

University of Aden, Faculty of Dentistry, Yemen.
Universidad de Ciencias Médicas de La Habana.
Facultad de Estomatología "Raúl González Sánchez".

Mouth breathing and its relationship to some oral and medical conditions: physiopathological mechanisms involved

Respiración bucal y su relación con algunas afecciones bucales y médicas: mecanismos fisiopatológicos involucrados

Dr.C. Bárbara Elena García Triana^I, Dr. Ahlam Hibatulla Ali, Ph.D^{II}, Dr.C. y Ileana Bárbara Grau León^{III}

^IDoctor in medical Science. Full Professor. Faculty of Dentistry, University of Aden, Yemen babygt@infomed.sld.cu

^{II}Full Professor, Faculty of Dentistry, University of Aden, Yemen. ahlamtas@gmail.com

^{III}Doctor in medical Science. Full Professor. Universidad de Ciencias Médicas de La Habana Facultad de Estomatología "Raúl González Sánchez". iluchy@infomed.sld.cu

ABSTRACT

Introduction: Excessive mouth breathing may be related to different oral and medical conditions, but the underlying mechanisms for these complex interactions are not fully understood.

Objective: To explore the possible physiopathological mechanisms involved in the relationship between mouth breathing and some oral and medical conditions.

Material and Methods: A review of the literature was performed by using PubMed, Scielo and Hinari. Relevant and updated articles were selected.

Results: Mouth breathing has been linked to oral conditions such as dry mouth and lips, dental caries, periodontal disease, secondary halitosis, craniofacial deformity and malocclusion, as well as abnormal swallowing. It is also related to medical conditions such as altered head, neck and body posture, obstructive sleep apnea, poor physical and learning performance, and asthma. Among the physiopathological mechanisms

that may explain that relationship are chronic hypoxemia with hypercapnia, increased water and energy lose, decreased growth hormone release, inflammatory and oxidative mediators release, large load on the upper back and neck muscles, deformity in the airway passage and craniofacial deformities.

Conclusions: Physiopathological mechanisms underpinning the relationship between mouth breathing and oral and medical diseases vary from biochemical, physiological and immunological deficiencies to anatomical effects. More studies are needed to explore a causal relationship.

Key words: Mouth breathing, dental caries, periodontal disease, halitosis, malocclusion, sleep apnea, performance, posture, asthma.

RESUMEN

Introducción: La respiración bucal excesiva puede relacionarse con diferentes afecciones bucales y médicas, pero los mecanismos involucrados en tan complejas interacciones no son comprendidos totalmente.

Objetivo: Explorar los posibles mecanismos fisiopatológicos involucrados en la relación entre la respiración bucal y algunas afecciones bucales y médicas.

Material y Métodos: Se realizó una revisión de la literatura a través de PubMed, Scielo y Hinari. Se seleccionaron artículos relevantes y actualizados sobre el tema.

Resultados: La respiración bucal se ha relacionado con afecciones bucales como: boca y labios secos, caries dental, enfermedad periodontal, halitosis secundaria, deformidad craneofacial y mal oclusión, así como deglución anormal. También se relaciona con afecciones médicas como: alteración de la postura corporal, de la cabeza y el cuello, apnea obstructiva del sueño, pobre desempeño físico y del aprendizaje y asma. Entre los mecanismos fisiopatológicos involucrados en esa relación están: hipoxemia crónica con hipercapnia, incremento de la pérdida de agua y energía, disminución de la liberación de hormona del crecimiento, liberación de mediadores inflamatorios y oxidativos, sobrecarga en la espalda alta y músculos del cuello, deformidad en la vía aérea y deformidades craneofaciales.

Conclusiones: Los mecanismos fisiopatológicos involucrados en la relación entre la respiración bucal y algunas afecciones bucales y médicas incluyen deficiencias bioquímicas, fisiológicas, e inmunológicas, así como efectos anatómicos. Se requiere realizar más estudios para explorar una relación causal.

Palabras clave: respiración bucal, caries dental, enfermedad periodontal, halitosis, maloclusión, apnea obstructiva, desempeño, postura, asma.

INTRODUCTION

Mouth breathing refers to the state of inhaling and exhaling through the mouth. The literature describes the prevalence of mouth breathing as ranging from 5 to 75% of tested children.^{1, 2}

Excessive mouth breathing is problematic because of different disturbances. The air is not filtered and warmed as much as when inhaled through the nose, as it bypasses the nasal canal and paranasal sinuses, and dries out the mouth, among other mechanisms. Mouth breathing is often associated with congestion, obstruction, or

other abnormalities of the upper respiratory tract as well as other oral and medical conditions.³⁻¹²

One requirement to establish that certain condition can act as a risk factor for diseases is to determine the theoretical plausibility of the relationship. However, despite the published data about mouth breathing as a risk factor for certain oral and medical conditions, the mechanisms underlying these complex relationships are not fully understood. These reasons motivated this review of the literature.

