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ASSESSMENT OF OROFACIAL MYOFUNCTIONAL PROFILES OF UNDERGRADUATE
STUDENTS IN THE UNITED STATES

by
Rachel A. Yockey

A thesis submitted to the faculty of The University of Mississippi in partial fulfillment of
the requirements of the Sally McDonnell Barksdale Honors College.

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May 2020

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ABSTRACT

Background: Previous research indicates a high prevalence of orofacial myofunctional disorders in the general population. It was further reported that orofacial dysfunction may have wide ramifications, such as teeth displacement, articulation errors, swallowing difficulties, middle ear infections, and frequent colds. The purpose of this study was to examine orofacial myofunctional profiles of undergraduate students in the United States.

Method: The English version of the Nordic Orofacial Test-Screening (NOT-S) was used to assess 55 undergraduate university students (age range: 18 to 23 years). In addition, each participant completed a standard hearing screening, as well as a hearing history questionnaire.

Results: In our study sample, 31% of the undergraduate students who participated in the current research were ‘flagged’ to have an orofacial myofunctional disorder. There was no statistically significant correlation between middle ear infections and orofacial myofunctional disorders as assessed by the NOT-S.

Conclusion: Although 31% of the study participants were ‘flagged’ for an orofacial myofunctional disorder, it appears that orofacial myofunctional disorders might be over-diagnosed depending on the assessment measures used. These findings may have direct implications for clinical practice with respect to assessment and intervention of patients with orofacial myofunctional disorders.

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INTRODUCTION

Orofacial myofunctional disorders are commonly defined as atypical movement patterns within the orofacial structures. They have been reported to include changes of the resting position, appearance, and motility of the lips, cheeks, jaw, and tongue, as well as abnormal function during speech, chewing, and swallowing (de Felício & Ferreira, 2008; Rohrbach et al., 2018). Orofacial myofunctional disorders may also affect the stomatognathic system, which is composed of the bones, muscles, and soft tissue of the mouth and jaw (de Felício, Medeiros, & de Oliveira Melchior, 2012). Together, these structures coordinate actions such as speech, chewing, and swallowing. Furthermore, orofacial myofunctional disorders have often been reported to be accompanied by several secondary characteristics. These secondary characteristics include deficient motor skills, mouth breathing, open bite, difficulty articulating certain sounds, irregular swallowing patterns, respiratory obstruction, deviate mandibular movement, and pushing the tongue past the teeth (Leme, Barbosa, & Gavião, 2012; Serel Arslan, Demir, & Karaduman, 2017; Valera, Trawitzki, & Anselmo-Lima, 2006). A history of middle ear infections and frequent colds have also been associated with orofacial myofunctional disorders (Engel, Anteunis, Volovics, Hendriks, & Marres, 1999; van Bon, Zielhuis, Rach, & van den Broek, 1989). These symptoms are potentially threatening as they can disrupt normal growth and development and lead to additional health problems, as well as a lower quality of life (Leme, Barbosa, & Gavião, 2013). In addition, many disorders appear to be frequently comorbid with orofacial myofunctional disorders. It has been indicated that certain populations showing problems in the areas of dentition, orthopedics, articulation, and sleep, may also show signs and symptoms of orofacial dysfunction (de Felício et al., 2016; Korbmacher, 2005; Stahl, Grabowski, Gaebel, & Kundt, 2006; Wadsworth, 1998).

The cause of orofacial myofunctional disorders remains unclear, however many of their secondary characteristics are possible factors affecting or being affected by the disorder. For example, tongue thrusting and persistent infantile swallowing, mouth breathing, orofacial muscular imbalance, and sucking and chewing habits past the age of three can alter the structure and function of the orofacial system (Rohrbach et al., 2018; Serel Arslan et al., 2017). It has been suggested that extended use of a pacifier may lead to the development of orofacial myofunctional disorders (Verrastro, Stefani, Rodrigues, & Wanderley, 2006). These habits may lead to compensatory muscle behaviors that can further aggravate the stomatognathic system resulting in orofacial myofunctional disorders. If underlying problems are left untreated, future treatment for orofacial myofunctional disorders may be ineffective (Smithpeter & Covell, 2010). For this reason, a multi-disciplinary team consisting of speech-language pathologists, doctors, dentists, and orthodontists is often used to assess and treat orofacial myofunctional disorders (Paul-Brown & Clausen, 1999). In general, the accepted prevalence in the general population is estimated to be approximately 38% (Scarponi et al., 2018; Wadsworth, 1998). However, despite its high relevance, little research has been done on the actual prevalence of orofacial myofunctional disorders within the general population.

Dentition and Malocclusion

Orofacial myofunctional disorders are strongly related to dentition. Among children, the prevalence of orofacial myofunctional disorders appears to significantly increase in the transition from primary dentition (i.e., the first stage in which only primary teeth are visible) to mixed dentition (i.e., where both primary and permanent teeth are visible; Stahl et al., 2006). In a study conducted on the prevalence of malocclusion (i.e., improper alignment of the teeth) and orofacial

dysfunction, Stahl et al. (2006) found that orofacial dysfunction occurred in 62% and 81% in primary and mixed dentition groups respectively. The frequency of orofacial myofunctional disorders was significantly higher in children with various types of malocclusion and frontal open bite, and there was a significant increase in malocclusion and habitual open mouth from primary to mixed dentition (Stahl et al., 2006). Interestingly, this transition period is also the age in which children are most affected by habitual mouth breathing (Valcheva, Arnautska, Dimova, Ivanova, & Atanasova, 2018), a habit that is reportedly a factor in the prevalence of malocclusion in children (Souki et al., 2009; Valcheva et al., 2018).

Other aspects of orofacial dysfunction seem to impact dentition as well. Dentists and orthodontists are especially concerned with tongue thrusting and improper resting position of the tongue due to the resulting pressure exerted on the teeth (Hanson & Andrianopoulos, 1982). This muscular imbalance and pressure can cause misalignment and malocclusion and can make treatment more difficult (Smithpeter & Covell, 2010). However, treating underlying causes may help. In a study examining the relapse of anterior open bites, Smithpeter and Covell (2010) found that orthodontic treatment with orofacial myofunctional therapy was significantly more effective in maintaining closure of open bites than orthodontic treatment alone.

Additionally, orofacial myofunctional disorders can negatively impact mastication (i.e., chewing) which is a vital orofacial function (Marquezin, Kobayashi, Montes, Gavião, & Castelo, 2013). In a study conducted by Marquezin et al. (2013), masticatory performance was assessed along with orofacial dysfunction. By measuring the median particle size of chewed food, Marquezin et al. (2013) discovered that patients with a more severe score on a screening for orofacial myofunctional disorders displayed poorer masticatory performance than those who

showed no signs of orofacial myofunctional disorders. This research is particularly important because it shows that mastication is directly related to dietary intake, meaning orofacial myofunctional disorders may limit food choices and lead to poorer nutrition (Marquezin et al., 2013).

Temporomandibular Disorders

Similar to problems with dentition, orofacial myofunctional disorders are also related to temporomandibular disorders (de Felício et al, 2012; Ferreira, da Silva, & de Felício, 2009; Kobayashi, Gavião, Montes, Marquezin, & Castelo, 2014). Temporomandibular disorders refer to the disorders of the jaw muscles and temporomandibular joints. Although a relationship appears to exist, it is unclear which precedes the other. For instance, orofacial myofunctional disorders may disequilibrate the temporomandibular joint which functions to connect the lower jaw to the skull and allows for the jaw to move (de Felício et al., 2012; Ferreira et al., 2009).

According to Pizolato, Freitas-Fernandes, and Gavião (2013), children with open lip posture are six times more likely to develop temporomandibular disorder (Pizolato et al., 2013).

Alternatively, disorders of the temporomandibular joints can result in compensatory muscle actions causing orofacial myofunctional disorders (de Felício et al., 2012; Ferreira et al., 2009).

For example, Williamson, Hall, and Zwemer (1990) discovered that patients with temporomandibular disorder tend to have more deviant swallowing patterns compared to patients without temporomandibular disorder. These deviant patterns, such as a tongue-thrust swallow, may be due to pain and/or limited movement of the temporomandibular joint. These compensations may further aggravate symptoms of orofacial myofunctional disorders and lead to more severe problems, such as malocclusion (Williamson et al., 1990).

To expand upon this relationship, research has attempted to determine the prevalence of orofacial myofunctional disorders in patients with temporomandibular disorder. For example, Ferreira et al. (2009) sought to determine the frequency and degree of orofacial myofunctional disorders using subjects from a data bank of dental records at the orofacial pain and TMD clinic. Subject criteria included a diagnosis of temporomandibular disorder as well as a completed visual orofacial inspection. Results indicated that most subjects with temporomandibular disorder had some degree of orofacial myofunctional disorders and suggested that approximately 70% of the subjects showed a need for orofacial myofunctional therapy. However, because the data all came from dental records and were not evaluated in person, it is difficult to determine the exact extent and degree of the patients' symptoms. Therefore, these results should be taken with caution.

