

University of Nevada, Reno

Effects of perception on performed swallowing behavior: An investigation of the relationship between age, perception, and spontaneous swallowing frequency

A thesis submitted in partial fulfillment
of the requirements for the degree of

Bachelor of Science in Speech Pathology and Audiology and the Honors Program

by

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prepared under our supervision by

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Abstract

Community-dwelling elderly (CDE) are typically-aging, older adults that live independently in their communities. CDE do not live under the care of health professionals and are therefore at risk for health complications that result from normal aging processes. Aging processes such as decreased muscle mass and diminished sensory acuity may impact the older adult's swallowing function, putting them at risk for health complications such as aspiration pneumonia, malnutrition, and death. To ensure CDE receive services for potential changes in swallowing, they need to be able to detect when changes in their swallowing function occur. The objective of this study was to determine the relationship of age with concordance between spontaneous swallowing frequency and perception of swallowing function. Results from isolated audio swallow frequency recordings were compared with responses to six items from the Eating Assessment Tool (EAT-10) across two cohorts of 19-26 years ($n_1 = 11$) and 46-83 years ($n_2 = 11$). The results indicate that older adults swallow significantly less ($p = 0.047$) than younger adults but display no difference in perception of function or comfort. This suggests typically aging, older adults may not perceive natural changes to their swallowing ability that may be threatening their health.

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Introduction

The aging process results in physiological changes that can affect an individual's day-to-day functioning and comfort. Diminished muscle tone and strength and decreases in sensory acuity are examples of common aspects of aging that may result in changed swallowing function in the elderly, even if they do not experience secondary (disease related) aging processes, such as cerebrovascular accident (CVA) or neurodegenerative disease. One aim of speech-language pathology professionals is to better identify when such aging processes are affecting swallowing, especially in the community-dwelling elderly (CDE), or independently living population. In order to contribute to this aim, this paper seeks to answer the following question: How does the relationship between perceptions of swallowing ability and performed swallowing behavior change with age?

This study is done in coordination with the University of Central Florida (UCF). A portion of the data collection was done with a protocol that was designed by researchers at UCF to investigate a variety of changes to swallowing function in community-dwelling elderly, and this study seeks to use measures of spontaneous swallowing frequency and items from the Eating Assessment Tool (EAT-10) to address a gap in the current literature by investigating the relationship between age and concordance between perceptions of swallowing function and spontaneous swallowing frequency.

Speech-language pathologists have been evaluating swallowing function since the late 1970s when Jeri Logemann noticed Parkinson's and head and neck cancer patients demonstrated problems with swallowing in addition to their communication deficits

(Lazarus and Pauloski, 2015). This discovery contributed to the speech-language pathologist's role in evaluation and treatment of swallowing disorders (also known as dysphagia). Because this area of treatment within the field is still fairly new, however, foundational knowledge in the characteristics of normal swallowing function, especially in at-risk populations, is still minimal. For purposes of this study, at-risk populations are defined as independently living older adults. In order to better understand dysphagia risk, understanding the way swallowing functions and the way individuals perceive their swallowing function changes across the lifespan is imperative.

The American Speech-Language-Hearing Association (ASHA) (2018) defines dysphagia as a disorder characterized by problems involving oral preparation of a bolus—a rounded mass of food and saliva for swallowing—or the completion of a swallow. Dysphagia can result from several physical or neurological injuries to structures of the swallow mechanism, such as the oral cavity, pharynx, esophagus, and head and neck (ASHA, 2018). A study by Battacharyya (2014) found cerebral vascular accident (CVA) was the primary cause of dysphagia in American adults, responsible for approximately 11.2% of dysphagia diagnoses. Other neurologic etiologies followed at 7.2% and head and neck cancer last, with 4.9% of reported dysphagia cases due to cancer related problems (Battacharyya, 2014).

Individuals with dysphagia experience symptoms such as drooling, pain while swallowing, residue of food material remaining in the oral cavity and throat, or aspiration of food material into the respiratory system (ASHA, 2018). In addition to these medical symptoms, adults who experience dysphagia may also experience decreased enjoyment in eating as a result of discomfort leading to isolation in social situations involving eating

(ASHA, 2018). The broad variety of causes and presentations of dysphagia makes this disorder especially difficult to diagnose. Battacharyya (2014) states that 1 in 25 adults in the United States experience problems with swallowing; however, the varied nature of dysphagia means its prevalence in the adult population may be underestimated.

Typical aging can often result in a variety of physiological changes, and consequently, decreases in function in day-to-day life. Sarcopenia, age-related decrease in muscle mass; reduced oral moisture; and diminished sensitivity of smell and taste (Boyce and Shone, 2006; Sura et al., 2012) are common results of aging even when secondary disease processes, such as chronic disease or stroke, are not involved. These aging processes may predispose dysphagia in the elderly population (Sura et al., 2012). Aging individuals may experience diminished strength and range of motion in the swallow mechanism as a result of decreased muscle mass and connective tissue (Sura et al., 2012). Additionally, oral moisture and sensitivity to taste and smell may decrease with age (Sura et al., 2012; Boyce and Shone, 2006). As a result, it may take longer for oral preparation (chewing and forming a bolus in the mouth) and passing of the bolus through the swallow mechanism, and efficiency of the swallow may be lessened (Sura et al., 2012).

Elderly living independently in the community, referred to as community-dwelling elderly (CDE) in this study, are at particular risk because detrimental changes in swallow function may go undetected because they are not receiving consistent care from professionals trained to identify the symptoms of dysphagia. Elderly that do experience difficulty with swallowing may exhibit compensatory strategies such as slowed eating rate and reduced intake of food and drink (Sura et al., 2012). The consequences of

dysphagia in the CDE, however, can be far more severe. Unidentified dysphagia in the elderly can cause health problems, such as malnutrition, aspiration pneumonia, and sometimes death (Sura et al., 2012).

Development of better practice for identifying and treating diminished swallow efficiency in CDE may decrease these complications and effects on quality of life (Byeon, 2016). The original protocol, defined by the researchers at the University of Central Florida, includes a variety of measures: the Modified Mini-Mental State Test, Fried Frailty Index, Swallowing Kinesiophobia Scale, questionnaire containing items from the Eating Assessment Tool 10 (EAT-10), spontaneous swallowing frequency, lingual-palatal pressure, and surface electromyography for four different consistency swallows for a population of community dwelling elderly. This project will use only data from six items from the EAT-10 and spontaneous swallowing frequency, obtained from isolated audio recordings, to investigate the relationship between an individual's perception of their swallowing function and their natural swallowing behavior. It is hypothesized that higher scores on the EAT-10 will correlate with lower spontaneous swallowing frequencies. This study also seeks to add an additional cohort of young adults (aged 18-39 years) to provide a continuous picture of how swallowing function changes with age. It is also predicted that older adults will demonstrate both greater swallowing apprehension and consequent reduced spontaneous swallowing frequency.

Literature Review

This section will cover a review of literature concerning variables such as the speech-language pathologist's role in dysphagia diagnosis and treatment, age-related physiological changes that may affect swallowing ability, the EAT-10 questionnaire, and spontaneous swallowing frequency.