The **objective** is to explore the possible physiopathological mechanisms involved in the relationship between mouth breathing and some oral and medical conditions.

MATERIAL AND METHODS

A review of the literature was performed through PubMed, Hinari and Scielo. From the total articles obtained without limits of the period of time, original and review articles were selected (8 reviews and 38 original articles) according to relevance for the elucidation or explanation of the physiopathological mechanisms involved in the relationship of mouth breathing with oral and medical conditions. The selected articles were mainly from the last 10-5 years (70% of the last 5 years). In order to exemplify the explored mechanisms, some oral disorders (dry mouth and lips, dental caries, periodontal disease, secondary halitosis, craniofacial deformity and malocclusion, and abnormal swallowing), as well as some medical conditions (altered head, neck and body posture, obstructive sleep apnea, poor physical and learning performance, and asthma) were selected. The following key words were used: mouth breathing, dental caries, periodontal disease, halitosis, malocclusion, sleep apnea, performance, posture, asthma.

RESULTS

Causes of mouth breathing

Mouth breathing is characterized by inhalation and exhalation through the mouth and when it is chronically practiced, it is considered as an abnormal respiratory function. Different causes have been cited. The main are: chronic allergies, tonsil and adenoid hypertrophy, nasal polyps, deviated nasal septum, constricted upper airways, thumb sucking, excessive pacifier use or insufficient suckling as an infant.¹³

Some authors have considered that the two main causes of mouth breathing in children are firstly allergic rhinitis and secondly adenoid hypertrophy.³ Allergic rhinitis may play a key role in mouth breathing due to its high prevalence. This stresses the importance of allergological investigation in mouth-breathers, to establish specific treatments that may reduce morbidity in this patients.¹⁴

Consequences of mouth breathing

Due to the complex interactions involved, sometimes it is difficult to establish the cause-effect relationship between two factors. That is why some factors which may appear as causes in the previous item, will also be discussed next as consequences. It is probably the expression of mutual interaction and positive feedback mechanisms involved.

General mechanisms for disturbances on mouth breathing

There are different general mechanisms which may explain the consequences of mouth breathing. They are mainly composed of biochemical, physiological, immunological and anatomical disturbances which has been attributed to mouth breathing. Among the biochemical and physiological disorders are the lower oxygen absorption (chronic hypoxemia), increased CO₂ concentration (hypercapnia), and its related changes in the acid-base balance, towards respiratory acidosis. Also, there is increased water and energy loss, and changes in salivary profile. It has been shown that healthy subjects, experience a 42% increase in net water loss when they switch the breathing mode from nasal to oral expiration during tidal breathing. The authors considered that increased water and energy loss by oral breathing could be a contributing factor to the symptoms seen in patients suffering from nasal obstruction.¹⁵

Also a decreased nocturnal growth hormone (GH) release has been reported. It has been considered that snore at night and struggle for air interferes with growth hormone production in some way.¹⁶

Inflammatory and oxidative mediators release has also been linked to mouth breathing, however it is not clear if they are the result of mouth breathing, atopia, other related disturbances or the complex interactions among them. The oxidant nitricoxide (NO) is produced by the action of the enzyme NO synthase (NOS) on L-arginine in different cell types and found in air exhaled by humans. Most of the exhaled NO is derived from the upper airways and increases in patients with untreated asthma and allergic rhinitis, diseases which exhibit mutual interactions with mouth breathing. The induction of iNOS (inducible NOS) in patients with allergic rhinitis increases nasal NO which in turn produces the symptoms of nasal obstruction and rhinorrhea, contributing to mouth breathing.¹⁷

With respect to the immune system, lowered response has been described which is linked to poor health. It has been stated that nasal breathing produces a tissue hormone that regulates normal blood circulation. It also filters, warms and moisturizes the air. The lack of oxygen in mouth breathers is considered to weaken the immune system.¹⁶

Anatomical effects of mouth breathing are the result of the adaptation of the growing tissues to the abnormal breathing profile. They include among others, large load on the upper back and neck muscles and deformity in the airway passage which are involved in postural disturbances and obstructive sleep apnea. As the jaw in mouth breathers is positioned too far back, along with the tongue, the upper airway is constricted. Enlarged tonsils and adenoids due to chronic allergies may be the primary cause for mouth breathing; however mouth breathing will also cause a further increase in tonsil size, constricting the airway and posing obstacles to nasal breathing. The open mouth will also cause a decreased contractile efficiency of the upper airway muscles affecting nasal breathing.¹⁰. Also dent facial structures' growing is affected leading to altered profile and malocclusion, among others.^{7, 8, 18, 19}

