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Oral Motor and Laryngeal Exercises and Pharyngeal Transit Time

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To the Graduate Faculty:

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Abstract

Many people can experience difficulty with swallowing that may result in a decreased quality of life and could ultimately cost them their lives. Dysphagia can occur due to many different neurological diseases or conditions, such as Multiple Sclerosis, Parkinson's Disease, Alzheimer's Disease, and traumatic brain injury. However, dysphagia occurs most commonly post-cerebral vascular accident (CVA), also known as a stroke. The present study examined the effects of an oral-motor exercise program on oropharyngeal transit time and oral muscle strength to determine whether such exercises were effective at improving swallowing function.

Three participants (Participant 1, 67 year old male; Participant 2, 65 year old male; Participant 3, 90 year old female) residing within a nursing care facility and who had been previously identified as having oropharyngeal dysphagia were assessed using the Montreal Cognitive Assessment screener to determine individual ability to follow directions. All participants exhibited mild cognitive involvement, commensurate with age and physical condition. Participants were given a bedside evaluation that included use of EMG to measure oropharyngeal transit time, as well as use of the Iowa Oral Pressure Instrument (IOPI) to measure lingual strength, as well as swallow pressure and swallow reserve. Labial strength and sustained /s/ were used as control measures. This study was a replication of that performed by Dykman (2010).

Participants were placed into an 8 week training period following baseline measures. Treatment included performing the Shaker Head Lift maneuver and the Effortful Swallow, with measurements taken weekly. Participants 1 and 2 completed the study, while Participant 3 terminated the study after the first week. Both participants showed improvements in oropharyngeal transit time, but neither lingual pressure nor swallow pressure changed consistently as a result of the treatment. This study supported

the findings of Dykman's (2010) study in which a single individual who had suffered cerebrovascular accident with subsequent dysphagia showed clear improvement in oropharyngeal transit time

Chapter 1: Review of Literature

Introduction

Swallowing is an important part of our daily functioning and is crucial to our overall wellness and health. Many people can experience difficulty with swallowing that may result in a decreased quality of life and could ultimately cost them their lives (Kim & McCulloough, 2007). Normal swallowing is a highly coordinated neuromuscular process that allows for the passage of food from the mouth to the stomach for the purpose of nutritional and hydration gains (Shaker et al., 2002). Swallowing, though automatic for most people, is a highly complex and efficient process that requires many systems to function together (Vainman, 2007). There are four distinct stages of the swallow and problems with any one of these stages can result in difficulty swallowing or dysphagia.

Dysphagia can occur due to many different neurological diseases or conditions, such as Multiple Sclerosis, Parkinson's Disease, Alzheimer's Disease, and traumatic brain injury. However, dysphagia occurs most commonly post-cerebral vascular accident (CVA), also known as a stroke (Gonzalez-Fernandez & Daniels, 2008). There are a number of negative consequences of dysphagia post-stroke that can lead to an overall reduced quality of life, such as increased length of hospital stay, dehydration, malnutrition, and aspiration that leads to subsequent pneumonia and potentially death (Gonzalez-Fernandez & Daniels, 2008

Typical Deglutition

According to White and colleagues (2008), "Swallowing is a complex combination of voluntary and involuntary actions, requiring the coordination of several different muscles and brain areas" (p.15). Normal swallowing can be viewed as having four distinct stages: the oral preparatory stage, the oral propulsive stage, the pharyngeal stage and the esophageal stage (Logemann, 1998).

Oral Preparation

In the oral preparatory stage of the swallow, the food or liquid approaches the oral cavity and are perceived via sensory components which are sight and smell. The food or liquid is then placed in the mouth, requiring the individual to maintain labial seal using facial muscles to ensure that food remains in the mouth. In addition, the buccal musculature aids in keeping the food on the teeth and tongue and out of the lateral sulci. The tongue forms a seal against the alveolar ridge and slightly crushes the food material in preparation for the teeth with a solid bolus (Seikel, Drumright & King, 2015). Rotary mastication movements place the solid food on the teeth to allow the upper and lower teeth to crush and grind the food. The material is then moved medially toward the tongue allowing saliva to mix with the material in the oral cavity and aid in bolus formation. Lingual movements push the material back towards the teeth if more mastication is needed and the process repeats. The solid food in the oral cavity then becomes a cohesive bolus via rotary mastication and lingual movements. (Logemann, 1998). If the bolus is a liquid, once the labial seal occurs a cohesive bolus is formed and the liquid is placed on the tongue to prepare for transit (Logemann, 1998).

Oral Transit

Once the bolus is formed oral propulsion begins. Also known as the oral transit stage, a sequence of events causes the tongue to make contact with the hard palate and squeeze the newly formed bolus back in a posterior motion to the faucial pillars. This stage of the swallow lasts roughly 1 to 1.5 seconds in duration (Seikel et al., 2015). During this stage, tongue movement can be described as a rolling or stripping action by the midline of the tongue and an anchored position of the tip and sides of the tongue (Logemann, 1998). The tongue cups the bolus creating a chute to allow the bolus to move posterior in the mouth. Facial muscles also aid in the propulsion of the bolus by creating negative pressure and slight inward movement that aids in the posterior movement of the bolus (Logemann, 1998). Oral-pharyngeal transport is partially voluntary and partially involuntary in nature. The voluntary control of the bolus and the involuntary trigger of the pharyngeal swallow are responsible for this classification (Seikel et al., 2015).

Pharyngeal Stage

Many researchers disagree on the proposed stimulus of the trigger of the pharyngeal swallow. Though stimulation of the faucial pillars, the soft palate, the posterior tongue base by the presence of a cohesive bolus are among the many proposed areas of stimulation for trigger of the pharyngeal swallow, further research into this event needs to be done to identify a specific stimulus, or a combination of stimuli, that lead to the initiation of the pharyngeal swallow (Seikel et al., 2015). According to Logemann (1998), the pharyngeal trigger of the swallow initiates " when the bolus reaches the point of the lower edge of the mandible and crosses the tongue base" (p. 77) and terminates at the beginning of laryngeal elevation during pharyngeal phase of the swallow (Logemann, 1998). The initiation of the pharyngeal trigger of the swallow paired with the time required for the completion of the other steps in the pharyngeal phase of the swallow, which ends with the opening of the upper esophageal sphincter (UES) and passage of the bolus through the UES, is known as the pharyngeal transit time and should take no longer than one second to complete (Kim & Mcullough, 1992; Logemann, 1998.

The trigger of the pharyngeal swallow marks the beginning of the pharyngeal phase of the swallow. The pharyngeal phase requires complex coordination and sequencing: once the bolus is prepared properly, the velum seals off the nasopharynx by elevating and retracting to prevent the bolus or excess material from entering into the nasal cavity, the tongue base retracts, and the pharyngeal constrictors contract creating a stripping action in order to move the bolus downward (Logemann, 1998). Laryngeal and hyoid elevation aid in closure of the airway, and anterior movement aids in the opening of the UES. Epiglottic inversion and vocal fold adduction occur to prevent the bolus from entering the airway during this stage (Logemann, 1998). As the bolus moves downward, the cricopharyngeal muscle relaxes, the suprahyoid muscles contract creating hyolaryngeal excursion, and the pressure of the bolus facilitating opening of the UES. When this occurs and the bolus passes through the UES, marking the end of the pharyngeal phase and the beginning of the next and final phase of the swallow (Logemann, 1998). All of these sequences must be well-coordinated and timed because the pharyngeal phase of the swallow from initiation to completion is only approximately one second in duration or less (Seikel et al., 2015).

Esophageal Stage

Once the UES is open and the bolus passes through it, the bolus is carried down the esophagus by gravity and through peristalsis (Logemann, 1998). When the bolus reaches the lower esophageal sphincter, it relaxes and allows the bolus to pass into the stomach marking the completion of the stages of the swallow (Gonzalez-Fernandez & Daniels, 2008; Logemann, 1998). Normal transit time in this stage has a wide range from eight to twenty seconds based upon the type of bolus (Logemann, 1998). According to Seikel and colleagues (2015), once the bolus enters the esophagus a series of events occur. The cricopharyngeus contracts, the laryngeal valves open, the soft palate depresses and respiration resumes.

Neurophysiology of the Swallow

As discussed above, swallowing requires complex and succinct motor movements. In addition to the complex motor movements, many areas of the brain are required in order to produce a functional swallow. Overall, the swallow requires the use of five cranial nerves and the voluntary and involuntary contractions of 26 different muscles (Vaiman, 2007).

More specifically, the nucleus tractus solitarius and the reticular formation that surrounds it, which are housed in the rostral medulla of the brainstem, are responsible for the neural control of the swallow (Gonzalez- Fernandez & Daniels, 2008). This area in the brainstem is responsible for management and timing of the motor neurons that control both the swallow pattern and triggering of the pharyngeal swallow (Gonzalez-Fernandez & Daniels, 2008). In addition to the medullar contribution to normal swallowing, there are many areas that are encompassed within the cerebral cortex that contribute to the normal swallow.

Many portions of the cerebral cortex have an important neurophysiologic role in typical deglutition. The primary somatosensory, motor and supplementary motor cortices are all important locations in the cerebral cortex for swallowing sensorimotor control, regulation and execution (Gonzalez-Fernandez & Daniels, 2008). More specific subcortical structures activated during the swallow include the descending corticobulbar tracts, the thalamus and the basal ganglia, though further research is needed to describe their function in detail (Gonzalez- Fernandez & Daniels, 2008).

In a study by Martin and colleagues (2004), the researchers sought to determine which brain centers were activated during the swallow and which brain centers were activated during voluntary tongue movement used in the swallow. This study indicated that it was challenging to determine the specific regions of the cortex that were activated during the swallow versus other functions, such as tongue movement. In both the swallow and the voluntary tongue movement associated with the swallow, the following locations were active on fMRI: postcentral gyrus, precentral gyrus, frontoparietal operculum, cingulate motor area of the anterior cingulate gyrus and the supplementary motor cortex. In addition, fMRI indicated a few regions that were only activated during the swallow as compared to voluntary tongue movements: left postcentral gyrus, supramarginal gyrus, left lateral pericentral cortex, precuneus/cuneus, and the right insula/operculum. The above mentioned study did find a strong left hemisphere dominance for overall swallowing function. There are many complex structures working together to coordinate the correct sensory, motor and neural components of the swallow, and a problem with any of these areas could result in a problem with the swallowing process

Dysphagia

Dysphagia is a disruption in the flow of the bolus from the oral cavity through the pharynx that interrupts the safe passage of the bolus to the stomach potentially causing food to enter into the airway (Singh & Hamdy, 2006). In addition, dysphagia encompasses the sensory, behavioral, preliminary motor acts and cognitive awareness for the preparation of the swallow (Logemann, 1998). There are a number of negative consequences of dysphagia. Two of the main concerns with people who have dysphagia are reduced quality of life and increased risk of death. There are many different consequences of dysphagia that can lead to a reduced quality of life, such as increased length of hospital stay, dehydration, malnutrition, and aspiration that leads to subsequent pneumonia (Gonzalez-Fernandez & Daniels, 2008).

Aspiration pneumonia is a frequent complication of dysphagia and can cause serious health complications and even death in many people who experience dysphagia. The prevalence of pneumonia after a stroke is between 7% and 29% of known stroke patients, which is cause for concern (Martino et al., 2005). White and colleagues (2008) define aspiration pneumonia as "a result of aspiration of pharyngeal secretions (food and saliva) into the larynx and lower respiratory tract" (p.16). Dysphagia that is characterized by a delayed trigger of the pharyngeal swallow and subsequently increased pharyngeal transit time, allows food or liquid to seep past the tongue base and into the airway prior to the initiation of the protective mechanisms, which can result in aspiration and penetration issues associated with aspiration pneumonia (Logemann, Pauloski, Rademaker, & Colangelo, 1997).

When discussing dysphagia, there are a few different types of etiologies that can result in problems with the swallow including structural damage, neurological disorders and behavioral disorders.

Head and neck cancer is one etiology that can have negative impacts on swallowing and can lead to dysphagia. In a study that evaluated dysphagia post-chemotherapy and radiation for people with head and neck cancer, Nguyen and colleagues (2004) discussed the complications of radiation for deglutition. They stated that any of the structures for normal deglutition could be negatively impacted by doses of radiation. In addition, the larynx and pharyngeal muscles and other structures of the swallow could obtain excessive fibrosis from chemotherapy and radiation, which could cause abnormal motility of the bolus. As a result of this, there is an increased risk for dysphagia and aspiration in this population.

In the adult population, there are two broad subcategories of neurological etiologies that can contribute to dysphagia. The first of those broad categories is degenerative disorders, such as Alzheimer's disease and multiple sclerosis (Gonzalez-Fernandez & Daniels). The second broad category of neurological etiologies is acute disorders, namely cerebral vascular accidents. It should be noted that acute disorders can become chronic.

According to Gonzalez-Fernandez and Daniels (2008), dysphagia is prevalent in many etiologies, such as Alzheimer's disease, muscular dystrophy, multiple sclerosis, Parkinson's disease and amyotrophic lateral sclerosis. The incidence for each of these degenerative neurological diseases varies depending on the specific condition. Gonzalez and colleagues (2008) found that people with varying degenerative disorders had dysphagia incidence rates that ranged from 25% of the population to 80% of the population depending on the degenerative condition with the majority of the incidence percentages falling between 30-40% of the population. This is significantly lower than the incidence of dysphagia for people post-cerebral vascular accident (Gonzalez-Fernandez & Daniels, 2008).

In acute disorders, namely cerebral vascular accident, dysphagia can cause degradation in quality of life and even death (Martino et al., 2005). Unlike other functions that are stored in a more modular portion of the brain, dysphagia can occur as the result of a lesion in the brainstem, cerebral cortex or cerebellum, which results in a high incidence of the disorder. There are many different types of evaluation methods used to determine if an individual has dysphagia. As a result of this, the percentage of people who are diagnosed with dysphagia soon after a stroke varies across research and evaluation methods (Martino et al., 2005). With screening identification of patients post-stroke, the incidence of dysphagia is 39-40%, with clinical testing the overall incidence of dysphagia is 51-55%, and with instrumental testing the prevalence of dysphagia is 64-78% following a stroke (Martino et al., 2005). This places the population of people with dysphagia post-stroke at risk for pulmonary complications, aspiration, penetration and an increased risk of death (Martino et al., 2005). It is estimated that up to 76% of people who experience dysphagia post-stroke demonstrate deficits in the oral and pharyngeal stages of the swallow (Robbins et al., 2007). Each of the lesion sites of the brain can have a different impact on swallowing function. According to Martino and colleagues (2005), voluntary control of mastication and oral transport can be disrupted as a result of cerebral cortex lesions. In addition, lesions in the precentral gyrus disturb contralateral motor control of the lips, face, and tongue, as well as ipsilateral pharyngeal peristalsis. Brainstem lesions can affect attention, concentration and control of the swallow, as well as sensory issues with the articulators and the face, difficulty with timing of the pharyngeal swallow, problems with glottic closure, laryngeal elevation and cricopharyngeal relaxation.

