite and overjet measured by plaster models**

The included study did not assess this outcome.

#### **(12) Alteration of growth pattern measured in cephalometric data or facial analysis**

The included study did not assess this outcome.

#### **(13) Quality of life measured by validated scale**

The included study did not assess this outcome.

#### **(14) Side effects - tolerability - measured by patient's self report**

Side effects: the included study did not assess this outcome.

Tolerability: 73.7% fitted with oral appliance (14/19 children) tolerated the treatment well and 26.3% (five children) discontinued therapy (two preferred not to wear the oral appliance, two lost their appliances three times and then refused to wear them again and one did not tolerate it).

#### **(15) Economic evaluation - costs**

The included study did not assess this outcome.

#### **(16) Educational outcomes: cognitive function measured by validated scale**

The included study did not assess this outcome.

## **DISCUSSION**

### **Summary of main results**

The main aim of this review was to estimate the effects of the use of oral appliances or functional appliances for treating obstructive sleep apnoea in children compared to placebo or no treatment. We found no new studies for inclusion in this update, so [Villa 2002](#) remains as the only included study in the review.

[Villa 2002](#) compared an oral appliance to no treatment and presented results analysing each group before and after six months follow-up. It found favourable results in the treated group for apnoea/hypopnoea index, night-time symptoms (habitual snoring, restless sleep) and daytime symptoms (sleepiness, irritability, tiredness, thirstiness in the morning, oral breathing, nasal stuffiness) (Additional [Table 1](#); [Table 2](#); [Table 3](#); [Table 4](#); [Table 5](#)). When we compared the two groups at six months, the results were not as favourable as those presented in the original study. We found favourable results in the treated group for apnoea/hypopnoea index, night-time symptoms (habitual snoring, restless sleep) and daytime symptoms (oral breathing, nasal stuffiness) (Analysis 1.1; Analysis 1.2; Analysis 1.3; Analysis 1.4; Analysis 1.5; Analysis 1.6; Analysis 1.7; Analysis 1.8; Analysis 1.9; Analysis 1.10; Analysis 1.11; Analysis 1.12).

### **Overall completeness and applicability of evidence**

Unfortunately, the available information from one study ([Villa 2002](#)) with very low quality of evidence, is not enough to answer

whether oral appliances or functional orthopaedic appliances are effective in the treatment of sleep apnoea in children.

### Quality of the evidence

Villa 2002 was the single study included and although it showed some results that favoured the intervention, it must be considered with caution due to methodological problems such as a non-randomised generation of allocation, no allocation concealment, no blinding, no sample size calculation reported, the number of patients randomised was different from patients analysed, high number of losses to follow-up and no intention-to-treat analysis. Villa 2002 was therefore assessed as at high risk of bias and of very low-quality evidence (Summary of findings for the main comparison). There is an important methodological problem we found with many studies not showing important information necessary to assess their quality. Papers did not present information such as how participants were allocated to interventions, who generated the allocation, how sample size was determined, etc. Therefore it is important that all authors follow the Consolidated Standards of Reporting Trials (CONSORT) guidelines when designing and reporting trials (Begg 1996; Moher 2001).

### Potential biases in the review process

We conducted a sensitive search strategy of multiple databases to identify suitable studies for this review, with no restrictions on language, publication status, date or source of information. We attempted to contact some study authors for missing information, however, we could not find more studies, and some authors did not respond. We could not get all the necessary information to clarify our judgements of unclear or high risk of bias. Therefore, authors of the included study are encouraged to contact us to clarify these points. For future updates, we would also appreciate any information regarding unpublished or ongoing studies that we may not have identified.

### Agreements and disagreements with other studies or reviews

The aim of this systematic review was to assess the effects of oral appliances and functional orthopaedic appliances in the treatment of obstructive sleep apnoea in children when compared to placebo or no treatment. There is a clinical trial (Guilleminault 2008) whose participants were children with adenotonsillar hypertrophy and malocclusion that concluded that for most of the children, the two proposed treatments were needed (intraoral appliance and adeno-tonsillectomy) independently of which treatment was done first, but one treatment would complement the other in resolving obstructive sleep apnoea.