In order to build on Ferreira et al.'s (2009) findings, subsequent studies were conducted by de Felício et al. (2012) and Kobayashi et al. (2014). The purpose of these studies was to compare the stomatognathic system between patients with and without temporomandibular disorder using screenings for orofacial myofunctional disorders. The studies yielded similar results in which the scores indicating orofacial myofunctional disorders were more severe in patients with temporomandibular disorder than control patients (de Felício et al., 2012; Kobayashi et al., 2014). De Felício et al. (2012) found significant differences in facial symmetry, jaw posture and mobility, deglutition, and mastication between the two groups. Kobayashi et al. also found a higher proportion of facial asymmetry in subjects with temporomandibular disorder, as well as a higher proportion of deviant lip positions and the presence of a gag reflex when brushing the teeth.

Cleft Palate

Orofacial myofunctional disorders also appear to be more prevalent in patients with cleft lip or palate (Mariano et al., 2019). Cleft lip and cleft palate are birth defects caused by a lack of fusion of the lip or mouth. Both cleft lip and cleft palate may disrupt the integrity of the stomatognathic system which may lead to impaired orofacial function. There has been more research in recent years on this topic, but much of it is focused mainly on speech, and more research is needed to confirm their results (Graziani, Berretin-Felix, & Genaro, 2019). However, current research does suggest a statistically significant difference in the orofacial myofunctional characteristics between cleft and non-cleft patients. For example, Mariano et al. (2019) looked for differences among these groups in a screening for orofacial myofunctional disorders and found that the groups differed greatly on many domains, particularly breathing, chewing and swallowing, and dryness of the mouth. Surprisingly, all domains on the examination portion of the screening were significantly higher in cleft patients than non-cleft patients. These results suggest a higher degree of orofacial dysfunction in cleft patients than non-cleft patients (Mariano et al., 2019). A similar study was conducted by Sundell and Marcusson (2019) which yielded comparable results on a sample of children. Again, patients with cleft lip or palate scored more severely on a screening for orofacial myofunctional disorders than typical controls. According to the results, the most impaired domains for children with either cleft lip or palate were in the areas of speech, face at rest, and facial expression (Sundell & Marcusson, 2019).

Speech and Language

Because speech and language disorders are commonly affected by orofacial abnormalities (Bigenzahn, Fischman, & Mayrhofer-Krammel, 1992; Wadsworth, 1998), it is expected that

children in this population will show a higher prevalence of orofacial myofunctional disorders. In a study of children diagnosed with speech and language disorders, Wadsworth (1998) sought to determine both the prevalence of orofacial myofunctional disorders, as well as the correlations between various aspects of the disorder. The results of the study suggests the prevalence to be approximately 50% in school-aged children receiving speech and language services at school (Wadsworth, 1998). More specifically, it was found that tongue thrust swallow (51%), open bite (24%), abnormal resting posture of the tongue (59%), and open mouth posture (33%) were commonly observed in the sample. Furthermore, the relationships between these variables were all found to be statistically significant, and, compared to all children receiving speech and language services, tongue thrust swallow and open bite were more prevalent among those with articulation disorders (Wadsworth, 1998). Similar results have also been found in a longitudinal study of tongue thrusting (Hanson & Andrianopoulos, 1982). Following 225 children from birth to eight years old, Hanson and Andrianopoulos (1982) also found a positive correlation between the retention of tongue thrust and dentalization of speech sounds.

Of all the speech sounds, individuals with orofacial myofunctional disorders often demonstrate the most difficulty articulating the /t/, /d/, /l/, /n/, /s/, and /z/ phonemes (Bigenzahn et al., 1992). However, there is evidence that orofacial myofunctional therapy can be used to correct these errors (Bigenzahn et al., 1992; Smithpeter & Covell, 2010). For example, Bigenzahn et al. (1992) found that myofunctional therapy resulted in normal articulatory production for 66% of patients with orofacial dysfunctions affecting speech. This information may be beneficial for school based speech-language pathologists, who, according to research, should expect to see a high prevalence of orofacial myofunctional disorders in their caseload

(Wadsworth, 1998). These findings further support the benefits of a multi-disciplinary approach to treating orofacial myofunctional disorders.

In particular, orofacial myofunctional disorders affecting speech have been found among children presenting with a lisp (Christensen & Hanson, 1981). Lisps usually refer to a person's difficulty pronouncing /s/ and /z/ due to incorrect tongue placement (Hitos, Arakaki, Solé, & Weckx, 2013). According to Bigenzahn et al. (1992), lisps are often associated with tongue thrusting, deviate swallowing, and orofacial muscular imbalance. Furthermore, adequate lip strength and complete lip closure are necessary in the utterances of fricatives such as /s/ and /z/ (Bigenzahn et al., 1992). In fact, effective lisp treatment requires additional treatment of any underlying orofacial myofunctional components. For example, in Bigenzahn et al.'s (1992) study, patients with orofacial dysfunctions affecting speech were treated using myofunctional therapy along with articulation training. The results of the research showed that the correction of lisps was highly correlated with increased lip strength when compared to those with persistent speech deficits (Bigenzahn et al., 1992).

Respiration

Furthermore, orofacial myofunctional disorders are believed to be connected to an individual's primary breathing pattern. The ability to breathe through the nose is vital for optimal growth and development. Nasal respiration allows for the warming and purification of air before entering the lungs and sustains normal stomatognathic function (Hitos et al., 2013). When nasal respiration is obstructed, compensatory modifications are made, leading to disordered breathing. Disordered breathing refers to any breathing pattern in which respiration is not solely through the nose (Abreu, Rocha, & Guerra, 2008). Disordered breathing, namely mouth breathing, may

underlie orofacial myofunctional disorders, result from orofacial myofunctional disorders, or co-occur with orofacial myofunctional disorders. Daytime mouth breathing is one common type of disordered breathing, with symptoms including open lips, drooling, low tongue position, dry mouth, and nasal congestion (Abreu et al., 2008; Harari, Redlich, Miri, Hamud, & Gross, 2010). At night, sleep disordered breathing is a collective term used to describe a spectrum of conditions such as mouth breathing, primary snoring, and obstructive sleep apnea. These conditions can potentially alter the stomatognathic system and lead to abnormal functioning (Harari et al., 2010; Lundeborg, McAllister, Graf, Ericsson, & Hulcrantz, 2009).

Postural Alterations and Mouth Breathing

Significant correlations have been found between postural alterations and orofacial function (Korbmacher, 2005; Vig, Phillips, & Showfety, 1980). In fact, a high prevalence of orofacial myofunctional disorders have been noted among children being referred to manual therapists for postural impairments (Korbmacher, 2005). Korbmacher (2005) assessed orofacial myofunctional disorders in children with asymmetry of the posture and locomotion apparatus, specifically examining orthopedic posture and function, as well as open mouth posture, tongue dysfunction, incompetence of lips, habit history, articulation disorders, and reclined head position (Korbmacher, 2005). The results of this study found that 70% of these patients presenting asymmetry of the upper cervical spine revealed orofacial myofunctional dysfunction (Korbmacher, 2005). However, it is unclear how orofacial myofunctional disorders were defined in this study and it is possible that its findings may not be generalized to patients with postural alterations from other clinics.

Some prior research indicates that postural alterations may be related to mouth breathing. Krakauer and Guilherme (2000) identified a relationship between mouth breathing and postural alterations by grouping children based on their breathing pattern and photographing them in frontal, lateral, and dorsal positions. Analysis of these photos revealed that children between the ages of five and ten years present postural alterations despite either mouth breathing or nasal breathing. However, past the age of eight, differences in posture can be seen between children who breathe through their nose and those who breathe through their mouth. Krakauer and Guilherme (2000) concluded that children older than eight improve their posture as they grow, but mouth breathing may jeopardize this process (Krakauer & Guilherme, 2000). These findings may be explained by Vig et al. (1980). In this study, researchers induced total nasal obstruction in college students while analyzing postural control. The results showed a statistically significant progressive extension of the head (Vig et al., 1980). However, since nasal obstruction was only induced for two hours, it is unknown whether this postural adaptation would persist following prolonged obstruction. Because mouth breathing and respiratory obstruction is a common feature among individuals with orofacial myofunctional disorders, future research may wish to further examine this observation.

Craniofacial Alterations and Mouth Breathing

Chronic mouth breathing can also lead to craniofacial alterations (Harari et al., 2010). It has been argued that nose breathing is essential for the development of craniofacial structures (Andrada e Silva, Marchesan, Ferreira, Schmidt, & Ramires, 2012; Harari et al., 2010). According to Harari et al. (2010), mouth breathing results in a lowered position of the tongue and mandible, departed lips, and decreased muscle tone in the orofacial complex, thus creating

disharmony in growth and development. To confirm this hypothesis, Harari et al. (2010) performed a retroactive study analyzing the anatomical differences between mouth-breathing and nose-breathing pediatric orthodontic patients. The results indicate that individuals who breathe through their mouth exhibit a backward and downward rotation of the mandible resulting in a long, thin face, an increased overjet, and a higher palatal plane. In another study, Andrada e Silva et al. (2012) found that the majority of mouth breathing children had a semi-open mouth posture (33%), lowered lower lip tone (80%), low-lying tongue posture (58%), and a lowered tongue tone (53%). However, both tongue and lip mobility appeared normal (Andrada e Silva et al., 2012).