Post-stroke, lingual pressure and strength can be negatively impacted, which can cause issues with manipulation of the bolus in the oral preparation stage, oral stage, and the triggering of the pharyngeal swallow. People who have dysphagia post-stroke have a limited muscular reserve, which is the difference between the maximal tongue strength and swallowing pressure. When a person displays an overall decreased reserve, they require more strength to complete sub-maximal activities. This means that their systems must work harder to generate the same pressure levels (Youmans & Stierwalt, 2007). If the tongue is unable to generate enough lingual pressure, it could cause a delayed trigger of the swallow as a result of an inability to push the bolus posteriorly in the oral cavity (Hewitt et al., 2008).

Assessment of Dysphagia

An important assessment tool for dysphagia is the bedside swallowing evaluation performed by a clinician. The bedside swallow evaluation is a useful tool to determine the presence, severity and prognosis of dysphagia. In addition, the bedside swallow evaluation can aid in creating treatment recommendations and diet level recommendations. If the results of the bedside swallow evaluation do not identify the etiology of the dysphagia, or if further assessment in needed to determine appropriate compensatory techniques in order to reduce risk and increase the effectiveness and efficiency of the swallow, then the clinician refers for an evaluation to be done via instrumentation, such as a videofluoroscopic swallowing study (VFSS), fiberoptic endoscopic evaluation of swallowing (FEES), and surface electromyography (sEMG). The first step in the bedside swallowing evaluation is for the clinician to determine the client's overall attention, consciousness, posture, voluntary cough, saliva control and his or her vocal quality (White et al., 2008). According to White and colleagues (2008), if the patient has adequate attention, consciousness and posture and is deemed safe to swallow by clinical impressions, then the patient can sip a teaspoon of water and the clinician observes the swallow and looks for signs of aspiration. If the teaspoon is cleared safely, then the clinician may recommend that the patient drink from a cup of water, they will monitor the swallow and check for signs of aspiration (White et al., 2008). If water is determined to be safe, the clinician may order more trial boluses with different viscosities and textural consistencies to determine if the patient is able to swallow different consistencies. Laryngeal palpation is also used during the bolus trials to allow the clinician to feel the movement of hyolaryngeal excursion and the structures of the swallow (Logemann, 1998).

The gold standard for identification of normal and disordered swallowing using instrumentation is the videofluoroscopic evaluation, which is often referred to as the modified barium swallow (Logemann, 1997). In this procedure, patients consume different boluses with many different textures. Each of the boluses has a radio-opaque barium substance added to it which allows the movement of the bolus from the oral cavity to the pharynx to be evaluated via x-ray (Gonzaez-Fernandez & Daniels, 2008; Kim & McCullough, 2007; Logemann, 1998). During the videofluoroscopic evaluation procedure, the bolus can be visualized during the actual swallow in order to view it through all the stages of the swallow. According to Bours and colleagues (2009), the videofluoroscopic evaluation allows the clinician to follow the bolus and track the movement of the entire swallowing system and to view the coordination of the musculature to determine the swallow function (Bours, Speyer, Lemmens, Limberg & De Wit, 2009). White and colleagues (2008) noted that the VFSS " ...allows clinicians to see where swallowed material actually goes (i.e. if food or fluid is entering the respiratory tract and if so, how much, and whether pharyngeal or esophageal muscles are functioning properly) (p. 17). Though there are many benefits to this approach. Some of the risks involved are that each VFSS trial contains radiation, which can cause an increased risk of radiation exposure. Other assessment methods may be selected as a result of this risk (Bours et al., 2009).

The Iowa Oral Performance Instrument (IOPI) though not a diagnostic measure for swallowing, can be useful because it measures force by having the participant push his/her tongue against a flexible ball that is able to transduce pressure to an electrical signal (Seikel et al., 2015). According to Seikel and colleagues (2015) the IOPI force measurement may "translate directly into a person's ability to move the bolus in the mouth, or squeeze the tongue onto the roof of the mouth to support movement of the bolus in swallowing" (p. 448). Though not directly diagnosing a patient with either having dysphagia or normal swallowing function, IOPI can provide useful information about pneumonic pressure, lingual pressure, labial pressure and peak swallowing pressure. This device provides visual feedback of pressure generation through light-emitting diodes and can be useful when comparing normal swallowing pressures to those of people with dysphagia (Robbins et al., 2007).

According to Crary, Carnaby, and Groher (2007), surface electromyography (sEMG) is becoming a highly used tool for speech-language pathologists to identify the occurrence of a normal swallow, a disordered swallow, and the physiological observations associated with them. In recent years, sEMGs also have been used to aid in the treatment of impaired swallowing function. The muscle activity associated with the swallow can be evaluated through electrodes that are adhered to the skin to evaluate the muscle coordination and movements. Electromyographic signals from electrodes placed on the skin evaluate muscle activities from the multiple muscles of the swallow. These signals measure activation of the muscles as a whole unit but do not provide information about which specific muscles are activated during the swallow (Crary et. al., 2007). These procedures are non-invasive, simple to use and can provide real-time information about the swallowing musculature (Stepp, 2012).

According to Vaiman (2007) in a study that evaluates the use of sEMGs for the identification of dysphagia, it was stated that the sEMG provides muscle contraction timing and duration amplitude information during the swallow as well, and has been shown to be an easy to use method for healthcare personnel compared to other methods. Vaiman states that an assessment should be noninvasive, radiation-free, simple to learn and use, reliable, lack a financial burden, time efficient and accurate in the assessment of dysphagia. He states that the sEMG as a way to assess dysphagia meets all of the above criteria making it arguably one of the best ways to evaluate swallowing function, especially when the dysphagia has an unknown origin.

Treatment of Dysphagia

There are many methods used for the treatment of swallowing disorders. Traditionally, postural changing techniques, compensatory strategies, oral motor exercises, swallowing maneuvers p.o. trials and sensory stimulation techniques have been used to improve overall swallowing function and provide a safer swallow for the patient (Logemann, 1998).

Swallowing maneuvers such as the supraglottic swallow maneuver, the super-supraglottic swallow maneuver, the effortful swallow maneuver, and the Mendelsohn maneuver are implemented in order to place specific portions of the pharyngeal physiology under volitional control by the individual. These maneuvers can be done using only saliva from the participant (Logemann, 1998).

One of the best known and most effective swallowing maneuvers is the Mendelsohn maneuver. This maneuver is referenced to increase the overall laryngeal elevation duration, which will in turn lead to increase width of the cricopharyngeal muscle during swallowing and increased coordination of the overall swallow (Logemann 1998). According to Wheeler-Hegland and researchers (2008), the Mendelsohn maneuver "...results in higher peak amplitudes and longer duration of submental muscle activation" (p.1073). Hoffman and researchers (2012) noted that during the Mendelsohn maneuver, patients are educated on the normal movement of the larynx. Then patients are instructed to push their tongue against the roof of their oral cavity and feel their larynx elevate. Once their larynx is elevated they are instructed to hold it there for a couple of seconds by engaging their neck muscles. In this way laryngeal elevation is prolonged and it increases the amount of time that the larynx is elevated (Hoffman et al., 2012). A specific example of instructions that can be provided to a patient doing the Medelsohn maneuver according to Logemann (1998), is as follows: "Swallow your saliva several times and pay attention to your neck as you swallow. Tell me if you can feel that your Adam's apple lifts and lowers as you swallow. Now this time, when you swallow and you feel something lift as you swallow, don't let your Adam's apple drop" (p. 222). Research has shown that the Medelsohn maneuver improves UES functioning by prolonging laryngeal elevation and has been shown to improve the functional swallow of brainstem stroke patients (Lazarus, Logemann, & Gibbons, 1993).

In a study conducted by Hoffman and researchers (2012), the Mendelsohn maneuver was observed via High Resolution Manometry (HRM), a tool used to measure pressure during the swallow along the length of the esophagus and pharynx, in order to study its effects on swallowing pressure and timing characteristics. The results of their study indicated that the Mendelsohn maneuver aided in improved velopharyngeal rise rate and duration, decreased maximum UES pre-opening pressure, and increased the minimum UES opening pressure.

Another maneuver, that has been found to be effective in the treatment of swallowing function is the effortful swallow. This maneuver can also be done as an exercise, it's use as a maneuver and as an exercise can help to facilitate improvements to overall pharyngeal function, specifically, anterior movement of the pharyngeal wall and posterior tongue base movement. This improves the clearance of materials from the valleculae. This maneuver has also been shown to improve maximum velopharyngeal pressure and UES pressure duration during the swallow (Hoffman et al., 2012). According to Wheeler-Hegland and colleagues (2008), the effortful swallow, "Increases hyoid vertical displacement, the duration of hyoid anterior excursion, duration of UES opening, and the amplitude of submental muscle activation" (p.1073). Specific instructions for a patient to use the effortful swallow would be accomplished by asking patients to squeeze hard with all of their muscles as they swallow (Logemann, 1997; Logemann 1998). According to Logemann (1998), providing these instructions to the patient will "improve the pressure exerted by the oral tongue at all points along the palate and at the tongue base and will increase tongue base movement" (p.221).

There are several exercises such as the Shaker head lift, effortful swallow, and the Masako technique that can aid in improving swallow function. Both the effortful swallow and the Shaker head lift are pertinent to the present study, the effortful swallow was addressed in the previous section and the Shaker head lift will be addressed in the subsequent section.

The Shaker exercise is aimed at improving UES dysfunction and reducing the amount of residue remaining in the pharynx. This is accomplished through the improvement of the duration and width of the opening of the UES, which reduces aspiration risk (Logemann, 2005). The Shaker exercise utilizes a series of isometric and isokinetic head-lift exercises that are involved in strengthening the neck muscles over time (Logemann, 2005). Participants lie supine and raise their head for a designated amount of time and then perform consecutive head raises in the same supine position, this is known as the Shaker head lift exercise (Shaker et al., 2002).

In a study conducted by Shaker and colleagues (2002) looking at the benefits of the Shaker head lift procedure for people with dysphagia that resulted from abnormal UES function, it was found that the Shaker head lift exercise improved the participants' overall anterior to posterior UES opening, improved the participants' maximum laryngeal excursion and overall improvement of the functional outcome of swallowing. The control group showed no improvements, indicating that the above mentioned improvements were likely a result of the Shaker head lift exercise. It was also found that participants had a decrease in pyriform sinus residue after the treatment and no persisting issues with post-swallow aspiration. This study indicates that the Shaker head lift exercises can reduce aspiration risk and improve dysphagia outcomes, which ultimately leads to an improved quality of life and potential for decreased medical expenses.

Diet level modification, such as increasing the viscosity of liquids or modifying the consistencies of solids (e.g. puree, moist mechanical soft, mechanical soft) are considered a last resort in swallowing therapy and are not a desired treatment option due to the impacts to quality of life and the overall challenges of patient compliance that diet modification presents (Kiger, Brown, & Watkins, 2006). However, for some patients, this may be an option while they are working on associated exercises and maneuvers or it may be the best long-term option.

Postural techniques in general are meant to systematically alter or control the movement of food flow and don't focus on altering the musculature or physiology of the swallow. With correct diagnosis, postural techniques can improve dysphagia for many different patients. It should be noted that different techniques work for different patients (Logemann, 1998). The following are examples of postural techniques that can be used during the swallow: chin tuck, chin up, lying down, head back, head tilt to strong side, head turn, and chin tuck with a head turn (Logenmann, 1998)

Dykman (2010) sought to determine if oropharyngeal transit time post-stroke could be decreased with the use of oromotor and laryngeal elevation exercise programs on people with a delayed pharyngeal trigger of the swallow post-stroke. In this case study, sEMGs were used to measure the oropharyngeal transit time and the Iowa Oral Performance Instrument was used to determine lip pressure, lingual strength, swallow reserve, and peak swallowing pressure. Though only a case study, the results indicated a strong effect of an intensive six week exercise program on decreasing oropharyngeal transit time resulting in a safer swallow with decreased risk of aspiration.

The researcher targeted improvement of the pharyngeal swallow through the use of the Mendelsohn maneuver, the Shaker head lift and the effortful swallow. This study confirmed that there were improvements made to lingual pressure, peak swallow pressure, and laryngeal elevation, which resulted in an overall improvement of the oropharyngeal transit time. There was no confirmed change in the control measures, indicating that this program was likely the cause of the improved swallowing function. This study examined procedures that could be extremely functional for the treatment of pharyngeal phase dysphagia in patients six months or longer post-stroke and specifically those patients with reduced pharyngeal function as a result of a delayed trigger to the pharyngeal swallow and increased oropharyngeal transit time (Dykman, 2010).

Goals and Rationale

As a result of these promising findings, the current study has aimed at replicating the previous procedures by Dykman (2010). The current study is a partial replication of the methods used in the previous study examining two additional participants. It was hypothesized that oral motor and laryngeal elevation exercises would improve the oropharyngeal transit time of people with pharyngeal phase dysphagia post-stroke. The rationale is that these exercises were effective during the previous case study and should be explored in more detail with more participants in the current study. Thus the question for the present study is: What is the effect of a six week intensive oral motor and laryngeal exercise swallowing treatment on the oropharyngeal transit time in people with oral and pharyngeal dysphagia at least six months post-stroke?

Research Hypothesis

This thesis is a partial replication of a previous single subject thesis by Dykman (2010). As such, the methods in the present study are similar to the methods used by the previous thesis in order to replicate the previous study. A single treatment AB research design was used with four baseline points and six treatment points. In this study, one post-treatment measure was obtained one week after the treatment was completed.