Speech-Language Pathology and Swallowing

A speech-language pathologist (SLP) is a professional that provides clinical intervention in the areas of communication and swallowing to individuals of all ages (ASHA, 2016). The treatment of swallowing disorders, known as dysphagia, is one of the most recent additions to the SLP's scope of practice. This area of intervention did not fall under the umbrella of services provided by SLPs until the 1970s, when Jeri Logemann noticed that many of her patients with Parkinson's disease were struggling with swallowing in addition to their communication concerns (Lazarus & Pauloski, 2015). This insight led to her research in the area of swallowing intervention for Parkinson's, as well as head and neck cancer patients (Lazarus & Pauloski, 2015). Logemann now is known for three major contributions to the field: establishing methods for evaluating swallowing function, spearheading treatment procedures for swallowing disorders, and validating such interventions (Lazarus & Pauloski, 2015). Evaluation and treatment of dysphagia has since been added to the American Speech-Language Hearing Association's Scope of Practice for Speech-Language Pathology, in which ASHA defines swallowing as "all aspects of swallowing, including related feeding behaviors," (ASHA, 2016, p. 2).

Dysphagia may be caused by a variety of medical conditions, such as stroke, traumatic brain injury, neurodegenerative disease, and head and neck cancer (ASHA, 2018), and speech-language pathologists may be expected to evaluate and provide intervention in all of these areas. While data describing the swallowing ability of these affected populations has been established, research investigating objective characteristics of swallowing function in a healthy population is minimal.

Swallowing Function

Deglutition, or swallowing, is a complex biological process, involving the passing of a bolus from the mouth to the stomach. A typical swallow includes several voluntary behaviors and neuromuscular coordination of over 30 nerves and muscles (Matsuo & Palmer, 2008) to ensure the bolus is transported safely (Logemann, 2007; Miller, 2008).

This complex process can be broken down into a few stages. Earlier research describes swallowing through three separate stages: the oral stage, pharyngeal stage, and esophageal stage; however, more recent literature has expanded that description to include four phases: the oral preparatory phase, oral transit (sometimes oral-propulsive) phase, pharyngeal phase, and esophageal phase (Hennessy & Goldenberg, 2016; Matsuo & Palmer, 2008; Walton & Silva, 2018). Deglutition begins with the oral-preparatory phase, during which a bolus (ball of food material and saliva) is formed, through coordinated movements of the tongue and lips with the jaw. During this stage the upper esophageal sphincter closes to ensure there is no premature passage of the bolus (Walton & Silva, 2018). Following the oral-preparatory phase is the oral-transit phases. This phase is also sometimes called the oral-propulsion phase because it is characterized by the propulsion of the bolus into the pharynx by the tongue (Walton & Silva, 2018). In the

average individual, this phase should last approximately 1 second (Walton & Silva, 2018).

After being propelled posteriorly by the tongue, the bolus stimulates the glossopharyngeal (CN IX) and vagus (CN X) cranial nerves, prompting the pharyngeal phase. Coordination with the respiratory system is vital during this stage, otherwise aspiration of food and liquid matter could occur, contributing to consequences from discomfort to pneumonia. Two processes occur to protect the airway during this phase. First, the soft palate raises to seal the nasopharynx to prevent food matter entering the nasal passageways, and, second, laryngeal penetration is avoided by the elevation of the larynx under the base of the tongue, the channeling of the bolus over the epiglottis, and the adduction of the true and false vocal folds (Walton & Silva, 2018).

The esophageal phase begins when the bolus enters the esophagus, a muscular tube that transports swallowed material to the stomach, through the upper esophageal sphincter. The cervical portion of the esophagus is striated muscle, but the lower, thoracic esophagus is composed of smooth muscle (Matsuo & Palmer, 2008). Transport of the bolus in the thoracic esophagus is done by peristalsis, which are wavelike contractions of the muscle regulated by the autonomic nervous system (Hennessy & Goldenberg, 2016).

The timing of a swallow and pressure exerted by the mechanism are dependent on the volume and viscosity of the swallowed material; thicker and larger boluses require more pressure to swallow completely and take longer to move through to the stomach (Logemann, 2007). However, the duration of a swallow is so brief (< 2 seconds for both the oral and pharyngeal phases) (Logemann, 2007), that any disturbance to this coordination can result in a variety of detrimental consequences to comfort and health.

The typical aging process results in several physiological changes that can disturb the coordination and strength of the swallow mechanism.

Swallowing and Aging

Most often, the cited causes of dysphagia are due to age-related disease processes, such as myopathies, stroke, dementia, and Parkinson's disease, although other etiologies are common, like traumatic brain injury, lack of dentition, head and neck cancer, or gastroesophageal disease (Roy, Stemple, Ray, & Thomas, 2004; Byeon, 2016; Holland, Jayasekeran, Pendleton, Horan, Jones, & Hamdy, 2011; Battychara, 2014). These processes, however, are secondary to the typical changes of aging. Dysphagia that results from abnormal aging processes that are related to disease rather than typical aging is easier to identify because a swallow evaluation is part of the standard of care for these patients. One study by Walton & Silva (2018) found that duration in the oral transit phase of swallowing increased with advanced age, without the presence of disease processes. Research such as this supports the notion that elderly who are not receiving treatment for more severe, age-related diseases may still experience decreases in swallow efficiency that pose a danger to their health because their swallowing may not be evaluated regularly.

Sarcopenia. Processes of typical aging can influence swallowing function. Sarcopenia, an age-related decrease in muscle mass, may result in decreased efficiency of and range of motion in the swallowing mechanism (Sura et al., 2012).

Decreased oral moisture and sensory acuity. Additionally, many elderly experience decreased oral moisture and diminished sensory acuity in taste and smell (Boyce and Shone, 2006; Sura et al., 2012) that affect their ability to prepare and swallow

a bolus or eat properly. These changes may result in longer time to transport a bolus or residue of swallowed material staying in the throat.

Symptomatology. The four most common swallowing symptoms reported by CDE are a feeling of food stuck in the throat, a sensation of choking or coughing while eating, difficulty swallowing hard foods, or taking longer to eat due to discomfort (Holland et al., 2011; Roy et al., 2004). These symptoms are similar in that they are all identified by the individual. This suggests that one of the best ways to identify dysphagia in the CDE is to determine how well the individual can recognize differences in their swallowing function and seek help from a medical professional.

Supposed prevalence of swallowing disorder in CDE. Dysphagia in the community-dwelling elderly may go undiagnosed and untreated for a variety of reasons. CDE live independently and may not interact with health professionals often enough for swallowing problems to be detected. Professional identification of dysphagia is especially important because many elderly individuals may consider swallowing problems a symptom of aging and not seek treatment (Byeon, 2016). The lack of consistent care and education in this population means the true prevalence of dysphagia in the CDE is uncertain, although several studies (Kawashima, Motohashi, & Fujishima, 2004; Roy et al., 2004; Holland et al., 2011) report somewhere between 11-33% of independently living elderly may experience difficulty swallowing. Identifying prevalence becomes more pressing with an increasingly aging population, as a study by Holland et al. (2011) found a positive correlation ($r=0.11$) between the presence of symptomatic dysphagia and increasing age and that increasing age is also associated with increased severity of dysphagia (Holland et al., 2011).