Obstructive Sleep Apnea

Respiratory obstruction and mouth breathing are also strongly related to obstructive sleep apnea (de Felício et al., 2016; Valera et al., 2006). Multiple studies have shown that orofacial myofunctional disorders are common among both children and adults with obstructive sleep apnea (de Felício et al., 2016; Folha, Valera, Giglio, Voi Trawizki, & de Felício, 2013). This upper airway obstruction is often caused by an increase in the size of an individual's tonsils and adenoids (de Felício et al., 2016). The enlargement of these structures can lead to functional maladaptations such as mouth breathing, which, in turn, can cause changes in neuromuscular function and position of the lips, jaw, and tongue. Consequently, problems with breathing, mastication, deglutition, and phonation may occur (de Felício et al., 2016; Valera et al., 2006).

Compared to typically developing peers, children with adenotonsillar hypertrophy present a higher degree of oral motor dysfunction (Lundeborg et al., 2009; Valera et al., 2006). Due to this phenomenon, Valera et al. (2006) analyzed orofacial function in children before and after

adenotonsillar surgery. The results of the study describe a spontaneous improvement in oral motor function post-surgery with most improvement occurring in the first six months but continuing for up to two years. However, only partial normalization was ever achieved (Valera et al., 2006).

In order to improve the orofacial myofunctional status for these patients further, many researchers recommend orofacial myofunctional therapy (Kayamori & Bianchini, 2017; Valera et al., 2006). According to Kayamori and Bianchini (2017), orofacial myofunctional therapy is used in these patients to correct abnormal breathing patterns and strengthen the oropharyngeal muscles to reduce collapsing of the airway during sleep. In a systematic review of the literature on the effectiveness of orofacial myofunctional therapy in adults with obstructive sleep apnea, Kayamori and Bianchini (2017) conclude that a three-month program of orofacial myofunctional therapy reduces symptoms and improves the physiological parameters of obstructive sleep apnea and snoring.

Middle Ear Infections and Colds

It has also been indicated that middle ear infections and frequent colds may be a factor in orofacial myofunctional disorders. Although data on the direct relationships between orofacial myofunctional disorders and these pathologies are scarce, correlations have been made between its symptoms, specifically mouth breathing (Bianchini, Guedes, & Hitos, 2008; van Bon et al., 1989). In fact, van Bon et al., (1989) suggests that habitual mouth breathing is one cause for otitis media with effusion, a common precursor or side-effect of middle ear infections, in 20% of cases in Dutch preschool children. Additionally, in this same population, it was found that a history of frequent common colds at two years of age was more prevalent in children with a habit

of mouth breathing (31%) than intermediate breathing (29%) and nose breathing (26%; van Bon et al., 1989).

Bianchini et al. (2008) also found correlations between mouth breathing and indicators for middle ear infections. The researchers found that although most individuals who breathe through their mouth have normal hearing, certain etiologies make those who breathe through their mouth more vulnerable to middle ear infections. Four etiologies were studied in relation to hearing ability: 1) tonsils hypertrophy- patients with obstruction due to enlargement of the palatine tonsils and/or pharyngeal tonsils (adenoids); 2) atopy- patients with swelling of the nasal mucosa in allergic cases; 3) atopy associated with hypertrophy; and 4) functional patients whose mouth breathing is of unknown cause. Normal hearing was observed in 80% of atopic individuals, 62% of atopic individuals who had hypertrophy, 58% of individuals with hypertrophy, and in all individuals with a functional etiology (Bianchini et al., 2008). Results of the study indicate a higher prevalence of hearing disorder among individuals with hypertrophy, with many showing signs of fluid in the middle ear. It is likely that these etiologies lead to malfunction of the eustachian tube, or, as with enlarged adenoids, prevention of airflow to and from the middle ear, making affected individuals vulnerable to middle ear infections and hearing loss (Bianchini et al., 2008).

Because breathing through the nose acts to warm and purify the air entering the lungs, breathing through the mouth can also lead to respiratory tract infections, such as common colds. In a study of healthy preschool children, Van Cauwenberge and Derycke (1983) analyzed the relationship between nasal and middle ear pathology. The study asked parents of preschool children to report the annual frequency of common colds and middle ear infections in their

children in the last two years, as well as answer questions related to their children's breathing habits at night. Data analysis discovered a highly statistically significant trend between the annual incidence of common colds and middle ear infections (Van Cauwenberge & Derycke, 1983). However, these studies cannot confirm a direct relationship to orofacial myofunctional disorders.

Prevalence of Orofacial Myofunctional Disorders

As outlined above, the prevalence of orofacial myofunctional disorders have been studied in various sub-groups of the population (Korbmacher, 2005; Leme et al., 2012; Wadsworth, 1998; See Table 2). Current research suggests that factors such as age, physical abnormalities, and neurogenic disorders affect the prevalence of orofacial myofunctional disorders (Bergendal, Bakke, McAllister, Sjögreen, & Åsten, 2014). For example, Stahl et al. (2006) found that a child's age affects its prevalence based on their stage of dentition. Also, orofacial myofunctional disorders are a common feature in many genetic and congenital disorders (Bergendal et al., 2014). Bergendal et al. (2014) reviewed data from various studies that used the Nordic Orofacial Test-Screening in their methods. The results of the review indicate that individuals diagnosed with disorders such as Parkinson's disease, Prader Willi syndrome, and Treacher Collins syndrome demonstrate more orofacial myofunctional impairment compared to healthy control subjects.

However, orofacial myofunctional disorders have also been indicated to occur in the absence of any neurological or genetic component. According to the literature, the common agreement on the prevalence in the general population is about 38% (Scarponi et al., 2018; Wadsworth, 1998). Compiling the results of several studies comparing individuals with orofacial

myofunctional disorders to healthy controls revealed that, for adults, dysfunction occurred most often in the domains of *Breathing* and *Habits*, suggesting a need for a more detailed evaluation in these areas (Bergendal et al., 2014). In addition to adults, orofacial myofunctional disorders have also been studied in typically developing children (Cavalcante-Leão, Todero, Ferreira, Gavião, & Fraiz, 2017). For example, McAllister and Hammarström (2014) note that the prevalence of orofacial dysfunction steadily decreases as age increases in children between the ages of three and seven. Although, Cavalcante-Leão et al. (2017) also found that children in Brazil between the ages of eight and ten have a significantly high prevalence of orofacial disorders. According to researchers in orthodontics, orofacial myofunctional disorders are relatively common in this age population (Stahl et al., 2006).

Statement of Problem

Previous research indicates a high prevalence (38%) of orofacial myofunctional disorders in the general population. Orofacial myofunctional disorders have been shown to have wide ramifications such as teeth displacement, articulation errors, and swallowing difficulties (Leme et al., 2012; Serel Arslan et al., 2017; Valera et al., 2006), as well as middle ear infections and frequent colds (Engel et al., 1999; van Bon et al., 1989). Despite its high relevance, the majority of studies on orofacial myofunctional disorders are mostly concentrated throughout Europe and Brazil (Bakke, Bergendal, McAllister, Sjögreen, & Åsten, 2007; Cavalcante-Leão et al., 2017; de Felício et al., 2012; Leme et al., 2012). However, research on the prevalence of orofacial myofunctional disorders in the United States is limited. Considering the reported high prevalence in other countries, identifying the prevalence of orofacial myofunctional disorders in the United States within different populations and identifying associated symptoms might ultimately

contribute to improved service and treatment outcomes. In the long-term, this could improve the general quality of life for individuals with orofacial myofunctional disorders.

Current Study

The purpose of the current study was to examine the prevalence of orofacial myofunctional disorders among undergraduate university students in the United States. Based on findings of previous research on the prevalence of orofacial myofunctional disorders in the general population, this study aimed to address the following research questions:

1. What is the prevalence of orofacial myofunctional disorders in undergraduate university students?

We hypothesize that approximately 38% of undergraduate students will show signs of orofacial dysfunction.

2. What are some of the secondary symptoms of students presenting with orofacial myofunctional disorders?

We hypothesize that individuals who show a prevalence of orofacial myofunctional disorders will also present with a variety of the following symptoms: oral habits, increased or decreased oral sensitivity, abnormal breathing patterns, chewing and swallowing difficulties, speech problems, asymmetry of the face, deviant lip or tongue position, and a history of middle ear infections.

METHODS

Participants

In total, 55 students from the University of Mississippi were recruited to participate in this study. Participants included 13 male and 42 female undergraduate university students between the ages of 18 and 23 years ($M = 21.0$, $SD = 0.962$). Inclusion criteria required all students to be considered typically developing with no history of mental or physical illness. The sample consisted solely of English native speakers. Participant characteristics are provided in Figures 1 and 2 (see appendix).

Procedures

All procedures for this research study were reviewed and approved by the Institutional Research Board (IRB) of the University of Mississippi. The participants were recruited by contacting organizations across campus and online advertising (see Appendix A). Prospective participants received an information sheet (see Appendix B) which contained details of the study. Participants were also invited to discuss the project beforehand with one of the researchers present during data collection. Students who elected to participate in the study were asked to sign a consent form and complete a screening at the South Oxford Center. The screening involved: 1) a brief questionnaire regarding the subject's medical history (e.g., family history of hearing loss, middle ear infections, etc.), 2) a hearing screening, and 3) an orofacial screening.

