Evaluating the Link Between Orofacial Myofunctional Disorders and Obstructive Sleep Apnea and Their Relevance to the Dental Hygiene Clinical Evaluation

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Approval of the Dissertation

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Abstract

Background: Dental professionals are in a prime position to recognize the signs and symptoms of obstructive sleep apnea (OSA) and make the appropriate referrals for a medical consultation. Due to the frequency of prophylaxis appointments, the dental office is an appropriate setting to conduct OSA screenings, however, dental hygienists are often lacking the knowledge, impacting their attitudes and screening practices during the dental hygiene examination. The aim of this dissertation was to determine if there is a link between orofacial myofunctional disorders and OSA, if the dental hygienist is provided with the education necessary to identify OSA risks and make referrals, and if there is a benefit to including the identification of orofacial myofunctional disorders as risk factors for OSA in the dental hygiene curriculum.

Methods: A comprehensive review of the literature related to OMD and OSA was conducted, using the University of Bridgeport Wahlstrom Library databases.

Results: The findings of this dissertation demonstrate a clear link between orofacial myofunctional disorders and OSA. Craniofacial features impact upper airway size and contributing factors to its narrowing can lead to an increased risk of collapse and consequently, disrupted nighttime sleep. Dental hygienists are lacking education on sleep-disordered breathing, OSA, and orofacial myofunctional disorders as risk factors for OSA, preventing them from screening for OSA and feeling confident in making referrals. Including orofacial myofunctional disorders as risk factors for OSA into the dental hygiene curriculum would be beneficial.

Conclusions: The link between orofacial myofunctional disorders and obstructive sleep apnea is clear. Dental hygienists are not provided adequate education on OSA, or orofacial myofunctional disorders as risk factors for OSA. Including OSA identification and screening into the dental hygiene examination will increase diagnosis and treatment. Including preventative medical screening into the dental appointment reduces the risk of medical comorbidities and increases

medical evaluation and treatment, therefore, it has the potential for reducing costs to the healthcare system over time.

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Table of Contents

List of Tables

Evaluating the Link Between Orofacial Myofunctional Disorders and Obstructive Sleep Apnea and Their Relevance to the Dental Hygiene Clinical Evaluation

Sleep-disordered breathing (SDB) is a dysfunction of the upper airway that occurs during night-time sleep. Characteristics include snoring and increased respiratory effort due to increased upper airway resistance and weakened oropharyngeal musculature (Villa et al., 2017). Snoring is often considered a harmless problem, particularly in children. However, it may be a sign of a more serious upper airway obstruction, such as increased upper airway resistance or obstructive sleep apnea (OSA) (Pirilä-Parkkinen, et al., 2009). Obstructive sleep apnea is characterized by repetitive episodes of upper airway occlusion during sleep and is associated with fragmented sleep, daytime hypersomnolence, and increased cardiovascular risk (Guimarães et al., 2009). Obstructive sleep apnea is the most severe type of sleep-disordered breathing (Villa et al., 2017). Reduction in airflow can either be partial, known as hypopnea, or complete, known as apnea. The severity of OSA is based on the apnea-hypopnea index (AHI), which is the total number of apneas and hypopneas per hour of sleep (West & Turnbull, 2018). Obstruction of the airway during sleep leads to systemic oxygen deprivation and may result in potentially detrimental effects on the organs, such as the heart and brain.

OSA occurs in both adults and children. In 1993, OSA was reported to be prevalent in 9% of women and 24% of men, however, studies indicate a rise in prevalence and estimate that OSA occurs in 15–25% of middle-aged and older adults and 70-90% of cases go undiagnosed. (An & Ranson, 2011). Undiagnosed OSA is likely attributed to the lack of awareness in the medical and dental health professions and the inability to recognize common OSA symptoms (An & Ranson, 2011).

The most common cause of OSA is adenotonsillar hypertrophy, however, other anatomical factors such as craniofacial dysmorphism may also be involved (Villa et al., 2017). Dentofacial morphology and adenotonsillar hypertrophy in children is associated with mouth breathing and has been reported in the literature. When a child has a collapsed airway during sleep, it is necessary to change the body position, head posture, and/or tongue positioning within the oral cavity in order to breathe. Studies have shown these positional changes also impact dental occlusion (Pirilä-Parkkinen et al., 2009). Nocturnal breathing disorders, such as obstructive sleep apnea and snoring, have been shown to impact the developing dental arches. In addition, there is a relationship between adenotonsillar hypertrophy and dentofacial morphology in children, and this relationship is often connected to mouth breathing. Children with SDB and OSA often present with a narrower maxilla, deeper palatal height, and a shorter lower dental arch when compared to healthy children with ideal occlusion. They also have a higher prevalence of lateral crossbites (Pirilä-Parkkinen et al., 2009). Historically, adenotonsillectomy (T&A), which is the surgical removal of the palatine tonsils and adenoids, has been the treatment of choice for children with sleep-disordered breathing. There are reports, however, of T&A not being an effective treatment for long-term resolution of SDB (Guilleminault & Sullivan, 2014). Emerging research is showing orofacial structures as the predisposing factor involved in recurrences of SDB, even after T&A. Recently, the relationship between normal breathing, especially during sleep, and normal orofacial growth has been incorporated into the field of sleep medicine despite the dental and orthodontic professions having long understood this link (Guilleminault & Sullivan, 2014). Craniofacial features of OSA include intraoral and extraoral findings (An & Ranson, 2011).

In 2009, the American Academy of Sleep Medicine recommended that questions regarding OSA be incorporated into routine health evaluations and that suspicions of OSA should trigger a comprehensive sleep evaluation. A polysomnogram (PSG) is considered the gold standard for diagnosing OSA. The PSG records the number of apnea and hypopnea events that occur during the sleep cycle, as well as other factors such as sleep latency, oxygen saturation, and sleep position (An & Ranson, 2011). Dental hygienists can screen for OSA by identifying associated comorbid conditions, recognizing craniofacial and oral risk factors, using OSA related health questionnaires, and referring the patient to their primary care physician as indicated. The dental hygienist can also provide support and education to patients with OSA by discussing behavior modifications that can improve the condition, such as tobacco cessation and nutritional counseling (An & Ranson, 2011).

Dental professionals are in a prime position to recognize the signs and symptoms of OSA and make the appropriate referrals for a medical consultation. Due to the amount of time that dental hygienists spend with patients, and the frequency of prophylaxis appointments, the dental office has the potential to provide an appropriate setting to conduct OSA screenings. Unfortunately, dental hygienists may be lacking OSA knowledge which impacts their attitudes and screening practices (Reibel et al., 2019). Most dental hygienists routinely perform extra/intraoral examinations during dental hygiene appointments, although the current emphasis of this procedure is on oral cancer detection. Educating dental hygienists on anatomical variations indicative of OSA would be a practical addition to this routine assessment. Standardized OSA screenings could be easily incorporated into clinical practice as dental hygienists also conduct routine medical history reviews, head and neck examinations, and blood pressure screenings in addition to the extra/intraoral examination (Reibel et al., 2019).

Statement of the Problem

The amount of education and training available to dental hygienists may not be adequate for identifying the risk factors associated with obstructive sleep apnea, conducting OSA screenings, or making appropriate referrals for an OSA consultation. Dental hygienists do not always feel confident in conducting OSA screenings or making referrals. Additionally, the awareness of the relationship between orofacial myofunctional disorders (OMD) and obstructive sleep apnea is lacking within the fields of sleep medicine and dental health, and the link between OMD's and OSA is lacking from dental hygiene curricula.

Research Questions

- Is there a link between orofacial myofunctional disorders and obstructive sleep apnea?
- Is the dental hygienist provided with the education necessary to identify the risks for sleep apnea and make the appropriate referrals?
- Is there a benefit to including the identification of orofacial myofunctional disorders as risk factors for obstructive sleep apnea in the dental hygiene curriculum?

Hypothesis

Incorporating the identification and understanding of OSA and OMD risk factors into the dental hygiene curriculum would allow for the dental hygienist to be better prepared to screen for OSA and make physician referrals, thereby increasing OSA diagnosis and treatment.

Purpose of the Research

The purpose of this research is to demonstrate the relationship between sleep-disordered breathing and craniofacial development and the vital role dental hygienists play in the early intervention and prevention of obstructive sleep apnea.

Significance of the Research

This research is significant because it will evaluate the need to include OSA risk factors, symptoms, and screening methods, as well as OMD recognition, into the dental hygiene curriculum. Providing this education to dental hygiene students may lead to an increase in timely and appropriate physician referrals for patients at risk for OSA.

Definition of Terms

The following definitions are illustrated to ensure uniformity and understanding of these terms throughout the dissertation.

Adenotonsillar Hypertrophy: abnormal growth of the pharyngeal and palatine tonsils.

Adenotonsillectomy (T&A): the surgical removal of the palatine and pharyngeal tonsils.

Anterior Open Bite (AOB): a type of malocclusion where the maxillary and mandibular anterior teeth do not come into contact upon complete occlusion.

Apnea: a complete reduction of airflow.

Apnea-Hypopnea Index (AHI): the total number of apnea and hypopnea episodes per hour of sleep.

BEARS Questionnaire: a screening tool to help identify sleep problems in children. The acronym stands for bedtime, excessive daytime sleepiness, awakening during the night, regularity and duration of sleep and snoring.

Central Sleep Apnea: a decrease in oxygen saturation levels due to the brain failing to deliver the message for the body to breathe, resulting in ineffective and shallow breaths.

Cephalometry: a diagnostic radiograph used to measure and study the proportions of the head and face, especially during development and growth.

Class II Malocclusion: a malocclusion where the molar relationship shows the buccal groove of the mandibular first molar distally positioned when in occlusion with the mesiobuccal cusp of the maxillary first molar.

Complex Sleep Apnea: a combination of obstructive sleep apnea and central sleep apnea.

Cone Beam Tomography: a radiographic imaging tool that allows accurate, three-dimensional (3D) imaging of hard and soft tissue structures such as the teeth, soft tissues, nerve pathways, and bone in a single scan.

Continuous Positive Airway Pressure (CPAP): a breathing therapy device that delivers air to a mask worn over the nose and/or mouth to aid with consistent breathing.

Daytime Hypersomnolence: excessive daytime sleepiness or excessive time spent sleeping, is a condition in which a person has trouble staying awake during the day.

Epworth Sleepiness Scale (ESS): a self-administered questionnaire that evaluates sleep tendencies and rates the chance of dozing off in various scenarios, determining the extent of daytime hypersomnolence, which is the most common symptom of OSA.

*Hypopne*a: a partial reduction of airflow.

Obstructive Sleep Apnea (OSA): a potentially fatal condition that is characterized by repetitive complete, or partial obstruction of the upper airway during sleep causing a cessation of airflow.

Orofacial Myofunctional Disorder (OMD): alterations or dysfunctions to the appearance, posture, and/or mobility of the lips, tongue, mandible, and cheeks.

Overbite: an abnormal vertical relationship between the maxillary and mandibular anterior teeth.

Overjet: An abnormal horizontal relationship between the maxillary and mandibular anterior teeth.

Mallampati Classification: the Mallampati classification relates tongue size to pharyngeal size and is an important factor in determining the degree of difficulty of direct laryngoscopy. This classification allows one to assess upper airway access based on the visibility of the oral pharynx ranging from complete visualization including tonsillar pillars to no visualization with the uvula pressed against the tongue.

Mandibular Advancement Device (MAD): an oral appliance used to open the airway by moving the mandible forward.

Myofunctional Therapy (MFT): therapy of malocclusion and other dental and speech disorders utilizing muscular exercises of the tongue and lips; most often intended to alter a tongue thrust or swallowing pattern.

Patency: the condition of being open, expanded, or unobstructed.

Polysomnogram (PSG): the technique or process of using a polygraph to make a continuous record during sleep of multiple physiological variables such as breathing, heart rate, and muscle activity.

Posterior Crossbite: an inadequate transversal relationship of maxillary and mandibular teeth.

Sleep-disordered breathing (SDB): a dysfunction of the upper airway that occurs during night-time sleep.

Primary snoring: characterized by loud upper airway breathing sounds during sleep without episodes of apnea.

Sleep Disordered Breathing: upper airway obstruction during sleep.

Sleep Bruxism: grinding or clenching the teeth during sleep.

STOP and STOP-Bang Questionnaire: a tool used to identify OSA risk. The acronym stands for snoring history, tired during the day, observed stop breathing while sleep, high blood pressure, BMI more than 35 kg/m^2, age more than 50 years, neck circumference more than 40 cm, and male gender.

Literature Review

The dental hygiene curriculum is often lacking the education and training necessary for identifying the risk factors associated with obstructive sleep apnea, conducting OSA screenings, or making appropriate referrals for an OSA consultation (Schroeder & Gurenlian, 2019). Dental hygienists, once in clinical practice, must rely on continuing education to become informed about sleep medicine and how it relates to dentistry. Once licensed, dental hygienists are free to pursue continuing education on any topic they choose, as long as it meets the continuing education criteria for maintaining licensure within the state they practice. Therefore, there is no guarantee that they will become educated in obstructive sleep apnea, orofacial myofunctional disorders, or the importance of conducting OSA screenings in the dental setting. Additionally, the awareness of the relationship between orofacial myofunctional disorders (OMD's) and obstructive sleep apnea is lacking within the fields of sleep medicine and dental health, and the link between OMD's and OSA is lacking from dental hygiene curriculum (Schroeder & Gurenlian, 2019).

The review of the literature aims to demonstrate the link between orofacial myofunctional disorders and obstructive sleep apnea and demonstrate their relevance to the dental hygiene clinical evaluation. It will also aim to determine if the dental hygienist is provided with the education necessary to identify the risks for sleep apnea and make appropriate referrals. In addition, it aims to identify gaps in previous research and recommend future research that will determine if dental hygiene programs should consider providing education within the curriculum that will prepare future dental hygienists to identify orofacial myofunctional disorders and the risk factors for obstructive sleep apnea.

Sleep Apnea

Obstructive sleep apnea (OSA) is a potentially fatal condition that is characterized by repetitive complete or partial obstruction of the upper airway during sleep causing a cessation of airflow. Obstruction of the airway during sleep leads to systemic oxygen deprivation which causes deleterious health effects (An & Ranson, 2011). In the United States, the prevalence of adult OSA is currently estimated between 4% - 9%, however, 70% - 90% of adult cases remain undiagnosed (Reibel, et al., 2019).

During the various stages of sleep, upper airway dilator muscle activity decreases, leading to a narrowing of the upper airway, snoring, and a reduction in airflow (West & Turnbull, 2018). During wakefulness, the airway is protected by several mechanisms that maintain pharyngeal airway patency, including an increase in pharyngeal dilator muscle activity. However, during sleep these mechanisms are not sufficient to keep the airway open, resulting in decreased space and a greater resistance to airflow (Palombini, 2010). The various stages of the sleep cycle influence breathing due to systems within the brain that are responsible for controlling ventilation. Patency of the upper airway is maintained when awake, however, with the onset of sleep, changes occur that affect patency such as neuromuscular activation and ventilation, as well as increased mechanical load, causing a significant increase in upper airway resistance (Palombini, 2010). These changes can result in hypoventilation if there is a loss of reflex response to increased airway load, or the reflex can increase and stimulate ventilation and blood gas maintenance, however, some degree of hypoventilation will occur at the beginning of the sleep cycle (Palombini, 2010). With the onset of sleep, changes in upper airway muscle activity also occur. There is a decrease in tonic and phasic activity of the genioglossus, geniohyoid, palatine tensor, palatine lift, and palatoglossus muscles, which lead to a transient decrease in ventilation and an increase in upper airway resistance (Palombini, 2010). Palombini (2010) also notes respiratory changes observed at the beginning of the sleep cycle that cause a reduction or loss of respiratory drive in response to the increased resistive load and increased carbon monoxide (Palombini, 2010).