Eating Assessment Tool (EAT-10)

The Eating Assessment Tool (EAT-10) is a ten-item, self-administered survey used to assess dysphagia, primarily in older adults (Igarashi, Kikutani, & Tamura, 2019). The items on the EAT-10 were designed to evaluate specific symptoms of individuals with dysphagia on an ordinal scale, in which a response of “1” corresponds to no issue and a response of “5” corresponds to a severe problem (Belafsky, Mouadeb, Rees, Pryor, Postma, Allen, & Leonard, 2008). The EAT-10 addresses topics such as comfort and socioemotional symptoms of swallowing problems. The nature of the selected items from this tool will provide information about an individual’s perceptions of their swallowing function in their day-to-day lives.

Studies have determined that the EAT-10 has outstanding validity, reliability, and internal consistency across dysphagic populations with varying etiologies and disease processes (Igarashi et al., 2019; Belafsky et al., 2008). In one study that used the EAT-10 to evaluate dysphagia in independently living older adults, the EAT-10 was able to identify dysphagia in 1 in 4 CDE and recorded that the primary symptom that indicated dysphagia in this population was coughing while eating (Igarashi et al., 2019). However, one study (Wilmskoetter et al., 2017) did identify weaknesses in the construct validity of the test when comparing the results to other measures of dysphagia severity, namely the Penetration-Aspiration Scale (PAS) and Functional Oral Intake Scale (FOIS). For the purposes of this study, six items relating to the individual’s comfort, coughing, and socioemotional status have been selected.

Spontaneous Swallow Frequency

Spontaneous swallowing is considered a reflex of the aerodigestive system for clearing the pharynx and larynx (Crary, Sura, & Carnaby, 2013) and protecting the respiratory tract. Swallow Frequency Analysis (SFA), the measurement of the number of spontaneous swallows over a period of time, can be an excellent indicator of dysphagia (Crary et al., 2013). One study by Crary, Carnaby, and Sia (2014) determined that swallow frequency measurement was more reliable at predicting dysphagia after acute stroke than nurse administered clinical swallow screenings. Decreased swallow frequency is associated with increasing age and higher risk of dysphagia (Crary et al., 2013), and therefore can be a predictor of risk for aspiration pneumonia among other consequences of swallowing disorder.

An isolated acoustic recording, taken by adhering a microphone to the neck, is a new method for measuring swallow frequency. Studies (Crary et al., 2013; Crary, Carnaby, & Sia, 2014; Golabbakhsh et al., 2013) have found that isolated acoustic recording is between 82-95% accurate in measuring swallow frequency and is comparable to the use of surface electromyography for the same purpose (Crary et al., 2013). In addition to its reliability, isolated acoustic recordings are a good option for measuring spontaneous swallows because it is a relatively safe method compared to videofluoroscopy, which requires exposure to radiation, and is more cost-effective than surface electromyography, which includes the use of expensive equipment (Golabbakhsh et al., 2013). This method does present some limitations, as interference from ambient noise can pollute audio recordings and put the quality of listener evaluation into question.

Perception and swallowing

There is minimal research on the associations between an individual's perception of swallowing function and physical swallowing characteristics. Due to the lack of literature, it is uncertain whether perceptions of swallowing function change throughout the lifespan or if perception affects performed swallowing behaviors. Inuma et al. (2017) found statistically significant relationships between self-reported, perceived swallowing problems and physical health effects, such as body mass index (BMI), cerebral vascular accident (CVA), and gastrointestinal disease. This study also found that individuals who reported a perception of difficulty in swallowing were nearly twice as likely to have died once the researchers contacted the participants again three years later.

That perception of swallowing difficulty can contribute to health decline, and this correlation between perception and mortality is important to consider because there is evidence that suggests elderly individuals experience changes to their perceptual abilities regarding swallowing related functions. Another study by Kamarunas, McCullough, Mennemeir, and Munn (2015) determined that the ability to detect changes in bolus volume decreased with increasing age. Kamarunas et al. (2015) found that a volume increase of four times was necessary for older adults to perceive an approximant volume increase of just two times. Such results suggest that decreased sensory acuity may contribute to decreased perceptual ability that might lead to detrimental health effects.

With so little information contributing to this issue, there is a great need for research that can determine when and how perceptions in swallowing ability change and how these changes may contribute to dangerous swallowing problems in elderly populations. By comparing questions surrounding the individual's perceptions of

swallowing function and comfort and spontaneous swallowing behavior, this study seeks to add to the literature in this area.

Methodology

This project involved quantitative and subjective measures for assessing an individual's perception of their swallowing ability and their physical swallowing behaviors.

Participants

Two volunteer cohorts ($n_1 = 11$, age 19-26 years; $n_2 = 11$, age 46-83 years) were recruited from the University of Nevada, Reno School of Medicine, University of Nevada, Reno undergraduate student population, and from among the Reno community. Participants were not incentivized.

The primary method of recruitment was via recruitment posters [Appendix A] that were posted around the University of Nevada, Reno School of Medicine. Participants were invited to email the research team expressing their interest, after which they were contacted through phone or email to schedule an appointment for data collection.

Individuals were also invited to participate in-person by research assistants in undergraduate classes at the University of Nevada, Reno. The consent form [Appendix B] describing the study processes and details was read aloud to the class and those interested were invited to write their name and contact information on a 4" by 5" index card. Participants were then contacted by the research team to set up an appointment via phone or email.

Persons eligible for this study were typically aging, independent adults, and all participants were screened for eligibility before their participation [Appendix C].

Inclusion eligibility criteria for the participants were as follows:

1. Participants were between the ages of 18 and 90 years old at the time of participation
2. Participants had to be independently living in the Reno community at the time of participation, in which independently living refers to individuals not living in care institutions, such as hospitals, skilled nursing facilities, or assisted living homes or not receiving consistent care from a medical aid or caretaker.
3. Participants had no previous or current history of medical illness affecting swallowing function, no previously identified swallowing difficulty, and no previous history of or current non-oral feeding for illness.
4. All participants were English speaking.

Instruments

The protocol for this study included measures of subjective perceptions of swallowing and feeding, cognitive ability, and objective swallowing ability. Paper and pen materials for this study included a questionnaire containing items from the EAT-10 [Appendix D]. Responses for the six items from the EAT-10 were scaled as follows: (1) never, (2) sometimes, (3) most times, (4) always.

This study also included the use of the Voice Technologies VT-506MOBILE microphone, which is a Broadcast quality, lavalier microphone (Voice Technologies, 2017b). Voice Technologies is a Swiss company that produces audio equipment. They are located at: Audio Bauer Pro AG, Bernerstrasse Nord 182, CH-8064 Zurich Switzerland (Voice Technologies, 2017a). The recording software used was the internal

voice memo recorder on a HP laptop. The voice memo software saved each recording as a m4a file for download and playback.

Table 1: depicts the six items from the EAT-10 that were included in the feeding and swallowing questionnaire

Question:	
1	Eating/swallowing solids takes extra effort.
2	Eating/swallowing liquids takes extra effort.
3	Swallowing pills takes extra effort.
4	When I swallow food sticks in my throat.
5	I cough when I eat.
6	I have difficulty eating / swallowing that interferes with my ability to go out to eat.