## AUTHORS' CONCLUSIONS

### Implications for practice

Despite a thorough search for evidence relating to the effects of treatment with oral appliances or functional orthopaedic appliances for obstructive sleep apnoea in children, very low-quality evidence was found, but it must be interpreted as 'very low evidence of effect' and not as 'evidence of very low effect'. At present there is not enough evidence to affirm that oral appliances and functional orthopaedic appliances are effective in the treatment of obstructive sleep apnoea in children. Oral appliances or functional orthopaedic appliances may be considered in specified cases as an auxiliary in the treatment of children who have craniofacial anomalies which are risk factors for apnoea.

### Implications for research

We suggest that clinical trials on malocclusion problems or respiratory disease should include information and results about how to improve respiratory and malocclusion problems. It is important that dentists look for any respiratory problems when treating a malocclusion because they can be treating respiratory problems without knowing, or when they diminish the oral space they can be promoting the tongue to fall into the oropharynx and cause obstructive sleep apnoea, or they can face difficulties when treating some malocclusion because there is a respiratory problem associated. It is also important that physicians treating respiratory problems look for malocclusion problems, because some respiratory problems can return if the malocclusion problem is not solved.

Clinical trials must have well established the objective of the research. It will be make a difference when the results are interpreted. If the objective is only a palliative or immediate care to diminish the apnoea index, the oral appliance can be indicated because it will change the mandibular position forwards and enlarge the upper airway space. The polysomnography to assess the results can be made after a short period of time that the oral appliance has been fitted, and at the moment of the polysomnography the oral appliance must be in the mouth. But if the objective is to treat and cure with the use of the oral appliance that not only will change the mandibular position forwards and enlarge the upper airway but also promote dento-alveolar and skeletal growth, the polysomnography to assess the results must be made after a longer period of time and the oral appliance must not be in the mouth.

Good quality randomised controlled trials that involve a representative number of patients with apnoea and malocclusion are necessary to answer the principal question of this systematic review: are oral appliances or functional orthopaedic appliances an effective treatment for obstructive sleep apnoea in children.

Reporting of clinical trials could be improved adopting the Consolidated Standards of Reporting Trials (CONSORT) statement

(Begg 1996; Moher 2001) to ensure that all relevant information is provided.

## ACKNOWLEDGEMENTS

Cochrane Oral Health, especially Luisa M Fernandez Mauleffinch and Anne Littlewood.

Brazilian Cochrane Center.

MAC Machado and H Saconato for their contribution to the previous version of this review.

## REFERENCES

### References to studies included in this review

#### Villa 2002 *{published data only}*

Villa M, Bernkopf E, Pagani J, Barreto M, Broia V, Massa F, et al. An oral appliance for the treatment of obstructive sleep apnea in children. *American Journal of Respiratory and Critical Care Medicine* 2000;**161**(3 (Suppl)):A27. [4391187]

\* Villa MP, Bernkopf E, Pagani J, Broia V, Montesano M, Ronchetti R. Randomized controlled study of an oral jaw-positioning appliance for the treatment of obstructive sleep apnea in children with malocclusion. *American Journal of Respiratory and Critical Care Medicine* 2002;**165**(1):123–7. [2918898]

### References to studies excluded from this review

#### Ghodke 2014 *{published data only}*

Ghodke S, Utreja AK, Singh SP, Jena AK. Effects of twin-block appliance on the anatomy of pharyngeal airway passage (PAP) in class II malocclusion subjects. *Progress in Orthodontics* 2014;**15**:68. [4391189]

#### Guilleminault 2011 *{published data only}*

\* Guilleminault C, Monteyrol PJ, Huynh NT, Pirelli P, Quo S, Li K. Adeno-tonsillectomy and rapid maxillary distraction in pre-pubertal children, a pilot study. *Sleep & Breathing* 2011;**15**(2):173–7. [4391191]  
Guilleminault C, Quo S, Huynh NT, Li K. Orthodontic expansion treatment and adenotonsillectomy in the treatment of obstructive sleep apnea in prepubertal children. *Sleep* 2008;**31**(7):953–7 [Erratum Sleep 2009;1;32(1):table of contents] [Retraction Sleep 2010;33(1):8]. [4391192]