A partial reduction of airflow is known as hypopnea, and complete airflow reduction is known as apnea (West & Turnbull, 2018). The severity of OSA is based on the total number of apneas and hypopneas per hour of sleep and is measured using the apnea-hypopnea index (AHI). Less than five apneas and hypopneas per hour is not indicative of OSA, however, an AHI of 5–14/hour indicates mild OSA, an AHI of 15–30/hour indicates moderate OSA, and an AHI > 30/hour indicates severe OSA (Maspero et al., 2015).

There are 3 categories of sleep apnea which include obstructive sleep apnea, central sleep apnea, and complex sleep apnea. Central sleep apnea is defined as a decrease in oxygen saturation levels due to the brain failing to deliver the message for the body to breathe, resulting in ineffective and shallow breaths. Complex sleep apnea is a combination of OSA and central sleep apnea (Kornegay & Brame, 2015).

OSA is diagnosed by polysomnography (PSG). The PSG measures the sleep cycle, sleep stages, airflow, blood oxygen levels, brain waves, eye movement, and heart rate of the individual being tested. The PSG, although an accurate measurement, is costly and time-consuming and must be conducted in a laboratory (Kornegay & Brame, 2015). Due to its limitations, additional screening tools have been developed to identify high-risk individuals and provide them with the opportunity to pursue a definitive diagnosis (Kornegay & Brame, 2015). The Mallampati

Classification is an evaluation that was designed to determine the difficulty of intubation during surgery, with higher scores in those at risk for OSA. While the patient is seated in an upright position and with the tongue extruded, the posterior pharynx is evaluated and classified accordingly. Class I and II is considered adequate exposure of the posterior pharynx, and class III or IV is considered inadequate. Less exposure relates to a higher risk of OSA (Kornegay & Brame, 2015). The Epworth Sleepiness Scale is a self-administered questionnaire that evaluates sleep tendencies and rates the chance of dozing off in various scenarios, determining the extent of daytime hypersomnolence, which is the most common symptom of OSA (Kornegay & Brame, 2015). The STOP and STOP-Bang questionnaires are additional tools used to identify OSA risk (Kornegay & Brame, 2015). The STOP-BANG acronym stands for snoring history, tired during the day, observed stop breathing while sleep, high blood pressure, BMI more than 35 kg/m^2, age more than 50 years, neck circumference more than 40 cm, and male gender (Pavarangkul et al., 2016). BEARS is a user-friendly screening tool to help identify sleep problems in children. The acronym stands for bedtime, excessive daytime sleepiness, awakening during the night, regularity, and duration of sleep and snoring (Ebarhim et al., 2013).

Repetitive episodes of total or partial upper airway collapse during sleep leads to fragmented sleep and decreased oxygen levels or hypoxia, which have harmful consequences on systemic health. The results of hypoxia, such as inflammation, oxidative stress, and increased sympathetic activity cause several comorbidities that may affect the patients' health (Reibel, et al., 2019). Effects of impaired night-time breathing also include exaggerated fluctuations in heart rhythm, blood pressure, and intrathoracic pressure. These physiologic changes result in long-term sequelae such as hypertension, cardiovascular damage, decreased cognitive function, decreased mood and quality of life, and premature death (Peppard et al., 2013). OSA is also linked to other cardiovascular diseases such as heart failure, arrhythmias, and stroke (Reibel, et al., 2019). If OSA remains undiagnosed, complications may be exacerbated, with negative effects such as hypertension, cardiovascular disease, daytime hypersomnolence, automobile accidents, increased risk of home and work-related injuries, and a decrease in cognitive function severely impacting life quality (Maspero et al., 2015).

Obstructive sleep apnea (OSA) is becoming increasingly recognized as a health concern in children due to the consequences it has on behavior, function, and quality of life (Guilleminault et al., 2013). Recognizing and treating children early is important in order to maximize the resolution of symptoms and potentially avoid OSA in adulthood (Guilleminault et al., 2013). Adenotonsillectomy and palatal expansion are established treatment options for OSA due to demonstrating considerable improvement related to adenoid or tonsillar hypertrophy, maxillary or mandibular deficiency, and orthodontic or craniofacial abnormalities (Guilleminault et al., 2013).

Effective treatment of OSA is dependent on its effect on the body and the health and quality of life of the patient. OSA not only disrupts sleep but also deprives the body of the necessary oxygen required to thrive (Agarwal & Shahidi, 2018). Agarwahl & Shahidi (2018) state that the primary role of dental professionals in relation to OSA and sleep-disordered breathing should be creating awareness of this condition and its risks. Although diagnosis must come from a physician, dentists and oral health professionals should be able to recognize the signs and symptoms of OSA, educate patients, and make appropriate referrals (Agarwal & Shahidi, 2018).

Orofacial Myofunctional Disorders

The stomatognathic system is composed of fixed structures which include the mandible, maxilla, dental arches, TMJ, and hyoid bone, along with dynamic structures which include masticatory muscles, supra- and infrahyoid muscles, and the muscles of the tongue, lips, and cheek (Andrade et al., 2017). These structures work together and are balanced and controlled by the central nervous system to perform stomatognathic functions such as suction, breathing, swallowing, speech, and chewing (Andrade et al., 2017). The stomatognathic system functions in a coordinated manner, however, coordination of the systems may be disrupted, resulting in alterations or dysfunctions to the appearance, posture, and/or mobility of the lips, tongue, mandible, and cheeks. Dysfunction can also impact respiration, swallowing, mastication, and speech (Folha et al., 2015). These changes are termed orofacial myofunctional disorders (OMDs) and they can occur at any age. They are associated with various oral manifestations, such as malocclusion, temporomandibular joint disorders, and mouth breathing (Folha et al., 2015). Feliciano et al. (2012) state that OMD is also associated with dentofacial deformity, many genetic and congenital disorders, and anatomical abnormalities such as cleft lip and palate (Felício et al., 2012).

Orofacial myofunctional disorder interferes with normal growth, development, and function of oral structures. Abnormal facial development and malocclusion develops when timely intervention does not occur (D'onofrio, 2019). Oral dysfunction can begin at birth but often becomes apparent as speech develops and solid foods are introduced (D'onofrio, 2019). Most children with OMD are diagnosed after experiencing speech disorders, sleep-disordered breathing (SDB), or malocclusion. Orthodontic relapse, obstructive sleep apnea (OSA), and temporomandibular disorder (TMD) are anticipated sequela of long-term oral dysfunction and

OMD (D'onofrio, 2019). OMDs have been observed in both adult and pediatric patients with obstructive sleep apnea (Folha et al., 2015).

D’onofrio (2019) composed a review article that provides an overview of the symptoms associated with orofacial myofunctional disorders and outlined areas of oral function that impact occlusal and facial development which include breastfeeding, airway obstruction, soft tissue restriction, mouth breathing, oral rest posture, oral habits, swallowing, chewing, the impact of orofacial myofunctional disorder (OMD) over time, and maternal oral dysfunction on the developing fetus.

Breastfeeding is the first and the most critical experience related to facial development. Breastfeeding differs from bottle-feeding in that infants draw the breast deep into the mouth and as the breast expands, it shapes the hard palate through repeated pressure. It also requires jaw compression, which aids in better masseter muscle development (D'onofrio, 2019). Children exclusively breastfed tend to have a lower incidence of malocclusion later in life when compared to bottle-fed babies and the longer a child is breastfed, the lower the risk of malocclusion (D’onofrio, 2019).

Airway obstruction has many etiologies and is common in early childhood which can change the course of craniofacial growth. Allergic rhinitis and otitis media are associated with both anterior and posterior open bites, enlarged tonsils and adenoids, a retrognathic jaw, steep mandibular angle (SMA), and a high narrow palate (HNP), demonstrating an inter-relationship of these facial features and breathing (D'onofrio, 2019). By the time a child reaches adolescence, dysmorphic facial structures potentially put them at permanent risk for a lifetime of airway disorders (D'onofrio, 2019). Research is increasing on ankyloglossia and its impact on oral function due to its implication in OSA (D'onofrio, 2019). Significant airway obstruction and soft tissue restriction result in inadequate nasal breathing, leading to the development of mouth breathing. Mouth breathing not only changes the anterior structure of the face, but also the shape of the oropharyngeal airway. Mouth breathing is associated with smaller retropalatal and retroglossal areas and lengthening of the pharynx, which are risk factors for OSA (D'onofrio, 2019). Mouth breathing at night contributes to other symptoms of SDB, such as snoring. Children who snore are more likely to have a high, narrow palate and posterior crossbite. Mouth breathing at night is a risk factor for OSA and is associated with increased OSA severity and upper airway collapsibility (D'onofrio, 2019). Once a child has been diagnosed with OSA, they often present with extreme malocclusions and dysmorphology. D’onofrio (2019) suggests that structural changes are caused by long-term functional changes in the head, neck, and tongue in order to maintain a patent airway during sleep. The ability to breathe effortlessly through the nose, with the tongue placed against the maxilla and the lips gently closed, is necessary for optimal craniofacial growth and development (D'onofrio, 2019).

The proper placement of the tongue within the oral cavity is important for appropriate dentofacial development (Frey et al., 2014). The negative effects that an improper oral rest posture has on the muscles and the sympathetic nervous system has been established. Frey et al. (2014) state that tongue rest posture, along with tongue muscle elevation to the palate, increases electromyographic activity in the temporalis and the suprahyoid muscles, compared with a low tongue rest posture. The muscular pressure on the bones of the face, or lack thereof, can influence growth over time. D’Onofrio (2019) suggests that sucking habits may lead to an airway disorder due to the pressure that is placed on the hard palate, and the tongue being forced low and forward in the mouth, which promotes an open mouth resting posture and the cascade of effects that may follow (D'onofrio, 2019).

Research involving SDB and OSA links poor sleep quality resulting from airway obstruction to behavioral disorders in children. The relationship between SDB and an increased risk for academic and social failure is well documented (D'onofrio, 2019). Children of 6 months to 7 years of age that snore, have OSA, or breath through the mouth are at a greater risk of ADHD, social behavior problems, increased aggression, and anxiety (Fabbie, 2015).

D'onofrio (2019) states that the combination of a long face, reduced nose prominence and width, and a retrognathic mandible are facial features that may be indicative of SDB, therefore, they may warrant a referral to a specialist for an evaluation of other clinical symptoms. He also states that in addition to providing structural solutions to problems once they occur, dentists and orthodontists must play a proactive role in preventing acquired craniofacial disorders and supporting optimal craniofacial growth (D'onofrio, 2019). Due to the growing body of scientific and clinical evidence, all medical and dental professionals have a responsibility to screen for breathing disorders, enlarged or restricted oral tissues in patients of all ages, and for feeding and oral dysfunction in children (D'onofrio, 2019).

The Link Between Orofacial Myofunctional Disorders and Obstructive Sleep Apnea

The upper airway (UA) is inherently collapsible. Sleep-disordered breathing and obstructive sleep apnea are both related to upper airway (UA) collapse during sleep. The muscles that comprise the borders of the UA attach to the bones of the orofacial region and are controlled by reflexes. Reflex-loops are triggered by sensory receptors, nerve fibers, and brainstem neuron integrators. The reflexes cause motor function to activate the muscles (Guilleminault & Huang, 2018). During sleep, many of these reflexes are diminished, or even non-functional at times, particularly during rapid eye movement (REM) sleep, leading to an increased risk for airway collapse (Guilleminault & Huang, 2018). Abnormal collapsibility in both children and adults has been related to sleep, and specific sleep stages, causing modifications of pharyngeal muscle tone and reflex responses (Guilleminault & Huang, 2018). Intrinsic and extrinsic factors both impact the risk of collapsibility, however, there are three external factors that impact the retropalatal and retroglossal space of the UA that have been firmly established. These factors include upper airway fat deposits, non-fat-related hypertrophy of UA tissues caused by chronic inflammation, and craniofacial features impacting UA size (Guilleminault & Huang, 2018). The size of the upper airway, and factors that contribute to its narrowing, can lead to an increased risk of collapse and consequently, abnormal breathing during sleep (Guilleminault & Akhtar, 2015). The UA is located below the skull and behind the face, therefore, any developmental changes in either of these two areas will affect its size (Guilleminault & Akhtar, 2015). Facial growth occurs relatively early in life, with the face representing one-seventh of the craniofacial structures at birth and 80% of facial development occurring by 5-6 years of age (Guilleminault & Akhtar, 2015). The two facial components that are crucial to the size of the UA are the naso-maxillary complex and the mandible. The naso-maxillary complex is located at the anterior part of the skull. Genetic factors influence the growth of the brain, and directly relate to the growth of the skull and its base, and ultimately the size of the upper airway (Guilleminault & Akhtar, 2015). The posterior width of the middle fossa of the skull is the exact lateral size of the erect and awake adult pharynx and the development of these structures defines the relationship between the maxilla and the mandible (Guilleminault & Akhtar, 2015). The mandible is also involved in determining the size of the upper airway; however, it is independent of the skull base. Any changes in the position of the condyles will result in the growth region migration, and chronic mouth breathing may develop. If the articulation position of the condyles change within the glenoid fossa, the growth location will also change, transferring the production of cartilage more posteriorly. This alters the incline at which bone grows, causing a posterior mandibular rotation during childhood development and leading to narrowing of the upper airway (Guilleminault & Akhtar, 2015).