Method

Data collection was conducted at the University of Nevada, Reno Speech and Hearing Clinic. Participants were greeted by a research assistant in the waiting room at the University of Nevada, Reno Speech and Hearing Clinic. Each was screened for eligibility by the research assistant [Appendix C] and provided with two copies of the consent materials [Appendix B]. Participants were then given one copy of the signed consent forms for their record.

After obtaining consent, the research assistant led the participant to a treatment room where they were fitted with a microphone taped to the anterolateral portion of the neck, adjacent to the Adam's apple. The participant was then told to sit quietly for 15 minutes. The research assistant recorded the participant during that timeframe using the voice memo application on a HP laptop. During the 15-minute recording period,

participants were asked to complete the questionnaire about their feeding habits and swallow function.

Due to a technological error with the recording software, some recordings were cut off prematurely. As a result, only spontaneous swallows up to 13 minutes were counted for each participant. The swallow frequencies recorded reflect the shortened recording period, although it is not anticipated this change will have any significant effect on the frequency calculation.

Data Analysis

To determine if there was a significant difference of spontaneous swallow frequencies between age groups, an analysis of variance (ANOVA) test was run, using SPSS Statistics software. Age group was the independent variable and swallow count was the dependent variable.

Then, to evaluate differences in perception between age groups, a logistics regression analysis for each group was run, with swallow perception as the dependent variable and age group and swallow frequency as the covariates.

Data and Results

Statistical tests revealed significant trends in the relationships between swallowing frequency and perceived swallowing ability across age groups. This section describes the results based on the following analyses: swallowing frequency and age and swallowing frequency and perception.

Sample demographics

Of 24 eligible participants, 22 full data sets were obtained. The young adult group (n_1) was comprised of 11 individuals between the ages of 19 and 26 years ($\bar{x} = 22$), and the CDE group (n_2) was comprised of 11 individuals between the ages of 46 and 83 ($\bar{x} = 55$). Of the first group, 81% were female and 19% were male. Of the second group, 63% were female and 37% were male.

Swallowing frequency and age

An ANOVA comparing the swallow counts of each group resulted in a statistically significant difference ($p=0.047$) between swallow frequencies for older and younger adults. It can be concluded that the older individuals swallowed less frequently than their younger counterparts. This trend can also be seen in Figure 1, which shows that more older adults swallowed between 5 and 7 times than young adults, and none swallowed more than 9 times in the 13-minute recording period. Conversely, five younger adults (45%) swallowed more than any of their older counterparts (between 12 and 21 times).

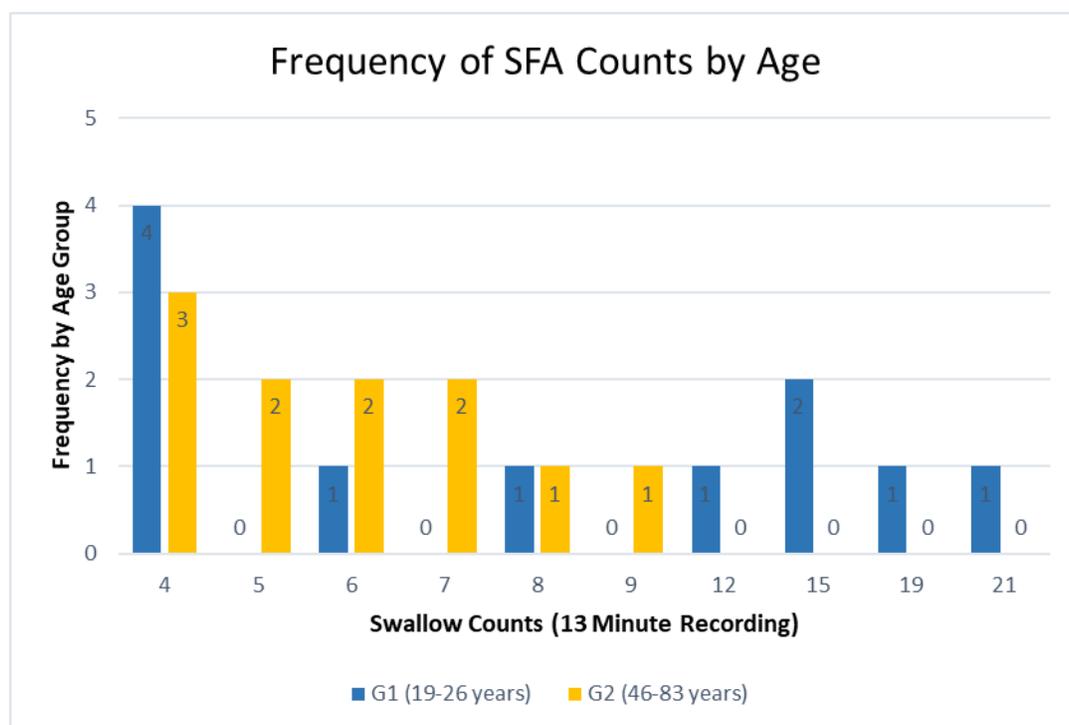


Figure 1: shows the frequency of swallow counts during the 13-minute recording period by age group

Swallowing frequency and perception

For question 1 (“Eating/swallowing solids takes extra effort.”) and question 6 (“I have difficulty eating / swallowing that interferes with my ability to go out to eat.”) all participants reported no difficulty in their day-to-day lives. For questions 2-5, logistics regression tests determined no difference of perceived swallowing function between the two groups. Figure 2 through Figure 7 show the participants’ responses by swallow frequency and age group. It is apparent that no participant reported a significant swallowing problem in their daily life, regardless of age or spontaneous swallowing frequency. These results suggest that older adults may not be aware of changes in their swallowing ability and report no difficulty despite a decrease in swallow frequency.

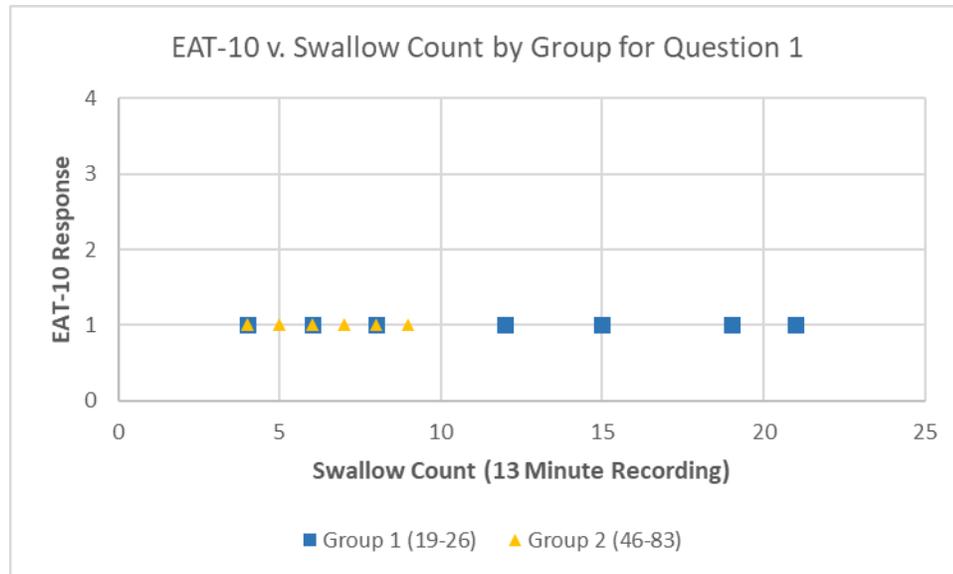


Figure 2: shows the participants' response to the EAT-10 survey question 1 v. their swallow count over the 13-minute recording period