#### Nunes 2011 *{published and unpublished data}*

\* Nunes Junior WR, Di Francesco RC. Snoring children treatment with orthodontic and orthopedic appliance - randomized clinical trial. *Sleep & Breathing* 2011;**15**(2): 257–8. [4391194]  
Nunes Junior WR, Francesco-Mion RCD. Early treatment and preventive strategies for obstructive sleep apnea and

hypopnea with the bioajusta x orthodontic-orthopedic treatment. *Sleep Medicine* 2009;**10** Suppl 2:S41–2. [4391195]

### Additional references

#### AAP Guideline 2002

American Academy of Pediatrics (AAP). Subcommittee on Obstructive Sleep Apnea Syndrome. Clinical practice guideline: diagnosis and management of childhood obstructive sleep apnea syndrome. *Pediatrics* 2002;**109**(4): 704–12.

#### Begg 1996

Begg C, Cho M, Eastwood S, Horton R, Moher D, Olkin I, et al. Improving the quality of reporting of randomised controlled trials. The CONSORT statement. *JAMA* 1996; **276**(8):637–9.

#### Bell 2001

Bell RB, Turvey TA. Skeletal advancement for the treatment of obstructive sleep apnea. *The Cleft Palate-Craniofacial Journal* 2001;**38**(2):147–54.

#### Brouillette 1982

Brouillette RT, Fernbach SK, Hunt CE. Obstructive sleep apnea in infants and children. *The Journal of Pediatrics* 1982;**100**(1):31–40.

#### Carroll 1995a

Carroll JL, Loughlin GM. Obstructive sleep apnea syndrome in infants and children: clinical features and pathophysiology. In: Ferber R, Kryger M editor(s). *Principles and Practice of Sleep Medicine in the Child*. Saunders (WB) Co Ltd, 1995:163–91.

#### Carroll 1995b

Carroll JL, Loughlin GM. Obstructive sleep apnea syndrome in infants and children: diagnosis and management. In: Ferber R, Kryger M editor(s). *Principles and Practice of Sleep Medicine in the Child*. Saunders (WB) Co Ltd, 1995: 193–216.