Oral breathing and lip hypotonia are additional characteristics of children with OSA. These conditions increase nasal resistance and are associated with malposition of the tongue, thereby exacerbating the impaired development, and further hindering the growth of the maxilla and mandible. Oral breathing that persists during sleep directly affects the position and strength of the tongue and orofacial muscles, thereby causing abnormal airway development and SDB (Villa, et al., 2017). Features of a long and narrow face have been associated in children with SDB along with an increased facial height, steep mandibular plane angle, transverse maxillary deficiency, retrusive chin angle, sagittal jaw discrepancy, reduced posterior airway, and habitual mouth breathing (Yap et al., 2019). Reduced mandibular size has been proposed as a craniofacial contribution to residual SDB. The developing dentition is also known to be associated with breathing obstruction and OSA. Class II malocclusion and posterior crossbite are among the most reported findings (Yap et al., 2019). Research suggests that orthodontic treatments such as maxillary expansion or mandibular advancement with functional appliances might be effective in improving pediatric SDB (Yap et al., 2019). The relationship between dentofacial disharmony and SDB is significant, therefore Yap et al. (2019) suggest that a feasible clinical method that can detect dentofacial differences may help to identify appropriate patients for targeted therapy. Their study aimed to evaluate the baseline differences in dentofacial morphology of children who have SDB, validated by polysomnography (PSG), using routine orthodontic diagnostic records (Yap et al., 2019). This study demonstrated that routine orthodontic records can identify quantitative differences in dentofacial morphology in children with SDB confirmed by PSG (Yap et al., 2019). Although the sample size in this study was small, with only nine controls and ten with SDB, significant differences were noted. Children with SDB had a longer and lower anterior face height, a larger maxillo-mandibular angle, a narrower maxillary arch, and an increased frequency of posterior crossbite, class II molar relationship, and decreased palatal volume (Yap et al., 2019). There was a trend for the SDB group to have a shorter and narrower nose, increased facial convexity, and steeper mandibular plane angle, however, these trends were not significantly different (Yap et al., 2019). The study used standardized clinical photography as a method to evaluate facial morphology because it provided a detailed quantification of facial features. The authors state it is a simple, safe, and quick method for acquiring images with minimal measurement error (Yap et al., 2019). Although cephalometry and cone-beam tomography are available radiographic tools that provide a more detailed examination of skeletal, soft tissue, and upper airway structures. Yap et al. (2010) state they involve radiation exposure, therefore, ethically they were not a good choice. Three-dimensional facial scanning is also an option, but it was not utilized due to its time-consuming analysis (Yap et al., 2019). Yap et al. (2019) suggest that increased awareness of these features may result in early referrals for orthodontic and dentofacial management. Yap et al. (2019) acknowledge that further investigation is required to determine if these features are associated with residual SDB post-adenotonsillectomy (T&A).

A study by Pirilä-Parkkinen et al. (2009) aimed to examine the effects of nocturnal breathing disorders such as OSA and snoring on the developing dental arches. The study evaluated two study groups. The first study group contained 41 children with diagnosed OSA and the other contained 41 children with documented snoring. The control group contained 41 non-obstructed children (Pirilä-Parkkinen et al., 2009). The control group did not undergo polysomnography to confirm OSA status, rather the determination was made based on parental reports regarding history of obstructive symptoms. The differences between the dental arch measurements of the OSA, snoring, and control groups were evaluated using study models and clinical findings. Children with diagnosed OSA had a significantly increased overjet, which is an abnormal horizontal distance between the maxillary and mandibular anterior teeth, a reduced overbite, and narrower upper and shorter lower dental arches when compared with the control group (Felicio et al., 2016). Snoring children had similar, but not as significant, differences as OSA children when compared with the controls (Pirilä-Parkkinen et al., 2009). There were more children with an anterior open bite in the OSA group and a higher incidence of Class II or asymmetric molar relationship in the OSA and snoring groups compared with the non-obstructed controls (Felicio et al., 2016). Also, the higher the AHI score, the higher the prevalence of mandibular crowding and an anterior open bite (Pirilä-Parkkinen et al., 2009). Pirilä-Parkkinen et al. (2009) state that the effects of increased upper airway resistance on dental arch morphology can be explained by long-term changes in the position of the head, mandible, and tongue to maintain sufficient airway during sleep. Although parental reports of obstructive symptoms can aid in determining OSA risk, Pirilä-Parkkinen et al. (2009) state that polysomnography is required to separate primary snoring children from those with OSA and to determine disease severity. Control groups, however, were determined only by the report of symptoms provided by the parents. Typically, an AHI score below five is not indicative of OSA. However, Pirilä-Parkkinen et al. (2009) state that in younger children, many studies have shown the AHI to be normally below one. It is for this reason that Pirilä-Parkkinen et al. (2009) considered an AHI value of one or more to be abnormal. The mean AHI in the OSA group was 3.5, which indicates that the majority of the OSA children had mild OSA (Pirilä-Parkkinen et al., 2009).

Increased size of the tonsils and adenoids causes narrowing of the airway and is the most common factor associated with pediatric obstructive sleep apnea (OSA). Surgical removal of the tonsils and adenoids, known as adenotonsillectomy (T&A), is the first line of treatment for OSA during childhood and often leads to a cure, or improvement, of the disorder. The number of patients, however, with postoperative residual OSA after T&A ranges from 13% to 29% in low-risk populations (Felício et al., 2016). When obese children are included in the analysis, residual OSA rises to 73% post-surgery (Felício et al., 2016). T&A can bring partial recovery of orofacial muscular dysfunction, particularly during the first month after surgery, but myofunctional disorders have been shown to return after six-months post-surgery (Felício et al., 2016). Adenotonsillectomy (T&A), although effective at treating sleep disordered breathing (SDB) and obstructive sleep apnea (OSA) in children, may not eliminate SDB. Residual SDB can result in the progressive worsening of abnormal nighttime breathing and persistent mouth breathing post-adenotonsillectomy (T&A) due to an increase of upper airway resistance during sleep, and a secondary impact on orofacial growth (Lee et al., 2015). A retrospective study by Lee et al. (2015) evaluated pre-pubertal children with SDB that were treated by T&A, both pre- and post-surgery. Evaluations included polysomnography (PSG), clinical exam, and monitoring of mouth breathing. All children with mouth breathing were referred for myofunctional therapy (MFT) and a clinical follow-up after 6 months, and PSG 1-year post-surgery was recommended (Lee et al., 2015). There was significant symptomatic improvement in all children post-T&A, however, out of 64 children studied, 26 children had residual sleep-disordered breathing with an AHI > 1.5 events/hour and 35 children had evidence of mouth breathing during sleep. Due to the inclusion criteria for this study, these children had no evidence of nasal allergies or indication for orthodontic treatment, which are factors that may play a role in persistent mouth breathing. The follow-up data for this study is limited with only 18 children returning at 12 months for polysomnography (PSG), and only nine having received six months of myofunctional therapy. The non-myofunctional therapy subjects had significantly worse clinical findings and polysomnography results than those treated with myofunctional therapy (Lee et al., 2015). Lee et al. (2015) recognize that confounding factors, such as the time of year or current illness, could have influenced the results. Lee et al. (2015) also acknowledge that the subjects that returned for the follow-up PSG may represent a bias group. The possibility that low-grade symptoms being observed by parents, or encouragement by the myofunctional therapist, leading to the subsequent PSG cannot be eliminated. Additionally, this is not a double-blind randomized study. However, even with limited numbers, the data indicates that myofunctional therapy may help in the elimination of mouth breathing during sleep, and chronic mouth breathing leads to changes in orofacial growth with impairment of maxillomandibular development relatively early in life (Lee et al., 2015). Based on the results, Lee et al. (2015) concluded that myofunctional therapy led to normalization of clinical and polysomnography findings and suggest that assessment of mouth breathing during sleep be systematically performed post-T&A and the persistence of mouth breathing should be treated with myofunctional therapy. Myofunctional Therapy is aimed at correcting abnormal breathing patterns and muscular dysfunctions that may impair upper airway patency. Promising results, such as decreases in apnea-hypopnea index (AHI), have been reported following myofunctional therapy in adults with OSA and children with residual OSA (Felício et al., 2016).

A 2016 study by Felicio et al. aimed to identify possible differences in muscular and orofacial functions between children with obstructive sleep apnea (OSA) and primary snoring (PS), to examine the standardized difference of myofunctional scores between subjects with normal breathing and those with OSA or PS, and to identify the features associated with OSA. Thirty-nine children participated, of which 27 had a diagnosis of OSA and 12 had PS. All participants were examined by an otorhinolaryngologist and underwent polysomnography (PSG) (Felicio et al., 2016). The OSA group had lower scores in breathing and mastication and more unbalanced masticatory muscle activity than the PS group, however, both groups had similar reductions in orofacial strength (Felicio et al., 2016). The OSA group had a large, standardized difference in all analyzed orofacial myofunctional exam scores (OMES), while the PS group showed minor and moderate differences in breathing and mastication scores (Felicio et al., 2016). Unilateral mastication is common during the period of a mixed dentition due to natural occlusal instability, but it may become chronic, therefore, Felicio et al. (2016) state that the crossbite seen in subjects with OSA is relevant and should be referred for orthodontic treatment for a better muscular and functional outcome. Felicio et al. (2016) concluded that children with tonsillar hypertrophy and OSA had relevant impairments in orofacial functions and less muscular coordination than children with primary snoring. These results should be interpreted with caution due to the limited number of participants and the lack of reference data and normal values for other variables besides myofunctional conditions that could be compared to those of the samples studied (Felicio et al., 2016). Additionally, there have been similarities demonstrated in both behavioral and health problems between children with PS and OSA. Therefore, further investigation is warranted (Felicio et al., 2016). However, Felicio et al. (2016) state that the therapeutic implications of these findings suggest that children with SDB require intervention with myofunctional therapy to promote nasal breathing, orofacial muscle strength, and adequate oral rest posture, and that children with OSA would benefit from strategies to improve orofacial motor control (Felicio et al., 2016).

Due to the function of the upper airway musculature playing an important role in the maintenance of upper airway patency, muscular dysfunction is a contributing factor to the origin of OSA (Guimarães, 2009). A study evaluating the impact of oropharyngeal exercises on patients with moderate OSA suggested that oropharyngeal exercises derived from speech therapy may be an effective treatment option for patients with moderate OSA. Guimarães et al. (2009) evaluated 31 patients with moderate OSA. Subjects were randomized into a control group that was assigned to 3-months of a daily sham therapy, or a study group that received oropharyngeal exercises that involved the tongue, soft palate, and lateral pharyngeal wall (Guimarães, 2009). Anthropometric measurements, snoring frequency and intensity, Epworth daytime sleepiness and Pittsburgh sleep quality questionnaires, and PSG were performed at baseline and conclusion (Guimarães, 2009). Body mass index (BMI) and abdominal circumference of the entire group did not change significantly over the study period and the control group did not exhibit any significant changes in any of the variables (Guimarães, 2009). In contrast, subjects that performed oropharyngeal exercises had a significant decrease in neck circumference, snoring frequency, snoring intensity, daytime sleepiness, and sleep quality scores. Additionally, OSA severity decreased with AHI reducing from 22.4 to 8.5 events/hour (Guimarães, 2009). The data shows that changes in neck circumference correlated inversely with changes in AHI, therefore Guimaraes et al. (2009) concluded that oropharyngeal exercises significantly reduced OSA severity and symptoms and is a promising treatment for moderate OSA. It is important to note that this study was not designed to explore the exact manner in which the oropharyngeal exercises improve OSA severity and symptoms; however, a moderate association between changes in neck circumference with changes in AHI suggests that the exercises induce upper airway remodeling that correlates with airway patency during sleep (Guimarães, 2009). The therapy utilized in this study is based on an integrative approach; therefore, it does not determine the effects of each specific exercise on the overall results (Guimarães, 2009). Additionally, the exercises were derived from oral-motor techniques used to improve speech and/or swallowing activity, which is an area that lacks the factual support required for evidence-based practices (Guimarães, 2009). The oropharyngeal exercises provided for moderate OSA is dependent on the training of the speech pathologist; therefore, the results should be viewed with caution. The upper airway muscles must also be continuously exercised, which raises the issue of compliance. (Guimarães, 2009). The overall effects of oropharyngeal exercises were present in both rapid eye movement (REM) and non-REM sleep; however, there was no statistical significance in non-REM sleep, which Guimarães (2009) believes may be justified by the relatively small sample size.

Restoring nasal breathing should be the primary goal when treating OSA. As demonstrated in the above studies, the relationship between orofacial structural growth and muscle function begins in the earliest stages of development and continues throughout childhood. Chronic mouth breathing is an important clinical marker of orofacial muscle dysfunction which is associated with restricted palatal growth, nasal obstruction, and muscle or connective tissue dysfunction (Guilleminault et al., 2014). Treatment of OSA and SDB in children requires restoring proper nasal breathing. To prevent relapse, Guilleminault et al. (2014) suggest that the only realistic endpoint of OSA treatment is the elimination of mouth breathing. Preventative measures in at-risk groups and using MFT as part of the treatment of OSA are important approaches to appropriately treating SDB and its comorbidities (Guilleminault et al., 2014).

Obstructive Sleep Apnea and the Dental Setting

The root cause of obstructive sleep apnea often stems from improper jaw growth and improper facial development during childhood. A lack of proper dentoskeletal development contributes to improper airway development and function (Hodge, 2015). Dental crowding, a lack of available tongue space, class II malocclusion, a retruded mandible, or a narrow maxilla have significant implications on a child's airway (Hodge, 2015). Failure to provide early treatment of such conditions can contribute to childhood obesity, juvenile diabetes, and behavior disorders such as ADHD (Hodge, 2015). Hodge (2015) states that disorders that affect the airway often go undiagnosed and untreated. He recommends that the best time for treatment is as soon as the potential for a dentoskeletal or airway problem is identified, which in the dental setting can happen as early as four years of age (Hodge, 2015). The value of screening for undiagnosed medical conditions in the dental setting is established. On average, 23% of adults that visit their dentist annually do not have regular contact with a physician (Dillow et al., 2016). This provides a unique opportunity for dental practitioners to monitor the overall health of patients and identify potential risk factors for disease (Dillow et al., 2016).

The American Academy of Dental Sleep Medicine (AADSM) is one of several organizations that address obstructive sleep apnea (OSA) by developing and delivering educational programs regarding dental sleep medicine. They have also developed a certifying examination in dental sleep medicine that is administered and maintained by the American Board of Dental Sleep Medicine (ABDSM) (Ramar et al., 2015). A diagnosis of OSA must come from a physician; however, patients are often referred to dentists for evaluation and treatment with an oral appliance. The American Academy of Dental Sleep Medicine recommends that physicians seek qualified dentists who have a valid state license, proof of liability insurance, and experience or training in OSA treatment (Ramar et al., 2015). The American Academy of Dental Sleep Medicine states that desirable qualifications of a dentist include at least one of the following: dental sleep medicine certification by a non-profit organization, designation as the dental director of a dental sleep medicine facility that is accredited by a non-profit organization, or a minimum of 25 hours of recognized continuing education in dental sleep medicine (Ramar et al., 2015). The American Academy of Dental Sleep Medicine (AADSM) recognizes that there are inconsistencies in the sleep medicine curricula provided in both U.S. and Canadian dental schools (Levine et al., 2018). Educational opportunities are available to dentists, providing the requisite knowledge required to effectively treat and manage OSA patients; however, uniform standards on the practice of dental sleep medicine are still lacking (Levine et al., 2018). To ensure high-quality patient care is provided, Levine et al. (2018) recommend that dentists treating and managing patients with sleep-disordered breathing (SDB) should adhere to the standards of care in dental sleep medicine regarding screening, treating, and managing adults with SDB, and ethical and legal standards including best practices for informed consent, risk management, quality assurance, and record keeping. Levine et al. (2018) recommend that dentists educate their patients on the etiology of sleep disordered breathing (SDB) according to evidence-based practices, critical thinking, and outcomes assessments. Dentists should also be able to identify known risk factors and work with patients and other health care professionals to effectively manage SDB using evidence-based practices (Levine et al., 2018). The American Academy of Dental Sleep Medicine (AADSM) appointed a task force in 2017, consisting of five AADSM-certified dentists, to create standards that would define the scope of dental sleep medicine practice (Levine et al., 2018). The task force, using current literature and current guidelines, developed these standards and established a framework for the scope of dental sleep medicine practice (Levine et al., 2018). Levine et al. (2018) state that standardization will promote a methodical approach to patient care, which will allow dentists to provide the best possible care in collaboration with the physician.