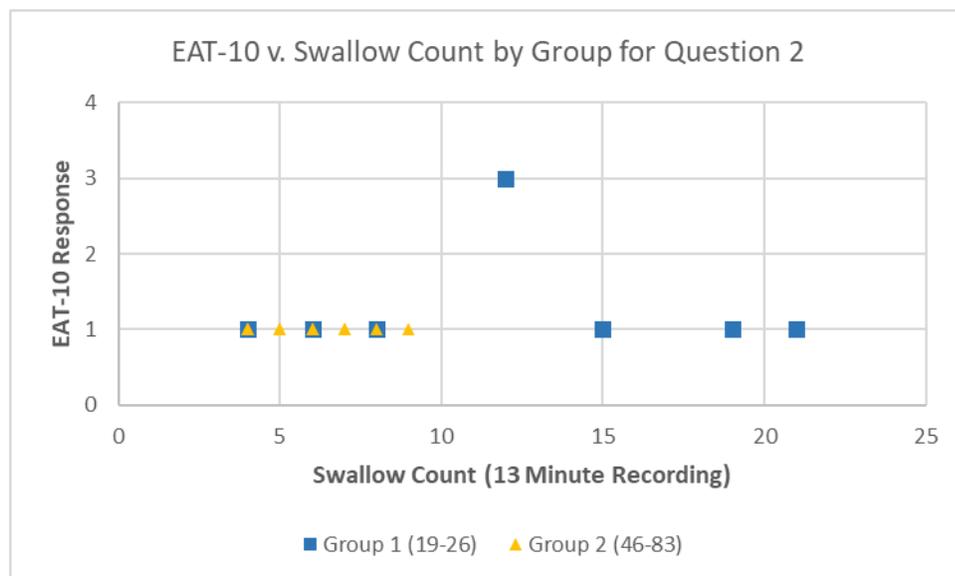


Figure 3: shows the participants' response to the EAT-10 survey question 2 v. their swallow count over the 13-minute recording period

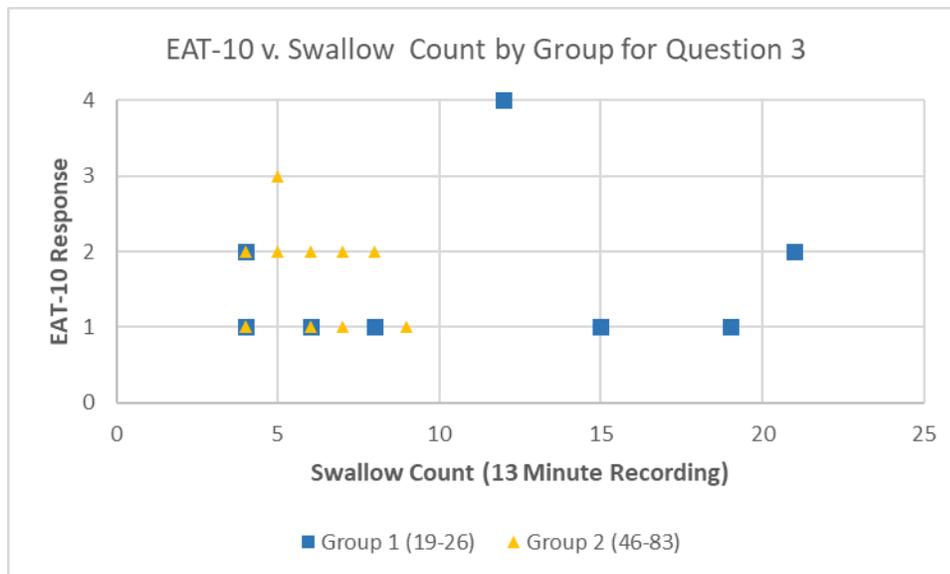


Figure 4: shows the participants' response to the EAT-10 survey question 3 v. their swallow count over the 13-minute recording period

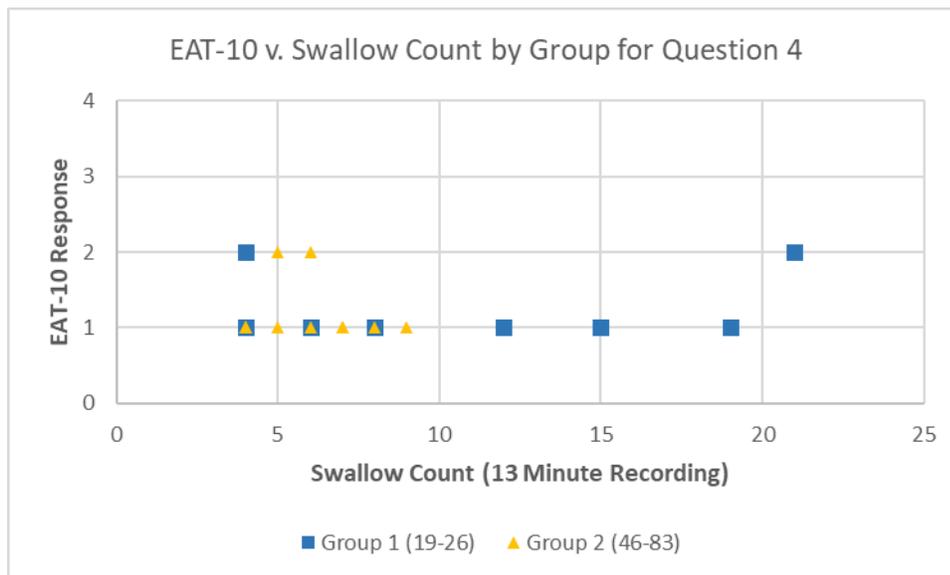


Figure 5: shows the participants' response to the EAT-10 survey question 4 v. their swallow count over the 13-minute recording period

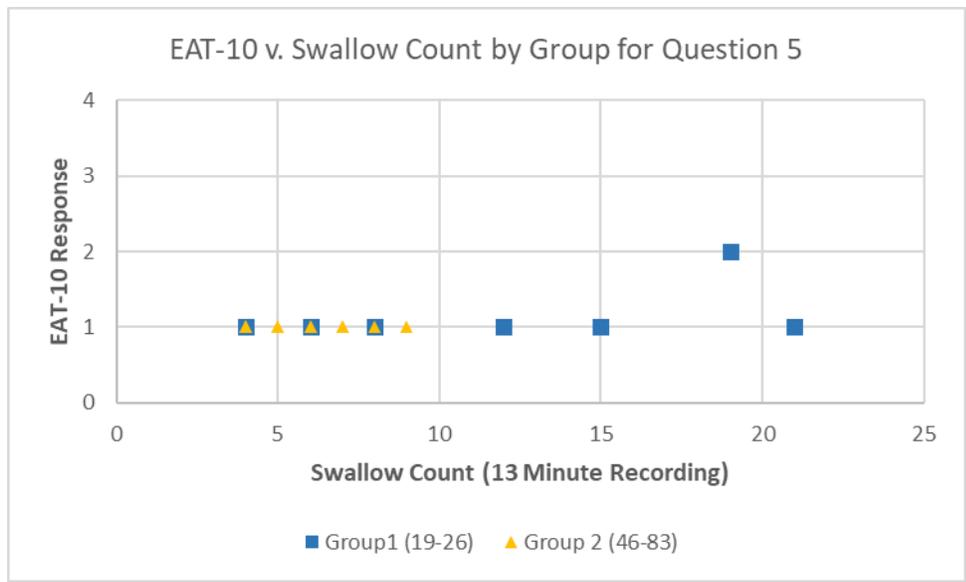


Figure 6: shows the participants' response to the EAT-10 survey question 5 v. their swallow count over the 13-minute recording period