Hearing Screening

Participants were asked to fill out a questionnaire regarding their medical history of middle ear infections and hearing loss as well as its associated factors (see Appendix C). Next, an otoscopy was performed on each participant which allowed the examiner to view the participant's ear canal and eardrum. The results of the otoscopy were either "pass" or "refer." Finally, a standard hearing screening was performed on each participant. The screening consisted of a series of tones presented at 25dB and tested at 1,000; 2,000; and 4,000 Hz to determine each individual's hearing level. The subjects were told to raise their right hand when they heard a sound in their right ear, and their left hand when they heard a sound in their left ear. The outcome of the screening resulted in either "pass," "rescreen," or "refer." Due to the nature of the study, participants who failed the hearing screening were still included in data analysis. The hearing screening was conducted due to the previously reported increased occurrence of middle ear infections in people with symptoms of orofacial myofunctional disorders.

Orofacial Screening

There are currently three validated protocols for evaluating orofacial myofunctional disorders: 1) The Nordic Orofacial Test- Screening (NOT-S), 2) the Orofacial Myofunctional Evaluation with Scores (OMES), and 3) the Expanded Protocol of Orofacial Myofunctional Evaluation with Scores (OMES-E; Bakke et al., 2007; de Felício et al., 2012; de Felício, Folha, Ferreira, & Medeiros, 2010). For this study, participants were screened using the NOT-S because it is quick and easy to administer as a screening. The NOT-S has been validated for the use in adults and children aged three and older (Bakke et al., 2007; Bergendal et al., 2014; Leme et al., 2012).

The NOT-S consists of a structured interview and a clinical examination, each assessing six domains of orofacial function. For the interview this included: 1) Sensory Function, 2) Breathing, 3) Habits, 4) Chewing and Swallowing, 5) Drooling, and 6) Dryness of the Mouth. Within each domain, participants were asked to answer “yes” or “no” to each question (see Appendix D). The questions are designed to investigate symptoms such as hypersensitivity and reduced sensitivity in the oral cavity, weakened breathing muscles, bite deviation and malocclusion, and chewing and swallowing difficulties.

During the examination, participants were asked to perform a task related to each item assessed. The exam was used to evaluate the following characteristics (see Appendix E):

1) *Face at Rest.* This required participants to watch a picture for one minute while the clinician examined asymmetry of the skeletal and soft tissue, deviant lip and tongue position, and involuntary movement.

2) *Nose Breathing.* This required participants to close their mouth and take five deep breaths through their nose.

3) *Facial Expression.* This required participants to close their eyes tightly, then show their teeth, and then try to whistle.

4) *Masticatory Muscle and Jaw Function.* This required participants to bite hard on their back teeth and open their mouth as wide as possible.

5) Oral Motor Function. This required participants to stick out their tongue as far as possible, lick their lips, “blow up” their cheeks and hold for at least three seconds, and open their mouth wide and say “ah, ah, ah!”

6) Speech. This required participants to count out loud to ten and say “pataka-pataka-pataka.”

All of these above-mentioned tasks are specifically designed to investigate symptoms such as mouth breathing, facial deformity, tonal deviation, muscle weakness, temporomandibular joint problems, and speech and language disorders.

Scoring on the NOT-S is based on a dichotomous judgment whether a functional impairment is present. (de Felício et al., 2012). A “yes” in any category of a domain receives a score of ‘1’, while a “no” in all categories of a domain receives a score of ‘0’ (Bakke et al., 2007). At the end of the screening, the total marks of each domain are totaled. Thus, the highest possible score is ‘12’, suggesting severe orofacial dysfunction, while the lowest possible score is ‘0’, suggesting completely normal function (Bakke et al., 2007). Subjects with a score of three or higher were considered to fail the screening and were referred for further examination.

RESULTS

All participants passed the hearing screening. There was no statistically significant correlation between middle ear infections and the NOT-S score, $r_{pb} = .218$, $p = .110$. The mean NOT-S score was 1.87 (SD 1.306; range: 0-5). Specifically, within this subject group, the total NOT-S score was 0 in 16% of the sample (9 subjects), 1 in 24% (13 subjects), 2 in 29% (16 subjects), 3 in 24% (13 subjects), 4 in 2% (1 subject), and 5 in 6% (3 subjects). The results are displayed in Figure 3 (see appendix), and the specific dysfunction across all assessed domains are listed in Table 1.

Domain	Typical	Atypical
NOT-S interview	%	%
I Sensory function	82	18
II Breathing	78	22
III Habits	35	65
IV Chewing and swallowing	67	33
V Drooling	89	11
VI Dry mouth	76	24
NOT-S Examination	%	%
1 Deviation with the face at rest	93	7
2 Nose breathing	100	0
3 Facial expression	100	0
4 Masticatory muscle and jaw function	91	9
5 Oral motor function	100	0
6 Speech	100	0

Table 1. *Percentage of Dysfunction Across Domains*

NOT-S Interview

The mean NOT-S score on the interview portion was 1.71 (SD 1.197; range: 0-5). The total interview score was 0 in 18% of the sample (10 subjects), 1 in 26% (14 subjects), 2 in 31% (17 subjects), 3 in 20% (11 subjects), 4 in 4% (2 subjects), and 5 in 2% (1 subject).

Sensory Function: Out of 55, 10 subjects (18 %) showed some sensory dysfunction compared to 45 subjects (82%) who did not show any atypical behaviors.

Breathing: Out of 55, 12 subjects (22 %) showed some sensory dysfunction compared to 43 subjects (78%) who did not show any atypical behaviors.

Habits: Out of 55, 36 subjects (65 %) showed some sensory dysfunction compared to 19 subjects (35%) who did not show any atypical behaviors.

Chewing and Swallowing: Out of 55, 18 subjects (33 %) showed some sensory dysfunction compared to 37 subjects (67%) who did not show any atypical behaviors.

Drooling: Out of 55, 6 subjects (11 %) showed some sensory dysfunction compared to 49 subjects (89%) who did not show any atypical behaviors.

Dryness of the Mouth: Out of 55, 13 subjects (24 %) showed some sensory dysfunction compared to 42 subjects (76%) who did not show any atypical behaviors.

NOT-S Examination

The mean NOT-S score on the examination portion was 0.16 (SD 0.373; range: 0-1). The total interview score was 0 in 84% of the sample (46 subjects), and 1 in 16% (9 subjects).

Face at Rest: Out of 55, 4 subjects (7%) showed some sensory dysfunction compared to 51 subjects (93%) who did not show any atypical behaviors.

Nose Breathing: Out of 55, all subjects showed typical nose breathing function.

Facial Expression: Out of 55, all subjects showed typical facial expression function.

Masticatory Muscle and Jaw Function: Out of 55, 5 subjects (9%) showed some sensory dysfunction compared to 50 subjects (91%) who did not show any atypical behaviors.

Oral Motor Function: Out of 55, all subjects showed typical oral motor function.

Speech: Out of 55, all subjects showed typical speech function.

DISCUSSION

This study assessed orofacial myofunctional disorders in undergraduate students in the United States aged 18 to 23 years. Specifically, it was aimed to evaluate the prevalence of these disorders as previously done in other countries. Following indicated high prevalence of orofacial myofunctional disorders in the general population, as reported by other researchers (Bergendal et al., 2014; Cavalcante-Leão et al., 2017), it was hypothesized that approximately 38% of undergraduate students would show some signs of a orofacial dysfunction. It was further hypothesized that individuals who show a prevalence of orofacial myofunctional disorders also present with a variety of the following symptoms: oral habits, increased or decreased oral sensitivity, abnormal breathing patterns, chewing and swallowing difficulties, speech problems, asymmetry of the face, deviant lip or tongue position, and a history of middle ear infections.

In our study sample, 31% of the undergraduate students who participated in the current research were ‘flagged’ to have an orofacial myofunctional disorder. Although this is a significant portion of the general population, this number is lower than what was reported in other studies. Previous research suggests that the prevalence of orofacial myofunctional disorders in the general population is 38%, but this estimate may be high as there have been a limited number of studies conducted on the topic (Scarponi et al., 2018; Wadsworth, 1998). The NOT-S was quick and easy to use, taking approximately five minutes to administer to each subject. However, the NOT-S is only a screening tool and its results must be taken with caution. For example, the NOT-S is better at correctly identifying individuals with orofacial myofunctional disorders (sensitivity) than it is at correctly identifying individuals without orofacial myofunctional disorders (specificity); therefore, the test runs a risk of false positives (Bakke et

al., 2007). Those who developed the NOT-S note that the sensitivity of the test is 0.96 while the specificity is only 0.63 (Bakke et al., 2007). This is important to keep in mind when evaluating the prevalence of orofacial myofunctional disorders in the general population.

Each domain on the NOT-S considered a different area related to orofacial function. Majority of subjects had at least one domain affected with most dysfunction occurring in *Habits* and *Chewing and Swallowing*. Previous studies on both adults and children report similar findings (Bakke et al., 2007, 2011; Cavalcante-Leão et al., 2017; Leme et al., 2012). However, children also tend to report problems with *Oral Motor Function* and *Speech* (McAllister & Hammarström, 2014). Dysfunction in the *Habits* domain may indicate possible bite deviation/malocclusion, which in turn may cause other symptoms of orofacial myofunctional disorders (Bakke et al., 2007; Stahl et al., 2006). Similarly, dysfunction in the domain of *Chewing and Swallowing* may suggest deviant swallowing patterns or chewing difficulties, indicative of an incohesive stomatognathic system or possible temporomandibular disorder (Bakke et al., 2007).