Most often, dentists treat obstructive sleep apnea (OSA) at the request of physicians and do not regularly contribute to diagnosis and treatment (Nakai et al., 2018). Considering that facial morphology is a determinant of OSA and is evaluated using a cephalogram, which is a radiographic diagnostic tool utilized mostly by dental professionals, physicians involved in OSA management are likely to miss the contribution of facial morphology in the pathogenesis of OSA (Nakai et al., 2018). Additionally, oral appliances often are not recommended by physicians if temporomandibular disorders and missing teeth are present, leading to the exclusion of this treatment option upon initial diagnosis (Nakai et al., 2018). Therefore, many patients may be denied the recommended first-line treatment, indirectly increasing the medical costs involved (Nakai et al., 2018). Integrating sleep medicine and dental sleep medicine has been shown to improve patient care, reduce treatment costs, and improve physician education (Nakai et al., 2018). Since an integrated, multidisciplinary approach to OSA management may be the most effective, Nakai et al. (2018) conducted a study evaluating the frequency and efficacy of various treatment modalities for OSA, administered via an integrated care delivery model, and assessed the role of dental sleep medicine as part of a multidisciplinary team. Nakai et al. (2018) retrospectively evaluated 1,115 patients being treated for OSA by a multidisciplinary team under one roof. The treatment methods utilized included continuous positive airway pressure (CPAP), oral appliance (OA), surgery, and behavioral therapy. Surgery aimed to widen the airway and included either uvulopalatopharyngoplasty and genioglossal advancement to remove excess tissue in the throat and pull the tongue muscle forward, or maxillomandibular advancement.

Behavior therapy included dietary counseling and postural changes during sleep (Nakai et al., 2018). Sixty-nine percent of patients received CPAP therapy, 21.5% used an oral appliance, 6.8% received behavior modification, and 3% underwent surgery (Nakai et al., 2018). Although surgery was determined to be the first-choice treatment in > 10% of patients, significantly fewer patients underwent surgery, meaning that the selected surgical approach depended on the patient preferences (Nakai et al., 2018). The success rate of oral appliance and mandibular advancement was 74.4% and 80% respectively, 30% of patients with OSA were treated with modalities other than CPAP, and more than 20% of patients were treated with an oral appliance (Nakai et. al., 2018). Nakai et al. (2018) state that there is a possibility of regulatory bias because OSA treatments were performed according to the rules of the government-provided national health insurance in Japan, which mandates that only CPAP be used in patients with an AHI > 20. The evaluation of the efficacy of oral appliance therapy was limited by the small sample size and the selection of oral appliance therapy was greatly affected by craniofacial conditions such as the temporomandibular joint (TMJ) and missing teeth (Nakai, et al., 2018). Nakai et al. (2018) concluded that the results suggest that proper treatment selection for the management of patients with OSA is possible under a one-roof system, and dental sleep medicine can play a significant role in facilitating oral appliance treatment.

A visit to the dental office should include a screening process that aims to identify findings associated with sleep-disordered breathing (SDB), and the patient should then be referred to a physician if needed (Levine et al., 2018). Various screening tools are available that identify common factors associated with OSA and should be utilized in addition to the routine examination. The goal of screening is to assess the patient for both nocturnal and daytime symptoms such as snoring, witnessed apneas, gasping, and sleepiness (Levine et al., 2018).

When using questionnaires for initial screening of adults, certain criteria such as elevated BMI, witnessed apneas, excessive daytime sleepiness, and the presence of medical comorbidities warrant a referral to a physician for evaluation and diagnosis. Many medications can negatively impact sleep quality and respiratory patterns; therefore, the patient's current medications, medical and dental histories should be documented (Levine et al., 2018). Screening questionnaires can be valuable in identifying patients at risk for SDB when correlated with a history of interrupted sleep, medical history, family history, medications, and clinical findings (Levine et al., 2018). Anatomic considerations associated with SDB also need to be considered during the screening process, as they may indicate the need for physician referral (Levine et al., 2018).

Early identification and treatment would improve OSA management and reduce excess morbidity (Dillow et al., 2016). However, despite the public health and economic benefit of screening for OSA in clinical settings, it is unclear whether screening in a dental setting is feasible or would result in physician consultation when indicated (Dillow, 2016). Research demonstrates that most dentists believe that medical screenings are important and are willing to conduct chairside screenings for oral cancer, diabetes, cardiovascular disease, and hypertension. Furthermore, most dentists are willing to refer patients to a physician for disease assessment and diagnosis when indicated. Dental patients are equally receptive to medical screenings provided in the dental setting (Dillow et al., 2016). Health screenings in the dental setting not only identifies patients at an increased risk for disease, but also integrates patient management across healthcare disciplines (Dillow et al., 2016). Due to the prevalence of obstructive sleep apnea (OSA), and the support of both dentists and their patients for medical screenings, Dillow, et al. (2016) conducted a study evaluating the patient response to dentist recommendations of physician evaluation following OSA screening. A community-based dental practice in Raleigh, North Carolina screened patients for OSA using a pulse oximeter and the STOP questionnaire (Dillow et al., 2016). Of the 119 patients screened, 18.5% were considered high-risk on the STOP questionnaire, 26.1% were considered high-risk based on pulse oximetry, and 31.9% were considered high-risk on both instruments (Dillow, 2016). A physician consultation within three months was recommended for those considered at high-risk for OSA (Dillow et al., 2016). After three months, all patients were contacted to determine if they had consulted a physician regarding the outcome of the screening. The results of the study demonstrated that 47.1% of those at high-risk for OSA on one or both instruments sought physician evaluation and those that screened high-risk on pulse oximetry were 2.5 times as likely to seek physician evaluation compared with those who screened low risk on both instruments. Screening high-risk on the STOP questionnaire did not significantly increase the likelihood of a physician evaluation (Dillow, 2016). Screening high-risk on the objective screening instrument, or both objective and subjective screening measures, increased the likelihood for physician consultation. There was a similar trend observed for screening high-risk on the subjective screening instrument; however, it was not statistically significant. This demonstrates the importance of an objective measurement to motivate patients to seek medical consultation (Dillow, et al., 2016). Dillow et al. (2016) concluded that nearly half of dental patients considered high-risk for OSA may be responsive to a recommendation to seek physician evaluation. It should be noted, however, that the participants of this study were volunteers from a single dental practice, that were scheduled for a routine dental cleaning. Due to their willingness to participate in the study, the subjects may have had a previous interest in sleep apnea and, for this reason, are unlikely to be representative of all adults. Additionally, the participants may have been more willing to seek physician consultation than the dental patients who chose not to participate in the study. Therefore, the percentage of patients at high-risk for OSA, that will seek physician evaluation, may be overestimated (Dillow, et al. 2016).

As previously demonstrated, there are often signs related to OSA that can be observed during routine dental examinations. However, dentists' opinions regarding whether they are able, or should take part in such treatment protocol, has remained unclear. Dentists may suspect OSA, but little is known about their knowledge and attitudes towards the topic (Vuorjoki-Ranta et al., 2016). In a 2016 study conducted by Vuorjoki-Ranta et al., dentist's overall knowledge of OSA and associated factors, as well as their willingness to take part in the recognition and treatment of OSA, was evaluated. Vuorjoki-Ranta et al. (2016) emailed a questionnaire to dentists working in the Helsinki Health Centre, in Helsinki, Finland. The questionnaire consisted of demographic data, items on dentists' overall knowledge of OSA and associated factors, and their willingness to evaluate and treat OSA patients (Vuorjoki-Ranta et al., 2016). Of the 189 dentists that completed the questionnaire, 79.1% were general dentists, and 20.9% were dentists with specialty training (Vuorjoki-Ranta et al., 2016). Continuous positive airway pressure (CPAP) and weight control were both recognized as effective methods to treat OSA. However, there were significant differences of opinion found between general dentists and specialists regarding the efficacy of other treatment methods (Vuorjoki-Ranta et al., 2016). For example, mandibular advancement devices (MAD) were less often reported by general practitioners than dental specialists. The possible risk factors, signs and symptoms, and consequences of OSA were overall well recognized regardless of the years in practice, however, specialists identified more often that nocturnal sweating and snoring may signify OSA (Vuorjoki-Ranta et al., 2016). Vuorjoki-Ranta et al. (2016) concluded that dentists could play an important role in identifying

OSA, but they need more education to do so effectively. A strength of this study is the good response rate of 70.9%. Additionally, the percentage of general dental practitioners and specialists is comparable to the entirety of dental providers in Finland overall (Vuorjoki-Ranta et al., 2016). Vuorjoki-Ranta et al. (2016) state that the results, however, may not represent the nationwide knowledge and attitudes of dentists because of the limited number of eligible subjects.

Oral health professionals are in a prime position to identify sleep quality concerns due to the oral presentation of chronic sleep issues. When poor sleep is suspected, it is the responsibility of oral health professionals to refer patients to a primary care physician for evaluation (Schroeder & Gurenlian, 2019). The American Dental Association (ADA) has adopted a formal policy statement indicating that dentists should screen for SDB during all dental examinations. Dentists are also responsible for referring at-risk patients to a primary care provider and work with both the provider and patient to determine the best course of action. The American Dental Hygienists' Association (ADHA) also recognizes the dental hygienists' ability and responsibility to identify oral and systemic health relationships, and appropriately refer patients to achieve optimal health outcomes (Schroeder & Gurenlian, 2019). Although oral health professionals are already providing examinations and assessments that could lead to the detection and diagnosis of SDB and OSA, educational deficiencies within dental health programs may prevent oral health providers from linking oral health assessments with indicators of poor sleep quality (Schroeder & Gurenlian, 2019). Additionally, Schroeder & Gurenlian (2019) state that even when sleep quality concerns are suspected, the general lack of communication and support between medical and dental professionals prohibits continuity of care (Schroeder & Gurenlian, 2019).

The Role of the Dental Hygienists in Obstructive Sleep Apnea Detection

The education that the dental hygienist receives includes obtaining medical and dental histories, identifying abnormal oral structures, detecting oral disease, identifying oral/systemic health links, and identifying signs and symptoms of sleep-related bruxism (Schroeder & Gurenlian, 2019). Dental hygienists routinely provide many chairside health screenings which include screening patients for hypertension, oral cancers, diabetes mellitus, obesity, human papillomavirus, and oral side effects from cancer treatments and medications (Schroeder & Gurenlian, 2019). Schroeder & Gurenlian (2019) state that dental providers report a willingness to conduct health screenings if they are well trained in the medical condition, the screening process, and if the screening is cost-effective. Early detection of an oral health and systemic health-related condition, such as sleep-disordered breathing (SDB) or obstructive sleep apnea (OSA), has the potential to reduce comorbidities associated with poor sleep (Schroeder & Gurenlian, 2019). Medical histories used in a dental setting should include questions regarding sleep quality and quantity, and previous diagnosis of any sleep conditions (Schroeder & Gurenlian, 2019). A patient's dental history can also reveal a history of SDB or OSA due to the formation of oral structures and wear patterns on the dentition. A history of orthodontics, missing teeth, bruxism or clenching, mouth breathing, and high caries risk can all indicate poor sleep quality when paired with other aspects of the patient's health (Schroeder & Gurenlian, 2019). The extraoral and intraoral examination is performed at every dental appointment and may reveal signs of SDB or OSA. Facial features that may indicate an airway or sleep disorder may include a flaccid skin tone, recessed chin, short upper lip, open lip posture, open bite, dried food at the commissures of the lips, a long and narrow face, and dark circles under the eyes (Schroeder & Gurenlian, 2019). Abnormal tongue placement may also lead to a compromised airway and SDB.

Open-mouth breathing and improper tongue posture are directly related to the formation of the maxilla, sinuses, nasal cavity, and palate. Therefore, the formation of the oral structures has a direct effect on the ability to breathe, chew, and swallow properly (Schroeder & Gurenlian, 2019). Additional signs and symptoms related to sleep-disordered breathing that may be evident during the intra/extraoral examination include ankyloglossia, enlarged tonsils, malocclusion, and a high narrow palate (Schroeder & Gurenlian, 2019). Schroeder and Gurenlian (2019) state that a tongue thrust and macroglossia may indicate that the patient is using the tongue to protect the airway. Missing teeth may also result in the tongue occluding the airway while awake and asleep due to the lack of teeth keeping the tongue in proper position when a prosthetic is not worn (Schroeder & Gurenlian, 2019). Missing teeth also cause alterations in the vertical dimension of the face, which can affect the upper airway and retropharyngeal space (Schroeder & Gurenlian, 2019). Enlarged tonsils that restrict the airway can lead to open-mouth breathing and poor sleep quality. Schroeder & Gurenlian (2019) state additional oral indicators of open-mouth posture and poor sleep quality may include gingivitis, periodontal disease, xerostomia, high caries risk, poor plaque control, hypersalivation, or missing teeth. When signs of sleep-disordered breathing are present, Schroeder & Gurenlian (2019) recommend further evaluation by a medical provider.

Dental healthcare professionals need to evaluate for orofacial myofunctional disorders (OMD) in patients during early development, and they need to be knowledgeable in recognizing the presence and potential consequences of these disorders (Fabbie, 2015). Improper facial growth and development can contribute to a restricted upper airway and associated sleep disorders since form and function are interdependent (Fabbie, 2015). Fabbie (2015) states that any delay in addressing the primary etiology may lead to orthodontic re-treatment and the possible need for surgical re-alignment of the maxilla and mandible. Orthodontists recommend children have an orthodontic consultation by age seven, however, since 60-70% of facial growth is complete by seven years of age, this may be too late to achieve optimal results (Fabbie, 2015). Screening for orofacial myofunctional disorders and sleep-disordered breathing should begin when the dental hygienist takes the medical history and specific questions regarding sleep should be asked at this time (Fabbie, 2015). Dental hygienists should also gather data during the assessment regarding myofunctional issues and patients' habits, as well as evaluate for tongue and lip habits, speech disorders, nail biting, thumb or finger sucking, teeth grinding or clenching, cheek biting, tongue thrust, and mouth breathing (Fabbie, 2015). Fabbie (2015) also recommends questionnaires such as Epworth Sleepiness Scale, STOP-BANG, and BEARS be provided to patients or integrated into the medical history. As stated earlier, the STOP-BANG acronym stands for snoring history, tired during the day, observed stop breathing while sleep, high blood pressure, BMI more than 35 kg/m^2, age more than 50 years, neck circumference more than 40 cm and male gender (Pavarangkul et al., 2016). BEARS is a screening tool that aims to identify sleep problems in children. The acronym stands for bedtime, excessive daytime sleepiness, awakening during the night, regularity, and duration of sleep and snoring (Ebarhim et al., 2013).