Oral conditions related to mouth breathing

Dry mouth and lips

The appropriate humidity of the mouth is guaranteed by saliva and any factor that reduces body fluids will reduce salivary output. In mouth breathers, there is a water loss produced mainly through evaporation. So, the decreased resting salivary flow rate could be not high enough to counteract the evaporation effect (estimated up to

0.21 mL/min) of mouth exhalation and this imbalance will lead to dry mouth and lips. This has serious consequences with a declining in gustatory sensitivity, impaired swallowing activity and protective function of saliva, among others.^{20, 21}

Dental caries

Saliva has many important functions. Among them are self-cleaning of the mouth, buffering and clearing acids, acquired pellicle formation, antimicrobial actions, and provision of ions for remineralization of demineralized enamel. It protects the teeth from organic acids produced by bacteria which cause dental caries, and the extrinsic and intrinsic acids that initiate dental erosion. The depressed resting salivary flow is associated with lower plaque pH, increased numbers of lactobacilli and candida species, and greater caries risk. This could have serious consequences for caries activity, and will also increase the risk of tooth loss via dental erosion.^{20, 21}

As mouth breathing causes water loss it is a potential factor which could contribute to oral dryness. Some studies have failed to find associations between mouth breathing and caries risk or salivary patterns. For example, Koga-Ito et al. found no differences in caries risk between treated and untreated children for mouth breathing syndrome, although the level of IgG antibodies to *S. mutans* (cariogenic bacteria) was higher in the treated group.²² Another study did not find differences in flow rates or buffering capacities of resting and stimulated saliva between mouth- or nose-breathers adolescents aged 10-19 years.²³ However, Al-Awadi et al. found lower salivary flow rate among male patients¹⁸⁻²² years old with mouth breathing associated with nasal obstruction in comparison to nose breathers. Mouth breathing was also associated with lower salivary pH, higher plaque index and increased salivary *mutans streptococci* counts.⁵ Other studies also report association between mouth breathing and dental caries.^{24, 25}

Periodontal disease

The mouth breathing is also considered as one of the predisposing factors for initiation of periodontal disease and/or its progression. The anterior dental open bite produced by chronic mouth breathing is associated with high incidence of periodontal disease and high risk of losing the anterior teeth in early ages. This causes the absence of anterior guidance which also predisposes the patients for temporomandibular disorders. The precise mechanisms are not fully understood, but probable causes are gingival surface dehydration, decreased epithelial resistance to bacterial plaques, and lack of salivary auto-cleaning.²⁵⁻²⁹

Secondary halitosis

Halitosis is a condition characterized by altered halitus in an unpleasant manner for both the affected individual and those interacting around. The majority of halitosis cases are secondary and associated with oral problems. In particular, the changes in salivary flow patterns and water imbalance leading to surface drying of the mucosa induced by mouth breathing may be related to halitosis. A reduction in salivary flow avoids its protective functions in the cleaning of the mouth and antibacterial actions, causing a shift in the bacterial flora in the mouth. So, the growth of protolithic bacteria produces volatile odoriferous sulfur compounds.^{6, 15}

Conditions which may appear as consequences of mouth breathing such as dental caries and periodontal disease can also contribute to halitosis. Also chronic allergies and infections of the nose and throat related to mouth breathing can give rise to bad breath.³⁰

Craniofacial deformity and malocclusion

While craniofacial structures are growing, they adapt to the different breathing pattern in mouth breathers. The changes in facial musculature affect the dental arches and positioning of the teeth, linked to structural disturbances in the lips, tongue, palate and mandible with subsequent facial deformity.⁶ Also, mouth breathing decreases chewing activity, reducing the vertical effect on the posterior teeth, which can affect negatively their vertical position, leading to malocclusion^{31,32}.

The altered fashion is characterized by: long faces with an increase in the anterior lower facial height, constricted maxillary arches, increased palatal height with reduction of the palatal surface area and volume, tooth crowding, a narrowed nasal airway passage, and enlarged nostrils. The lower jaw remains too far behind in its growth with increased mandibular plane angle and gonial angle, producing a small chin, dental malocclusion (Class II), hypotonic upper lips, hypertonic lower lips, protrusion of the anterior teeth and nasal prominence, with unfavorable profile^{1,7,8,18,19,33}.