Previous research has suggested a relationship between middle ear infections and orofacial dysfunction (Bianchini et al., 2008; van Bon et al., 1989); however, our results indicate otherwise. In our study sample, there was no correlation between those who presented with a history of middle ear infections and their results on the NOT-S.

An important finding of the current study was that even though 31% of the study sample were flagged for having a disorder, orofacial myofunctional disorders might be over-diagnosed in certain populations depending on the screening measures used. Interestingly, there was significantly more dysfunction flagged in the interview portion of the screening compared to the

examination portion. In fact, the only affected domains on the examination were *Masticatory Muscle and Jaw Function* and *Face at Rest*. The total NOT-S score, which the recommendation for a follow up is based on, is a combination of both the interview as well as the examination portions of the screening. However, the 31% who were flagged for needing further evaluation had scores that came almost entirely from the interview questionnaire. This may be due to the nature of some of the questions. For example, the question, “do you snore much when you sleep?” may be misleading as individuals may snore without having any obstruction relating to orofacial function. Similarly, 65% of the participants in the current research displayed dysfunction in the *Habits* domain, but behaviors such as nail biting and cheek sucking are not necessarily associated with orofacial myofunctional disorders.

These results raise the question of whether these tests really measure what they are meant to (i.e., validity). This is in line with critique from some researchers questioning the prevalence of orofacial myofunctional disorders and measures used to assess patients. While some researchers have suggested for orofacial myofunctional disorders to cause a variety of disorders (Korbmacher, 2005; Leme et al., 2012; Wadsworth, 1998), others question the evidence of their correlations (Lof, 2008). For example, Lof and Watson (2010) argue that nonspeech oral motor exercises, such as the ones used in orofacial myofunctional therapy, are not suitable techniques for treating articulation disorders. This is in direct contrast with Bigenzahn et al. (1992) and Ray (2002), who believe in the positive effects of these exercises on speech and language.

Clinical Implication

The current findings may have direct implications for clinical practice with respect to assessment and intervention of patients with orofacial myofunctional disorders as well as other

disorders. With respect to our data, people might be referred for or receive myofunctional services who do not actually require them. As a result, this could lead to needless time and money spent on therapy.

However, although myofunctional services may not be beneficial for all populations, treatment may still be valid for working within certain disciplines. Orofacial myofunctional disorders may be over-diagnosed in the general population, but they may be more prevalent in certain subgroups, especially with respect to dentition and malocclusion. In particular, characteristics of orofacial myofunctional disorders have been shown to change the position of the teeth (Hanson & Andrianopoulos, 1982; Stahl et al., 2006). This could become problematic for dentists and orthodontists who are trying to treat patients who have these underlying causes. For example, misalignment or malocclusion may relapse after treatment if the underlying cause such as tongue thrusting or improper resting position of the tongue is not first attended to (Smithpeter & Covell, 2010).

Limitations and Directions for Future Research

A number of limitations were encountered while conducting the study that need to be addressed in order to minimize these negative effects for potential future research in the area of orofacial myology and its related fields. The largest limitation of this study is the small sample size. The current study collected preliminary data on 55 subjects and a larger sample size is needed to further investigate the prevalence of orofacial myofunctional disorders in the general population. Also, the data collection only took place at the University of Mississippi and only screened for orofacial myofunctional disorders in undergraduate students. However, it can be

assumed that the muscular functions of other university students are similar. Therefore, future studies should aim for a bigger sample size and also expand the recruitment age of participants.

Another limitation of the study is the question of whether the methods used accurately tests for orofacial myofunctional disorders. Because the NOT-S has a considerably lower specificity compared to its sensitivity, it is possible that there are multiple false diagnoses in the sample. Therefore, the prevalence of orofacial myofunctional disorders may be overestimated in the studied population. Future research should work on improving the accuracy of screening tools used to assess orofacial function.

In addition, it might be beneficial to expand upon the current study, having those participants who were flagged to have an orofacial myofunctional disorder come in for a follow-up assessment, which should include a full evaluation. This would (a) provide more information on validity of the NOT-S as a screening tool, and (b) provide a more accurate statistic on prevalence of orofacial myofunctional disorders in the general population.

REFERENCES

- Abreu, R. R., Rocha, R. L., & Guerra, Â. F. M. (2008). Prevalence of mouth breathing among children. *Jornal de Pediatria*, *84*(5). doi.org/10.2223/JPED.1806
- Andrada e Silva, M. A. de, Marchesan, I. Q., Ferreira, L. P., Schmidt, R., & Ramires, R. R. (2012). Postura, tônus e mobilidade de lábios e língua de crianças respiradoras orais. *Revista CEFAC*, *14*(5), 853–860. doi.org/10.1590/S1516-18462012005000002
- Bakke, M., Bergendal, B., McAllister, A., Sjögreen, L., & Åsten, P. (2007). Development and evaluation of a comprehensive screening for orofacial dysfunction. *Swedish Dental Journal*, *31*(2).
- Bergendal, B., Bakke, M., McAllister, A., Sjögreen, L., & Åsten, P. (2014). Profiles of orofacial dysfunction in different diagnostic groups using the Nordic Orofacial Test (NOT-S)—A review. *Acta Odontologica Scandinavica*, *72*(8), 578–584.
doi.org/10.3109/00016357.2014.942874
- Bianchini, A. P., Guedes, Z. C. F., & Hitos, S. (2008). Respiração oral: Causa x audição. *Revista CEFAC*, *11*(suppl 1). doi.org/10.1590/S1516-18462008005000009
- Bigenzahn, W., Fischman, L., & Mayrhofer-Krammel, U. (1992). Myofunctional therapy in patients with orofacial dysfunctions affecting speech. *Folia Phoniatrica*, *44*(5).
- Cavalcante-Leão, B. L., Todero, S. R. B., Ferreira, F. M., Gavião, M. B. D., & Fraiz, F. C. (2017). Profile of orofacial dysfunction in Brazilian children using the Nordic Orofacial Test-Screening. *Acta Odontologica Scandinavica*, *75*(4), 262–267.
doi.org/10.1080/00016357.2017.1290823
- Christensen, M. S., & Hanson, M. L. (1981). An investigation of the efficacy of oral myofunctional therapy as a precursor to articulation therapy for pre-first grade children.

Journal of Speech and Hearing Disorders, 46(2), 160–167.

doi.org/10.1044/jshd.4602.160

de Felício, C. M., Medeiros, A. P. M., & de Oliveira Melchior, M. (2012). Validity of the 'protocol of oro-facial myofunctional evaluation with scores' for young and adult subjects. *Journal of Oral Rehabilitation*, 39(10), 744–753. doi.org/10.1111/j.1365-2842.2012.02336.x

de Felício, C. M., da Silva Dias, F. V., Folha, G. A., de Almeida, L. A., de Souza, J. F., Anselmo-Lima, W. T., Trawitzki, L. V. V., & Valera, F. C. P. (2016). Orofacial motor functions in pediatric obstructive sleep apnea and implications for myofunctional therapy. *International Journal of Pediatric Otorhinolaryngology*, 90, 5–11. doi.org/10.1016/j.ijporl.2016.08.019

de Felício, C. M., & Ferreira, C. L. P. (2008). Protocol of orofacial myofunctional evaluation with scores. *International Journal of Pediatric Otorhinolaryngology*, 72(3), 367–375. doi.org/10.1016/j.ijporl.2007.11.012

de Felício, C. M., Ferreira, C. L. P., Medeiros, A. P. M., Rodrigues Da Silva, M. A. M., Tartaglia, G. M., & Sforza, C. (2012). Electromyographic indices, orofacial myofunctional status and temporomandibular disorders severity: A correlation study. *Journal of Electromyography and Kinesiology*, 22(2), 266–272. doi.org/10.1016/j.jelekin.2011.11.013

de Felício, C. M., Folha, G. A., Ferreira, C. L. P., & Medeiros, A. P. M. (2010). Expanded protocol of orofacial myofunctional evaluation with scores: Validity and reliability. *International Journal of Pediatric Otorhinolaryngology*, 74(11), 1230–1239. doi.org/10.1016/j.ijporl.2010.07.021

- Engel, J., Anteunis, L., Volovics, A., Hendriks, J., & Marres, E. (1999). Risk factors of otitis media with effusion during infancy. *International Journal of Pediatric Otorhinolaryngology*, 48(3), 239–249. doi.org/10.1016/S0165-5876(99)00037-3
- Ferreira, C. L. P., da Silva, M. A. M. R., & de Felício, C. M. (2009). Orofacial myofunctional disorder in subjects with temporomandibular disorder. *Cranio : The Journal of Craniomandibular Practice*, 27(4).
- Folha, G. A., Valera, F. C. P., Giglio, L. D., Voi Trawizki, L. V., & de Felício, C. M. (2013). Orofacial myofunctional evaluation with scores in subjects with obstructive sleep apnea. *Sleep Medicine*, 14, e51. doi.org/10.1016/j.sleep.2013.11.084
- Graziani, A. F., Berretin-Felix, G., & Genaro, K. F. (2019). Orofacial myofunctional evaluation in cleft lip and palate: An integrative literature review. *Revista CEFAC*, 21(1). doi.org/10.1590/1982-0216/20192116418
- Hanson, M. L., & Andrianopoulos, M. V. (1982). Tongue thrust and malocclusion: A longitudinal study. *International Journal of Orthodontics*, 20(2).
- Harari, D., Redlich, M., Miri, S., Hamud, T., & Gross, M. (2010). The effect of mouth breathing versus nasal breathing on dentofacial and craniofacial development in orthodontic patients. *The Laryngoscope*, 120(10), 2089–2093. doi.org/10.1002/lary.20991
- Hitos, S. F., Arakaki, R., Solé, D., & Weckx, L. L. M. (2013). Oral breathing and speech disorders in children. *Jornal de Pediatria*, 89(4), 361–365. doi.org/10.1016/j.jpmed.2012.12.007
- Kayamori, F., & Bianchini, E. M. G. (2017). Effects of orofacial myofunctional therapy on the symptoms and physiological parameters of sleep breathing disorders in adults: A