Dental hygienists are taught to perform a very thorough oral examination on every patient and are in a unique position to identify risk factors for OSA and make appropriate referrals (Kandray et al., 2013). Dental professionals are also in an ideal position to evaluate and classify the pharyngeal soft tissues. There are several intraoral traits that OSA patients exhibit including macroglossia, narrow palate, a wide uvula, tonsillar hypertrophy, and a narrow opening of the oropharynx (Kandray et al., 2013). The Mallampati score has been shown to be progressively higher in patients who exhibited more severe degrees of OSA as determined by polysomnography, however, Kandray et al. (2013) state there is little data to demonstrate the use of the Mallampati classification by dental hygienists in the clinical setting. A 2013 study by Kandray et al. aimed to assess the inter-rater reliability between dental hygiene students and a supervising dentist using the Mallampati classification to evaluate and classify the pharyngeal soft tissues. Twenty-one dental hygiene students performed Mallampati classifications on 234 patients during a 12-month period. During the same period, the clinic dentist performed an independent assessment on the same patients (Kandray et al., 2013). Kandray et al. (2013) state that the clinic dentist, for convenience, was chosen to be the standard by which the students were measured, therefore, repeating the study using an expert in the use of the Mallampati classification, such as an anesthesiologist, to compare with the student results may have a different outcome. Quantitative research methods were used to evaluate the inter-rater reliability between dental hygiene students and the clinical dentist in performing the Mallampati classification and found that there was an agreement between the dental hygiene student and the dentist in the majority of the independent assessments (Kandray et al., 2013). There was no observation, however, of the dental hygiene students or the dentist while the Mallampati classification was recorded, leading to a possibility that inaccurate positioning of the patient occurred, which may explain the differences in student and dentist reporting results. Kandray et al. (2013) concluded that dental hygiene students can evaluate and classify the pharyngeal soft tissues comparable to a supervising dentist in the clinical dental hygiene setting.

Bewley (2014) also conducted a study evaluating the feasibility of incorporating OSA screenings into dental hygiene appointments. The purpose was to obtain information about dental hygienists' attitudes, acceptance of, and perceived barriers to performing OSA screening during dental hygiene appointments (Bewley, 2014). Sixteen practicing dental hygienists were recruited to complete a pre-screening survey, conduct OSA screenings on five patients using the Berlin questionnaire, and then complete a post-screening survey. Body Mass Index (BMI) of patients were recorded during the screening process. Individual screening time and accuracy were evaluated (Bewley, 2014). A total of 81 patients were screened and 30% were identified to be at high risk of having OSA. Participants determined the BMI correctly for 89% of patients, and the mean time spent on screenings was just under five minutes. Pre-screening survey results showed 25% of participants felt that it was very important for dental hygienists to screen patients for OSA, compared to 50% post-screening (Bewley, 2014). Bewley (2014) concluded that the results indicate that dental hygienists can provide patients with a valuable health service by including OSA screening as part of the routine health assessment. Additionally, dental hygienists recognize the importance of screening patients for undiagnosed medical conditions and are proficient at conducting these screenings (Bewley, 2014). This study had a small sample size of only sixteen dental hygienists; therefore, additional research is needed in this area.

Dental Sleep Medicine in the Dental Health Curriculum

The tools used to detect sleep-disordered breathing (SDB) and obstructive sleep apnea (OSA) can be easily implemented during the patient assessment and extra/intraoral examination (Kornegay & Brame, 2015). Therefore, dental hygienists have the opportunity to educate patients on the risk factors, potential health conditions, and treatment options for OSA. Medical referrals are also part of the dental hygienists' role, which can promote collaboration between the medical and dental fields (Kornegay & Brame, 2015). By including the dental team in screening and detection for OSA, Kornegay & Brame (2015) state that patients may be more likely to receive an accurate diagnosis and seek treatment, therefore, improving their overall quality of life. Most dental school curricula, however, do not provide adequate content for sleep apnea (Kornegay & Brame, 2015). Research has demonstrated that the available screening tools can effectively detect OSA, therefore, Kornegay & Brame (2015) state that it is imperative to present sleep disorder education in the curriculum of dental and dental hygiene programs. Patients generally value the education and healthcare advice provided by the dental hygienist; therefore, it is important that dental hygienists receive education pertaining to sleep disorders in order to provide evidence-based information to the patient (Kornegay & Brame, 2015).

Dental practitioners report a lack of adequate training in the screening of obstructive sleep apnea (OSA); therefore, they may be reluctant to engage in management of OSA due to concerns of litigation and malpractice (Güneri et al., 2016). The training that is currently available is mainly derived from courses offered by oral appliance manufacturers, scientific meetings, and information gathered from the literature (Güneri et al., 2016). It is reported that in 49 dental schools in the United States, the total average predoctoral time spent on sleep medicine is 2.96 hours (Güneri et al., 2016). Additionally, Güneri et al. (2016) state that only prosthodontics, oral medicine, and orofacial pain post-doctoral programs include sleep-related disorders in their curricula. Due to the insufficient curricular content, resources, and teaching facilities, Güneri et al. (2016) suggest that dental schools lack the appropriate training regarding sleep disorders and over half of dental practitioners fail to recognize OSA in their patients. Dental practitioners who receive some education regarding OSA report managing patients with OSA more frequently (Güneri et al., 2016).

In 2013, the University of North Carolina School of Dentistry hosted a national conference to determine the need to provide education in sleep-related breathing disorders to pre- and post-doctoral students, dental hygiene students, and other health care providers (Moreno-Hay et al., 2020). There were 21 dental schools from the United States and three Canadian dental schools in attendance. It was widely recognized that a consensus regarding the extent of sleep medicine education that should be provided was lacking (Moreno-Hay et al., 2020). A few dental schools had programs for predoctoral students aimed at teaching the pathophysiology and epidemiology of sleep-related breathing disorders, as well as how to screen patients and refer them to physicians for further evaluation (Moreno-Hay et al., 2020). The schools that offered clinical training in oral appliance therapy did so only through post-graduate programs (Moreno-Hay et al., 2020). In October 2017, the American Dental Association (ADA) released a policy statement on the role of dentistry in the treatment of sleep-related breathing disorders, including obstructive sleep apnea and primary snoring (The Role of Dentistry in the Treatment of Sleep-Related Breathing Disorders, 2017). The ADA recognizes and supports the role of a trained dentist in the diagnosis and management of SDB and OSA and recognizes a trained dentist as the only health care provider with the knowledge and expertise to provide oral appliance therapy (Moreno-Hay et al., 2020). The American Dental Hygienists' Association (ADHA) has yet to develop a policy regarding sleep disordered breathing or obstructive sleep apnea. The ADHA's standards for clinical dental hygiene practice, however, indicated that "the purpose of the dental hygiene process of care is to provide a framework where the individualized needs of the patient can be met; and to identify the causative or influencing factors of a condition that can be reduced, eliminated, or prevented by the dental hygienist" (Standards for Clinical Dental Hygiene Practice, 2016, p.5).

Current dental curricula have failed to respond to this health trend and provide at least an introduction to OSA, therefore, Güneri et al. (2016) suggest that it is prudent for dental programs to be at the forefront of education on this subject matter. Güneri et al. (2016) recommend that the inclusion of specific courses regarding sleep disorders and the role of the dental practitioner is warranted, with emphasis directed towards recognition, screening, and management of OSA

(Güneri et al., 2016). The topics recommended by Güneri et al. (2016) to be considered in the dental curricula include epidemiology of sleep issues in society, normal sleep, prevalence of sleep disorders, anatomy and physiology of the upper airway, terminology and signs and symptoms of OSA, physiologic effects of OSA, risk factors/predisposing factors for OSA, medical assessment, health history and symptom history related to snoring and OSA, head and neck examination, polysomnography evaluation and diagnosis, treatment options, and oral appliance therapy.

Most clinicians are unaware of various sleep disorders; therefore, many individuals remain undiagnosed. To effectively address this issue, healthcare professionals must work collaboratively to educate, identify, and treat patients with sleep disorders (Minichbauer et al., 2015). Dental hygienists are at the forefront regarding prevention and counseling, therefore, their role in patient education, screening, and management of sleep disorders is important. In 2014, Minichbauer et al. conducted a study that aimed to assess the amount of sleep medicine content in U.S. dental hygiene programs. An electronic survey was emailed to all 334 accredited dental hygiene programs in the United States (Minichbauer et al., 2015). The 18-question survey assessed the sleep medicine content included during the 2012-13 academic year. This study had a relatively low response rate with a total of 35.3% of the programs responding. The mean number of hours devoted to sleep medicine in their curricula was 1.55 hours. Although 69% of the responding programs reported spending time on sleep bruxism, only 28% reported including other topics such as snoring and obstructive sleep apnea with an average time of 1.39 hours (Minichbauer et al., 2015). Geographic location and the type of institutional setting had little or no effect on how much sleep medicine was taught in these programs. These results suggest that although sleep medicine is included in most dental hygiene programs, the content is limited and focused on sleep bruxism (Minichbauer et al., 2015). Minichbauer et al. (2015) concluded that the level of training is inadequate to prepare dental hygienists for their potential role in patient education, screening, and management of sleep-related breathing disorders. The sample size in this study was representative of dental hygiene programs regionally but not by institutional setting, therefore, the findings cannot be generalized to represent all U.S. dental hygiene programs (Minichbauer et al., 2015). Additionally, the survey had a higher response rate from programs in university settings, particularly those with a dental school, than from programs in non-university settings. Minichbauer et al. (2015) state that it is possible that faculty members at the university level are more likely to be involved in research, therefore, are more willing to participate. It is also possible that programs without a university affiliation are more likely to exclude sleep medicine content in their curricula, therefore, were less interested or motivated to participate in the survey (Minichbauer et al., 2015). The data showed that 57% of responding dental hygiene programs include the association between OSA and periodontal disease in their curricula, which may indicate that findings directly related to dental hygiene are more likely to be added to the curriculum (Minichbauer et al., 2015). Minichbauer et al. (2015) state that acknowledging the potential role of dental hygienists in screening for sleep-related breathing disorders is the first step in curriculum additions.

Dental hygienists spend the most time with patients and have the potential to provide an appropriate setting to conduct OSA screenings (Reibel, et al. 2019). While the potential for this practice has been proposed there is little evidence on the level of knowledge and attitudes about the importance of identifying OSA among dental hygienists (Reibel, et al. 2019). In order for busy clinicians to adopt practice modifications, both a positive attitude toward the need, and adequate knowledge base in the subject matter, is required to implement and sustain change

(Reibel, et al. 2019). A 2019 study by Reibel et al. aimed to determine the current knowledge and attitudes of OSA among Minnesota dental hygienists and determine OSA screening protocols currently used in dental practices. In this study, Reibel et al. (2019) used a survey that included demographic variables and measured the attitudes, knowledge, and perceived knowledge regarding obstructive sleep apnea (OSA), routine screening procedures, and the use of validated OSA screening protocols. Surveys were mailed to a random sample of 750 licensed Minnesota dental hygienists with a 26% return rate (Reibel, et al. 2019). Respondents' mean self-rated level of OSA knowledge was 3.5 out of five and the total knowledge average score was 9.5 out of 18. Close to 90% of respondents reported that they routinely conducted extra- and intraoral examinations, 41.6% reported that they regularly checked patients' blood pressure and only 36% reported including an OSA item on their practice's medical history form. Additionally, only ten respondents reported using an established OSA screening tool with half reporting use of the STOP-BANG tool, either exclusively or in addition to, another method (Reibel, et al. 2019). Reibel et al. (2019) concluded that dental hygienists perceive that assessing patients for OSA is important, however, they only have moderate knowledge of the disease. Furthermore, the results of the study support incorporating OSA into dental hygiene practice through additions to the dental hygiene education curriculum and ongoing professional development courses to improve the screening and referral of patients presenting with OSA symptoms (Reibel, et al., 2019). Although the sample size of this study was low, Reibel et al. (2019) state that the significance is that the dental hygienists that responded consider OSA to be an important disorder, and that their confidence in identifying and managing OSA is lower than attitudes regarding its importance. Furthermore, the perception of OSA knowledge coincides with actual OSA knowledge among dental hygienists. Reibel et al. (2019) state that the results from this study support increasing educational opportunities on OSA for dental hygiene students and practicing clinicians.

Methodology

Methods

Search Procedures

A comprehensive review of the literature related to orofacial myofunctional disorders and obstructive sleep apnea was conducted. The review highlighted the following topics: (a) sleep apnea, (b) orofacial myofunctional disorders, (c) the link between orofacial myofunctional disorders and obstructive sleep apnea, (d) obstructive sleep apnea and the dental setting, (e) the role of the dental hygienist in obstructive sleep apnea detection, and (f) dental sleep medicine in the dental health curriculum.

Libraries Used

Only one library was used for the search of sources for this dissertation. The University of Bridgeport Wahlstrom Library was used for this literature review.

Search Engines and Databases Used

A comprehensive search of the literature was performed using the University of Bridgeport Wahlstrom Library online databases including Cochrane Library, Dentistry and Oral Sciences Source, PubMed, and Science Direct. The search began 5/4/20 and concluded on 11/11/20.

Search Terms

The search terms used were a combination of "myofunctional therapy," "sleep apnea," "orofacial myofunctional disorder," "oral rest posture," "dental sleep medicine," "orofacial myofunctional disorder and dental hygiene education," "sleep medicine and dental hygiene curriculum," and "sleep medicine and dental education." The search language selected was English and was used to identify both primary and review articles published between 2009 and 2020. Additionally, publications from professional organizations such as the American Dental Association and the American Dental Hygienists' Association were used as additional references.

Inclusion Criteria

Criteria for inclusion included peer-reviewed clinical trials, review articles, cohort studies, and retrospective studies that evaluated the impact of obstructive sleep apnea, sleep disordered breathing, orofacial myofunctional disorder, and myofunctional therapy on both pediatric and adult populations, as well as the extent of dental sleep medicine in the dental health curriculum. Only literature published within the last eleven years was included.

Exclusion Criteria

Literature published before 2009 was excluded. Literature that was not published in English was also excluded. Additional criteria for exclusion included myofunctional therapy as a treatment for conditions not related to sleep disordered breathing or orofacial myofunctional disorders as a cause of conditions not related to sleep disordered breathing.

Results

The amount of education and training provided to dental hygienists may not be adequate for identifying the risk factors associated with obstructive sleep apnea, conducting obstructive sleep apnea (OSA) screenings, or making appropriate referrals for an OSA consultation. Dental hygienists do not always feel confident in conducting OSA screenings or making referrals. Additionally, the awareness of the relationship between orofacial myofunctional disorders (OMD) and obstructive sleep apnea is lacking within the fields of sleep medicine and dental health, and the link between OMD and OSA is lacking from dental hygiene curricula. The aim of this research was to identify if there is a link between orofacial myofunctional disorders and obstructive sleep apnea, if the dental hygienist is provided with the education necessary to identify OSA risks and make the appropriate referrals, and if there is a benefit to including the identification of orofacial myofunctional disorders as risk factors for obstructive sleep apnea in the dental hygiene curriculum. It was hypothesized that incorporating the identification and understanding of OSA and OMD risk factors into the dental hygiene curriculum would allow for the dental hygienist to be better prepared to screen for OSA and make physician referrals, thereby increasing the diagnosis and treatment of OSA.

Research Questions

Is there a link between orofacial myofunctional disorders and obstructive sleep apnea?