Inclusion criteria for participants were as follows: participants were at least six months post CVA with documented pharyngeal swallow concerns determined by the modified barium swallow or by a licensed and certified speech-language pathologist with experience in dysphagia assessment, diagnosis and treatment. In addition, each participant's cognitive level was measured by the Montreal Cognitive Assessment (MOCA) screener and verified by the speech-language pathologist. No more than a mild cognitive deficit was accepted for the present study as determined by the MOCA. Finally, the participant was able to consume food and liquid orally despite presenting dysphagia.

Recruitment took place in Southeast Idaho, through direct contact with a licensed speech- language pathologist (SLP) working in the skilled nursing facility setting. The research proposal and inclusion criteria were disclosed upon contact with the professionals in the field. A discussion of inclusion criteria and the methods of the research proposal were discussed in-depth with the SLP.

Chapter 2: Methodology

Participants

Prior to the initiation of the study, the researcher taught the participants how to complete the Shaker head lift series and the effortful swallow to ensure competence and understanding of how to correctly complete the exercises. A licensed speech-language pathologist was present during all of the assessment periods to ensure correct placements of the electrodes, for the sEMG, the correct placement of the IOPI bulb and to ensure that the participants were completing the exercises correctly. In addition, the SLP was present to ensure safety and to aid the researcher in noting any overt signs or symptoms of aspiration and/or penetration.

Participant One

Participant one was a 67 year old male who was approximately a year and a half post-stroke at the time of the study. The participant was diagnosed with mild oral-pharyngeal dysphagia post infarction by a certified and licensed speech-language pathologist in the field. The participant had received treatment for his swallow following the CVA. Post-treatment, the participant exhibited a mild oral-pharyngeal dysphagia.

Medical records indicate that the participant had a CVA in the spring of 2014. As a result, the participant was diagnosed with oral-pharyngeal dysphagia in 2014. The participant received swallowing therapy for a short duration and was later discharged. The participant progressed from moist mechanical soft solids to regular solids, nectar thick liquids to thin and was returned to a regular solid and thin liquid diet with the modification of chopped meats during meals to reduce aspiration risk. The participant still displayed residual wet vocal quality and infrequent coughing at the time of testing for this study, but denied any difficulty with swallowing or any need for speech therapy services at the time of the study.

At the time of the study, the participant was residing in a skilled nursing facility. The participant experienced mobility issues that required the full time use of a wheel chair and assistance from nursing for bed to chair transfers.

The participant was on a non-restricted diet with the exception of meats, which were chopped as an aspiration precaution. However, overt signs of aspiration/penetration were noted with occasional wet vocal quality and throat clearing after the participant ingested thin liquids. A standardized test was not performed, but informal measure noted that the quality, rate, and articulation of the participant's speech were within normal limits for his age and gender.

The Montreal Cognitive Assessment screener was administered and the patient was noted to have a mild cognitive deficit. The licensed and certified speech-language pathologist noted that his cognitive function was no more than mildly impacted.

Participant Two

Participant Two was a 65 year old male who had experienced two CVAs that impacted his swallowing function. The initial infarction was approximately seven and a half years prior to the initiation of the study and the second infarction was approximately two and a half years prior to the initiation of the study. The patient was diagnosed with oral-pharyngeal dysphagia following a videofluoroscopic swallow study with barium in

2013. The certified speech-language pathologist analyzed and confirmed this diagnosis for the present study. At the time of the study, the participant continued to have a moderate oral-pharyngeal delay.

Medical records for participant two stated that in 2008 the participant had an initial CVA and was placed in a skilled nursing facility where he resided during the study. The participant was diagnosed with dysphagia and placed on *nil per os* (NPO) due to profound deficits in the trigger of the pharyngeal swallow and oral-pharyngeal dysphagia deficits. Following the CVA, the client received swallowing therapy. With swallowing therapy by a certified SLP, the participant advanced to a puree solid and nectar thick liquid diet. However, the participant would independently modify his nectar thick liquids to thin, though this was not recommended. In 2013, the participant contracted aspiration pneumonia and had another infarction that resulted in subsequent profound oral-pharyngeal dysphagia as confirmed by a videofluoroscopic swallow study. The participant had a percutaneous endoscopic gastrostomy (PEG) tube placed in 2013. The participant was initially discharged from speech and swallowing due to non-compliance with safety strategies and modifications to presentation of food. The participant would drink from a bowl quickly with a head back position, and refused to use a spoon, drink from a cup or use a straw. Once the patient was compliant with recommendations, he received swallowing therapy using thermal tactile stimulation, pharyngeal exercises and oral motor exercises, and neuromuscular electrical stimulation with placement four in the submental muscle region for 30 minutes paired with exercises for 12 weeks. The participant progressed to a puree solid and thin liquid diet with safe-intake strategies, such as multiple swallows, small bites and slow eating rate. The speech-language pathologist noted that he continued to have moderate oral-pharyngeal dysphagia. The participant was unable to take his medications orally and required them to be administered via his PEG tube. His current diet at the time of the study was puree solids and thin liquids. The participant was cleared for specific regular consistency foods with modifications per his request, such as Cheetos dipped in cheese, chocolate bars, M&Ms and cookies with milk poured over them.

At the time of this study the participant was residing at a skilled nursing facility, and had mobility limitations and utilized a wheelchair. The participant was deemed able to self-transfer, although sometimes he requested assistance from the nursing staff. The participant received oxygen via a nasal cannula when lying supine in bed for long periods of time.

The participant was ingesting puree solids and thin liquids with overt signs of aspiration/penetration, specifically coughing and wet vocal quality were noted when the participant ingested thin liquids. The participant also received medication via PEG tube. A standardized test was not performed, but the client exhibited severe articulation and intelligibility deficits due to suspected dysarthria. This was a result of the initial CVA and the dysarthria was indirectly treated at that time. There were no noticeable changes in his dysarthria and the patient was discharged from treatment related to speech production following the initial CVA. At the time of the study the participant's former SLP noted that he had a moderate delay of the trigger of the pharyngeal swallow.

The Montreal Cognitive Assessment was administered to measure potential cognitive impairments. The results indicated a mild cognitive impairment and the speech-language pathologist working with the individual confirmed that his cognition was functional for the current living environment.

Participant two had a member of the nursing staff complete the exercise program for the study with the participant when she was available, though she commented that she did not work with him during every scheduled session.

Participant Three

Participant three was a 90 year old female who was approximately a year and a half post cerebral vascular accident. The participant was diagnosed by a certified speech-language pathologist to have mild pharyngeal dysphagia and a delayed pharyngeal swallow through a field assessment. The Speech-Language Pathologist also noted that the client had some esophageal swallowing concerns likely due to an esophageal stricture.

Medical records at the facility where the participant was living indicated that she entered the facility and self-reported having a cerebral vascular accident in 2014. The participant's swallow was assessed upon her entry into the facility where she resided in 2014, and she received a pharyngeal dysphagia diagnosis from the speech-language pathologist at that time. No further neurological insult has been reported since the initial cerebral vascular accident.

Dysphagia was still a concern with this participant and mild pharyngeal dysphagia was still noted in this participant due to overt signs of aspiration and/or penetration, such as wet vocal quality and coughing/throat clearing following liquid oral intake.

The participant was residing in a skilled nursing facility at the time of the study and lived at the facility full time since 2014. Upon entry to the facility in 2014, the participant received swallowing therapy by a certified speech-language pathologist for her pharyngeal and esophageal swallowing concerns. The participant was ambulatory with the assistance of a front wheeled walker and was able to self-transfer from her chair to her bed without the assistance of nursing.

At the time of the study, the participant was on a regular diet with thin liquids, but did require modifications to her medication intake. Her pills were crushed instead of taken whole by mouth. Though she was on a regular diet, wet vocal quality and coughing were observed during her assessment during the present study. The speech-language pathologist who administered services to the participant noted that she still, at the time of the study, had a mild pharyngeal delay as observed by her overt signs and symptoms of aspiration/penetration, based upon clinical and professional judgment. Though a formal assessment was not given, clinical evaluation noted that the client's speech intelligibility was within normal limits and her vocal quality was appropriate for her age and gender.

The MOCA screener for cognition was used to screen for cognitive deficits. The results demonstrated that the participant had a mild cognitive impairment and the certified speech-language pathologist who worked with the participant noted that the participant's cognitive function was normal to mildly delayed for her age and that her cognition was not a concern for her swallowing function.

She participated in the assessment portion of the study and one week of treatment sessions and measurements before choosing to discontinue the study due to reported discomfort when performing her exercise program.

Materials

Materials for initial, interim and follow up assessment include the following: alcohol pads were used to clean and prepare the skin surface, the IOPI Northwest Model 2.1 by IOPI™ (Northwest Co., LLC, Carnation, WA) was used to take all IOPI measurements, the MyoTrac Infiniti two channel sEMG (Thought Technology Ltd) was used to record sEMG measurements, the Montreal Cognitive Assessment screener was used to acquire an objective measure of cognitive abilities, and Microsoft Excel 2007® by Microsoft Corporation, (Seattle, WA) was used to record and graph data. A teaspoon and water were used for the liquid bolus trials.

Procedures

The sEMG trials were done initially during each assessment and treatment session for the oropharyngeal transit time. After data were collected from the sEMG, the IOPI measurements for labial strength, lingual strength and swallow pressure were taken. After the IOPI was completed, the researcher timed the participant producing a sustained /s/ for as long as he or she could as a control measure. This procedure was repeated each session in the order listed above.

Baseline measurements for swallowing function were taken using the IOPI and sEMG. Measurements were obtained over the course of two days ending with four sets of data points and 3 data points for each session (three sets of data points on the initial day and one set of data points on the second day). These data points were taken in the morning, afternoon and evening on the first day and in the morning on the subsequent day.

Placement of electrodes for the sEMG were determined based on the article by Vaiman, Eviatar and Segal (2009). The first electrodes were placed on the skin of the anterior belly of the digastric muscles, the mylohyoid and the geniohyoid, which make up the submental muscle group. Two standard electrodes were placed over the platysma and under the chin. The initial set of electrodes was placed 10 mm apart, on the left and right side of the midline. Placement of the ground electrode was on the participant's clavicle bone. The second set of electrodes was placed on the skin over the sternohyoid, thyrohyoid, omohyoid and sternothyroid muscles also known as the infrahyoid group. An additional ground electrode was placed on the opposing clavicle bone. To hold the electrodes in the correct position, the participant's neck was prepped with an alcohol wipe and shaved as needed and the electrodes were placed. Once the electrodes were placed securely on the participant, three swallows using one teaspoon of thin liquids were administered to the participant and the electrical data were recorded. Oroharyngeal transit time was calculated by averaging the duration of the three swallows for each session. For each swallow, oropharyngeal transit time was measured in seconds. The initiation of oropharyngeal transit time was recorded when the initiation of posterior tongue movement occurred (activation of submental activity) and termination of oropharyngeal transit time was recorded as the termination of infrahyoid activation.

Lingual strength, labial strength and swallow pressure were measured using the IOPI. The exercises in this program were not expected to improve labial musculature and as such, this was used as the control variable in this trial. In addition, a sustained consonant /s/ was used because this exercise program did not target respiratory support for speech so no changes in respiration were expected. The IOPI was administered over the four baseline trials as specified above. Lingual strength was measured by using the IOPI bulb and placing it on the alveolar ridge behind the upper incisors. The participants were instructed to push up against the bulb using their tongue with as much force as possible. Labial strength was also measured using the IOPI bulb by placing the bulb between the lips and instructing the participants to close their lips as firmly as possible without using their teeth. The IOPI was set to measure the peak pressures for the above processes and the results were recorded. Oral swallow pressure was also measured using the IOPI bulb, by placing the bulb on the alveolar ridge, behind the upper incisors. The participants were asked to swallow normally and their swallow was evaluated based on the highest pressure generated during the swallow. The above measurements were taken once per assessment session, and the difference between swallow pressure and maximal lingual strength was calculated and recorded as the swallow reserve. In addition, during each session, outward signs of aspiration and penetration were counted and recorded, including wet vocal quality after the swallow, throat clearing and coughing.

Following baseline measurements, an exercise program that targets improved power and strength of the laryngeal elevators and the posterior tongue was implemented. For this exercise program, the researchers followed the instructions provided by Burkhead and colleagues (2007) on the correct way to perform the effortful swallow maneuver. For the completion of the effortful swallow, the participants were asked to "swallow as hard as you can" and to make sure that the swallow was audible. Participants were encouraged to increase the contact force between the tongue and the palate as well as to increase the force at which the participants forced the bolus posteriorly. This exercise was completed using a thin liquid bolus. Each of the above mentioned exercises were performed 15 times, twice a day, five days a week for six weeks (three days on, one day of rest, two days on, one day of rest). According to the instructions from Shaker and colleagues (2002), participants performed the Shaker head lift, which involves lying down in supine, lifting the head until the participant can see the toes and holding that position for one minute. The Shaker head lift was performed three times for one minute each, with one minute of rest in between each repetition. Then the participant was asked to lift the head 30 times in a row at a constant speed. The Shaker head lift was done on the same schedule as the previous exercises, twice a day, five days a week for six weeks with the same rest and work schedule.

The Mendelsohn maneuver was part of the original study done by Dykman in 2010, however, it was not used in this study due to the repetitive nature of the muscles targeted, the fact that it is a maneuver and not an exercise and that it was going to require too much effort for the participants to complete in this study.