It has been also hypothesized that decreased mandibular growth in adenoid face children is due to the abnormal nocturnal secretion of growth hormone and its mediators. The secretion of the hormone is normalized following adenotonsillectomy and rehabilitation of mouth breathing, with acceleration in the growth of the mandible and change in its growth direction. It has been explained by more intensive endochondral bone formation in the condylar cartilage and/or by appositional bone growth in the lower border of the mandible, after the reestablishment of normal nasal breathing and hormonal status¹⁶.

In children 3-6 year old, subjected to mouth breathing rehabilitation which included adenotonsillectomy, a significant normalization in the mandibular growth direction, a decrease in the mandible inclination, and an increase in the posterior facial height, was accomplished after 28 months, although occlusal features experienced no change.^{34,35}

Abnormal swallowing

It has been shown in patients 11-14 year old, that mouth breathing is related to abnormal swallowing⁹. Mouth breathing is often accompanied by anterior tongue thrust, instead of a lip closure, in order to create the anterior seal necessary for the initiation of physiological deglutition.³⁶

Nasal breathing is the most effective way of tongue control during swallowing. In normal swallowing, the tongue pressures the roof of the mouth creating peristaltic waves which send the food bolus down the esophagus and into the stomach, with partial closure of the epiglottis. Mouth breathers disturbances (infant swallowing, tongue thrust, facial rictus when swallowing) cause abnormal peristaltic activity which lead to the swallowing of a lot of air. In the long term, the concomitant stomach secretions reflux can cause loss of elasticity of the throat, which consequently will collapse, as it can be found in moderate and severe obstructive sleep apnea. In severe apnea, the entire pharynx could collapse.⁶

The abnormal swallowing profile of mouth breathers can also cause aspiration of foreign particles and fluid into the lungs, which would also enhance pneumonia, emphysema, and other chronic obstructive pulmonary diseases. This illustrates the complex interactions and links that are established between different disturbances associated to mouth breathing.

Medical conditions

Altered head, neck and body posture

The unphysiological process of breathing through the mouth produces a reflex forward head posture. This puts a large load on the upper back and neck muscles, which if sustained, will cause permanent posture changes, such as abnormal curvatures in the cervical and thoracic vertebrae, an altered shoulder posture, which in turn will affect hips, knees and feet. In adults, jaw joint dysfunction can be derived from postural disturbances.^{10,37,38}

Open-mouth breathing is also associated with reduction of the retropalatal and retroglossal areas, lengthening of the pharynx and shortening of the distance between the mandible and hyoid bone in the upper airway.^{6,7,38,39}

Obstructive sleep apnea (OSA)

The decreased contractile efficiency of the upper airway muscles in mouth breathers may lead to increased collapsibility of the upper airways. In newborns, it has been related to sudden infant death syndrome and in children, this is manifested as snoring, bed-wetting, poor quality of sleep and obesity. In adults, OSA is linked to death. Snoring is a milder version of sleep apnea and an expression of a blocked airway. The treatment of nasal obstruction in mouth-breathing patients with OSA results in better sleep, as well as a modest improvement in OSA severity. These points to the role of nasal obstruction and mouth breathing in the pathology of OSA.¹¹ Chronic hypoxemia, which is present in these patients during the night, has also been implicated in the genesis of ventilatory depression by affecting the synthesis and activity of several neurotransmitters and by altering the central and peripheral function of chemoreceptors. Chronic adaptation of these chemoreceptors to hypoxemia and hypercapnia has been reported to result from recurrent apnea. A new, increasingly higher point of regulation for CO₂ occurs during the course of the disease.^{15,39}

OSA can bring as consequence other diseases such as cardiovascular disease and stroke, lung dysfunction, obesity, high blood pressure and diabetes mellitus. There is a lot of evidence linking obstructive sleep apnea syndrome with atherogenic processes, cardiovascular mortality, and vehicle and workplace accidents, so an increasing severity of the condition should be associated with increased mortality. Systemic inflammation has also been linked to OSA and its consequences. It has been reported the presence of sub epithelial oedema, inflammatory cell infiltration, inflammatory and oxidative mediators in the tissues of the upper ways, nasal lavage fluid, sputum or serum, which positively correlated with the severity of OSA in many cases. Recurrent vibration in the upper airway of children with OSA has been suggested to promote such inflammatory changes in the tonsillar tissue and upper airway mucosa (Figure 1).^{40,41}