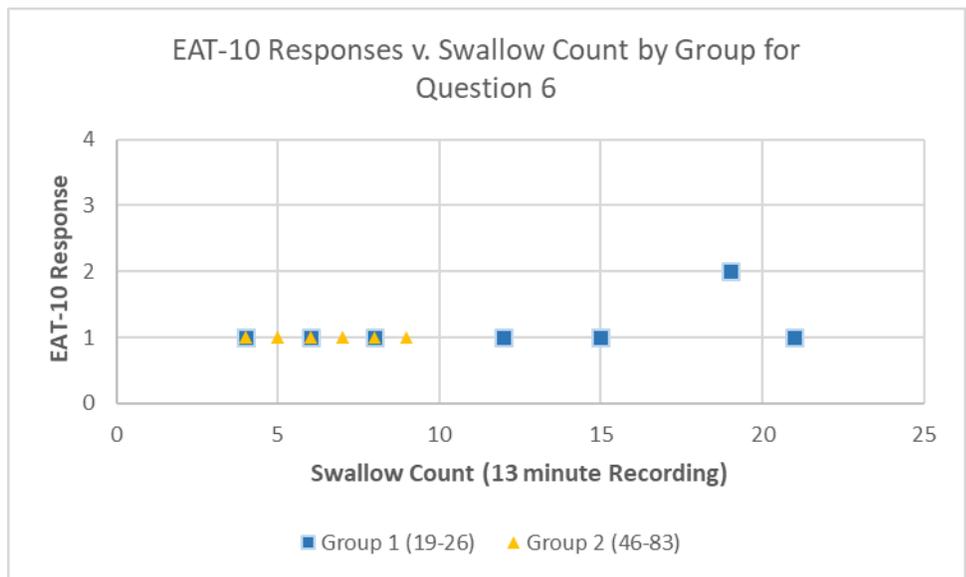


Figure 7: shows the participants' response to the EAT-10 survey question 6 v. their swallow count over the 13-minute recording period

Discussion

The results from this study suggest a disconnection between an individual's perception of their swallowing function and the physiological changes that may be occurring during the aging process. Based on the statistically significant analysis of variance, we can conclude that the older adults swallow less often than their younger counterparts, even without the presence of secondary disease processes, such as stroke or neurodegenerative disease (e.g. Alzheimer's, Parkinson's, etc.). Despite the decreased swallow frequency for the CDE group indicating possible physiological changes, the older adults reported no difference in perception of their swallowing comfort or function. It is possible that older adults may experience diminished swallow ability after forty but may not perceive when these changes begin.

The inability to perceive changes in physiology may be that the physiological changes occur gradually and subtly. Literature suggests that sensory changes are real and may impact the oropharyngeal mechanism therefore making it difficult to detect bolus size and position (Kamarunas et al., 2015).

The incapacity to detect when swallowing changes occur presents a danger to adults that are aging without receiving consistent care from a healthcare professional. Without the awareness of any physiological changes, older adults may be at risk for age related swallow deficits. Older adults that are not aware of changes to their swallowing may unknowingly self-modify their diets. They may begin avoiding certain foods or liquids and stop taking oral medications if they find pills hard to swallow. Self-modifying diets in this way can put older adults at risk for malnutrition, dehydration, and weight

loss. Additionally, without knowledge of changes in swallow function and its risk to health, they may not know to seek help from a physician until after the onset of other, severe health problems.

Not only is inefficient swallowing a risk factor for the multitude of health problems described above, it may present challenges to an individual's socioemotional health. Older adults that cannot swallow efficiently and are avoiding certain foods or eating slower as a result may not be able to participate comfortably in meals with loved ones. Such avoidance of eating with others can contribute to social isolation, feelings of loneliness, and depression.

Limitations

This study was completed with a limited sample size. As a result, these conclusions are not easily generalized to the greater population of CDE, requiring further investigation with a larger sample. In addition to the limited sample, this study did not cover an adequate range of ages. While Group 1 (young adults) included a satisfactory age range, the average age of Group 2 (CDE) was lower than would have been ideal to determine any significant differences between age groups. The wide range of ages in the CDE group (46-83 years) also leaves questioned unanswered about when and to what extent changes begin to occur during the aging process. To have a better understanding of how and when swallowing changes with age, a higher proportion of older adults past middle age would have been necessary.

The accuracy of objective data describing swallowing frequency should be taken into consideration as well. As mentioned in the literature review, swallow frequency is a reliable indicator of swallowing health when identifying dysphagia in affected

populations, but the use of isolated audio recordings has its limitations. Audio recordings are easily polluted with ambient noise, making other sounds on the recording, such as chewing, coughing, or sniffing, hard to distinguish from a swallow.

Future research

Although this study suggests that individuals may not be able to perceive changes in their swallowing during typical aging, no direct relationship can be determined from this study's results. Additionally, a causal relationship between age and swallow frequency could not definitively be established. In the future, investigations on the effects of aging and perception on swallowing function may prove to be fruitful as a swallow frequency and perception screening maybe a way to address swallow issues and improve healthcare practices.

Additionally, the use of quantitative measures of swallowing function such as surface electromyography (sEMG), fiberoptic endoscopic evaluation of swallowing (FEES), or manometry used in conjunction with swallow frequency measurements may provide a better understanding of an older adult's swallow.

Conducting another study with age-matched cohorts of typically aging individuals and those diagnosed with a swallowing disorder may establish a better understanding of the relationships between spontaneous swallowing frequency and the ability to perceive changes in swallowing physiology. A future investigation will determine a relationship between diminished swallowing function and decreased swallowing frequency.

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Appendix A

Subjects were invited to contact the research team with the following flier. The flier was posted in buildings around the University of Nevada, Reno School of Medicine and Sanford Center for Aging.

	<h2>Participate in Research!</h2> <p>We NEED volunteers</p>	 <p>University of Central Florida</p>
<p>Purpose: To better understand age related swallowing changes in community dwelling elderly</p> <p>Time Commitment: 45 minutes</p> <p>What will you do? Swallow water, pudding and M&M's No compensation will be provided Free parking One session only!</p>	 <p>Swallowing Function in the Community Dwelling Elderly: An Exploratory Study</p> <p> Find us on Facebook: http://www.facebook.com/RAVSS.UNR</p> 	<p>Who? All adults ages 40 to 90+ No history of swallowing/feeding issues</p> <p>Where? University of Nevada, Reno Nell J. Redfield Building 1664 North Virginia Street</p> <p><u>YOU WILL MAKE A DIFFERENCE!</u> Contact us: UNR Research for the Advancement of Voice and Swallow Science Phone: 775-682-7049 Email: UNRRAVSS@gmail.com</p>

Appendix B

The following consent form was provided to each subject before their participation in the study.