- systematic review. *Revista CEFAC*, 19(6), 868–878. doi.org/10.1590/1982-0216201719613317
- Kobayashi, F. Y., Gavião, M. B. D., Montes, A. B. M., Marquezin, M. C. S., & Castelo, P. M. (2014). Evaluation of oro-facial function in young subjects with temporomandibular disorders. *Journal of Oral Rehabilitation*, 41(7), 496–506. doi.org/10.1111/joor.12163
- Korbmacher, H. (2005). Orofacial myofunctional disorders in children with asymmetry of the posture and locomotion apparatus. *The International Journal of Orofacial Myology*, 31, 26–38.
- Krakauer, L. H., & Guilherme, A. (2000). Relationship between mouth breathing and postural alterations of children: A descriptive analysis. *International Journal of Orofacial Myology*, 26.
- Leme, M. S., Barbosa, T. de S., & Gavião, M. B. D. (2012). Assessment of orofacial functions in Brazilian children using the Nordic Orofacial Test-Screening (NOT-S). *Revista Odontologia*, 27(2), 108–114. doi.org/10.1590/S1980-65232012000200003
- Leme, M. S., de Souza Barbosa, T., & Gavião, M. B. D. (2013). Relationship among oral habits, orofacial function and oral health-related quality of life in children. *Brazilian Oral Research*, 27(3), 272–278. doi.org/10.1590/S1806-83242013000300006
- Lof, G. L. (2008). Controversies Surrounding Nonspeech Oral Motor Exercises for Childhood Speech Disorders. *Seminars in Speech and Language*, 29(04), 253–255. doi.org/10.1055/s-0028-1103388
- Lof, G. L., & Watson, M. M. (2010). Five reasons why nonspeech oral motor exercises (NSOME) do not work. *Perspectives on School-Based Issues*, 11(4), 109–117.

- Lundeborg, I., McAllister, A., Graf, J., Ericsson, E., & Hultcrantz, E. (2009). Oral motor dysfunction in children with adenotonsillar hypertrophy—Effects of surgery. *Logopedics Phoniatrics Vocology, 34*(3), 111–116. doi.org/10.1080/14015430903066937
- Mariano, N. C. R., Sano, M. N., Neppelenbroek, K. H., Almeida, A. L. P. F. de, Oliveira, T. M., & Soares, S. (2019). Orofacial Dysfunction In Cleft And Non-Cleft Patients Using Nordic Orofacial Test—A Screening Study. *Brazilian Dental Journal, 30*(2), 179–184. doi.org/10.1590/0103-6440201902376
- Marquezin, M. C. S., Kobayashi, F. Y., Montes, A. B. M., Gavião, M. B. D., & Castelo, P. M. (2013). Assessment of masticatory performance, bite force, orthodontic treatment need and orofacial dysfunction in children and adolescents. *Archives of Oral Biology, 58*(3), 286–292. doi.org/10.1016/j.archoralbio.2012.06.018
- McAllister, A., & Hammarström, I. L. (2014). Oral sensorimotor functions in typically developing children 3 to 8 years old, assessed by the Nordic Orofacial Test, NOT-S. *Journal of Medical Speech-Language Pathology, 21*(1).
- Paul-Brown, D., & Clausen, R. (1999). Collaborative approach for identifying and treating speech, language, and orofacial myofunctional disorders. *The Alpha Omegan, 92*(2).
- Pizolato, R. A., Freitas-Fernandes, F. S. de, & Gavião, M. B. D. (2013). Anxiety/depression and orofacial myofacial disorders as factors associated with TMD in children. *Brazilian Oral Research, 27*(2), 156–162. doi.org/10.1590/S1806-83242013000100021
- Rohrbach, S., Buettner, F., Pollex, D., Mathmann, P., Weinhold, L., Schubert, R., & Reilmann, R. (2018). Quantitative examination of isometric tongue protrusion forces in children with oro-facial dysfunctions or myofunctional disorders. *Journal of Oral Rehabilitation, 45*(3), 228–234. doi.org/10.1111/joor.12598

- Scarponi, L., de Felicio, C. M., Sforza, C., Pimenta Ferreira, C. L., Ginocchio, D., Pizzorni, N., Barozzi, S., Mozzanica, F., & Schindler, A. (2018). Reliability and Validity of the Italian Version of the Protocol of Orofacial Myofunctional Evaluation with Scores (I-OMES). *Folia Phoniatrica et Logopaedica*, 70(1), 8–12. doi.org/10.1159/000488027
- Serel Arslan, S., Demir, N., & Karaduman, A. A. (2017). Reliability and validity of a tool to measure the severity of tongue thrust in children: The Tongue Thrust Rating Scale. *Journal of Oral Rehabilitation*, 44(2), 119–124. doi.org/10.1111/joor.12471
- Smithpeter, J., & Covell, D. (2010). Relapse of anterior open bites treated with orthodontic appliances with and without orofacial myofunctional therapy. *American Journal of Orthodontics and Dentofacial Orthopedics*, 137(5), 605–614. doi.org/10.1016/j.ajodo.2008.07.016
- Souki, B. Q., Pimenta, G. B., Souki, M. Q., Franco, L. P., Becker, H. M. G., & Pinto, J. A. (2009). Prevalence of malocclusion among mouth breathing children: Do expectations meet reality? *International Journal of Pediatric Otorhinolaryngology*, 73(5), 767–773. doi.org/10.1016/j.ijporl.2009.02.006
- Stahl, F., Grabowski, R., Gaebel, M., & Kundt, G. (2006). Relationship between Occlusal Findings and Orofacial Myofunctional Status in Primary and Mixed Dentition Part II. *Journal of Orofacial Orthopedics / Fortschritte Der Kieferorthopädie*.
- Sundell, A. L., & Marcusson, A. (2019). A comparison of orofacial profiles in 5- and 10-year-old Swedish children with and without cleft lip and/or palate. *Clinical Oral Investigations*, 23(3), 1341–1347. doi.org/10.1007/s00784-018-2562-3

- Valcheva, Z., Arnautska, H., Dimova, M., Ivanova, G., & Atanasova, I. (2018). The role of mouth breathing on dentition development and formation. *Journal of IMAB - Annual Proceeding (Scientific Papers)*, 24(1), 1878–1882. doi.org/10.5272/jimab.2018241.1878
- Valera, F. C. P., Trawitzki, L. V. V., & Anselmo-Lima, W. T. (2006). Myofunctional evaluation after surgery for tonsils hypertrophy and its correlation to breathing pattern: A 2-year-follow up. *International Journal of Pediatric Otorhinolaryngology*, 70(2), 221–225. doi.org/10.1016/j.ijporl.2005.06.005
- van Bon, M. J. H., Zielhuis, G. A., Rach, G. H., & van den Broek, P. (1989). Otitis media with effusion and habitual mouth breathing in Dutch preschool children. *International Journal of Pediatric Otorhinolaryngology*, 17(2), 119–125. doi.org/10.1016/0165-5876(89)90087-6
- Van Cauwenberge, P., & Derycke, A. (1983). The relationship between nasal and middle ear pathology. *Acta Oto-Rhino-Laryngologica Belgica*.
- Verrastro, A. P., Stefani, F. M., Rodrigues, C. R. M. D., & Wanderley, M. T. (2006). Occlusal and orofacial myofunctional evaluation in children with primary dentition, anterior open bite and pacifier sucking habit. *The International Journal of Orofacial Myology*, 32.
- Vig, P. S., Phillips, C., & Showfety, K. J. (1980). Experimental manipulation of head posture. *American Journal of Orthodontics*, 77(3), 11.
- Wadsworth, S. D. (1998). The prevalence of orofacial myofunctional disorders among children identified with speech and language disorders in grades kindergarten through six. *The International Journal of Orofacial Myology*, 24.

Williamson, E. H., Hall, J. T., & Zwemer, J. D. (1990). Swallowing patterns in human subjects with and without temporomandibular dysfunction. *American Journal of Orthodontics and Dentofacial Orthopedics*, 98(6), 507–511. doi.org/10.1016/0889-5406(90)70016-6

APPENDICES

APPENDIX A: Recruitment Flyer

Volunteers Needed for Research Study

Participants are needed to investigate orofacial myofunctional profiles and hearing profiles of university students. We are looking for undergraduate students over the age of 18.

If you agree to participate, you will be seen at the speech and hearing clinic for a brief screening. The screening involves 1) a few questions regarding your medical history such as any past dentist/orthodontic treatment, middle ear infections, etc. and, 2) a hearing screening and an orofacial screening. The total administration time will be approximately 30 minutes.