Poor physical and learning performance

The same lack of oxygen and other hormonal factors make mouth breather children tend to be overweight, tired, and not perform well at school. Physically they are not athletic. Also mouth breathers show cognitive impairment as well as attention deficit hyperactive disorder (memory, concentration, attention, learning disability, low perception and sensorimotor integration); while surgical treatment which restores nasal breathing benefits also the learning abilities. It may be linked to sleep disorders as it has been shown that children with excessive day time sleepiness appear to have almost 10 times the risk of learning difficulties.^{11,42-44}

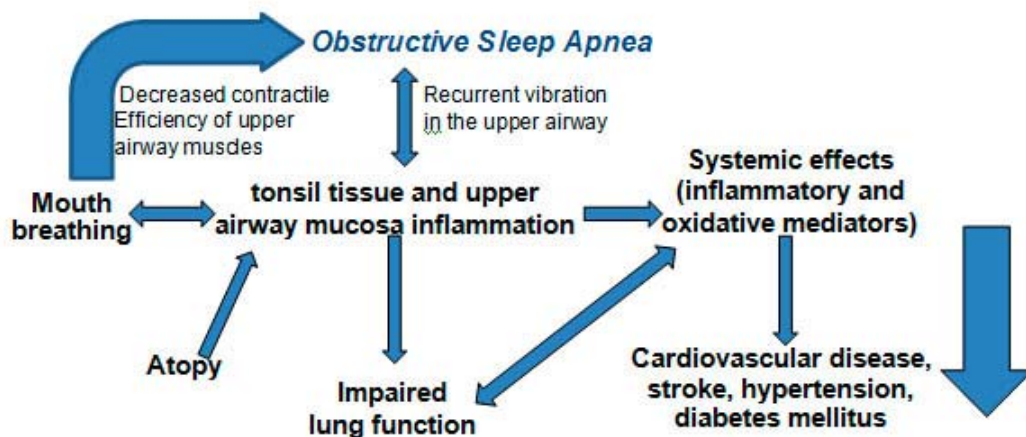


Figure. 1 Possible interrelationships between mouth breathing, atopia, tonsil and upper airway inflammation, obstructive sleep apnea and other systemic effects.

It has also been suggested that breathing through the mouth instead of the nose can adversely affect brain function. Hypertrophic pharyngeal and palatine tonsils in mouth breather children is associated to apnea and nocturnal hypoxemia, with the degree of systemic involvement directly related to the degree of tonsil hypertrophy.⁴³

It has been considered that mouth breathing associated alterations in the central nervous system may be caused by the change in the acid-base balance, with the resultant respiratory acidosis. This affects the activity of ATP-sensitive potassium channels, which play a crucial role in the function of the central nervous system.⁴³

Sano et al. showed that brain hemodynamic responses in the prefrontal cortex is different when adult individuals change from nasal to mouth breathing, with an increased oxygen load in the prefrontal cortex in mouth breathing. This has been interpreted as a way for the human body to maintain homeostasis over the changes in respiratory frequency and tidal volume triggered by mouth breathing. Although another explanation is that the increased oxygen load in the prefrontal cortex is the result of the voluntary input necessary for breathing through the nonpreferred mouth route.⁴²

Asthma

A strong connection has been found between mouth breathing and asthma. Enforced oral breathing causes a decrease in lung function in mild asthmatic subjects at rest, initiating asthma symptoms in some. So, oral breathing may play a role in the pathogenesis of acute asthma exacerbations.¹² The nose and not the mouth should be used for breathing as the nose has better air conditioning capacity. When air is inhaled through the mouth it may dry and cool the respiratory mucosa, which can lead to bronchoconstriction in sensitive patients with asthma.⁴⁶

In mouth breathers air is not filtered in the nose so the lungs may be exposed to higher concentrations of inhaled, ambient particles. Also enhanced perception of nasal loading may trigger increased oral breathing in asthmatics, potentially enhancing exposure to nonconditioned inhaled gas and contributing to the occurrence and/or

severity of bronchoconstrictive exacerbations.¹² As the site of upper airway obstruction in asthmatic children appears to be the epipharynx, the adenoids may play a key-role. So adenoiditis could be a common cause of both mouth breathing and asthma. In a multivariate analysis, atopy was significantly associated with the presence of asthma.^{14,46} The excessive release of oxygen free radicals as NO by the activation of iNOS in the upper airways has been reported in patients with untreated asthma and allergic rhinitis, which is counteracted by inhalation of steroids (Figure 2).¹⁷