**University of Nevada, Reno
Social Behavioral or Educational Research Consent Form**

Title of Study: Swallowing function in the Community Dwelling elderly: a study of swallow function across the lifespan

Principal Investigator: Kristine Galek, Ph.D.

Co-Investigators / Study Contact: Emily Tudorache

Study ID Number:

Sponsor: University of Nevada, Reno School of Medicine

Introduction

You are being invited to participate in a research study. Before you agree to be in the study, read this form carefully. It explains why we are doing the study; and the procedures, risks, discomforts, benefits and precautions involved.

At any time, you may ask one of the researchers to explain anything about the study that you do not understand.

It's important you are completely truthful about your eligibility to be in this study. If you are not truthful, you may be harmed by being in the study.

You do not have to be in this study. Your participation is voluntary. If you do not agree to participate, you will receive the care/education you would have received if the study was not taking place.

Take as much time as you need to decide. If you agree now but change your mind, you may quit the study at any time. Just let one of the researchers know you do not want to continue.

Why are we doing this study?

The purpose of this study is to evaluate how swallowing patterns and behaviors change as we age. As people age subtle changes can take place in their mouth and throat that alter the way people eat and their swallowing patterns. These can include changes like taking longer to eat, eating less or modifying or avoiding certain foods. Unfortunately, information on these age-related swallowing changes is incomplete. As part of this research we will objectively measure your swallow and ask you questions about how you eat and swallow.

Why are we asking you to be in this study?

You have been asked to take part in this research study because you are; living independently, have no previous history of difficulty in eating and swallowing, and do not suffer from an illness that may cause a problem with your eating or swallowing. You must be 18 years of age or older to be included in the research study.

How many people will be in this study?

We expect to enroll 200 participants at The University of Nevada, Reno Speech and Hearing Clinic.

What will you be asked to do if you agree to be in the study?

If you agree to take part in this study, it would involve seven activities; 1) completing four one-page questionnaires. These include questions about your current eating and swallowing patterns, concerns (if any) about swallowing and eating, your physical fitness and activity levels, and a review of your cognitive ability. In addition, you will undergo measurement of your tongue's strength using a lingual pressure recorder which is a bulb in your mouth that you push with your tongue. A measure of the number of times you spontaneously swallow your saliva using a tape recorder and a measure of your swallowing effort using surface electromyography (surface EMG) while you swallow. Surface EMG is simple and painless and involves wearing a "stick on" electrode under your chin while you swallow. Surface EMG is a common method used in speech pathology clinics to measure the strength of a swallow.

If you agree to participate in this study it would involve a one-time appointment where you will complete these pen and paper tasks along with swallowing 12 mouthfuls of food and fluid whilst wearing a surface electrode under your chin, your appointment will take approximately 45-60 minutes.

At your appointment you will be met by a student research assistant who will provide you with the page questionnaires to fill out. The questionnaires ask you some simple questions about your eating and swallowing patterns, your physical fitness and activity levels, and a review of your cognitive ability. You will then be escorted to the swallowing assessment room at the UNR Speech and Hearing Clinic for your swallow measurement. During this measurement you will be asked to do three tasks. 1) have your tongue strength measured by pushing against an air filled bulb in your mouth three times, 2) sit quietly for 15 minutes while we record the number of times you swallow your saliva using a miniature microphone taped to you neck 3) Stick an electrode on your neck, under your chin and swallow small amounts of 4 different foods and fluids, three times each for a total of 12 swallows. After your swallowing session a copy of your swallowing activity or "picture"/line tracing of your swallow will be provided upon request for your personal information and has no supporting medical utility.

You do not have to answer every question or complete every task. You will not lose any benefits if you skip questions or tasks.

How long will you be in the study?

The study will take about 45-60 minutes of your time.

What are your choices if you do not volunteer to be in this research study?

If you decide not to be in the study, your other choices may include:

- Getting no treatment.
- Getting standard treatment for your condition or standard education without being in a study.
- Getting a different experimental treatment/educational experience by taking part in another study.

What if you agree to be in the study now, but change your mind later?

Participation in this study is entirely voluntary. You are free to refuse to be in the study or stop participating at any time without penalty. If you decide to leave the study, contact the investigator so that the investigator can close out your participation in the study documentation.

What if the study changes while you are in it?

If anything about the study changes or if we want to use your information in a different way, we will tell you and ask if you if you want to stay in the study. We will also tell you about any important new information that may affect your willingness to stay in the study.

Is there any way being in this study could be bad for you?

There are no reasonably foreseeable risks or discomforts involved in taking part in this study. Some people may become fatigued when completing questionnaires or during the swallow test. If you experience any of the symptoms mentioned, please tell the researcher and you will be asked to rest until the symptoms disappear.

What happens if you become injured because of your participation in the study?

In the event that this research activity results in an injury, treatment will be available. This includes first aid, emergency treatment, and follow-up care as needed.

Will being in this study help you in any way?

We cannot promise any benefits to you or others from your taking part in this research. However, possible benefits include learning more about how you swallow and how people participate in a research study. Knowledge gained from this study will help the researchers understand how our swallowing changes as we age.

Who will pay for the costs of your participation in this research study?

No costs are associated with participation in this study.

Will you be paid for being in this study?

You will not receive any payment for being in this study.

Who will know that you are in in this study and who will have access to the information we collect about you?

The researchers, the University of Nevada, Reno Institutional Review Board and the researchers from the University of Nevada, Reno Speech Pathology and Audiology Department will have access to your study records.

How will we protect your private information and the information we collect about you?

We will treat your identity with professional standards of confidentiality and protect your private information to the extent allowed by law. We will do this by limiting your personal data collected in this study to people who have a need to review this information. All information provided to this study is confidential and no names will be recorded. We cannot promise complete secrecy. Authorized persons from the University of Nevada, Reno and the Institutional Review Board have the legal right to review your research records and will protect the confidentiality of those records to the extent permitted by law. Otherwise, your research records will not be released without your consent unless required by law or a court order.

We will not use your name or other information that could identify you in any reports or publications that result from this study.

Do the researchers have monetary interests tied to this study?

The researchers and/or their families have no monetary interests tied to this study.

Who can you contact if you have questions about the study or want to report an injury?

At any time, if you have questions about this study or wish to report an injury that may be related to your participation in this study, contact Kristine Galek, Ph.D. at 1(775)784-4887.

Who can you contact if you want to discuss a problem or complaint about the research or ask about your rights as a research participant?

You may discuss a problem or complaint or ask about your rights as a research participant by calling the University of Nevada, Reno Research Integrity Office at (775) 327-2368. You may also use the online *Contact the Research Integrity Office* form available from the [Contact Us page](#) of the University's Research Integrity Office website.

Agreement to be in study

If you agree to participate in this study, you must sign this consent form. We will give you a copy of the form to keep.