- Carroll 2003**  
Carroll JL. Obstructive sleep disordered breathing in children: new controversies, new directions. *Clinics in Chest Medicine* 2003;**24**(2):261–82.
- Carvalho 2014**  
Carvalho FR, Lentini-Oliveira DA, Carvalho GM, Prado LB, Prado GF, Carvalho LB. Sleep-disordered breathing and orthodontic variables in children - Pilot study. *International Journal of Pediatric Otorhinolaryngology* 2014;**78**(11):1965–9. [DOI: 10.1016/j.ijporl.2014.08.040]
- Chan 2004**  
Chan J, Edman JC, Koltai PJ. Obstructive sleep apnea in children. *American Family Physician* 2004;**69**(5):1147–54. [MEDLINE: 15023015]
- Chervin 1997**  
Chervin RD, Dillon JE, Bassetti C, Ganoczy DA, Pituch KJ. Symptoms of sleep disorders, inattention, and hyperactivity in children. *Sleep* 1997;**20**(12):1185–92.
- Defabjanis 2003**  
Defabjanis P. Impact of nasal airway obstruction on dentofacial development and sleep disturbances in children: preliminary notes. *Journal of Clinical Pediatric Dentistry* 2003;**27**(2):95–100.
- Egger 1997**  
Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ* 1997;**315**(7109):629–34.
- Goldstein 2000**  
Goldstein NA, Post JC, Rosenfeld RM, Campbell TF. Impact of tonsillectomy and adenoidectomy on child behavior. *Archives of Otolaryngology Head & Neck Surgery* 2000;**126**(4):494–8.
- Guilleminault 1989**  
Guilleminault C, Partinen M, Praud JP, Quera-Salva MA, Powell N, Riley R. Morphometric facial changes and obstructive sleep apnea in adolescents. *The Journal of Pediatrics* 1989;**114**(6):997–9.
- Guilleminault 1990**  
Guilleminault C, Stoohs R. Chronic snoring and obstructive sleep apnea syndrome in children. *Lung* 1990;**168** Suppl: 912–9.
- Guilleminault 2008**  
Guilleminault C, Quo S, Huynh NT, Li K. Orthodontic expansion treatment and adenotonsillectomy in the treatment of obstructive sleep apnea in prepubertal children. *Sleep* 2008;**31**(7):953–7 [Erratum *Sleep* 2009;**32**(1):table of contents], [Retraction *Sleep* 2010;**33**(1):8].
- Higgins 2011**  
Higgins JP, Green S, editor(s). *Cochrane Handbook for Systematic Reviews of Interventions* Version 5.1.0 (updated March 2011). The Cochrane Collaboration, 2011. Available from handbook.cochrane.org.
- Kheirandish-Gozal 2006**  
Kheirandish-Gozal L, Capdevila OS, Tauman R, Gozal D. Plasma C-reactive protein in non obese children with obstructive sleep apnea before and after adenotonsillectomy. *Journal of Clinical Sleep Medicine* 2006;**2**(3):301–4.
- Kohler 2008**  
Kohler M, Lushington K, Couper R, Martin J, Heuvel C, Pamula Y, et al. Obesity and risk of sleep related upper airway obstruction in caucasian children. *Journal of Clinical Sleep Medicine* 2008;**4**(2):130–6.
- Marcus 1992**  
Marcus CL, Omlin KJ, Basinki DJ, Bailey SL, Rachal AB, Von Pechmann WS, et al. Normal polysomnographic values for children and adolescents. *The American Review of Respiratory Disease* 1992;**146**(5 Pt 1):1235–9.
- Marcus 2001**  
Marcus CL. Sleep-disordered breathing in children. *American Journal of Respiratory and Critical Care Medicine* 2001;**164**(1):16–30.
- Marcus 2012**  
Marcus CL, Brooks LJ, Draper KA, Gozal D, Halbower AC, Jones J, et al. Diagnosis and management of childhood obstructive sleep apnea syndrome. *Pediatrics* 2012;**130**(3):e714–55.
- Moher 2001**  
Moher D, Schulz KF, Altman DG. The CONSORT statement: revised recommendations for improving the quality of reports of parallel-group randomized trials. *Lancet* 2001;**357**(9263):1191–4.
- Nixon 2005**  
Nixon GM, Brouillette RT. Sleep. 8: Paediatric obstructive sleep apnoea. *Thorax* 2005;**60**(6):511–6. [MEDLINE: 15923253]
- Schechter 2002**  
Schechter MS. Technical report: diagnosis and management of childhood obstructive sleep apnea syndrome. *Pediatrics* 2002;**109**(4):e69.
- Shintani 1998**  
Shintani T, Asakura K, Kataura A. The effect of adenotonsillectomy in children with OSA. *International Journal of Pediatric Otorhinolaryngology* 1998;**44**(1):51–8.
- Tarasiuk 2007**  
Tarasiuk A, Greenberg-Dotan S, Simon-Tuval T, Freidman B, Goldbart AD, Tal A, et al. Elevated morbidity and health care use in children with obstructive sleep apnea syndrome. *American Journal of Respiratory and Critical Care Medicine* 2007;**175**(1):55–61.
- Uliel 2004**  
Uliel S, Tauman R, Greenfeld M, Sivan Y. Normal polysomnographic respiratory values in children and adolescents. *Chest* 2004;**125**(3):872–8.
- Viva 1992**  
Viva E, Stefani S, Annibale G, Pedercini R, Zucconi M, Strambi LF. Aspects of prevention of obstructive sleep apnea syndrome in developing children. *Advances in Otorhinolaryngology* 1992;**47**:284–9.