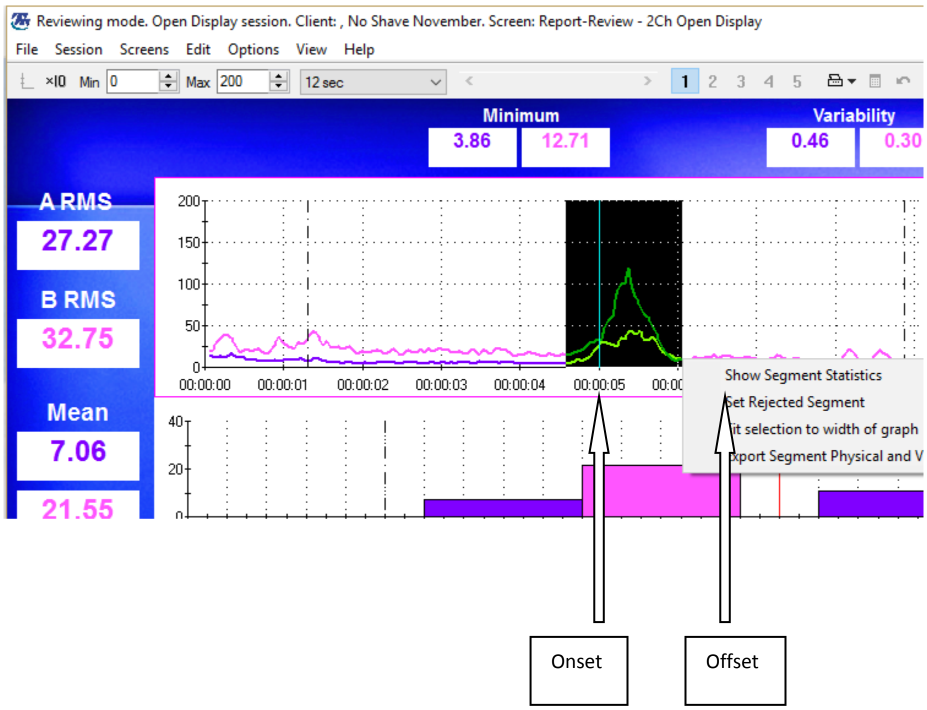
The researcher provided all of the participants with a binder that contained a weekly schedule and a weekly checklist of the exercises, how to do them and how often to complete them. The participants were asked to rate the swallow from one to ten with one being poor and ten being excellent. The home-health care provider or the individual were asked to record when the exercises were done and how the participant felt while completing the exercises.

Prior to the initiation of the exercise program, a trial session was completed to aid in understanding and accuracy of the exercises in the program. The researcher and the certified and licensed SLP taught each participant the exercises, demonstrated the exercises and then had the participants practice the exercises, providing feedback to the participants as needed.

Measurement Criteria for the sEMG

Surface EMG measurements of oropharyngeal transit time, or the time between the termination of the posterior bolus propulsion of the tongue and the initiation of laryngeal depression, and strength and pressure measurements by the IOPI were taken weekly (see Figure 2.1). The entire oropharyngeal transit time is displayed in the dark portion of the graph as indicated in Figure 2.1 Measurements, and data were taken at the beginning of each session and the researcher supervised the participant doing one entire sequence of the exercise program, providing feedback regarding performance for the participant. The researcher watched for the overt signs of aspiration during these sessions and noted them. Upon completion of the six week exercise program, the researcher recorded the objective data that were taken over the course of the exercise program and one week after the termination of the swallowing program. Data was then be analyzed.

Figure 2.1 Illustration of measurement criteria for onset and offset of swallowing using sEMG. Note that onset is indicated by the initial arrow and offset is indicated by the second arrow.



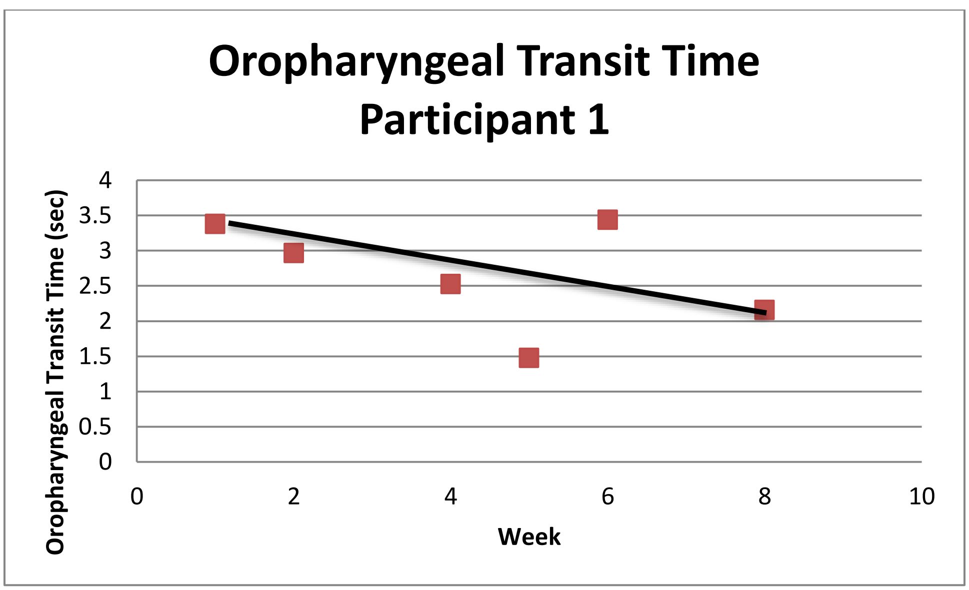
Chapter 3: Results

This study sought to examine the effects of a six week exercise swallowing exercise program on oropharyngeal transit time as measured by the sEMG in order to determine whether the exercise program produced a safer, more functional swallow for the participants. In addition, the present study sought to examine the effects of treatment on lingual strength, peak swallow pressure and the swallow reserve, indicators of a more functional swallow. The following is a compilation of the results found in the current study for the above mentioned categories.

Oropharyngeal Transit Time

A scatter plot of all the data points was constructed using Microsoft Excel and a trend line was drawn by the researcher in Microsoft Excel (see Figure 3.1).

Figure 3.1 Oroharyngeal transit times for thin liquid bolus for Participant one measured in seconds by the sEMG.

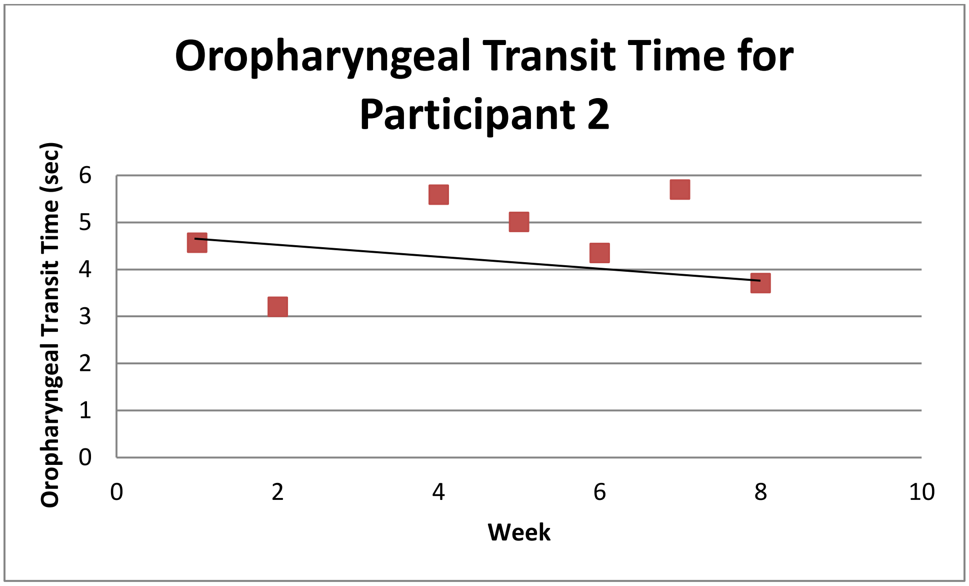


As can be seen in Figure 3.1, the trend line for Participant one indicated a decrease in oropharyngeal transit time from baselines to the post-treatment session. The longest average oropharyngeal transit time was during baseline assessment at 4.18 seconds and the shortest oropharyngeal transit time was during week four data collection with an average of 1.48. It should also be noted that all of the treatment data were shorter in duration than the longest average baseline data point. During the second week of data collection there was a system malfunction that prevented the researcher from recording the data. Post-treatment data indicated a decrease in oropharyngeal transit time as compared to the baseline measurements. The post-treatment oropharyngeal transit time was 2.16 seconds in duration.

During week three, the sEMG had technical difficulties and needed to be repaired, so the researcher was unable to gather sEMG data for that week for participant one given that the device was unable to connect to the software. In addition, there was a software error that prevented the measurements taken after treatment week six from being properly recorded.

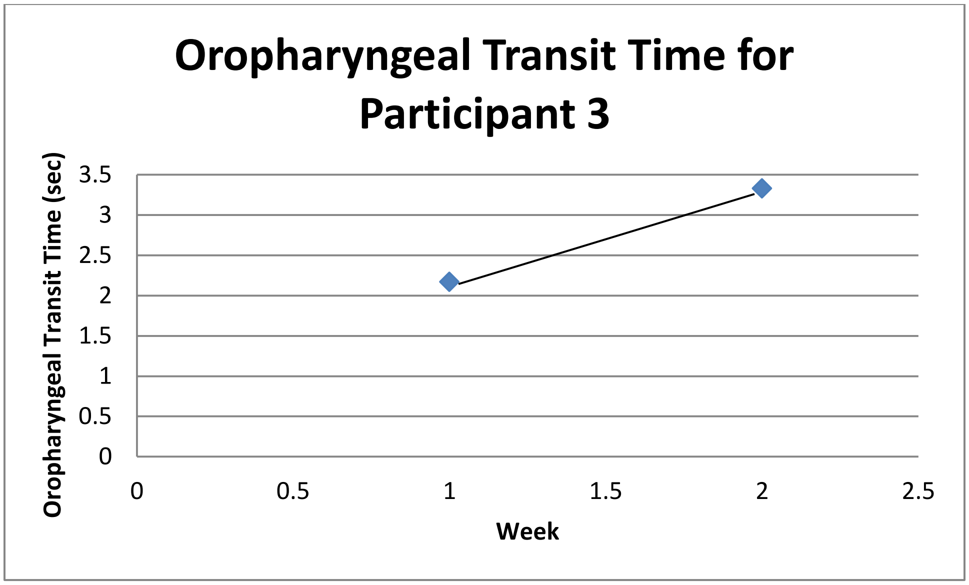
As seen in Figure 3.2, the trend line for Participant two indicated that there was likely no change to the oropharyngeal transit time. The longest average oropharyngeal transit time was 5.59 seconds in duration during the third week of data collection and the shortest oropharyngeal transit time in duration was 3.21 seconds during the first week of data collection post treatment.

Figure 3.2 Oroharyngeal transit time for thin liquid bolus for Participant two measured in seconds by the sEMG.



For Participant three, there was an increase in oropharyngeal transit time between the baseline trials and the first week of treatments as seen in Figure 3.3. This information should be taken with caution as the participant was unable to complete the whole program.

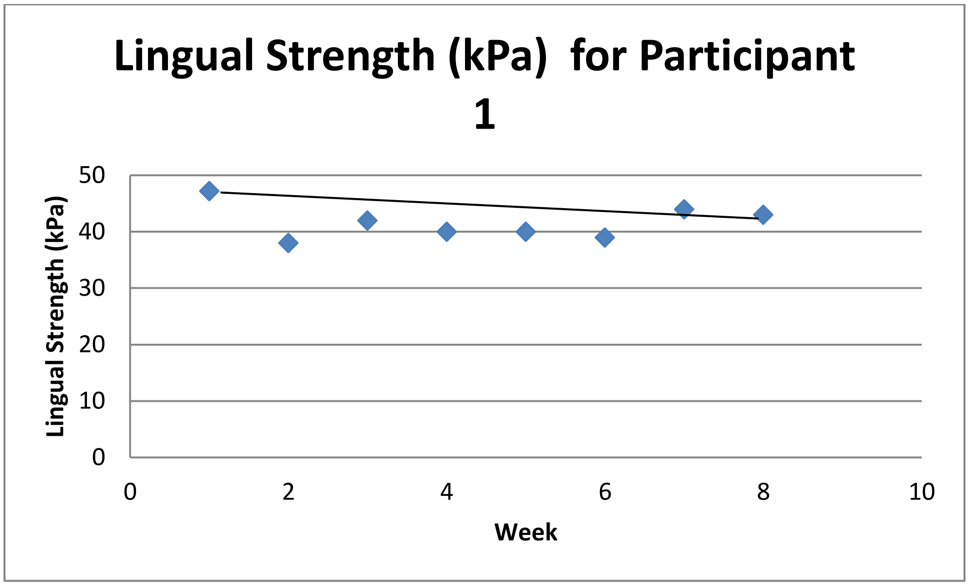
Figure 3.3 Oropharyngeal transit time for thin liquid bolus for assessment and treatment for one week for Participant three measured in seconds by the sEMG.



Lingual Strength

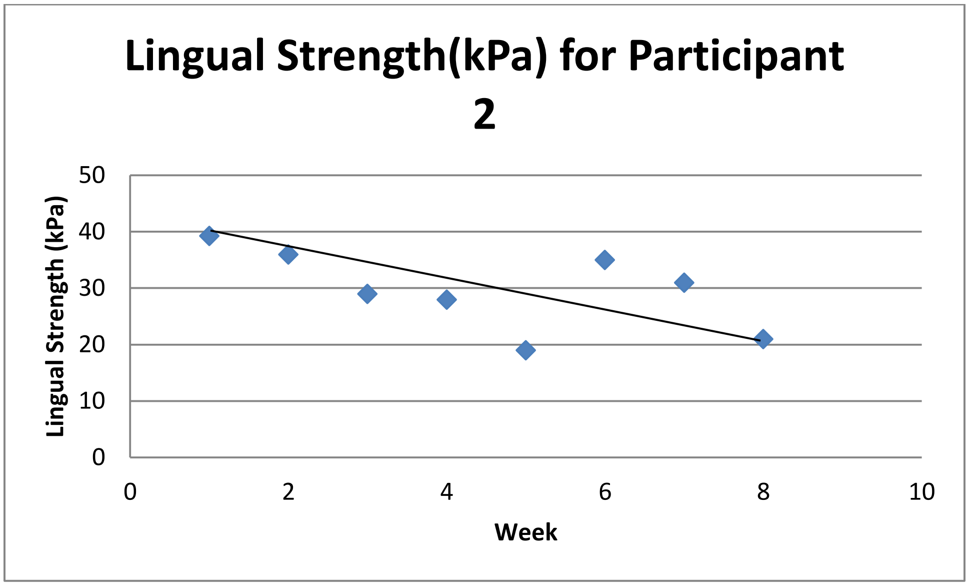
For Participant one, it was noted via the trend line generated by the researcher in Microsoft excel that there was a decrease in lingual strength over the course of the treatment (see Figure 3.5). Baseline measures ranged from 42 kPa- 52 kPa. Treatment measures ranged from 38 kPa- 44 kPa. Similar to Participant one, the baseline measures were the highest measure and the measurements during week four were noted to be the lowest measures, followed by a large increase in strength in the two weeks that followed. It should be noted that throughout the duration of the exercise program, Participant one's lingual strength remained below the age matched norm of 53.83 kPa.