Participant's Name Printed		
Signature of Participant		Date
Signature of Person Obtaining Consent		Date

Appendix C

The following is the script used to screen participants for eligibility during the recruitment and consent process.



Participant Telephone Screening Script

Hello, my name is (insert your name), and I am returning your call on behalf of UNR's Speech and Hearing Clinic in reference to your interest in our study. If you have a few minutes to spare, I would be glad to tell you more about it.

The study will take place at the UNR Speech and Hearing Clinic and will last for about 45 minutes. We will ask you to fill out a few survey questions when you arrive, and then measure your tongue strength, frequency of your swallowing and muscle activity while you swallow liquids, puddings and M&Ms. To measure your tongue strength, we will ask you to push against a little air-filled bulb that is placed in your mouth. To measure how often you swallow your saliva (called spontaneous swallowing frequency) we will count the number of swallows you produce while sitting quietly for 15 minutes – this is recorded via a microphone we will tape to your neck (like a radio announcer).

Lastly another adhesive patch will be placed on your neck to record your swallowing as you swallow 3 types of foods, water, pudding and an M&M in order to identify your swallowing muscle activity, and that data will be sent to a computer. At the end of the study, you will be offered a picture of your swallowing activity. The entire process is painless, and you will be allowed to pause at any time if you feel uncomfortable or you can opt out at any time if you wish to.

Unfortunately, we are unable to offer you any compensation for participating in this study, but you will be recognized as supporting important work at UNR.

Are you still interested in participating?

Before we schedule a day and time for you to come in, I have a few questions that I need to ask you to confirm that you will match the type of subject the study is looking for, so please bear with me for a moment.

Are you between the ages of 18 and 90 years old?

Are you currently living independently within the Reno community?

Do you have any history of a medical illness affecting your swallowing? (Now or in the past)

Have you ever had any identified (diagnosed) swallowing difficulty in the past for any reason?

Have you ever had or are you currently taking non-oral feeding methods due to illness?
Have you had any previous or have any planned surgical intervention for swallowing related illness?

Do you have any other medical disorder? Or diagnoses? (e.g. Parkinson's, stroke, heart problems?) Have you had any swallowing problems from this??

Have you had any prior radiotherapy or surgery? Tell me more...

Have you had any swallowing therapy? Have you had any within the last month?

(If they meet criteria):

For phone interview: Great, thank you very much, (insert their name). You definitely fit the criteria that we are looking for in this study, and we would appreciate the opportunity to have you participate in our study. When are you available to attend a session at the UNR Speech and Hearing Clinic if? Is this an appropriate phone number to reach you for a reminder phone call the day before, or would you rather we send you a text message?

In person, on site: Great, thank you very much, (insert their name). You definitely fit the criteria that we are looking for in this study, and we would appreciate the opportunity to have you participate in our study.

(To a male):

On the day of the evaluation please make sure that your neck area is shaved, and free of any hair because the recording device we use is very sticky and we do not want you to be uncomfortable in any way. Thank you very much for your participation, we look forward to seeing you!

(To a female):

On the day of the evaluation please make sure that there is no foundation or lotion on your neck area because that could potentially interfere with the recording device we will be using. Thank you very much for your participation, we look forward to seeing you!

(If they do not meet credentials):

Thank you very much for your time, but unfortunately, you do not fit our criteria for this research study. Thank you very much. Have a nice day.

Alternative questions response: Any immediate questions you have regarding your swallowing function should be brought to your general practitioner. Additionally, please feel free to make an appointment at our facility for a clinical evaluation. I can provide you with the name and phone number of the person you should speak with in order to move forward with that process. Thank you very much. Have a nice day.

Participant Orientation to Assessment Procedures Script

Hello, my name is (name) from UNR's Speech and Hearing Clinic! Thank you very much for coming in today. To start off we just need you to fill out a couple of forms. The

first of which is the Informed Consent. We want this process to be as clear as possible, and make sure that you know exactly what will happen in this study....so I have a few things to go over with you.

Intro:

What you should know about a research study:

You are a volunteer and whether or not to take part is up to you, and you should only take part in this study because you want to. You can agree to take part now and change your mind later, any decisions you make regarding your participation will not be held against you in any way. Feel free to ask all the questions you would like to.

The purpose of the research study:

The purpose of this study is to evaluate how swallowing patterns and behaviors change as we age. These changes include taking a longer time to finish a meal, eating less, and modifying or avoiding certain types of foods. Information regarding these age-related changes are incomplete and so this study aims to study this.

What you will be asked to do in the study:

To begin, we would like you to complete this one-page questionnaire about your current eating and swallowing patterns. Next you will have a measurement of your swallowing taken using surface EMG. This is a “stick on” electrode that will be worn under your chin while you swallow. It measures how hard your muscles work. While wearing the patch you will be asked to swallow small amounts of four different foods and fluids. We will ask you to do this for a total of twelve swallows. After you’ve completed the swallows, we will give you a picture of your swallow. The entire process is painless and should not take more than 15 minutes. If you feel uncomfortable at any point we can pause or stop, you can just let us know.

Benefits:

We cannot give you or others any compensation for taking part in this research, but you may gain insight on how you swallow and how people participate in a research study.

Your participation is very appreciated and will help further our knowledge swallowing with age.

Confidentiality:

All of your personal information is completely confidential. We will not record any names or identifiable information. Only authorized persons from UNR and the Institutional review board have legal right to review your research records and will protect their confidentiality to the fullest extent. Records will not be released without your consent.

IRB contact:

Research at UNR is carried out under the oversight of the Institutional Review Board. If

you have any additional questions about the research study, you can contact them using this information provided.

Withdrawing:

Again, your participation is completely voluntary, and you can stop the study whenever you would like.

Signature:

If you are still happy to participate, Please sign here (point to it) on the line indicated

Questionnaire:

Next, I will have you fill out this one-page questionnaire regarding your current ability to eat or swallow over the last 6 months.

Please feel free to let me know if you have any questions.

I'm going to make sure everyone is ready for you in the back so please fill that out and I'll be back in a few minutes to review it with you.

Thank you very much. Please follow me to the back and we can get started!

Appendix D

The following feeding and swallowing questionnaire was used to obtain information about the participants' self-reported swallowing function. The questionnaire contains the 6 items from the 10-item Eating Assessment Tool (EAT-10) that were included in this study.

Subject Number: _____

Please answer the following questions related to your ability to eat / swallow over the last 6 months

1. Have you lost weight unintentionally in the last 6 months?	Yes	No	unsure
Describe your current diet			
Breakfast			
Lunch			
Dinner			
Do you frequently experience dry mouth	Yes	No	unsure

Place a check mark in the box that best describes your response to each statement

Question	Never (1)	Sometimes (2)	most times (3)	Always (4)
I am concerned about my ability to eat /drink or swallow				
Eating /swallowing solids takes extra effort				
Eating /swallowing liquids takes extra effort				
Swallowing pills takes extra effort				
When I swallow, food sticks in my throat				
I cough when I eat				
I intentionally avoid eating certain foods				
I eat or drink very slowly				

I eat less to make it easier to swallow / consume my meal.				
I have difficulty eating / swallowing that interferes with my ability to go out to eat				
It takes me a long time to eat a meal				

Additional comments: _____