According to Guilleminault & Huang (2018), craniofacial features impact the size of the upper airway (UA). Guilleminault & Akhtar (2015) state that the size of the upper airway, and factors that contribute to its narrowing, can lead to an increased risk of collapse and abnormal breathing during sleep. Due to the location of the UA being below the skull and behind the face, any developmental changes in these areas will affect its size (Guilleminault & Akhtar, 2015).

Using polysomnography (PSG) results and measurements from photographs and models of children to compare children diagnosed with sleep-disordered breathing (SDB) to healthy non-snoring children, Yap et al. (2019) examined the differences in dentofacial morphology. Measurements of facial width, length, depth, convexity, and mandibular positions along with the occlusion, arch width, arch depth, maxillary arch form, and palatal height and volume were compared. Children with SDB had a significantly increased lower face height, maxillo-mandibular angle, and a narrower posterior maxillary arch. There was also a trend toward a decreased palatal volume, increased posterior crossbite and class II molar relationship (Yap et al., 2019). There were three facial morphology variables that were significantly different between the two groups. The *z*-score for the sleep-disordered breathing group (SDB) was increased for lower anterior face height ($p < 0.003$), lower jaw length ($p < 0.039$), and maxillo-mandibular angle ($p < 0.011$) of 1.73, 95% CI [0.45 -3.0]. There was also a trend for a shorter and narrower nose, increased facial convexity and steeper mandibular plane angle; however, it was not significant (Yap et al., 2019). There were, however, two dental morphology variables that were significantly different between the groups. The *z*-scores for maxillary width were decreased in the SDB group for both the maxillary inter-second premolar ($p < 0.009$) and maxillary inter-first molar width ($p < 0.033$). However, there were no significant differences found in any other dental arch measurements of width, depth, or occlusion (Yap et al., 2019). There was a trend for the SDB group to have an increased frequency of posterior crossbite (50% v 12.5%), class II molar relationship (60% v 25%), and a wider and longer mandibular arch, although it was not significant (Yap et al., 2019). The palatal index distal to the maxillary first molars was significantly greater in the SDB group, indicating a palate that is higher and narrower, however, no difference was found when the values were normalized (Yap et al., 2019).

Another study examining dental arch morphology in children with obstructive sleep apnea (OSA) and snoring evaluated measurements from dental casts and compared them to a control group. Pirilä-Parkkinen et al. (2009) found enlarged tonsils in 92% of the OSA children and 76% of the snoring children, however, there was no statistically significant relationship between the Apnea-Hypopnea Index (AHI) and tonsillar size ($p = 0.154$). When compared to the control groups, overjet was found to be larger in the OSA ($p < 0.05$) and snoring ($p < 0.05$) groups, there was a significant reduction in overbite in children with OSA ($p < 0.05$), and the width of the maxillary arch was significantly smaller in both the OSA and snoring groups (Pirilä-Parkkinen et al., 2009). Arch width was reduced at the level of first primary molars or first permanent premolars in the OSA group ($p < 0.05$), at the level of second primary molars or second permanent premolars in both the OSA ($p < 0.05$) and snoring ($p < 0.05$) groups, and at the level of the maxillary first permanent molars in the OSA children ($p < 0.05$) (Pirilä-Parkkinen et al., 2009). The lower arch length was also found to be significantly smaller in both the OSA ($p < 0.001$) and snoring ($p < 0.05$) children. There was no statistically significant difference in upper arch length, palatal height, or mandibular width between the groups (Pirilä-Parkkinen et al., 2009). The OSA group had a significantly increased number of subjects with an anterior open bite ($p = 0.016$) and there was an increased tendency of anterior open bite in the group that snored ($p = 0.063$). The number of subjects with a Class II molar relationship was increased in the OSA ($p = 0.013$) and snoring ($p = 0.004$) children and there was a tendency for increased crowding of the maxilla ($p = 0.057$) and mandible ($p = 0.077$) in the OSA group (Pirilä-Parkkinen et al., 2009). The effects of age, gender, tonsillar size, and the dental arch variables on AHI scores were analyzed and significant associations were found between AHI and mandibular crowding and anterior open bite (Pirilä-Parkkinen et al., 2009). More subjects were found to have mandibular crowding ($p = 0.002$) and an anterior open bite ($p = 0.019$) as the AHI increased. There was also a tendency for the overjet to be larger with increasing AHI ($p = 0.069$) (Pirilä-Parkkinen et al., 2009). The dental arch measurements for the OSA, snoring, and control groups are shown in Table 1.

Table 1.

Mean Values, Standard Deviations (Sds), and Significant Differences for Dental Arch Measurements in Children with Obstructive Sleep Apnea (OSA), Snoring, and Controls.

Variable (in mm)	Snoring group[A] (*n* = 41) Mean (*SD*)	OSA group[B] (*n* = 41) Mean (*SD*)	Control group[C] (*n* = 41) Mean (*SD*)	Statistical significance A– B	A – C	B – C
Overjet	3.7 (2.10)	3.5 (1.51)	2.6 (1.01)	-	*	*
Overbite	2.1 (1.47)	1.8 (1.81)	2.6 (1.00)	-	-	*
Upper arch length	30.4 (2.07)	30.2 (1.77)	30.5 (2.17)	-	-	-
W1 (maxilla)	30.4 (2.53)	29.6 (2.43)	31.2 (2.10)	-	*	**
W2 (maxilla)	30.4 (2.31)	30.1 (2.09)	31.3 (1.82)	-	-	*
W3 (maxilla)	34.2 (2.10)	34.3 (2.70)	35.5 (2.03)	-	*	*
W4 (maxilla)	38.7 (2.70)	38.7 (2.74)	40.0 (2.73)	-	-	*
Palatal height	12.2 (2.32)	12.4 (2.34)	12.4 (1.51)	-	-	-
Lower arch length	26.1 (1.42)	25.6 (1.29)	26.8 (1.44)	-	*	***
W1 (mandible)	24.9 (2.23)	24.5 (2.17)	24.4 (2.38)	-	-	-
W2 (mandible)	27.2 (2.08)	26.7 (1.88)	26.9 (1.64)	-	-	-
W3 (mandible)	30.2 (2.24)	29.7 (1.82)	30.2 (1.77)	-	-	-
W4 (mandible)	34.1 (2.23)	33.5 (2.40)	34.3 (2.15)	-	-	-

Note. Statistically significant difference between the groups * p <.05, ** p <.01, *** p <.001.

Adapted from "Dental Arch Morphology in Children with Sleep-Disordered Breathing" by Pirilä-Parkkinen et al., 2009, *European Journal of Orthodontics*, *31*, p. 163 (https://doi:10.1093/ejo/cjn061).

The superscripts (A – C) refer to the comparisons of statistical significance.

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When mouth breathing persists after adenotonsillectomy surgery (T&A), sleep disordered breathing (SDB) continues to worsen due to an increase of upper airway resistance during sleep with a secondary impact on orofacial growth. Lee et al. (2015) retrospectively examined children with SDB that were treated with T&A, that had a polysomnography (PSG) prior to, and after, surgery and were recommended myofunctional therapy. A significant improvement was found with increased oxygen saturation and decreased mean AHI (8.58 before, and 1.71 after surgery, $p < 0.001$). However, 26 children (40.6%) still presented with residual SDB, with an AHI equal or higher than 1.5 events/hour, and 35 children presented with mouth breathing for at least 35% of total sleep time. Those with mouth breathing had a significantly higher AHI compared to nasal breathing children. Nine children with no symptoms had an AHI below 1.5 event/hour and mouth breathing for more than 35% of total sleep time after T&A. Oxygen saturation, AHI, and nasal flow limitation were not significantly different 12 months after T&A, compared to immediately after surgery. There were, however, significant differences in AHI, oxygen saturation, and nasal flow limitation between children who reported undergoing myofunctional therapy compared to children that did not, as shown in Table 2. (Lee et al, 2015).

Table 2

Distribution of AHI, Flow Limitation, and Oxygen Saturation (SaO2) Between Myofunctional Therapy and Non-Myofunctional Therapy Groups 12 Months After T&A.

PSG findings	Myofunctional therapy (*n* = 9)		Non-myofunctional therapy (*n* = 9)		P-value
	Mean	*SD*	Mean	*SD*	
AHI	1.1	(1.19)	2.94	(1.37)	.015
Flow limitation	0.56	(1.67)	19.44	(14.24)	.003
SaO2	96.11	(1.05)	94.56	(1.67)	.037

Note. Two of the children that were asymptomatic, with normal PSG after T&A, are included in the non-myofunctional therapy group. They presented with abnormal findings at 12-month PSG with persistence of mouth breathing during sleep. Adapted from "Mouth Breathing, Nasal Disuse, and Pediatric Sleep-Disordered Breathing" by Lee et al., 2015, *Sleep and Breathing*, *19*(4), p. 1262 (https://doi.org/10.1007/s11325-015-1154-6). Reprinted with permission.

In a study examining the differences in muscular and orofacial function and myofunctional scores between children with obstructive sleep apnea (OSA) and children with primary snoring (PS), Felicio et al. (2016) found that children with tonsillar hypertrophy and OSA had impairments in orofacial function and less muscular coordination than children with PS. When comparing the OSA group to the PS group, eight children with OSA had posterior crossbite, no children with PS had crossbite, and no subjects in either group presented with an abnormal lingual frenum (Felicio et al., 2016). The OSA group had lower scores in breathing, swallowing, and a lower functions summary score ($p < 0.05$) (Felicio et al., 2016). Upon swallowing, 15 - 16% in each group had normal lip behavior, although the most pronounced changes, such as a lack of lip closure, excessive contraction of the perioral muscles, and mentalis muscle utilization to achieve lip closure, were found in the OSA group (Felicio et al., 2016). The groups did not demonstrate a significant difference in appearance, posture, or mobility and those with OSA and PS had lower effect size scores compared to the control group (Felicio et al., 2016). For example, in the OSA group, the effect size was large for appearance and posture, mobility, breathing, swallowing, mastication, summary score of the functions, and OMES total score (Felicio et al., 2016). The effect size between the PS and control groups, however, was small for breathing and medium for mastication (Felicio et al., 2016). The results of surface electromyography (sEMG) revealed that the OSA groups masticatory muscles had higher asymmetry between the right and left muscle groups during maximum voluntary clenching and a higher activity index compared to the PS group. A negative activity index indicates that the temporalis muscles predominate the masseter muscles (Felicio et al., 2016). The means of muscle activity between the OSA and PS groups during maximum voluntary clenching were not significantly different (Felicio et al., 2016). There were no significant differences in lip or tongue pressure ($p > 0.05$) among the groups (Felicio et al., 2016).

Guimarães et al. (2009) studied the effects of oropharyngeal exercises on patients with moderate obstructive sleep apnea (OSA) and concluded that oropharyngeal exercises significantly reduced the symptoms and the severity of OSA. After three months of subjects undergoing either myofunctional therapy or a sham therapy, there were no significant changes in the control group. Patients that received myofunctional therapy, however, had significantly decreased neck circumference, snoring symptoms, subjective sleepiness, quality of sleep scores, and a significant decrease in AHI (Guimarães et al., 2009). Additionally, minimal oxygen saturation in the control group decreased slightly, but significantly, while it increased in the treatment group (Guimarães et al., 2009). The OSA status changed for ten patients (62.5%), switching from moderate to mild OSA ($n = 8$) or to the elimination of OSA ($n = 2$). Overall, the changes in AHI did not significantly correlate with changes in anthropometric measurements, except for changes in neck circumference (Guimarães et al., 2009).

As demonstrated in the above studies, there is a clear link between orofacial myofunctional disorders and obstructive sleep apnea. The relationship between muscle function and the growth of orofacial structures begins early in the developmental process, continues throughout childhood, and impacts the ability to breathe properly through the nose. Chronic mouth breathing is an important clinical marker of orofacial muscle dysfunction and leads to sleep disordered breathing (SDB) and obstructive sleep apnea (OSA) (Guilleminault et al., 2014).

Is the dental hygienist provided with the education necessary to identify the risks for sleep apnea and make the appropriate referrals?

It is recognized by the American Academy of Dental Sleep Medicine (AADSM) that there are inconsistencies in curriculum content regarding sleep medicine in both U.S. and Canadian dental schools (Levine et al., 2018). Educational opportunities available to dentists provide the necessary knowledge required to effectively treat and manage OSA patients; however, there are no uniform standards on dental sleep medicine practice (Levine et al., 2018).

A study that evaluated the knowledge and attitudes of dentists regarding OSA treatment found that dentists could play an important role in diagnosing OSA, however, they need more education (Vuorjoki-Ranta et al., 2016). Of the 134 dentists that participated in the study, only six had taken courses in sleep medicine (Vuorjoki-Ranta et al., 2016). It was acknowledged by the dentists surveyed that continuous positive airway pressure (CPAP) (99.3%) and weight control (99.3%) are effective methods to treat obstructive sleep apnea (OSA). However, there were significant differences in opinion found between general dentists and dental specialists regarding the efficacy of other treatment modalities, such as orthognathic surgery (54.7% v 82.1%, $p < 0.01$), tennis ball attached to the back of a pajama top (35.8% v 57.1%, $p < 0.05$), occlusal splint (37.7% v 17.9%, $p < 0.05$) and mandibular advancement device (MAD) (69.8% v 89.3%, $p < 0.05$), (Vuorjoki-Ranta et al., 2016). Of the dentists surveyed, 41% responded that asking pertinent questions may indicate the possibility of OSA, 70.9% felt that they can participate in OSA treatment, and 49.3% felt that oral appliance treatment can be performed by a general dentist (Vuorjoki-Ranta et al., 2016). Possible risk factors, signs and symptoms, and consequences of OSA were recognized regardless of the number of years in practice; however, OSA causing an increased risk of mortality was recognized significantly more by general dentists in their mid- or late careers compared to general dentists with less experience ($p < 0.05$). Similarly, dental specialists recognized this risk significantly more often compared with general dentists ($p < 0.05$). Dental specialists also recognized more often that nocturnal sweating ($p < 0.01$) and snoring ($p < 0.05$) may suggest OSA. The more years a dentist was in the profession was positively associated with the possibility of consulting an OSA specialist ($p < 0.002$) (Vuorjoki-Ranta et al., 2016). Significant differences, however, were found regarding patient interview techniques, with dental specialists asking more often whether the patient snores (42.9%) than general practitioners (7.9%) ($p < 0.001$) (Vuorjoki-Ranta et al., 2016).