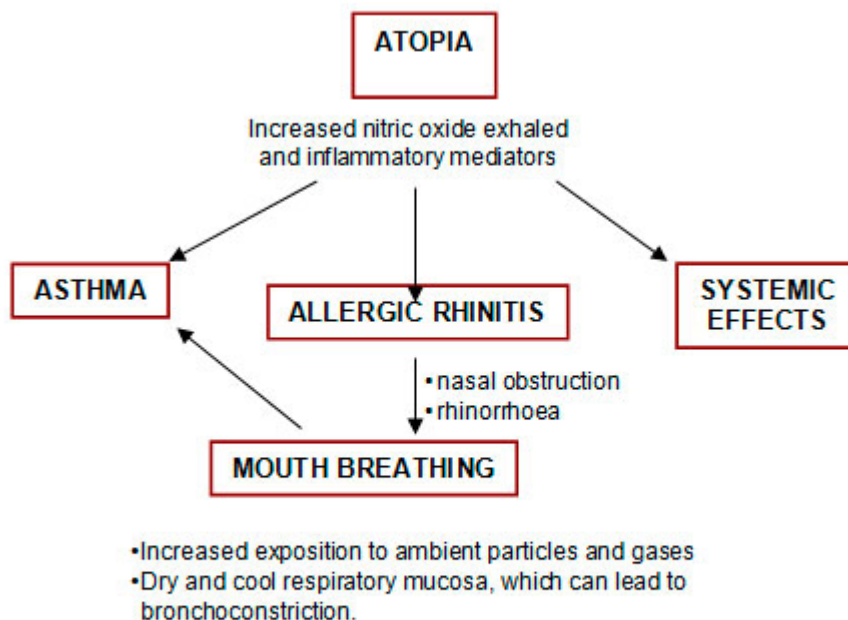


Figure 2. Possible relationships between atopy, allergic rhinitis and mouth breathing in asthma pathogenesis

Recently, it has been also evidenced that childhood mouth-breathing yields consequences for the ventilatory function at adult age, with lower respiratory muscle strength and functional exercise capacity, which could also adversely influence asthma episodes.⁴

This review has limitations for not covering all of the oral and medical conditions that has been related to mouth breathing in the literature. However, in the view of the authors, the selected disorders give good examples of the identified physiopathological mechanisms. This knowledge can be useful during comprehensive early diagnosis and treatment of mouth breathing and also in educational environments (undergraduate and postgraduate dentistry studies).

CONCLUSIONS

Physiopathological mechanisms underpinning the relationship between mouth breathing and oral and medical diseases vary from biochemical, physiological and immunological deficiencies to anatomical effects.

Although the relationship between mouth breathing and oral and medical conditions seems well established, it is difficult to assess in all cases from the literature data, the cause-effect link. So, more studies are needed to explore a causal relationship.

BIBLIOGRAPHY REFERENCES

1. Podadera Valdés ZR, Flores Podadera L, Rezk Díaz A. Repercusión de la respiración bucal en el sistema estomatognático en niños de 9 a 12 años [Internet]. 2013, Ago [cited 2015 Jul 24]; 17(4): 126-137. Available from: http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S1561-31942013000400014&lng=es
2. Bonuck KA, Chervin RD, Cole TJ, Emond A, Henderson J, Xu L, et al. Prevalence and persistence of sleep disordered breathing symptoms in young children: a 6-year population-based cohort study. *Sleep*. 2011; 34(7):875-84.
3. Farid MM, Metwalli N. Computed tomographic evaluation of mouth breathers among paediatric patients. *DentomaxillofacRadiol*. 2010; 39(1): 1-10.
4. Milanese JM, Weber P, Berwig LC, Ritzel RA, da Silva AMT, Rodrigues Corrêa EC. Childhood mouth-breathing consequences at adult age: ventilatory function and quality of life. *FisioterMov*. [Internet]. 2014 Jun [cited 2015 July 24]; 27(2):211-8. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-51502014000200211&lng=en
5. Al-Awadi RN, Al-Casey M. Oral health status, salivary physical properties and salivary Mutans Streptococci among a group of mouth breathing patients in comparison to nose breathing. *J Bagh College Dentistry*. 2013 Jun; 25 (Special Issue 1):152-9.
6. Motta LJ, Bachiega JC, Guedes CC, Laranja LT, Bussadori SK. Association between halitosis and mouth breathing in children. *Clinics (Sao Paulo)*. Jun 2011; 66(6): 939-42.
7. Chung Leng Muñoz I, BeltriOrta P. Comparison of cephalometric patterns in mouth breathing and nose breathing children. *Int J PediatrOtorhinolaryngol*. 2014 Jul; 78(7):1167-72.
8. Lione R, Buongiorno M, Franchi L, Cozza P. Evaluation of maxillary arch dimensions and palatal morphology in mouth-breathing children by using digital dental casts. *Int J PediatrOtorhinolaryngol*. 2014 Jan; 78(1):91-5.
9. Wang MW, Li HF, Wang QR, Xu H, HE JN. [Relationship between abnormal swallowing and mouth breathing]. *Zhonghua Kou Qiang Yi XueZaZhi*. 2013 Dec; 48(12):750-1. Chinese
10. Margosian Conti PB, Sakano E, Gonçalves de Oliveira MA, Santos Schivinski CI, DirceuRibeiro J. Assessment of the body posture of mouth-breathing children and adolescents. *J Pediat*. 2011; 87(4): 357-63.
11. SadakoKuroishi RC, Basso Garcia R, Pereira Valera FC, Anselmo-Lima WT, Hebihara Fukuda MT. Deficits in working memory, reading comprehension and arithmetic skills in children with mouth breathing syndrome: analytical cross-sectional study. *Sao Paulo Med J*. 2014 Sep 26;
12. Hallani M, Wheatley JR, Amis TC. Enforced mouth breathing decreases lung function in mild asthmatics. *Respirology*. 2008 Jun; 13(4):553-8.