**Ward 1996**

Ward SL, Marcus CL. Obstructive sleep apnea in infants and young children. *Journal of Clinical Neurophysiology* 1996;**13**(3):198–207.

**References to other published versions of this review****Carvalho 2005**

Carvalho FR, Lentini-Oliveira DA, Machado MAC, Prado GF, Prado LBF. Oral appliances and functional orthopaedics appliances for obstructive sleep apnoea in

children. *Cochrane Database of Systematic Reviews* 2005, Issue 4. [DOI: 10.1002/14651858.CD005520]

**Carvalho 2007**

Carvalho FR, Lentini-Oliveira DA, Machado MAC, Saconato H, Prado LBF, Prado GF. Oral appliances and functional orthopaedic appliances for obstructive sleep apnoea in children. *Cochrane Database of Systematic Reviews* 2007, Issue 2. [DOI: 10.1002/14651858.CD005520.pub2]

\* *Indicates the major publication for the study*

## CHARACTERISTICS OF STUDIES

### Characteristics of included studies *[ordered by study ID]*

#### Villa 2002

Methods	Trial design: Quasi-randomised, unblinded, prospective study Location: Italy Duration: 6 months
Participants	Inclusion criteria: Apnoea index of > 1 event/hour of sleep and dysgnathia (87% participants with deep and retrusive bite and 13% with cross-bite; 86% had deep and retrusive bite and 14% had cross-bite in treated group; 100% had deep and retrusive bite in control group) Gender: 20 male, 12 female Age range: 4 to 10 years Number randomised: 32 (Group 1 = 19; Group 2 = 13) Number evaluated: 23 (Group 1 = 14; Group 2 = 9). Dropouts: Group 1 = 5 (2 claimed that they lost their appliances 3 times and then refused to wear them again, 2 children found wearing the oral appliance at school embarrassing and discontinued therapy, and 1 child found the oral appliance intolerable because putting it into the mouth triggered violent, uncontrollable coughing that stopped only when the appliance was removed); Group 2 = 4
Interventions	Comparison: oral appliance versus no treatment Group 1: oral appliance (personalised acrylic resin oral bite plate for mandibular positioning) Group 2: no treatment
Outcomes	Reduction of apnoea episodes Daytime symptoms: sleepiness, irritability, tiredness, school problems, morning headache, morning thirstiness, oral breathing and nasal stuffiness Night-time symptoms: habitual snoring, restless sleep and nightmares Tolerability
Notes	We contacted the study author to obtain additional information and although we received new details, they were not sufficient to clarify our judgements of unclear or high risk of bias

#### *Risk of bias*

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Quasi-random method of allocation (alphabetically by surname)
Allocation concealment (selection bias)	High risk	Not reported, but due to the poor randomisation method used it could have been impossible to make an adequate allocation

**Villa 2002** (Continued)

Blinding of participants and personnel (performance bias) All outcomes	High risk	It was impossible to blind the participants because the intervention group wore an oral appliance and the control group wore nothing and could easily be distinguished from the active intervention; therefore we assessed the study at high risk of performance bias
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	High risk	The study lost 5 (26.3%) participants in the treatment group and 4 (30.8%) in the control group
Selective reporting (reporting bias)	Low risk	All outcomes analysed in the results section were reported under methods
Other bias	Unclear risk	The study authors did not report any other interventions during the same treatment time. The study authors reported that there were no differences between groups at baseline but there is no analysis to support this

**Characteristics of excluded studies** [ordered by study ID]

Study	Reason for exclusion
<a href="#">Ghodke 2014</a>	No sleep assessment
<a href="#">Guilleminault 2011</a>	No placebo or no treatment group
<a href="#">Nunes 2011</a>	Study did not use polysomnography to assess sleep