Dental hygiene students may be taught to play an active role in identifying the early risk factors for OSA. However, research shows dental professionals do not receive adequate training in screening for sleep disorders, and dental hygienists receive minimal, if any, training on recognizing intraoral signs related to sleep disordered breathing (SDB) (Kandray et al., 2013). Minichbauer et al. (2015) surveyed all 334 U. S. dental hygiene programs to assess the amount of sleep medicine content in dental hygiene program education and found that sleep medicine is included in the majority of U.S. dental hygiene programs, however, it is limited and focused on sleep bruxism (SB). Among the 118 programs included in the study, the mean number of hours devoted to sleep medicine was 1.55 ($SD = 1.37$; $n = 114$). Over two-thirds (69%, $n = 79$) of the programs reported teaching SB in the didactic curriculum, spending an average of 1.03 hours ($SD = 0.95$) on the topic. Two or more lecture hours were dedicated to SB in 18% of the programs, while 26% reported that SB was not included at all (Minichbauer et al., 2015). Minichbauer et al. (2015) found that of the other sleep medicine topics presented, obstructive sleep apnea (OSA) was taught in 32% ($n = 36$) and snoring was included in 25% ($n = 28$). The average time devoted to all other topics related to sleep medicine in the didactic curriculum, excluding SB, was 0.54 hours (*SD* = .81) (Minichbauer et al., 2015). Table 3 shows the percentage of sleep medicine content included in dental hygiene curricula and the topic dental hygiene students discuss with their patients. Programs at colleges and universities without a dental school were more likely to cover and spend more time teaching, additional topics (59%). Non-university-based programs included the least additional topics within the curriculum (33%) and spent the least time devoted to them (Minichbauer et al., 2015). The association between OSA and periodontal disease was included in 57% (*n* = 61) of the programs, and the oral and dental consequences of untreated sleep disordered breathing (SDB) was included in 46% (*n* = 49) (Minichbauer et al., 2015). Of these programs, 34% (*n* = 36) reported teaching the medical consequences of untreated SDB, but only 18% (*n* = 19) described the risk factors for OSA, and only 5% (*n* = 5) discussed the use of screening questionnaires as a detection tool (Minichbauer et al., 2015). Indications or contraindications for an oral appliance to treat SB was included in 62% (*n* = 70) of the responding programs, in contrast to only 35% (*n* = 37) describing the use of oral appliances to manage snoring or OSA (Minichbauer et al., 2015). Discussion of oral appliance for treatment of SB was not included in 17% (*n* = 19) of the responding programs and 54% *(n* = 56) did not include any education on the use of oral appliances to manage snoring or OSA (Minichbauer et al., 2015). During student clinics, 22% (*n* = 24) of responding programs discussed snoring with patients, 21% (*n* = 23) discussed OSA, and less than 13% (*n* = 23) discussed excessive daytime sleepiness or insomnia (Minichbauer et al., 2015). The majority of programs (74%, *n* = 81) did not include any time educating students how to make oral appliances for SB in the laboratory, and of those programs only 26% (*n* = 29) devoted one or more hours to making occlusal guards (Minichbauer et al., 2015). Among the respondents, 71% (*n* = 77) agreed that sleep medicine content should be incorporated into the dental hygiene curriculum, and 93%

(*n* = 100) felt that it is an important issue in health care. Most respondents also agreed that dental hygienists should have a role in identifying or assessing patients who have SB (85%, *n* = 92) and OSA (69%, *n* = 75). Most also indicated that they were interested in learning more about sleep medicine (85%, *n* = 93) (Minichbauer et al., 2015).

Table 3

Sleep Medicine Topics Taught to Students, or Discussed with Patients, in Dental Hygiene Curricula, by Percentage of Responding Programs.

Topics taught or discussed	Percentage
Topics taught in the curriculum	
Sleep bruxism	69
sleep apnea	32
Snoring	25
Topics discussed with patients	
Tooth attrition	82
Sleep bruxism	67
Snoring	22
Obstructive sleep apnea	21
Excessive daytime sleepiness	12
Insomnia	8

Note: Adapted from "Sleep Medicine Content in Dental Hygiene Education" by Minichbauer et al., 2015, *Journal of Dental Education*, *79*(5), p. 488 (https://doi.org/10.1002/j.0022-0337.2015.79.5.tb05907.x)

Reibel et al. (2019) evaluated the knowledge, attitudes and screening practices of dental hygienists related to obstructive sleep apnea (OSA) and found that although they feel it is important to evaluate patients for OSA, their knowledge of the disease is insufficient. Dental hygienists were surveyed and asked knowledge-based questions about OSA prevalence, diagnosis, risk factors, and treatment, as well as attitudinal questions including the importance of OSA as a disorder and their confidence in identifying and managing OSA patients (Reibel et al.

2019). The mean self-rated level of OSA knowledge was 3.3 out of 5 and the total knowledge mean score was 9.5 out of 18, as shown in Table 4. There was a moderate, and statistically significant correlation ($r = 0.46$, $p < 0.001$) between the respondents' perceived self-assessed knowledge and their total knowledge scores (Reibel et al. 2019). The mean scores for the importance of OSA as a clinical disorder and the importance of identifying OSA were 3.7 (0.8) out of 5, and confidence of identifying OSA risk factors was slightly lower at 2.8 (1.0) out of 5 (Reibel et al. 2019). There were no statistically significant differences found on the effect of age, degree type, or years in practice on the total knowledge scores. The majority of respondents reported that they routinely conducted extra/intraoral examinations (89.3%), however, less than half of the respondents reported including an OSA item on the medical history form (39.6%), and only ten (9.6%) of the respondents used an established OSA screening tool (Reibel et al. 2019). The results indicate that the attitudes of dental hygienists regarding the importance of OSA as a chronic disorder are higher than their knowledge of OSA and that dental hygienists are not sufficiently utilized to perform OSA screenings in the dental setting. Additionally, an increased knowledgebase of OSA would improve the dental hygienists' ability to screen and refer patients (Reibel et al. 2019).

Healthcare providers are not currently equipped to address the increasing need for skilled clinicians competent in sleep medicine due to the critical gap in sleep medicine training significantly impacting health, quality of life, and productivity (Meaklim et al., 2020). The results of the above studies indicate that obstructive sleep apnea education must be improved for all dental hygiene students and practicing dental health providers.

Table 4

Dental Hygienists' Responses to Obstructive Sleep Apnea (OSA) Knowledge Items.

OSA knowledge items	True *n* (%)	False *n* (%)	Don't know *n* (%)
The estimated prevalence of OSA among adults is between 2-10%.	29 (15)	67 (35)	101 (50)
An overnight sleep study is a gold standard for diagnosing obstructive sleep apnea.	165 (84)	10 (5)	21 (11)
AHI < 5 events/hour is normal in adults.	38 (20)	45 (23)	112 (57)
The majority of patients with OSA snore.	142 (74)	19 (9)	36 (17)
A craniofacial and oropharyngeal examination is useful in the assessment of patients with suspected OSA.	132 (68)	6 (3)	57 (29)
Women with OSA may present with fatigue alone.	95 (48)	29 (14)	73 (37)
OSA is more common in women than men.	10 (5)	98 (51)	88 (44)
OSA is associated with hypertension.	98 (51)	18 (9)	80 (40)
The loss of upper airway muscle tone during sleep contributes to OSA.	117 (61)	8 (4)	71 (36)
The most common cause of OSA in children is large tonsils and adenoids.	149 (77)	3 (2)	43 (22)
Alcohol at bedtime improves OSA.	5 (3)	162 (83)	29 (14)
Untreated OSA is associated with a higher incidence of automobile crashes.	117 (60)	10 (5)	68 (34)
In men, a collar size 17 inches or greater is associated with OSA.	92 (47)	15 (8)	88 (45)
Cardiac arrhythmias may be associated with untreated OSA.	139 (71)	1 (1)	56 (28)
Uvulopalatopharyngoplasty to remove and/or remodel tissues of the throat is curative for the majority of patients with OSA.	20 (9)	83 (43)	94 (47)
CPAP therapy may cause nasal congestions.	52 (36)	38 (19)	106 (54)
Laser-assisted uvuloplasty is an appropriate treatment for severe OSA	41 (21)	20 (11)	134 (68)
CPAP is the first-line therapy for severe OSA.	124 (64)	11 (6)	61 (31)

Note. Shaded areas indicate correct answers. Adapted from "Obstructive Sleep Apnea Knowledge: Attitudes and Screening Practices of Minnesota Dental Hygienists" by Reibel et al., 2019, *The Journal of Dental Hygiene, 93*(3), p. 32. Reprinted with permission.

Is there a benefit to including the identification of orofacial myofunctional disorders as risk factors for obstructive sleep apnea in the dental hygiene curriculum?

The root cause of obstructive sleep apnea often stems from improper jaw growth and facial development during childhood, leading to improper airway development and function (Hodge, 2015). Failure to provide early treatment of such conditions can contribute to factors such as childhood obesity, juvenile diabetes, and behavioral disorders such as ADHD (Hodge, 2015). Integrating sleep medicine and dental sleep medicine has been shown to improve patient care, reduce treatment costs, and improve physician education (Nakai et al., 2018). Early identification and treatment lead to improved OSA management and reduces excess morbidity (Dillow et al., 2016).

Dillow et al. (2016) evaluated the patient response to obstructive sleep apnea (OSA) screening in the dental office and found that nearly half of the dental patients that screened high-risk for OSA were responsive to a recommendation for physician evaluation. One hundred and nineteen patients screened high risk for OSA, with 18.5% considered high risk based on results from the STOP questionnaire, 26.1% based on results of pulse oximetry, and 31.9% considered high risk based on results from both instruments (Dillow et al., 2016). Those that screened high risk on at least one instrument (76.5%) were recommended to have a physician evaluation, and 47.1% (n = 540) sought physician evaluation within three months. In contrast, only 7.7% (n = 52) of those that screened low risk on both instruments sought physician evaluation within three months (Dillow et al., 2016). Univariate analyses revealed that the participant's sex, age, body mass index, or daytime sleepiness did not consistently affect the likelihood of seeking physician evaluation within three months of screening. However, a higher percentage of participants with a large neck circumference sought physician evaluation, particularly those considered high risk based on the results of pulse oximetry (91.3% v 63.2%, $p < 0.027$) (Dillow et al., 2016). Separate univariate analyses found that patients that were determined high risk based on results of the STOP questionnaire and pulse oximetry were more likely to consult with their physician compared to those that screened low risk on both instruments, however, the likelihood was marginal for the questionnaire ($p < 0.06$) (Dillow et al., 2016). Multivariate analyses also revealed that patients that screened high risk on pulse oximetry were 2.55 times as likely to seek physician evaluation compared to those that screened low risk on both instruments ($p = 52.55$) 95% CI [1.02, 6.37] (Dillow et al., 2016). The likelihood of seeking physician evaluation did not significantly increase based on the results of the STOP questionnaire, and was unaffected by the sex, age, body mass index, neck circumference, or Epworth Sleepiness Scale (ESS) score (Dillow et al., 2016). Dillow et al. (2016) concluded that the results suggest that screening for OSA with simply administered instruments is not only feasible, but well tolerated by dental patients and encourages preventive health-seeking behavior. It is estimated that medical screenings in the dental office can save the healthcare system between $42.4 and $102.6 million over the period of one year (Dillow et al., 2016).

Kandray et al. (2013) evaluated the inter-rater reliability between dental hygiene students and a supervising dentist, using the Mallampati classification to evaluate the pharyngeal soft tissues of patients, and found that dental hygiene students can classify the pharyngeal soft tissues comparable to a supervising dentist. Due to the students evaluating multiple patients, making the data non-independent, the adjusted McNemar test using Durkalski's method was used for testing the agreement in Mallampati ratings between the students and the dentist, and the bootstrapping method was used for examining the correlation between ratings (Kandray et al., 2013). Statistically, there was not a significant difference between the student and the dentist ratings (*p*

= 0.498). The Spearman's correlation was 0.54 with a 95% CI [0.50, 0.64] ($p < 0.001$) indicating a significant correlation in Mallampati ratings between the students and the dentist. The kappa score was 0.54 with a 95% CI [0.42, 0.64], which is satisfactory in the strength of agreement between student and dentist ratings. The percentage of agreement was approximately 77% with a 95% CI [72%, 82%], indicating a good strength of inter-rater agreement between the students and the dentist (Kandray et al., 2013). Kandray et al. (2013) concluded that dental hygiene students have the necessary skills to perform Mallampati classification, which is important in identifying OSA risk and that additional education and training is needed for dental hygiene students to increase their knowledge and recognition of OSA risk factors.

Bewley (2014) conducted a study evaluating the feasibility of incorporating obstructive sleep apnea (OSA) screenings into dental hygiene appointments to determine dental hygienists' attitude and acceptance of performing OSA screenings, along with perceived barriers. Dental hygienists were recruited to complete OSA screenings, as well as a pre- and post-screening survey. Individual screening time and accuracy determining body mass index (BMI) were recorded (Bewley, 2014). Of the 81 patients that were screened, 30% were identified to be high risk for OSA (Bewley, 2014). The participants determined the BMI correctly for 89% of patients and the mean time spent on screenings was only 4.49 minutes (Bewley, 2014). Pre-screening survey results revealed that 25% of participants felt that OSA screening by the dental hygienist is important, compared to 50% post-screening (Bewley, 2014). Bewley (2014) found that the participants felt that the patient's willingness was the most important factor when considering whether to incorporate OSA screening into practice, however, based on the above results from Dillow et al. (2016), dental patients recognize the importance of screening for medical conditions by dental practitioners.

There is a benefit to including the identification of orofacial myofunctional disorders as risk factors for obstructive sleep apnea into the dental hygiene curriculum because screening for sleep disordered breathing (SDB) and obstructive sleep apnea (OSA) can be easily implemented during the patient assessment and extra/intraoral examination (Kornegay & Brame, 2015). The dental hygienist has the opportunity to educate patients on the risk factors, potential health conditions, and treatment options for OSA and make medical referrals (Kornegay & Brame, 2015). Educating the dental hygienist to detect orofacial myofunctional disorders that increase the risk of OSA will improve the likelihood of patients receiving an accurate diagnosis and treatment (Kornegay & Brame, 2015). Dental health professionals already provide examinations and assessments that could lead to the detection and diagnosis of SDB and OSA, however, educational deficiencies within dental health programs prevent dental health providers from linking oral health assessments with indicators of poor sleep quality (Schroeder & Gurenlian, 2019). The policy statement put forth by the American Dental Association (ADA) recognizes and supports the role of a trained dentist in the diagnosis and management of SDB and OSA (The Role of Dentistry in the Treatment of Sleep Related Breathing Disorders, 2017). As well, the American Dental Hygienists' Associations standards for clinical dental hygiene practice indicate that "the purpose of the dental hygiene process of care is to provide a framework where the individualized needs of the patient can be met; and to identify the causative or influencing factors of a condition that can be reduced, eliminated, or prevented by the dental hygienist" (Standards for Clinical Dental Hygiene Practice, 2016, p.5). Due to the amount of time the dental hygienist spends with patients they have the potential to provide an appropriate setting to conduct OSA screenings (Reibel et al. 2019). Dental hygienists are at the forefront regarding prevention and education, therefore, their involvement in patient education, screening, and management of sleep disorders is needed (Minichbauer et al., 2015).

Based on the results of the aforementioned studies, the hypothesis that incorporating the identification and understanding of OSA and OMD risk factors into the dental hygiene curriculum would allow for the dental hygienist to be better prepared to screen for OSA and make physician referrals, thereby increasing the diagnosis and treatment of OSA is accepted.