Figure 3.4 Lingual strength for Participant one measured by the IOPI.



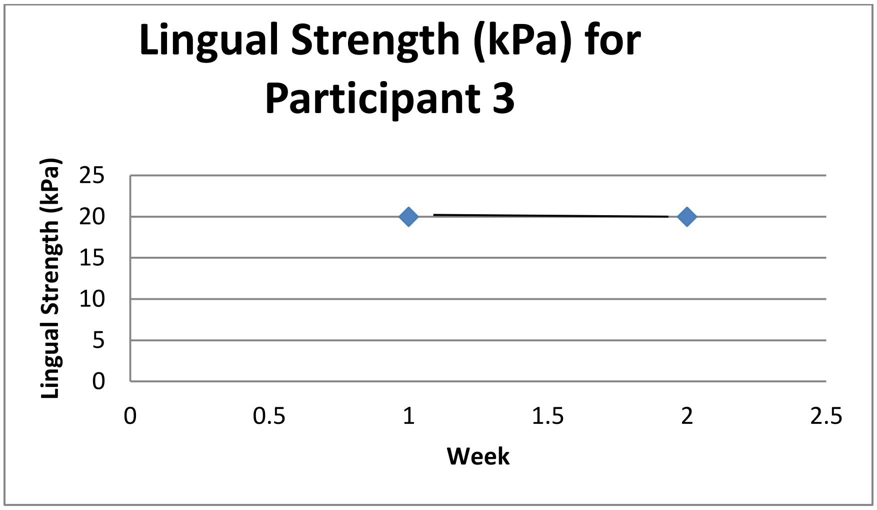
For Participant two, there was a slight decrease in the control measure of lingual strength across the course of treatment, though the data were variable (see Figure 3.4). Baseline measures were highly variable and ranged from 23 kPa- 53 kPa. Treatment measures ranged from 19 kPa- 36 kPa. The baseline measures were the highest lingual strength measures noted. After baseline measures, there was a large decrease, which was indicated as being the lowest lingual strength measure during week four, followed by an increase in strength. However, none of the subsequent strength measures were ever higher than the baseline measures. Similar to Participant one, none of the weekly measures were higher than the average baseline measure. Though participant two had one assessment trial that was close to the norm of 53.83 kPa, all of his treatment sessions were well below this norm throughout the entire exercise program.

Figure 3.5 Lingual strength for Participant two measured by the IOPI.



Participant three had a trend line that showed no change in lingual strength from her baseline measures to the first treatment week (see Figure 3.6). Again, it should be noted that the participant was only able to complete one week of treatment.

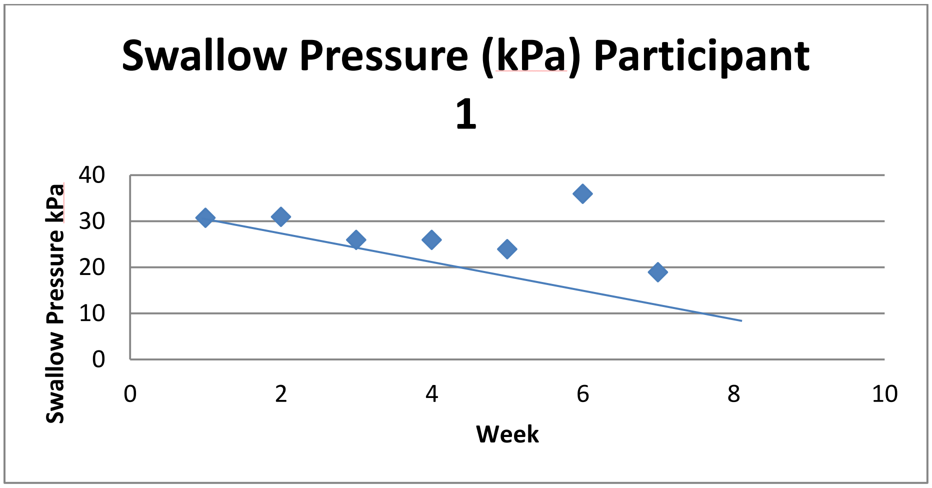
Figure 3.6 Lingual strength for assessment and one treatment session for Participant three measured by the IOPI.



Swallow Pressure

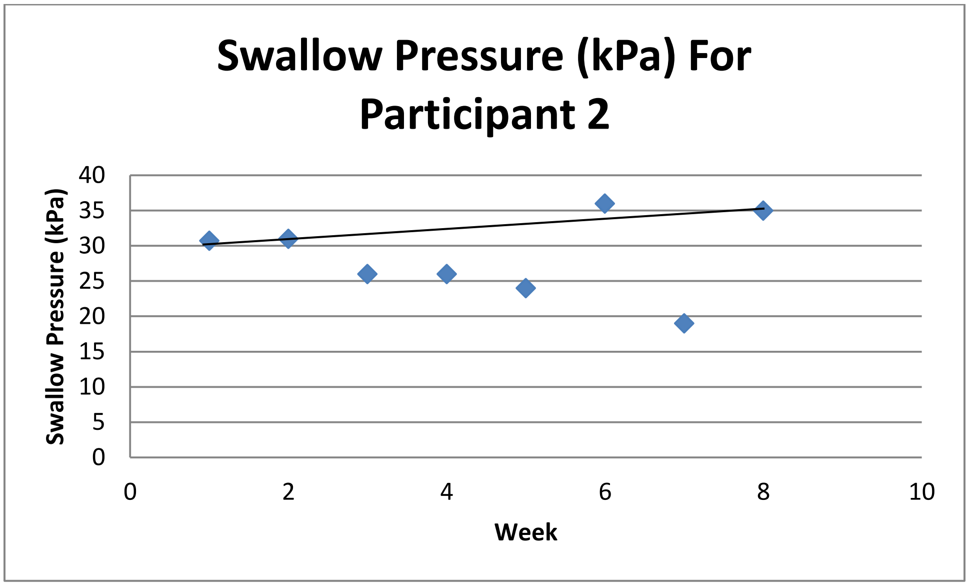
For Participant one, the trend line indicated a decrease in swallow pressure over the course of the study, however the data points were inconsistent (see Figure 3.7) . The baseline measures average was 30 kPa , there was an initial increase in swallow pressure after baseline measures were taken then a decline for three weeks followed by a peak increase in week five that was higher than the average baseline measures.

Figure 3.7 Swallow pressure for Participant one measured by the IOPI.



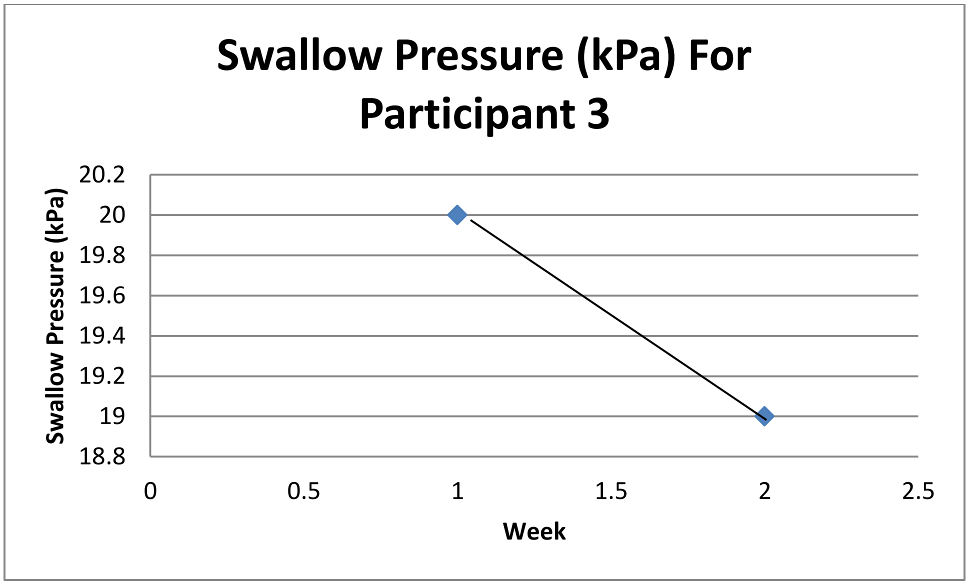
For Participant two it was noted visually that there was a slight increase in the trend line through the data, although the data were flat (see Figure 3.8). Baseline measures ranged from 25 kPa- 47 kPa and treatment measures ranged from 37 kPa- 48 kPa. After baselines, there was an increase for two weeks followed by a decrease for two weeks. There was an additional increase followed by a decrease in function, indicating that there was not a trend.

Figure 3.8 Swallow pressure for Participant two measured by the IOPI.



Participant three had an increase in swallow pressure between the assessment points and the treatment point (see Figure 3.9). The trend line indicated a positive trend.

Figure 3.9 Swallow pressure assessment and treatment week one for Participant three measured by the IOPI.

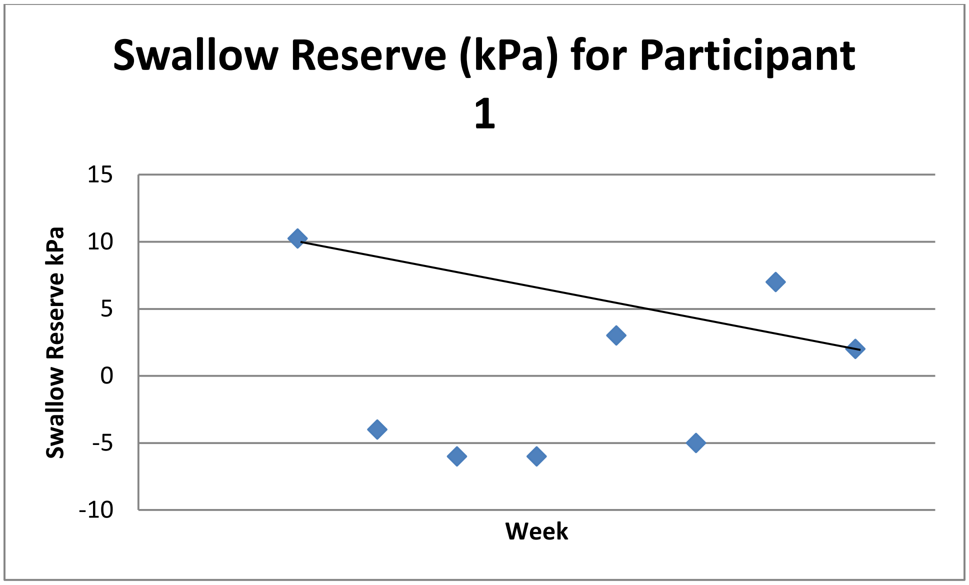


Swallow Reserve

A scatter plot for each participant was created in Microsoft excel and a linear trend line was created for that data set. The results for each of the participants are noted below.

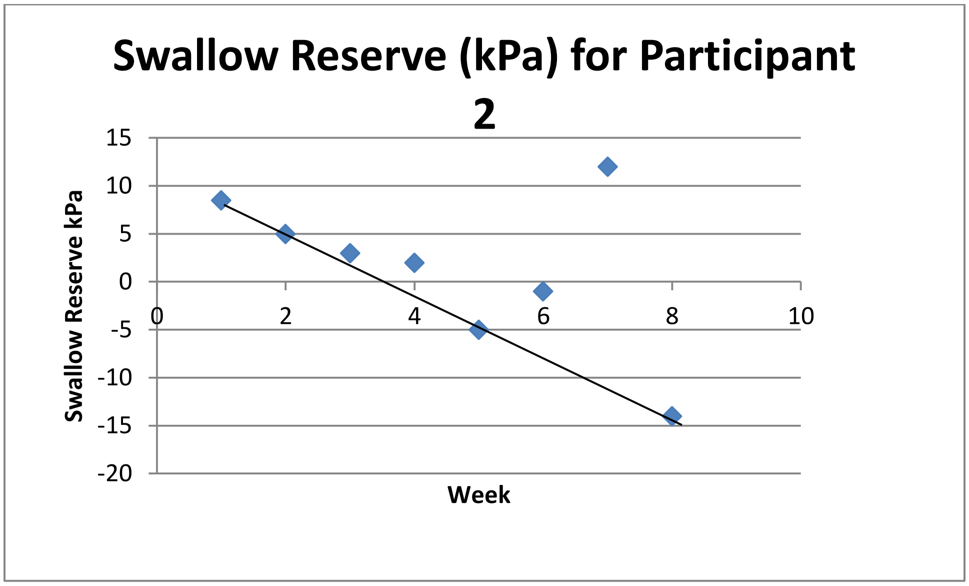
For Participant one, the highest swallow reserve noted was during the participant's baseline assessment at 10.25 kPa. There was a marked decline after the initial baseline measures were taken. The first three treatment weeks noted a decline in swallow reserve, however, the following weeks showed an increase in function with the highest of those points being the post-treatment data point.

Figure 3.10 Swallow reserve for Participant one measured by the IOPI.