If you would like to participate or have any questions about the study, please email Rachel Yockey at rayockey@go.olemiss.edu.

APPENDIX B: Information Sheet**INFORMATION SHEET**

Title: Profiles of general orofacial functions and hearing functions in university students

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By checking this box I certify that I am 18 years of age or older.

Description

The purpose of this research project is to gain information on the profile of general orofacial functions and hearing functions in university students. In this study, we are particularly interested in the profile of freshmen students between the ages of 18 and 21. The screening involves 1) a few questions regarding your medical history such as any past dentist/orthodontic treatment, middle ear infections, etc. and, 2) a hearing screening and an orofacial screening. The orofacial screening will be conducted using the Nordic Orofacial Test-Screening consisting of a structured interview and a clinical examination, each assessing six domains of function. Participants will be asked to answer questions related to sensory function such as when brushing their teeth, chewing and swallowing patterns when eating a meal, etc. During the examination, participants will also be asked to perform various actions such as opening their mouth as wide as they can and saying certain nonsense syllables while the clinician analyzes the orofacial features and function. Total administration time will be approximately 30 minutes.

Risks and Benefits

By participating in this study, you will receive a free hearing screening as well a free orofacial screening. There is hope that the information obtained through your participation will help our understanding of the profile of general orofacial functions and hearing functions in university students.

Confidentiality

Your results will be kept confidential. No personal information will be released to third parties without your written approval. The data for the research will be coded and the data will be saved on computers in password-protected files and in a locked cabinet in the principal investigator's office.

Right to Withdraw

You do not have to take part in this study and you may stop participation at any time. If you start

the study and decide that you do not want to finish, you may tell Dr. Kornisch or Dr. Lowe in person or by email at any time (contact information listed above). You may skip any questions you prefer not to answer.

IRB Approval

This study has been reviewed by The University of Mississippi's Institutional Review Board (IRB). If you have any questions, concerns, or reports regarding your rights as a participant of research, please contact the IRB at (662) 915-7482 or irb@olemiss.edu.

Statement of Consent

I have read the above information. I have had an opportunity to ask questions, and I have received answers. I consent to participate in the study.

Furthermore, I also affirm that the experimenter explained the study to me and told me about the study's risks as well as my right to refuse to participate and to withdraw.

Signature of Participant

Date

Printed name of Participant

Email address

APPENDIX C: Hearing Screening Form

University of Mississippi Speech and Hearing Center Student Hearing Screening Form

Name of student: _____

Age of student: _____

Major: _____

Date: _____

1) Do you have any known hearing loss? Yes No

 If "yes", do you wear any amplification? Yes No

2) Is there a family history of hearing loss? Yes No

 If so, who had hearing loss?

3) Have you had a history of loud noise exposure? Yes No

 If so, where were you exposed: Work Military Hobbies (woodworking, shooting,
 motorcycles, loud music etc.)

 How long were you exposed? _____

4) Have you used ear protection? Yes No

5) Have you had a history of middle ear infections? Yes No

6) Do you have any current pain/pressure in your ears? Yes No

Otoscopy Results

Right ear: Pass ____ Refer _____(reason)

Left ear: Pass ____ Refer _____(reason)

Hearing Screening at 25 dB HL (mark "+" for "pass" and "-" for "fail")

EAR	1000 Hz	2000 Hz	4000 Hz
Right ear			
Left ear			

Hearing Screening Results

Pass

Rescreen

Refer _____

APPENDIX D: NOT-S Interview

I) Sensory function

- A. Does brushing your teeth elicit a gag reflex?
Does this happen almost every time?
Obvious discomfort such as queasiness, vomiting, or refusal (increased sensitivity)
- B. Do you put so much food in your mouth that it becomes difficult to chew?
Does this happen every day?
Doesn't know when the mouth is full (decreased sensitivity).

II) Breathing

- A. Do you use any breathing support?
CPAP, respirator, oxygen, other.
- B. Do you snore much when you sleep?
Does this happen almost every night?
Snoring or apnea. Does not apply to symptoms from asthma or allergies.

III) Habits

- A. Do you bite your nails, or suck your fingers, or other objects every day?
Use of a pacifier and sucking on the fingers is not assessed under 5 years of age.
- B. Do you suck or bite your lips, your tongue, or your cheeks every day?
- C. Do you bite your teeth together hard or grind your teeth during the day?

IV) Chewing and swallowing

- A. Does not eat with the mouth (nasogastric tube, gastrostomy or other).
Skip question B-E.
- B. Do you find it difficult to eat foods with certain consistencies?
Exclude allergies and special diets such as vegetarian, vegan, and gluten-free.
- C. Does it take you 30 minutes or more to eat a main meal?
- D. Do you swallow large bites without chewing?
- E. Do you often cough during meals?
It happens at almost every meal.

V) Drooling

- A. Do you get saliva in the corner of your mouth or on your chin almost every day?
Needs to wipe their mouth. Does not apply during sleep.

VI) Dryness of the mouth

- A. Do you have to drink to be able to eat a cracker?
- B. Do you have a sore mouth or a sore tongue?
Recurrent pain or burning sensation at least once a week.
Does not apply to toothache or vesicles (blister-like lesions) in the mouth.

APPENDIX E: NOT-S Examination

1) Face at rest

- A. Asymmetry
Concerns both the skeleton and soft tissues.
- B. Deviant lip position
Open mouth or other deviations more than 2/3 of the time.
- C. Deviant tongue position
Tip of the tongue visible between the teeth more than 2/3 of the time.
- D. Involuntary movements
Repeated involuntary movements in the face.

2) Nose breathing

- A. Close your mouth and take 5 deep breaths through your nose
Is unable to take 5 breaths in succession through the nose.
If the patient cannot close their lips, the patient or the examiner can manually help the lips to close. Do not assess if the patient has a cold.

3) Facial expression

- A. Close your eyes tightly
The facial muscles are not activated in a strongly symmetrical fashion.
- B. Show your teeth
The lip and facial muscles are not symmetrically activated so that the teeth are easily visible.
- C. Try to whistle (blow)
Cannot pout and round the lips symmetrically

4) Masticatory muscle and jaw function

- A. Bite hard on your back teeth
No marked symmetrical activity can be registered when two fingers are held on the jaw muscles (the musculus masseter on both sides).
- B. Open your mouth as wide as you can
Cannot open their mouth a distance corresponding to the width of the forefinger and the middle finger on the patient's left hand. If the front teeth are missing, use a three-finger width (the forefinger, and the middle and ring fingers) as a measure.

5) Oral motor function

- A. Stick out your tongue as far as you can
Cannot reach outside of the Vermillion border of the lips with the top of the tongue.
- B. Lick your lips
Cannot use the tip of the tongue to wet the lips and cannot reach the corners of the mouth.
- C. "Blow up" your cheeks and hold for at least 3 seconds
Cannot "blow up" the cheeks without air leaking out or without making sounds.
- D. Open your mouth wide and say ah, ah, ah, [a]!
No marked elevation of the uvula and the soft palate can be observed.

6) Speech

- A. Does not speak. *Skip task B-C.*
- B. Count out loud to ten
Speech is unclear with one or more indistinct sounds or abnormal nasality.
Under 5 years of age, exclude R, S, and TH sounds from the assessment.
- C. Say pataka-pataka-pataka
Do not assess this in children under 5 years of age.

Title of Study	Authors	Age Group	Sample Size	Brief Summary
Profile of orofacial dysfunction in Brazilian children using the Nordic orofacial Test-Screening	Cavalcante-Leao, Toderro, Ferreira, Faviao, Fraiz	Age range 8-10 years	531 subjects	There is a high prevalence of orofacial myofunctional disorders in Brazilian school aged children.
Orofacial Myofunctional disorders in children with asymmetry of the posture and locomotion apparatus	Korbmacher	Age range 1-19 years; mean age 7.5 +/- 2.95 years	352 subjects	The prevalence of orofacial myofunctional disorders is 70% in children with asymmetry of the upper cervical spine.
Assessment of orofacial functions in Brazilian children using the Nordic Orofacial Test-Screening (NOT-S)	Leme, Barbosa, & Gaviao	Age range 8-14 years; mean age 10.48 +/- 1.69 years	332 subjects	The prevalence of orofacial myofunctional disorders is higher among Brazilian children with mixed dentition compared to those with permanent dentition, and higher among children with frontal open bite.
Relationship between Occlusal Findings and Orofacial Myofunctional Status in Primary and Mixed Dentition	Stahl, Grabowski, Gaebel, & Kundt	Mean age 4.5-8.3 years	3,041 subjects	Orofacial dysfunction occurred in 61.6% and 80.8% in primary and mixed dentition groups respectively. The frequency of orofacial myofunctional disorders was significantly higher in children with various types of malocclusion and frontal open bite.
The Prevalence of Orofacial Myofunctional Disorders Among Children Identified with Speech and Language Disorders in Grades Kindergarten Through Six	Wadsworth	Age range 5-12 years	200 subjects	The prevalence of orofacial myofunctional disorders is 50% in children receiving speech and language therapy in schools.
Orofacial myofunctional evaluation with scores in subjects with obstructive sleep apnea	Folha, Pereira, Giglio, Voi Trawizki, & de Felicio	Age range 19-60 years	133 subjects	Orofacial myofunctional disorders are common among both children and adults with obstructive sleep apnea.
Orofacial myofunctional disorder in subjects with temporomandibular disorder	Ferreira, da Silva, & de Felicio	Age range 12-68 years; mean age 31.9 years, with a predominance of young adults	240 subjects	Suggests approximately 70% of subjects would have an indication for orofacial myofunctional therapy.