## DATA AND ANALYSES

### Comparison 1. Oral appliance versus no treatment

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Apnoea-hypopnoea index measured by polysomnography	1	23	Risk Ratio (M-H, Fixed, 95% CI)	0.39 [0.20, 0.76]
2 Daytime symptoms: Sleepiness measured by questionnaire	1	23	Risk Ratio (M-H, Fixed, 95% CI)	0.64 [0.11, 3.78]
3 Daytime symptoms: Irritability measured by questionnaire	1	23	Risk Ratio (M-H, Fixed, 95% CI)	0.32 [0.07, 1.41]
4 Daytime symptoms: Tiredness measured by questionnaire	1	23	Risk Ratio (M-H, Fixed, 95% CI)	0.26 [0.06, 1.05]
5 Daytime symptoms: School problems measured by questionnaire	1	23	Risk Ratio (M-H, Fixed, 95% CI)	0.64 [0.11, 3.78]
6 Daytime symptoms: Morning headache measured by questionnaire	1	23	Risk Ratio (M-H, Fixed, 95% CI)	0.39 [0.12, 1.23]
7 Daytime symptoms: Thirstiness in the morning measured by questionnaire	1	23	Risk Ratio (M-H, Fixed, 95% CI)	0.16 [0.02, 1.22]
8 Daytime symptoms: Oral breathing measured by questionnaire	1	23	Risk Ratio (M-H, Fixed, 95% CI)	0.16 [0.04, 0.59]
9 Daytime symptoms: Nasal stuffiness measured by questionnaire	1	23	Risk Ratio (M-H, Fixed, 95% CI)	0.18 [0.05, 0.69]
10 Night-time symptoms: Habitual snoring measured by questionnaire	1	23	Risk Ratio (M-H, Fixed, 95% CI)	0.18 [0.06, 0.55]
11 Night-time symptoms: Restless sleep measured by questionnaire	1	23	Risk Ratio (M-H, Fixed, 95% CI)	0.21 [0.05, 0.84]
12 Night-time symptoms: Nightmares measured by questionnaire	1	23	Risk Ratio (M-H, Fixed, 95% CI)	0.22 [0.01, 4.93]



## ADDITIONAL TABLES

**Table 1. Apnoea/hypopnoea index - Treated group (from paper)**

Index	Baseline mean values	After 6 months	P value (Student t)
Apnoea/hypopnoea index	7.1 +/- 4.6	2.6 +/- 2.2	< 0.001

Values expressed by mean +/- standard deviation. Student t test before versus after therapy.

**Table 2. Daytime symptoms - Treated group (from paper)**

Symptoms	Baseline (n/N)	After 6 months (n/N)	P value (Pearson X <sup>2</sup> )
Sleepiness	78.6% (11/14)	14.3% (2/14)	0.002
Irritability	85.7% (12/14)	14.3% (2/14)	< 0.001
Tiredness	78.6% (11/14)	14.3% (2/14)	0.002
School problems	35.7% (5/14)	14.3% (2/14)	NS
Morning headache	57.1% (8/14)	21.4% (3/14)	NS
Thirstiness in the morning	71.4% (10/14)	7.1% (1/14)	0.002
Oral breathing	92.9% (13/14)	14.3% (2/14)	< 0.001
Nasal stuffiness	92.9% (13/14)	14.3% (2/14)	< 0.001

n = number of children with symptom; N = total number of children; NS = non-significant.

**Table 3. Daytime symptoms - Control group (from paper)**

Symptoms	Baseline (n/N)	After 6 months (n/N)	P value (Pearson X <sup>2</sup> )
Sleepiness	33.3% (3/9)	22.2% (2/9)	NS
Irritability	44.4% (4/9)	44.4% (4/9)	NS
Tiredness	55.6% (5/9)	55.6% (5/9)	NS
School problems	22.2% (2/9)	22.2% (2/9)	NS
Morning headache	55.6% (5/9)	55.6% (5/9)	NS
Thirstiness in the morning	55.6% (5/9)	44.4% (4/9)	NS

**Table 3. Daytime symptoms - Control group (from paper)** (Continued)

Oral breathing	100% (9/9)	88.9% (8/9)	NS
Nasal stuffiness	77.8% (7/9)	77.8% (7/9)	NS

n = number of children with symptom; N = total number of children; NS = non-significant.