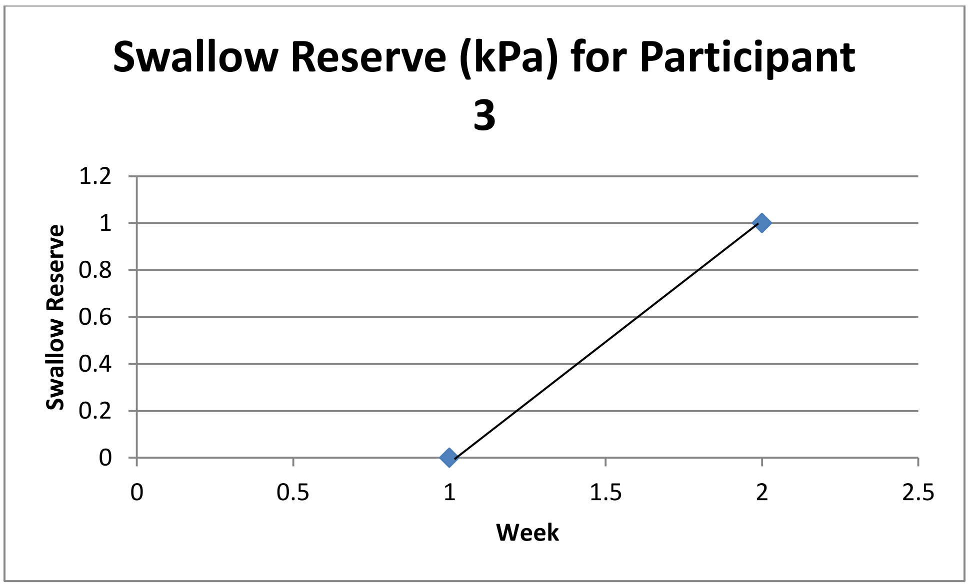
For Participant two, the trend line indicated a decrease in swallow pressure reserve over the course of treatment (see Figure 3.11), however, it should be noted at the end of the final week of the exercise program, swallow reserve was 12 kPa, up from the baseline measures which averaged 8.5 kPa. Post- treatment data greatly decreased following the exercise program to -14 kPa.

Figure 3.11 Swallow reserve for Participant two measured by the IOPI.



Participant three indicated an increase from the baseline measures as indicated by the trend line (see Figure 3.12). However, there were limited data points due to participant dropout.

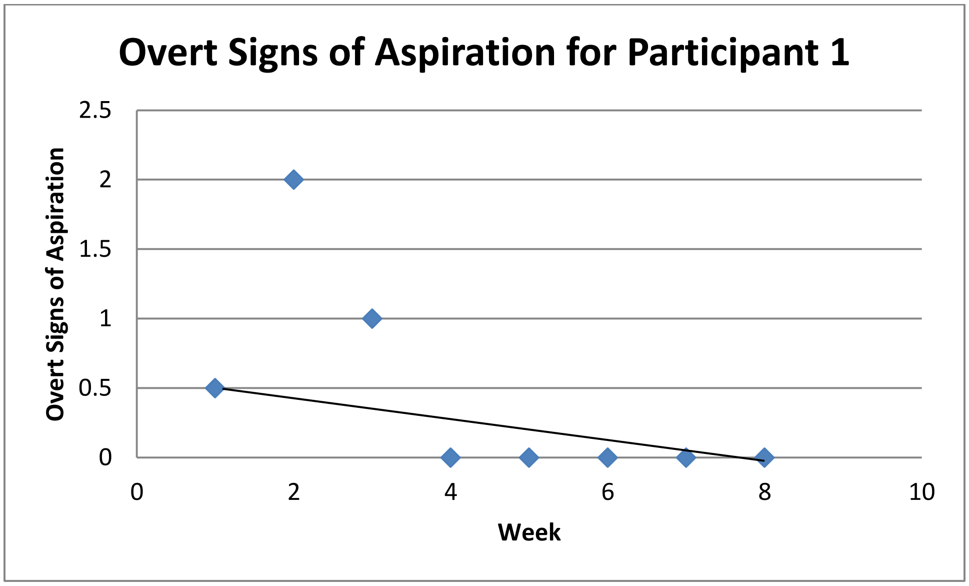
Figure 3.12 Swallow Reserve for assessment and week one of treatment for Participant three measured by the IOPI.



Overt Signs of Aspiration

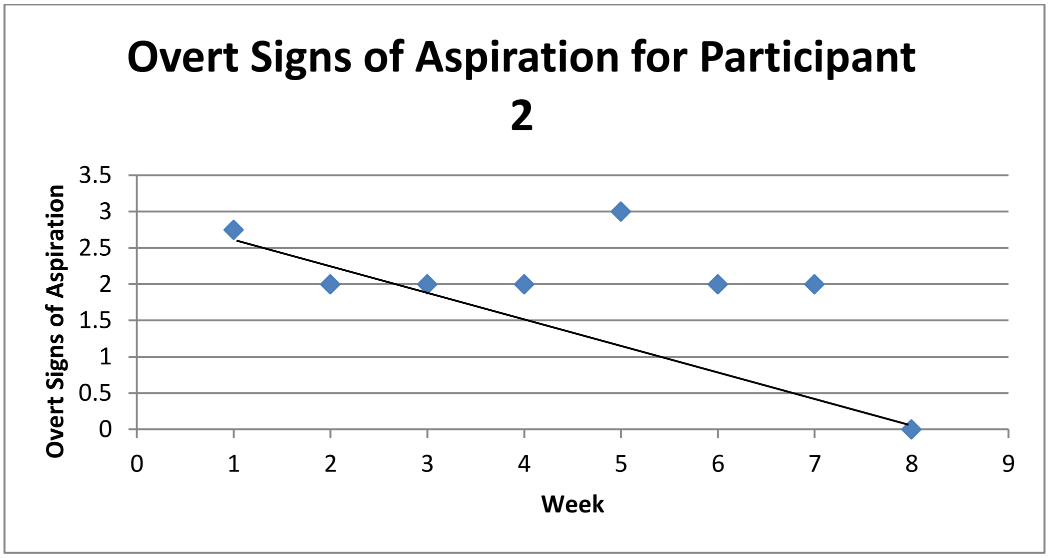
The number of overt signs of aspiration or penetration were recorded on a scatter plot for each participant and a trend line was created in Microsoft excel. Participant one had an overall trend of decreased signs or symptoms of aspiration or penetration over the course of the treatment (see Figure 3.13). Participant one began the exercise program with a cough after his swallow and a present wet vocal quality. After the exercise program, it was noted that the participant no longer expressed either overt sign of aspiration or penetration

Figure 3.13 Overt signs of aspiration Participant one measured subjectively.



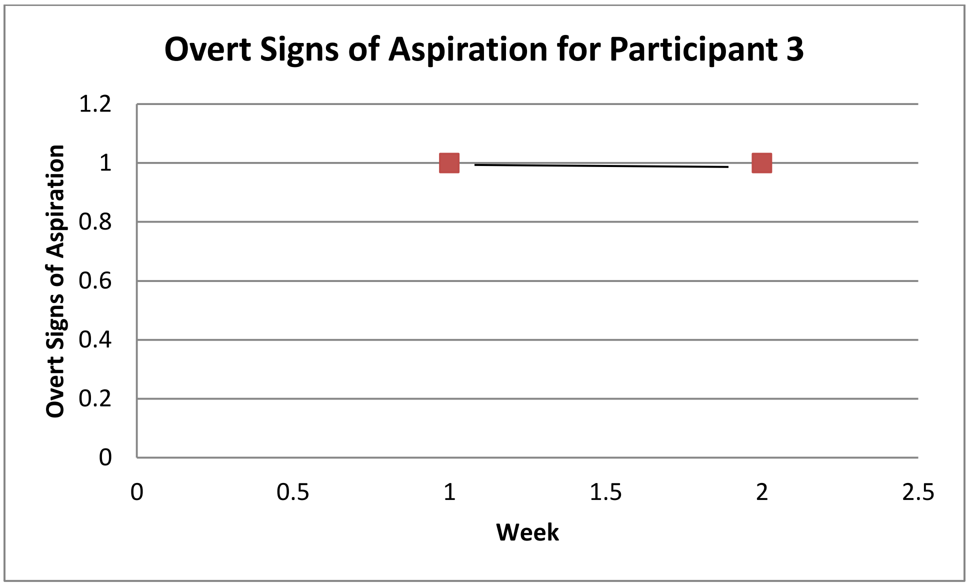
Participant two also had an overall decrease in overt signs and symptoms of aspiration and penetration (see Figure 3.14). At the beginning of the exercise program, the participant experienced coughing, wet vocal quality and a triple swallow to clear the bolus. After the exercise program, the only overt sign of aspiration or penetration that was noted was the triple swallow required to clear the bolus.

Figure 3.14 Overt signs of aspiration for Participant two measured subjectively.



For Participant three, there were no changes in the overt signs and symptoms of aspiration and penetration between the four baseline trials and the results of the first week of treatment (see Figure 3.15)

Figure 3.15 Overt signs of aspiration for assessment and one week of treatment for Participant three measured subjectively.



Control Variables

The control measures for this study were a sustained consonant /s/ and labial strength. Both of these variables were plotted individually on a scatter plot and a trend line was formed using Microsoft Excel. The results for each participant are indicated below.

Participant one noted an increase in his sustained /s/ over the course of treatment as observed by the trend line for the data collected (see Figure 3.16). However, the participant was able to sustain the /s/ phoneme for 23 seconds during baseline and 29 seconds during post-treatment data indicating a slight increase from baselines. According to Soman (1997), the /s/ phoneme in adults should be sustained for 23.47 seconds. This places the participant within normal limits throughout the study.

The participant also noted a trend line that indicated a slight increase in labial strength over the course of the treatment (see Figure 3.17). Though there was an increase in labial strength throughout the course of treatment, it should be noted that the assessment and treatment data points were all above the age matched norm of 20.11 kPa.

Figure 3.16 Sustained /s/ phoneme measured in seconds Participant one (control).

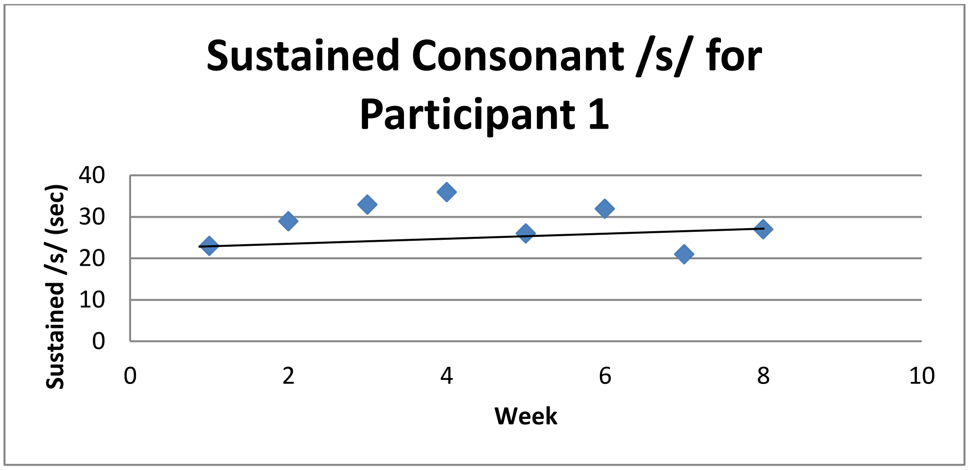
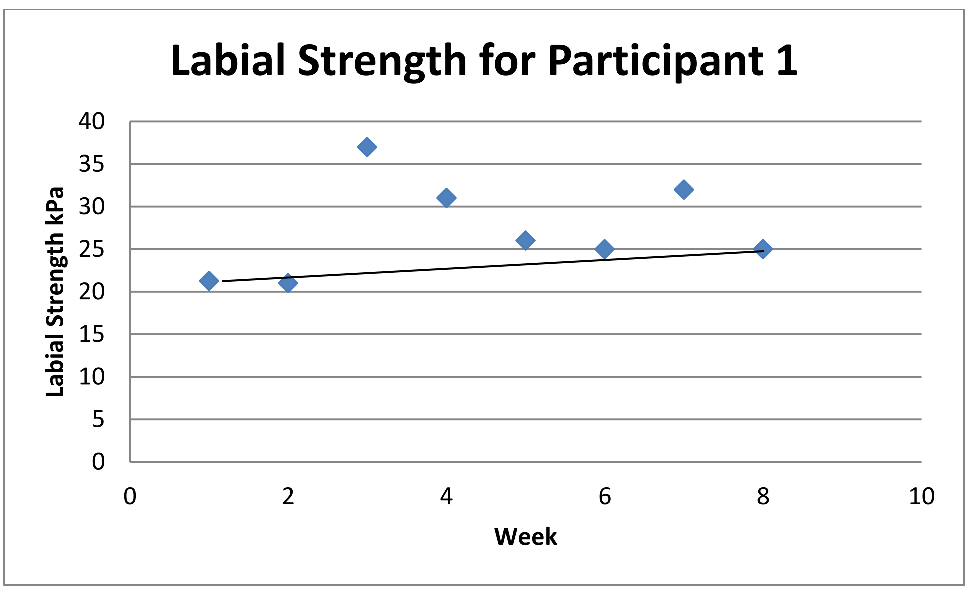


Figure 3.17 Labial strength for Participant one measured by the IOPI (control).



Participant two showed a decrease in sustained /s/ from baselines to post-treatment observations (see Figure 3.18). However, the participant's sustained /s/ stayed relatively constant, only fluctuating by a couple of seconds throughout the entire course of treatment. It should also be noted that the participant's sustained /s/ was well below the normal duration of sustained /s/ of 23.47 seconds (Soman, 1997). Labial strength showed an increase over the course of treatment for the second participant (see Figure 3.19). It should be noted, however, that the baseline measurement was 15 kPa and the post treatment measurement was 16 kPa, a total difference of 1 kPa. It should also be noted that all of the assessment and treatment data points were below the age matched norm of 20.11 kPa for labial strength as measured by the IOPI.

The trend line for labial strength indicated a slight increase between the baseline measurements and the first week of treatment. Sustained /s/ showed a three second decrease from the baseline measurements and the first week of treatment.

Figure 3.18 Sustained /s/ phoneme for Participant two measured in seconds (control).