13. Leboulanger N. Nasal obstruction and mouth breathing: the ENT's point of view. *Orthod Fr.* 2013 Jun; 84(2):185-90.
14. Barros JRC, Becker HMG, Pinto JA. Evaluation of atopy among mouth-breathing pediatric patients referred for treatment to a tertiary care center. *J Pediatr (Rio J).* 2006; 82(6):458-64.
15. Svensson S. Increased net water loss by oral compared to nasal expiration in healthy subjects. *Rhinology.* 2006 Mar; 44(1):74-7.
16. Peltomäki T. The effect of mode of breathing on craniofacial growth—revisited. *Eur J Orthod.* 2007 Oct; 29(5):426-9.
17. Kent DT, Soose RJ. Environmental factors that can affect sleep and breathing: allergies. *ClinChest Med.* 2014 Sep; 35(3):589-601.
18. Souki BQ, Lopes PB, Veloso NC, Avelino RA, Pereira TB, Souza PE, et al. Facial soft tissues of mouth-breathing children: do expectations meet reality? *Int J PediatrOtorhinolaryngol.* 2014 Jul; 78(7):1074-9.
19. Bolzan Gde P, Souza JA, BottonLde M, Silva AM, Corrêa EC. Facial type and head posture of nasal and mouth-breathing children. *J Soc Bras Fonoaudiol.* 2011 Dec; 23(4):315-20.
20. Scully C, Felix DH. Oral medicine - update for the dental practitioner: dry mouth and disorders of salivation. *Br Dent J.* 2005; 199(7):423-7.
21. GarcíaTriana BE, Delfin Soto O, LavanderoEspinosa AM, SaldañaBernabeu A. Salivary proteins: structure, function and mechanisms of action. *Rev HabanCiencMéd [Internet].* 2012 Dic [cited 2015 Jul 24]; 11(4):450-6. Available in: http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S1729-519X2012000400004&lng=es
22. Koga-Ito CY, Unterkircher CS, Watanabe H, Martins CA, Vidotto V, Jorge AO. Caries risk tests and salivary levels of immunoglobulins to *Streptococcus mutans* and *Candida albicans* in mouthbreathing syndrome patients. *Caries Res.* 2003; 37(1):38-43.
23. Weiler RM, Fisberg M, Barroso AS, Nicolau J, Simi R, Siqueira WL. A study of the influence of mouth-breathing in some parameters of unstimulated and stimulated whole saliva of adolescents. *Int J PediatrOtorhinolaryngol.* 2006; 70(5):799-805.
24. Wu L, Chang R, Mu Y, Deng X, Wu F, Zhang S, Zhou D. Association between obesity and dental caries in Chinese children. *Caries Res.* 2013; 47(2):171-6.
25. Altshuler A, Madison WI. Early childhood caries: new knowledge has implications for breastfeeding families. *LEAVEN.* 2006 Apr-May-Jun; 42(2):27-31.
26. Haralur SB, Al-Qahtani AS. Replacement of missing anterior teeth in a patient with chronic mouth breathing and tongue thrusting. *Case Rep Dent.* 2013; 2013:759162.
27. Ahmad NE, Sanders AE, Sheats R, Brame JL, Essick GK. Obstructive sleep apnea in association with periodontitis: a case-control study. *J Dent Hyg.* 2013 Aug; 87(4):188-99.