Discussion, Conclusions, and Recommendations

Discussion

Dental professionals are in a prime position to recognize the signs and symptoms of obstructive sleep apnea (OSA) and make the appropriate referrals for a medical consultation. Due to the frequency of prophylaxis appointments, the dental office has the potential to provide an appropriate setting to conduct OSA screenings, however, dental hygienists are often lacking OSA knowledge which impacts their attitudes and screening practices during the dental hygiene examination (Reibel, et al., 2019). Most dental hygienists routinely perform extra/intra-oral examinations during dental hygiene appointments, therefore, educating dental hygienists on anatomical variations indicative of OSA would be a practical addition to this routine assessment. Dental hygienists conduct routine medical history reviews, head and neck examinations, extra/intraoral examinations, and blood pressure screenings, therefore, screening for OSA could easily be incorporated into clinical practice (Reibel et al., 2019). The amount of education and training available to dental hygienists is inadequate for identifying the risk factors associated with obstructive sleep apnea, conducting OSA screenings, or making referrals for an OSA consultation, therefore, dental hygienists often do not feel confident screening for OSA or referring patients to their physician. Additionally, the awareness of the relationship between orofacial myofunctional disorders (OMD) and obstructive sleep apnea (OSA) is lacking within the fields of sleep medicine and dental health, and the link between OMD and OSA is lacking from dental hygiene curricula. The aim of this review was to determine if there is a link between orofacial myofunctional disorders and obstructive sleep apnea, if the dental hygienist is provided with the education necessary to identify OSA risks and make appropriate referrals, and if there is a benefit to including the identification of orofacial myofunctional disorders as risk factors for obstructive sleep apnea in the dental hygiene curriculum. It was hypothesized that incorporating the identification and understanding of OSA and OMD risk factors into the dental hygiene curriculum would allow for the dental hygienist to be better prepared to screen for OSA and make physician referrals, thereby increasing the diagnosis and treatment of OSA.

The purpose of this review was to demonstrate the relationship between sleep-disordered breathing and craniofacial development and the vital role dental hygienists play in the early intervention and prevention of obstructive sleep apnea. To accomplish this, a comprehensive review of the literature related to orofacial myofunctional disorders and obstructive sleep apnea was conducted, using the University of Bridgeport Wahlstrom Library databases. The search was focused on sleep apnea, orofacial myofunctional disorders, the link between orofacial myofunctional disorders and obstructive sleep apnea, obstructive sleep apnea and the dental setting, the role of the dental hygienist in obstructive sleep apnea detection, and dental sleep medicine in the dental health curriculum.

Conclusions

The Link Between Orofacial Myofunctional Disorders and Obstructive Sleep Apnea

The findings of this research demonstrate that there is a clear link between orofacial myofunctional disorders and obstructive sleep apnea. Craniofacial features impact the size of the upper airway, and factors that contribute to its narrowing can lead to an increased risk of collapse and consequently, abnormal breathing during sleep (Guilleminault & Akhtar, 2015). Oral breathing and lip hypotonia are characteristics of children with obstructive sleep apnea (OSA) which increases nasal resistance and leads to abnormal tongue position and impaired development and growth of the maxilla and mandible. Mouth breathing during sleep directly affects the position and strength of the tongue and orofacial muscles, thereby causing abnormal airway development and sleep-disordered breathing (SDB), (Villa et al., 2017). Yap et al. (2019) found facial features associated with SDB in children to include a longer and lower anterior face height, a larger maxillo-mandibular angle, a narrower maxillary arch, and an increased frequency of posterior crossbite, Class II molar relationship, and decreased palatal volume. They also found that those with SDB tend to have a shorter and narrower nose, increased facial convexity and steeper mandibular plane angle (Yap et al., 2019). Pirilä-Parkkinen et al. (2009) found children diagnosed with OSA have a significantly increased overjet, a reduced overbite, a narrower maxillary arch, and a shorter mandibular arch. They also found that children who snore have similar, although not as significant, differences (Pirilä-Parkkinen et al., 2009). Children with OSA more often have an anterior open bite and a higher incidence of Class II or asymmetric molar relationship (Pirilä-Parkkinen et al., 2009). As a child’s apnea-hypopnea index (AHI) score increases, the prevalence of mandibular crowding and an anterior open bite increases proportionately (Pirilä-Parkkinen et al., 2009).

Differences in muscular and orofacial functions of children with OSA and primary snoring (PS) are clear. Felicio et al. (2016) found that children with OSA have lower scores in breathing and deglutition, more unbalanced masticatory muscle activity, and reductions in orofacial strength. Guimarães (2009) found muscular dysfunction to be a contributing factor to the origin of OSA due to the contribution of upper airway musculature on upper airway patency. Oropharyngeal exercises proved to be an effective treatment for patients with moderate OSA. Subjects that utilized this treatment demonstrated a significant decrease in OSA severity, decreased AHI scores, neck circumference, snoring frequency, snoring intensity, daytime sleepiness, and sleep quality scores (Guimarães, 2009).

Due to the clear relationship between orofacial myofunctional disorders (OMD) and obstructive sleep apnea (OSA), and the ease with which OSA screening can be incorporated into the dental hygiene examination, the potential for early intervention is significant. Among healthcare providers, dental hygienists are in the ideal position to recognize orofacial myofunctional disorders. If dental hygienists learn to recognize orofacial myofunctional disorders as contributing factors to obstructive sleep apnea, early intervention can be initiated, possibly eliminating the development of OSA in the future, or at minimum, reducing its severity. As Hodge (2015) points out, failure to provide early treatment of orofacial myofunctional disorders can contribute to childhood obesity, juvenile diabetes, and behavior disorders such as ADHD due to their effect on the airway. Hodge (2015) recommends that treatment be initiated as soon as the possibility of a dentoskeletal or airway problem is identified, which in the dental setting can happen as early as four years of age. The dental hygienist, when properly educated on OMD and OSA risk factors, can contribute to early identification, referral, and prompt treatment as suggested.

Obstructive Sleep Apnea Education Provided to Dental Hygienists

The findings of this research demonstrate that dental hygienists do not have adequate education on sleep disordered breathing (SDB), obstructive sleep apnea (OSA), or orofacial myofunctional disorders (OMD) as risk factors for OSA. Additionally, the findings demonstrate that the lack of education and awareness prevents dental hygienists from screening for OSA and feeling confident to make referrals. Dental hygienists, as oral health educators, have a unique opportunity to assess for deviations from normal that may alert the dentist that a sleep referral is indicated. However, dentists and dental hygienists may not be comfortable addressing orofacial myofunctional disorders that can lead to malocclusion and improper facial growth (Fabbie, 2015). Although continuing education courses are available that provide information on the link between orofacial myofunctional disorders and sleep problems in children and adults, Fabbie (2015) suggests that more education is needed to provide timely intervention.

The role of the oral health provider is to bring awareness that sleep disordered breathing and obstructive sleep apnea might exist, provide education regarding the possible concern, refer the patient to an appropriate medical provider, and work with that provider to determine the best treatment options (Schroeder & Gurenlian, 2019). The role of the dental professional should begin with recognition, referral, and management of sleep disorders. Dental hygiene students may be taught to play an active role in the early identification of risk factors for OSA. However, research shows dental professionals do not receive adequate training in sleep disorder screening, and dental hygienists receive minimal training, if any, on recognizing signs within the oral cavity related to sleep-disordered breathing (Kandray et al., 2013). Oral health professionals are in an ideal position to identify sleep quality concerns due to the oral presentation of chronic sleep issues. When poor sleep is suspected, it is the responsibility of oral health professionals to refer patients to a primary care physician for evaluation (Schroeder & Gurenlian, 2019). The tools used to detect sleep disordered breathing (SDB) and obstructive sleep apnea (OSA) can easily be implemented by the dental hygienist into the patient assessment and extra/intraoral examination. This would provide an opportunity for patient education regarding OSA risk factors, potential health conditions, a discussion about treatment options, and referral for physician evaluation (Kornegay & Brame, 2015). Most dental school curricula, however, do not provide adequate content regarding OSA (Kornegay & Brame, 2015). Sleep medicine content in the dental hygiene curricula is lacking even further. Minichbauer et al. (2015) found that dental hygiene programs include little, if any, education on sleep medicine. Programs that include any aspect of sleep medicine in their curricula include less than two hours of content, with the focus on sleep bruxism. The amount of education provided regarding other sleep medicine topics is minimal, with most programs not including snoring or OSA in the curricula at all. Dental hygiene programs located within colleges and universities without a dental school are more likely to cover and spend more time teaching, additional sleep medicine topics compared to dental hygiene programs in a university with a dental school. However, non-university-based programs include very little sleep medicine content (Minichbauer et al., 2015). Minichbauer et al. (2015) also found that the medical relevance of sleep-related breathing disorders is taught more in dental schools than dental hygiene programs. This suggests that most graduates of dental schools begin their career with at least some knowledge of OSA, while the majority of dental hygiene students graduate with very little knowledge at all. Reibel et al. (2019) also found that dental hygienist's knowledge, attitudes, and screening practices related to OSA is insufficient. Although dental hygienists feel it is important to evaluate patients for OSA, their knowledge base and confidence regarding OSA prevalence, diagnosis, risk factors, and treatment is lacking (Reibel et al. 2019).

Additions to the dental hygiene education curriculum and ongoing professional development courses, with the goal of improving the screening and referral of patients presenting with OSA symptoms, is needed (Reibel, et al., 2019). Dental hygienists are beginning their careers without the knowledge or skills required for diagnosing and treating sleep disorders due to the lack of education and training within the dental hygiene curricula (Meaklim et al., 2020). Although dental hygienists are in an ideal position to screen for and recognize signs of obstructive sleep apnea (OSA), their lack of education prevents this needed service from occurring. Due to the lack of education in sleep medicine, healthcare providers start their careers without the sufficient knowledge or skills required for diagnosing and treating sleep disorders (Meaklim et al., 2020). Furthermore, healthcare providers are not currently equipped to address the increasing need for skilled clinicians competent in sleep medicine, as there is a critical gap in sleep medicine training (Meaklim et al., 2020). Meaklim et al. (2020) suggest that if left unaddressed, the cost to health, quality of life, and productivity at the individual and public levels will be significant; therefore, sleep education must be improved for all healthcare students and practicing healthcare providers.

The benefit of including orofacial myofunctional disorder and obstructive sleep apnea risk factors into the dental hygiene curriculum.

The findings of this review demonstrate that there is a clear benefit to including orofacial myofunctional disorders (OMD), as risk factors for obstructive sleep apnea (OSA), into the dental hygiene curriculum. As mentioned previously, dental hygienists, if properly educated, are easily able to identify sleep quality concerns due to the oral presentation of sleep-related breathing disorders. When sleep-disordered breathing (SDB) or obstructive sleep apnea (OSA) is suspected, it is the responsibility of oral health professionals to refer patients to a primary care physician for evaluation (Schroeder & Gurenlian, 2019). Although oral health professionals are already providing examinations and assessments that could lead to the detection and diagnosis of SDB and OSA, deficiencies within dental health education often prevents them from linking assessment findings with indictors of poor sleep quality (Schroeder & Gurenlian, 2019).

Additionally, when sleep quality concerns are suspected, the general lack of communication and support between medical and dental professionals prohibits continuity of care (Schroeder & Gurenlian, 2019).

Due to the root cause of obstructive sleep apnea (OSA) often stemming from improper jaw growth and facial development during childhood, early identification and treatment of orofacial myofunctional disorders will lead to improved OSA management and reduce excess morbidity (Dillow et al., 2016). The education that the dental hygienist currently receives includes obtaining medical and dental histories, identifying abnormal oral structures, detecting oral disease, identifying oral/systemic health links, and identifying signs and symptoms of sleep-related bruxism (Schroeder & Gurenlian, 2019). They routinely provide many chairside health screenings which include screening patients for hypertension, oral cancers, diabetes mellitus, obesity, human papillomavirus, and oral side effects from cancer treatments and medications (Schroeder & Gurenlian, 2019). Dental providers are willing to conduct health screenings if they are well trained in the medical condition and the screening process, and they understand that early detection of oral health and systemic health-related conditions has the potential to reduce medical comorbidities (Schroeder & Gurenlian, 2019). It is necessary for dental health professionals to evaluate for orofacial myofunctional disorders (OMD) in patients during early development and be knowledgeable in recognizing the presence and potential consequences of these disorders (Fabbie, 2015). Kandray et al. (2013) found, however, that additional education and training is needed for dental hygiene students to increase their knowledge and recognition of OSA risk factors and the use of oral assessment methods and techniques. When provided with the necessary training, Kandray et al. (2015) found that dental hygiene students are capable of, and proficient at, screening for OSA. Additionally, Dillow et al. (2016) found that when OSA screenings are conducted in the dental office, dental patients are responsive to recommendations for a physician evaluation. Bewley (2014) found that dental hygienists recognize the importance of screening patients for undiagnosed medical conditions such as OSA, that they are proficient at conducting these screenings, and they can provide patients with a valuable health service by including OSA screening as part of the routine health assessment. Administering screening tools into the dental hygiene examination is not only feasible, but well tolerated by dental patients and encourages preventive health-seeking behavior and reduces healthcare costs (Dillow et al., 2016).

Recommendations

Dental hygienists are in the ideal position to recognize the signs and symptoms of obstructive sleep apnea (OSA) and make the appropriate referrals for a medical consultation. However, they are not provided with the education needed to recognize signs and symptoms and provide screenings, and they lack the confidence to make physician referrals (Reibel, et al., 2019). Due to the clear relationship between orofacial myofunctional disorders (OMD) and obstructive sleep apnea (OSA), and the ease of which OSA screening can be incorporated into the dental hygiene examination, dental hygienists need to be educated in sleep medicine and how the link between OMD and OSA relates to the dental hygiene clinical examination. Based on this review of the literature, future research should address the link between orofacial myofunctional disorders (OMD) and obstructive sleep apnea (OSA) and their relevance to the dental hygiene clinical evaluation. Additional research is needed in several areas. First and foremost, research is needed on the amount of obstructive sleep apnea (OSA) education provided in dental hygiene programs. A thorough review of the literature only revealed one study that specifically evaluated sleep medicine content provided in dental hygiene programs. The current literature is mostly focused on the amount of OSA content provided in dental schools; however, this literature review shows that dental hygienists can, and should, be providing OSA screenings as well. Future research should also focus on whether, and to what extent, myofunctional disorder, as a risk factor for OSA, is taught in the dental hygiene curriculum. Reibel et al. (2019) studied the OSA knowledge, attitudes, and screening practices of Minnesota dental hygienists, however, this research should be conducted nationwide. Kandray et al. (2015) studied dental hygienists' ability to evaluate pharyngeal soft tissues, however, additional research is needed regarding their ability to effectively recognize other signs of OSA, such as OMD, and utilize other screening methods. Furthermore, additional research is needed to determine if including OSA screening into the dental hygiene examination increases OSA diagnosis. Fabbie (2015) states that scientific evidence supports that there is much more involved with orofacial myofunctional disorders (OMD) such as tongue thrust and improper oral rest posture, and that a family history of OSA and snoring is commonly found among children who exhibit these symptoms. She also states that screening for OMD and their associated comorbidities will provide dental patients with care that includes both dental and overall health (Fabbie, 2015). Therefore, additional research is needed to determine if OSA screening during the dental hygiene examination, not only increases OSA diagnosis, but improves health outcomes.

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