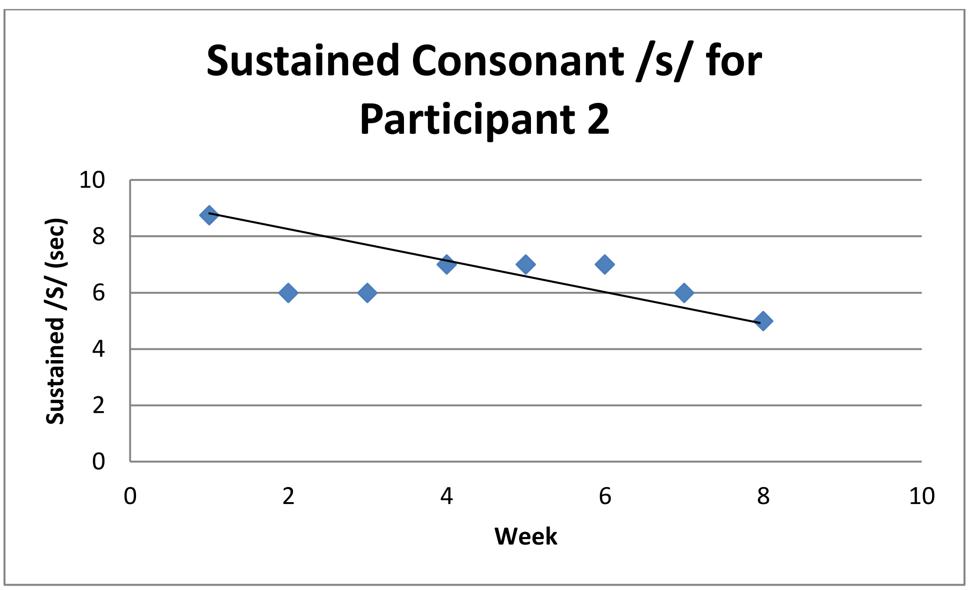
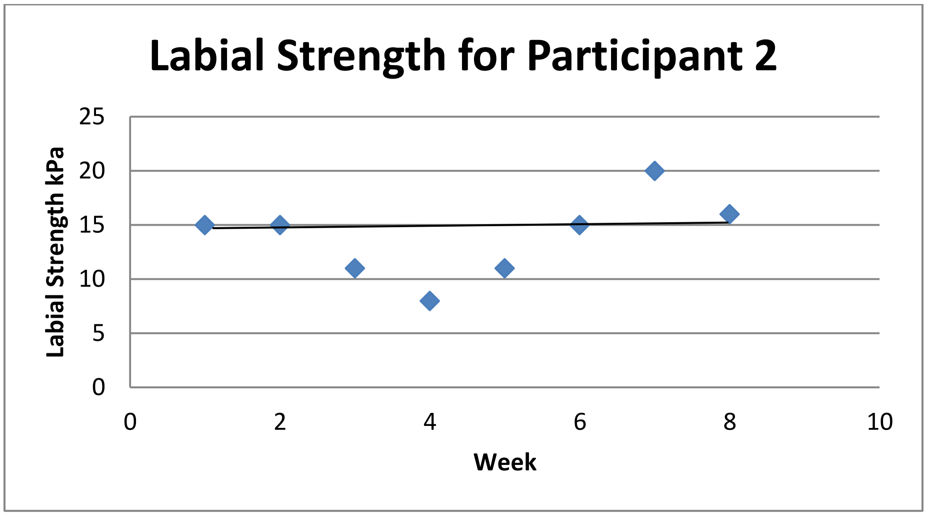


Figure 3.19 Labial strength for Participant two measured by the IOPI (control).



The trend line for Participant three indicated an increase in her sustained /s/ from the baseline trials to the treatment data point (see Figure 3.20). It should be noted that both data points fall well below the average of 23.47 seconds (Soman, 1997). It was also noted that there was an increase in labial strength from her baseline trials to her treatment trial as noted in the trend line on Figure 3.21.

Figure 3.20 Sustained /s/ phoneme measured in seconds for assessment and one week of treatment for Participant three (control).

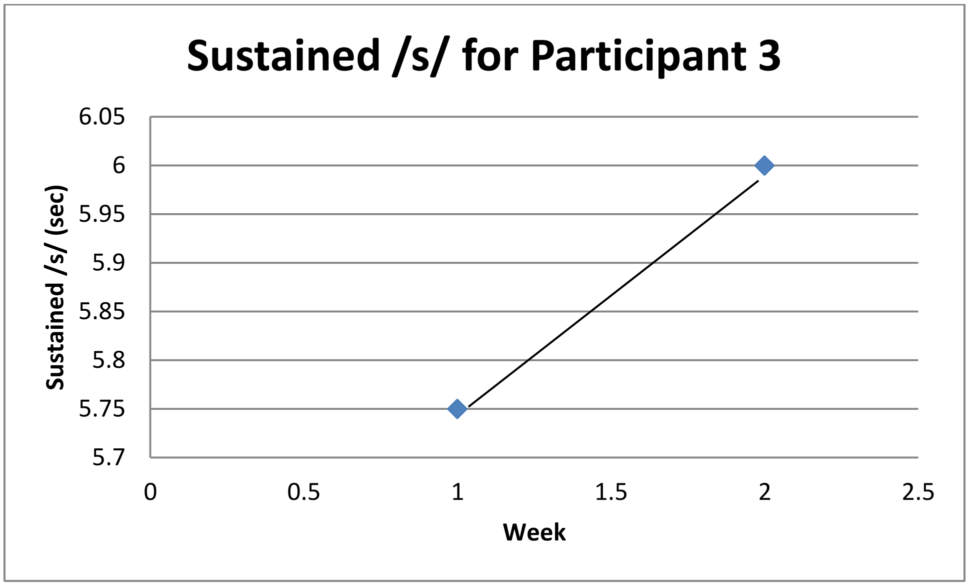
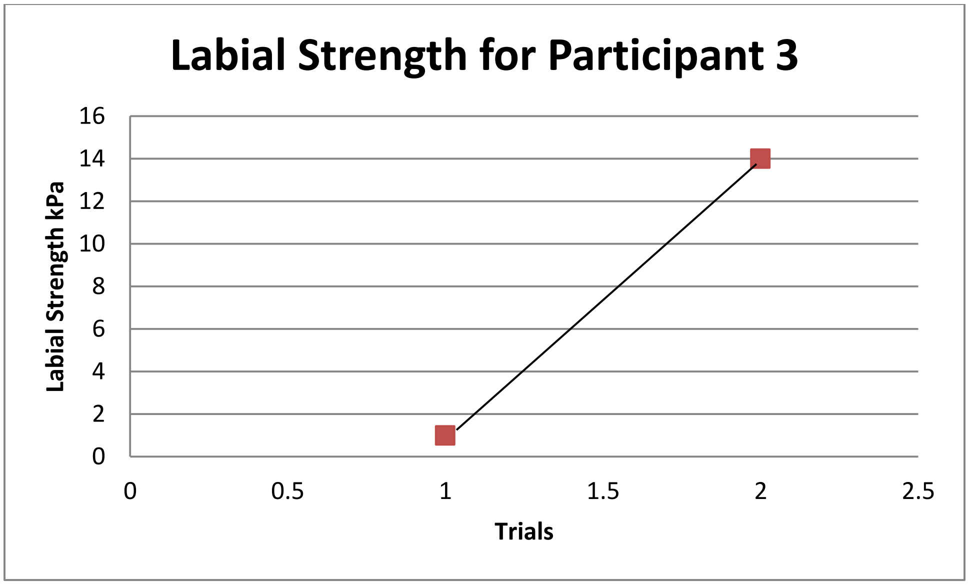


Figure 3.21 Labial strength measured by the IOPI for assessment and one week of treatment for Participant three (control)



Overall, for Participant one there was a slight increase in both control measures which could indicate a slight global increase in overall function. One control measure increased for Participant two while the other decreased, which may indicate that there was not a change in overall function as a result of the treatment. Labial strength could have been impacted by the current study, which may indicate why there was a slight increase. For Participant three, both control measures increased from the average baseline measures to the first week of treatment, which may have indicated an overall increase in function.

Subjective Findings

It should be noted that the speech-language pathologist who treated the patients prior to their discharge from swallowing therapy was present for all of the assessment, the training of the participants and for the majority of the treatment sessions.

Subjectively, the speech-language pathologist reported that she noticed a decrease in overt signs and symptoms of aspiration for Participants one and two, and she also noted that both participants appeared to have a stronger, more controlled swallow, especially the first participant. As the third participant did not complete the whole treatment program, there were no subjective improvements noted.

Chapter 4: Discussion

Three participants initiated the assessment and treatment portions of the exercise program, two of whom completed the entire program, including post-treatment measures. Following the six week treatment program, both participant had a decrease in overt signs and symptoms of aspiration and both participants appeared to have a subjectively safer swallow. Following the completion of the exercise program, both participants had post-treatment oropharyngeal transit times that were quicker than their initial baseline oropharngeal transit time, and the first participant had a oropharyngeal transit time that was markedly faster. However, according to data found by Kendall, Leonard and McKenzie, 2010 both participants continued to exhibit delayed oropharyngeal transit times as compared to the normal population, which exhibits a range from 1.25 seconds to .55 seconds (p.1063) and a oral transit phase of 1 to 1.5 seconds (Logemann, 1998). An increase in overall power and strength of the muscles of laryngeal elevation may be the cause of the increased oropharyngeal transit time as a result of the exercise program.

Both participants experienced a decrease in lingual strength and both participants had insignificant changes in peak swallow pressure during the course of the treatment. The unremarkable changes in peak swallow pressure may be because the participants were close to or exceeded the normal swallow pressure range of 28.12 kPa (Robbins et al., 1995) prior to the initiation of the study. The swallow reserve may have remained modest for both participants due to a normal level of function of swallow pressure prior to the initiation of the study and the slight decrease in lingual strength that occurred for both participants over the course of the exercise program. As a result of this, the decrease in oropharyngeal transit time is likely not due to a change in lingual strength, improved oral bolus propulsion or increased peak swallow pressure. However, the decrease in oropharyngeal delay, which causes an increase in oropharyngeal transit time, is likely due to the increased power of the muscles that assist in elevation of the larynx.

During the course of the study, two control variables were used, labial strength and sustained consonant /s/. Both participants demonstrated a slight increase in labial strength throughout the exercise program, which was not expected. However, in a study by Murray, Larson, and Logemann (1998) that evaluated labial musculature activity on the sEMG, it was noted that when people received a liquid bolus via spoon, straw or cup, and propelled the liquid bolus backward for the swallow, all of their research subjects indicated activation of the labial muscles. This indicates that, though these muscles were not directly targeted in the exercise program, they may have been indirectly improved through the research assessment techniques using the liquid bolus. The researcher implemented the use of the sustained consonant /s/ as there is no research to support that improving swallow function will have an impact on duration of consonant production. Over the course of treatment, one subject had a slight decrease in duration of the sustained /s/ and the other had a slight increase in sustained /s/. The researcher expected this measure to remain constant; however, the decrease may be due to fatigue after completing the other portions of the assessment process prior to this one or lack of consistent instruction and encouragement from the researchers

For both participants, the overt signs and symptoms of aspiration and penetration decreased over the course of the exercise program, which may indicate a safer swallow for both participants. Though both participants were asked to complete a log indicating their own subjective feelings about their swallow for each session of exercises, neither participant completed the log; therefore, the participants feelings about their own swallowing function are unknown. However, the researcher and the speech-language pathologist noted decreased signs and symptoms of overt aspiration and penetration and a seemingly stronger and safer swallow were also indicated.

As compared to the original study by Dykman (2010), the current study had similar findings in that oropharyngeal transit time decreased for both participants in this study and for Dykman's participant. In addition, overt signs and symptoms of aspiration decreased for all three participants. Unlike Dykman's participant who demonstrated an increase in lingual strength, the participants in the present study noted a decrease in lingual strength, and, possibly because lingual strength factors into swallow reserve, there was a decrease in swallow reserve for both participants in the present study. This having been said, swallow reserve increased slightly for Dykman's participant in the original study. Swallow pressure increased for one participant and decreased for the other in the present study, again, Dykman noted an increase in swallow pressure for her participant in the original study. The control measure of labial strength in the current study increased, similar to those of Dykman's participant. Sustained /s/ as a control measure was not used in Dykman's original study and was added to the present study

All of the measures were revaluated a week after the termination of the program. It was found that the first participant had a shorter oropharyngeal transit time, a constant decrease in overt signs and symptoms of aspiration, a slight decrease in swallow reserve and a slight decrease of 1kPa in lingual strength from the previous session. The second participant exhibited a decrease in lingual strength, an increase in swallow pressure, a decrease in overt signs and symptoms of aspiration a decrease in swallow reserve and a shorter oropharyngeal transit time. As a result of a decreased oropharyngeal transit time, and decreased overt signs and symptoms of aspiration and penetration, the exercise program may result in generalized shorter duration of the oropharyngeal transit time and a safer swallow for the individuals who participate.

One of the largest challenges presented in this study is participation commitment to the exercise program by the patient. Each participant must commit to four baseline trials, all of the required exercises, six treatment sessions and one post-treatment session. Large time commitment may be a factor in recruiting participants and may account for part of the small sample size in this study. For more accurate findings, more participants are desired for future research and validity. Two participants completed the program and one discontinued the program due to discomfort and illness. The length of the program itself is challenging and may fatigue the participants to the point of non-compliance.

As the researcher provided schedules and checklists that were not completed, it is evident that it is challenging to rely on verbal confirmation and reports of completed exercises from the participants. As such, if this study is to be replicated, the researcher or a trusted aide should be present while the participants complete the program to ensure accuracy. The study would have more conclusive results if the researcher did not rely on patient reports of the completed exercises and instead implemented direct supervision.

In addition, the inclusion criteria may need to be more stringent to account for more specific concerns in the future. Sensation concerns for dysphagia would be something to investigate as a possible exclusion of participants, as well as mobility concerns. Both of the participants in the present study required transfers from nursing, which may be a barrier to completion of exercises at certain times of the day or even at all. If the person has difficulty getting into bed, they may be less likely to complete the exercises that require them to lay supine.

Although there are some limitations to the single subject design that was implemented, the present study utilized instrumentation that was reliable and valid, and the procedures and data were completed uniformly throughout the research study. Though the participants did not log their exercise program or confirm how often they completed the exercises, improvement in overt signs and symptoms of aspiration and penetration were noted as well as improvement of the oropharyngeal transit time for both participants indicate that this program may be effective in improving swallowing function.

More research with a larger pool of participants needs to be done in this area to effectively carry out evidence based practice. Accounting for variables, such as utilizing participant reporting versus direct supervision, would also make this study more reliable and valid for future research. More stringent criteria with regards to mobility and access would benefit the study and the potential participants concerning the amount of time post-stroke would allow for a more specific population definition and account for the variability in results.