28. Keller JJ, Wu CS, Chen YH, Lin HC. Association between obstructive sleep apnoea and chronic periodontitis: a population-based study. *J ClinPeriodontol.* 2013 Feb; 40(2):111-7.
29. FuerteBakor S, Motta Pereira JC, S Frascino, Cellos Gonçalves TC, Shirley Shizue Nagata Pignatari, Maurice Weckx LL. Demineralization of teeth in mouth-breathing patients undergoing maxillary expansion. *Braz J Otorhinolaryngol.* 2010; 76(6):709-12.
30. American Dental Association. Bad breath. Causes and tips for controlling it. *JADA.* 2012; 143(9): 1053.
31. Hsu HY, Yamaguchi K. Decreased chewing activity during mouth breathing. *J Oral Rehabil.* 2012 Aug; 39(8):559-67.
32. Ikenaga N, Yamaguchi K, Daimon S. Effect of mouth breathing on masticatory muscle activity during chewing food. *J Oral Rehabil.* 2013 Jun; 40(6):429-35.
33. Malhotra S, Pandey R K, Nagar A, Agarwal S P, Gupta V K. The effect of mouth breathing on dentofacial morphology of growing child. *J Indian SocPedodPrev Dent.* 2012; 30:27-31.
34. Mattar SE, Valera FC, Faria G, Matsumoto MA, Anselmo-Lima WT. Changes in facial morphology after adenotonsillectomy in mouth-breathing children. *Int J Paediatr Dent.* 2011 Sep; 21(5):389-96.
35. Mattar SE, Matsumoto MA, Valera FC, Anselmo-Lima WT, Faria G. The effect of adenoidectomy or adenotonsillectomy on occlusal features in mouth-breathing preschoolers. *Pediatr Dent.* 2012 Mar-Apr; 34(2):108-12.
36. Knösel M, Klein S, Bleckmann A, Engelke W. Coordination of tongue activity during swallowing in mouth-breathing children. *Dysphagia.* Sep 2012; 27(3): 401–407.
37. FuerteBakor S, Enlow DH, Pontes P, Grigoletto de Biase N. Craniofacial growth variations in nasal-breathing, oral-breathing, and tracheotomized children. *DentofacOrthop.* 2011 Oct; 140(4):486–92.
38. Milanesi JM, Borin G, Corrêa EC, da Silva AM, Bortoluzzi DC, Souza JA. Impact of the mouth breathing occurred during childhood in the adult age: biophotogrammetric postural analysis. *Int J Pediatr Otorhinolaryngol.* 2011 Aug; 75(8):999-1004.
39. Haddad FL, Vidigal TA, Mello-Fujita L, Cintra FD, Gregório LC, Tufik S, et al. The influence of nasal abnormalities in adherence to continuous positive airway pressure device therapy in obstructive sleep apnea patients. *Sleep Breath.* 2013 Dec; 17(4):1201-7.
40. Enoz M. Effects of nasal pathologies on obstructive sleep apnea. *ActaMedica (Hradec Kralove).* 2007; 50(3):167-70.
41. Li AM, Chan MH, Yin J, So HK, Ng SK, Chan IH, Lam CW, Wing YK, Ng PC. C-reactive protein in children with obstructive sleep apnea and the effects of treatment. *Pediatr Pulmonol.* 2008 Jan; 43(1):34-40.

42. Sano M, Sano S, Oka N, Yoshino K, T Kato. Increased oxygen load in the prefrontal cortex from mouth breathing: a vector-based near-infrared spectroscopy study. *Neuroreport*. Dec 4, 2013; 24(17): 935–40.
43. Serrao G, Fensterseifer GS, Carpes O, Weckx LL, Martha VF. Mouth breathing in children with learning disorders. *Braz J Otorhinolaryngol*. 2013 Sep-Oct; 79(5):620-4.
44. Boas AP, Marson FA, Ribeiro MA, Sakano E, Conti PB, Toro AD, et al. Walk test and school performance in mouth-breathing children. *Braz J Otorhinolaryngol*. 2013 Mar-Apr; 79(2):212-8.
45. Niaki SE, Shafaroodi H, Ghasemi M, Shakiba B, Fakhimi A, Dehpour AR. Mouth breathing increases the pentylenetetrazole-induced seizure threshold in mice: A role for ATP-sensitive potassium channels. *Epilepsy Behav*. 2008 May 26.
46. Steinsvåg SK, Skadberg B, Bredesen K. Nasal symptoms and signs in children suffering from asthma. *Int J PediatrOtorhinolaryngol*. 2007 Apr; 71(4):615-21.

Recibido: 17 de Septiembre de 2015.

Aprobado: 16 de febrero de 2016.