Table 2. *Prevalence of Orofacial Myofunctional Disorders in Various Populations.*

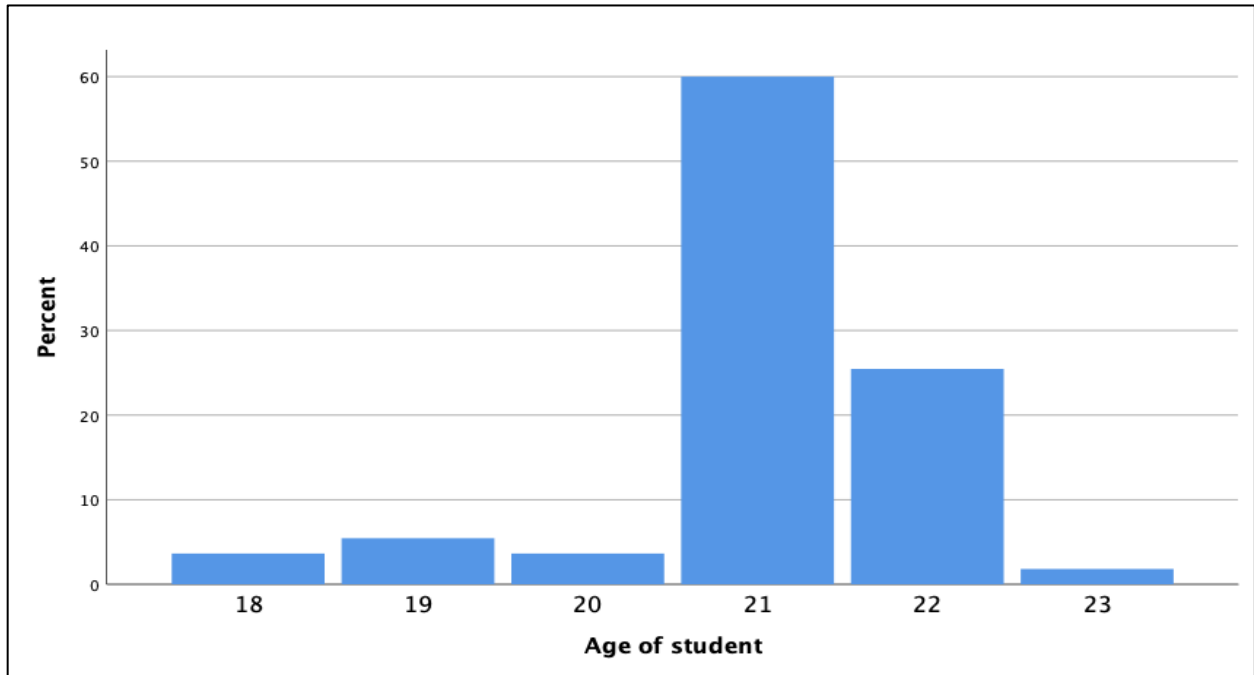


Figure 1. Age Demographics of Participants.

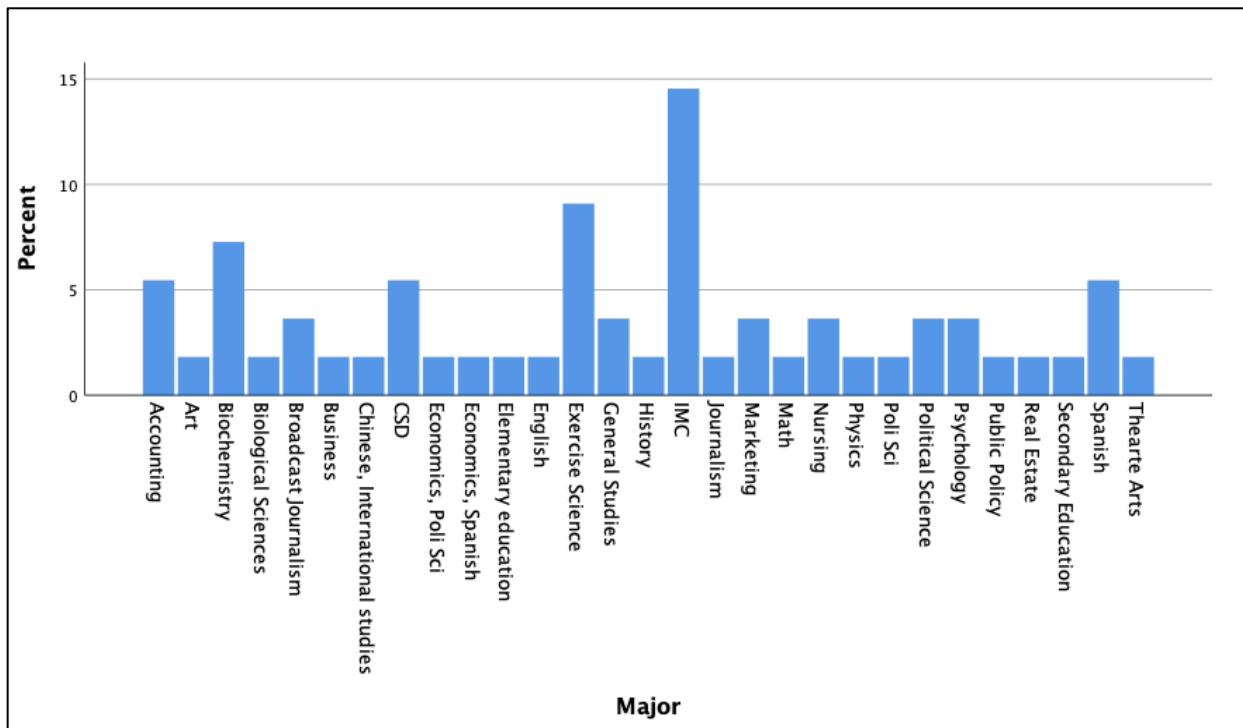


Figure 2. Education Demographics of Participants.

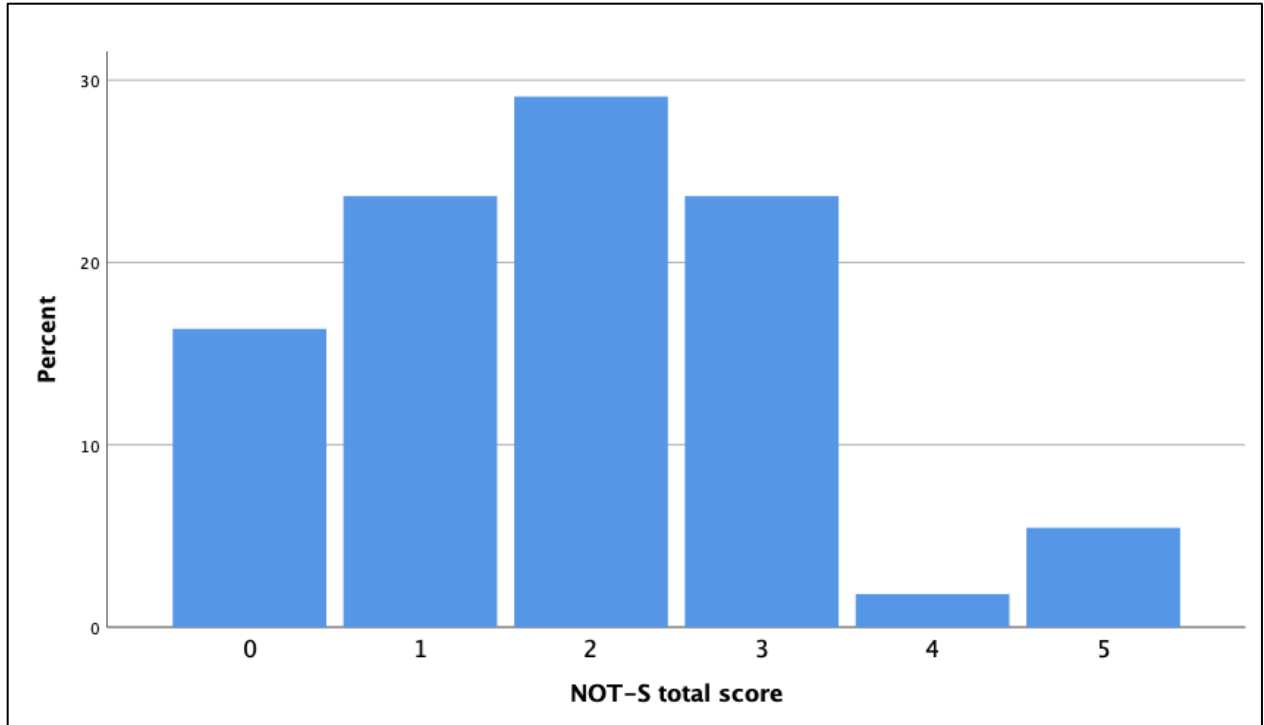


Figure 3. *Distribution of NOT-S Total Scores.*