**Table 4. Night-time symptoms - Treated group (from paper)**

Symptoms	Baseline (n/N)	After 6 months (n/N)	P value (Pearson X <sup>2</sup> )
Habitual snoring	92.9% (13/14)	14.3% (2/14)	< 0.001
Restless sleep	92.9% (13/14)	14.3% (2/14)	< 0.001
Nightmares	28.6% (4/14)	0% (0/14)	NS

n = number of children with symptom; N = total number of children; NS = non-significant.

**Table 5. Night-time symptoms - Control group (from paper)**

Symptoms	Baseline (n/N)	After 6 months (n/N)	P value (Pearson X <sup>2</sup> )
Habitual snoring	100% (9/9)	100% (9/9)	NS
Restless sleep	66.7% (6/9)	66.7% (6/9)	NS
Nightmares	11.1% (1/9)	11.1% (1/9)	NS

n = number of children with symptom; N = total number of children; NS = non-significant.

## WHAT'S NEW

Last assessed as up-to-date: 7 April 2016.

Date	Event	Description
1 November 2016	Review declared as stable	This review will not be updated until a substantial body of evidence on the topic becomes available. If trials are conducted and found eligible for inclusion in the future, the review would then be updated accordingly

## HISTORY

Protocol first published: Issue 4, 2005

Review first published: Issue 2, 2007

Date	Event	Description
15 September 2016	New citation required but conclusions have not changed	Two of the original authors not involved in the update. A new author was added. Background and methods sections updated. 'Risk of bias' assessment completed. 'Summary of findings' table added
7 April 2016	New search has been performed	Searches updated to April 2016. No new studies found for inclusion
1 August 2008	Amended	Converted to new review format

## CONTRIBUTIONS OF AUTHORS

Fernando Rodrigues Carvalho: review conception and design, study selection, data extraction, analysis and interpretation of data, quality assessment.

Debora Aparecida Lentini-Oliveira: quality assessment, study selection, data extraction, data analysis.

Gilmar Fernandes Prado: study selection.

Lucila Bizari Fernandes Prado: study selection.

Luciane Bizari Coin Carvalho: quality assessment, data analysis, methodological supervisor.

## DECLARATIONS OF INTEREST

Fernando R Carvalho: none known.

Débora A Lentini-Oliveira: none known.

Lucila BF Prado: none known.

Gilmar F Prado: none known.

Luciane BC Carvalho: none known.

## SOURCES OF SUPPORT

### Internal sources

- No sources of support supplied

### External sources

- Brazilian Cochrane Center, Brazil.
- National Institute for Health Research (NIHR), UK.

This project was supported by the NIHR, via Cochrane Infrastructure funding to Cochrane Oral Health. The views and opinions expressed therein are those of the review authors and do not necessarily reflect those of the Systematic Reviews Programme, the NIHR, the NHS or the Department of Health.

- Cochrane Oral Health Global Alliance, Other.

The production of Cochrane Oral Health reviews has been supported financially by our Global Alliance since 2011 ([ohg.cochrane.org/partnerships-alliances](http://ohg.cochrane.org/partnerships-alliances)). Contributors over the last year have been: British Association for the Study of Community Dentistry, UK; British Society of Paediatric Dentistry, UK; Centre for Dental Education and Research at All India Institute of Medical Sciences, India; National Center for Dental Hygiene Research & Practice, USA; New York University College of Dentistry, USA; NHS Education for Scotland, UK.

## DIFFERENCES BETWEEN PROTOCOL AND REVIEW

Methods have been updated.

## NOTES

This review will not be updated until a substantial body of evidence on the topic becomes available. If trials are conducted and found eligible for inclusion in the future, the review would then be updated accordingly.

## INDEX TERMS

### Medical Subject Headings (MeSH)

\*Orthodontic Appliances; \*Orthotic Devices; Randomized Controlled Trials as Topic; Sleep Apnea, Obstructive [\*therapy]

### MeSH check words

Adolescent; Child; Humans