Conclusion

An exercise program targeted to decrease delayed oropharyngeal transit time was implemented using an intensive exercise program that targets lingual and laryngeal elevation musculature on two subjects in a single subject design. The program included the effortful swallow and the Shaker Head Lift Series. As hypothesized, oropharyngeal transit time was shorter in duration after the exercise program and overt signs and symptoms of aspiration were decreased. However, lingual strength decreased, swallow pressure increased slightly and swallow reserve decreased slightly, which were not hypothesized prior to the study. Overall, decreased oropharyngeal transit time and overt signs and symptoms of aspiration and penetration could indicate that an intensive strength training exercise program could be a possible treatment modality for people who have a delayed trigger of the pharyngeal swallow post-CVA and even those individuals who are post-CVA and may be past the point of spontaneous recovery. However, more research still needs to be done with more participants to increase the evidence base for management and treatment of dysphagia post-CVA.

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Appendix A: Assessment Log

Assessment

Session 1

SEMG (3 times)	Tongue Strength	Swallow Pressure	Lip Strength (control)	Sustained "s"	MOCA	Signs of Aspiration	Swallow reserve= maximal lingual strength/swallow pressure

Session 2

SEMG (3 times)	Tongue Strength	Swallow Pressure	Lip Strength (control)	Sustained "s"	Signs of Aspiration	Swallow reserve= maximal lingual strength/swallow pressure

Session 3

SEMG (3 times)	Tongue Strength	Swallow Pressure	Lip Strength (control)	Sustained "s"	Signs of Aspiration	Swallow reserve= maximal lingual strength/swallow pressure

Session 4

SEMG (3 times)	Tongue Strength	Swallow Pressure	Lip Strength (control)	Sustained "s"	Signs of Aspiration	Swallow reserve= maximal lingual strength/swallow pressure

Appendix B: Treatment Log

Treatment log P1

Week 1 treatment

SEMG (3 times)	Tongue Strength	Swallow Pressure	Lip Strength (control)	Sustained "s"	Signs of Aspiration	Swallow reserve= maximal lingual strength/swallow pressure

Treatment log P2

Week 1 post treatment

SEMG (3 times)	Tongue Strength	Swallow Pressure	Lip Strength (control)	Sustained "s"	Signs of Aspiration	Swallow reserve

Treatment log P3

Week 1 post treatment

SEMG (3 times)	Tongue Strength	Swallow Pressure	Lip Strength (control)	Sustained "s"	Signs of Aspiration	Swallow Reserve

Appendix C: Treatment Checklist

Summary of exercises:

Effortful swallow: Swallow as hard as you can and try to make it so that you can hear your swallow. Try to use your tongue and throat muscles

Head lift: lie down and lift your head to look at your toes, hold this for one minute then lay back and relax for one minute and rest. Repeat this sequence twice more for a total of 3 times. Then, lift and lower the head at a constant rate up to 30 times.

<u>Wednesday</u>

Morning:

Head lift for 1 minute x3 ☐

Head lift 30 times ☐

Effortful swallow 15 times ☐

Evening:

Head lift for 1 minute x3 ☐

Head lift 30 times ☐

Effortful swallow 15 times ☐

<u>Thursday</u>

Morning:

Head lift for 1 minute x3 ☐

Head lift 30 times ☐

Effortful swallow 15 times ☐

Evening :

Head lift for 1 minute x3 ☐

Head lift 30 times ☐

Effortful swallow 15 times ☐

Friday

Morning:

Head lift for 1 minute x3 ☐

Head lift 30 times ☐

Effortful swallow 15 times ☐

Evening:

Head lift for 1 minute x3 ☐

Head lift 30 times ☐

Effortful swallow 15 times ☐

Saturday: Rest

Sunday

Morning:

Head lift for 1 minute x3 ☐

Head lift 30 times ☐

Effortful swallow 15 times ☐

Evening:

Head lift for 1 minute x3 ☐

Head lift 30 times ☐

Effortful swallow 15 times ☐

Monday:

Morning:

Head lift for 1 minute x3 ☐

Head lift 30 times ☐

Effortful swallow 15 times ☐

Evening: Michele and Casey will be here for the afternoon/evening exercises please wait for us!

Head lift for 1 minute x3 ☐

Head lift 30 times ☐

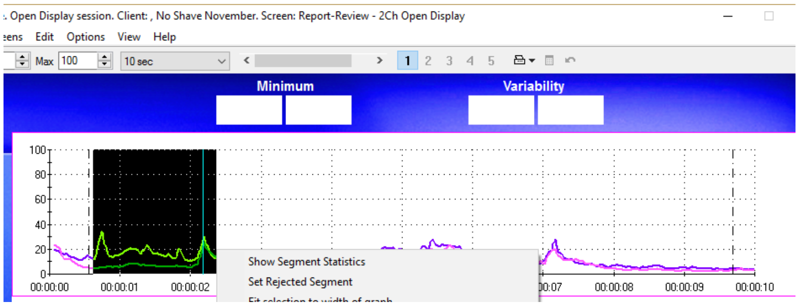
Effortful swallow 15 times ☐

Tuesday- Rest

Appendix D: Exercise Calendar

Day	Time completed	How did it feel scale of 1 to 10 (1 great, 10 terrible)	Comments?
Wednesday	AM		
	PM		
Thursday	AM		
	PM		
Friday	AM		
	PM		
Sunday	AM		
	PM		
Monday	AM		
	PM		
	Michele Here for Evening Exercises		

Appendix E: sEMG Graphics Participant 1



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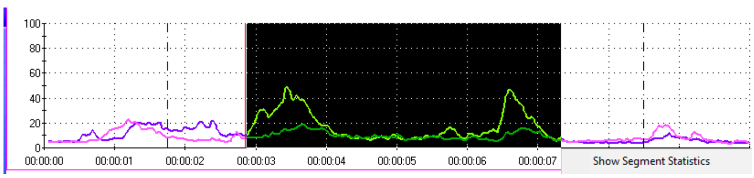

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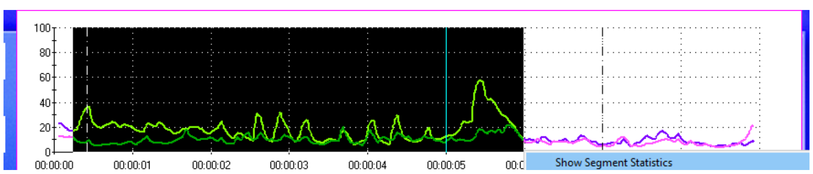

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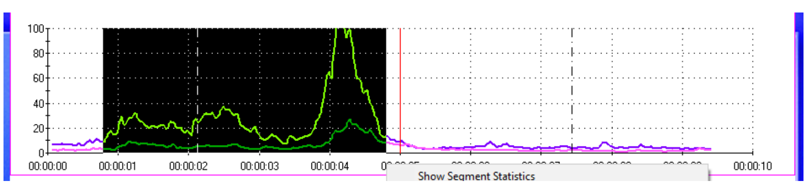

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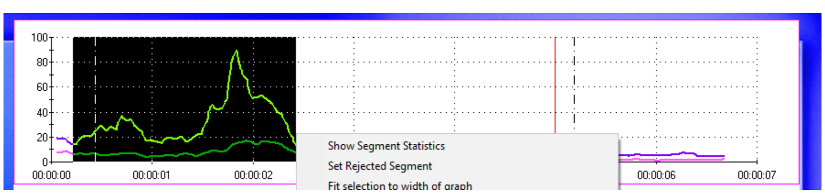

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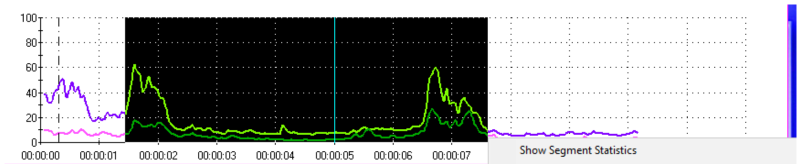

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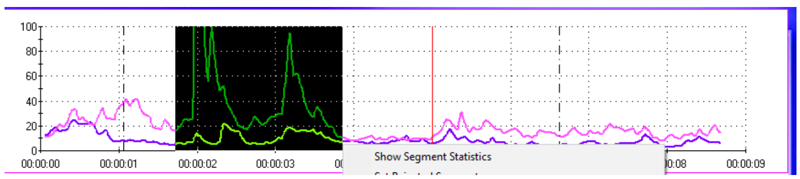
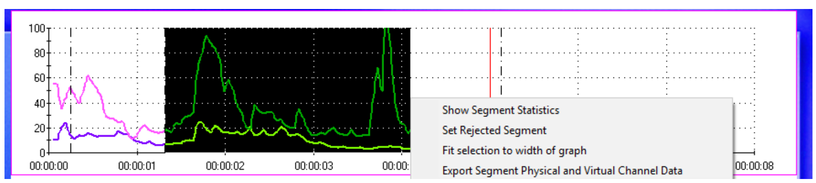


Assessment session 3 trial 1: PTT: 2.13 first of the day



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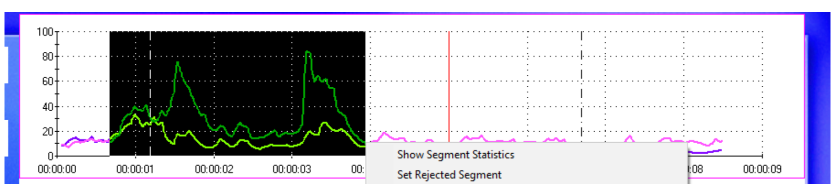
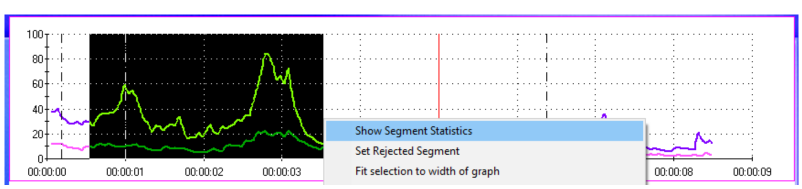


Assessment session 3 trial 3: PTT: 3.26



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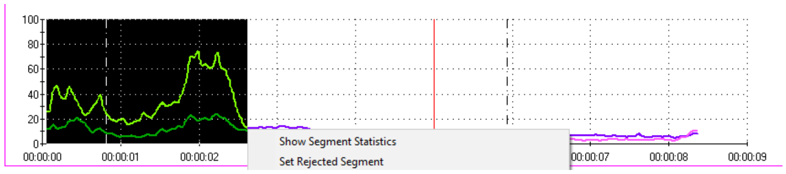

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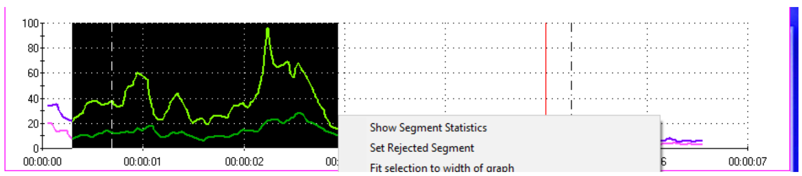

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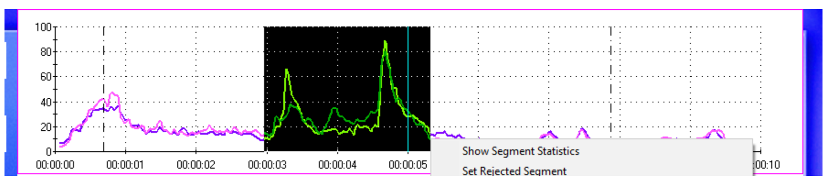
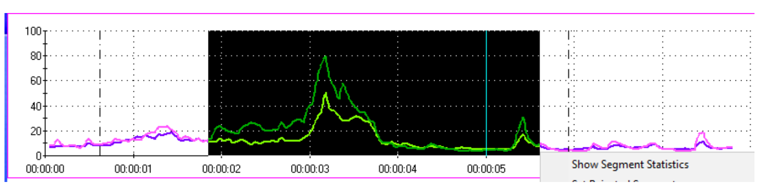


Treatment week 1 trial 1: PPT: 2.35



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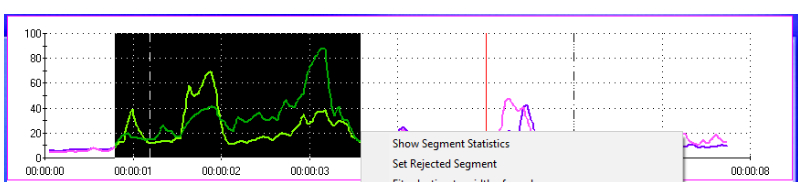

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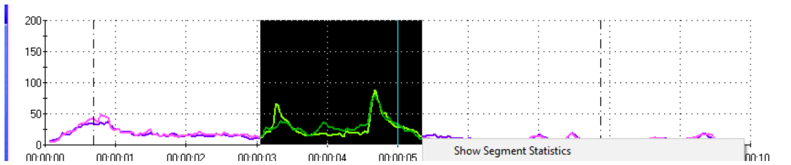
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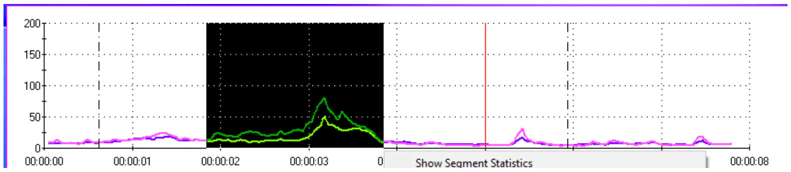
Show Segment Statistics

Treatment week 3 trial 1: PTT: 2.29



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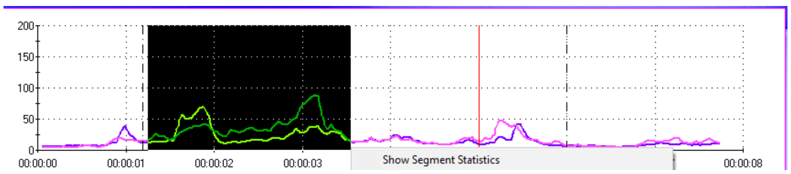
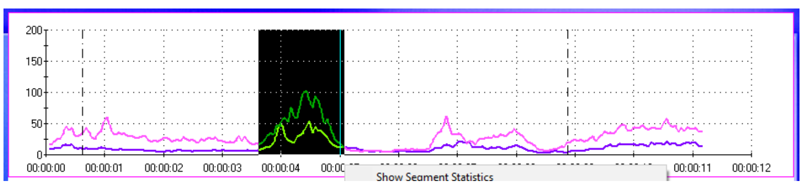
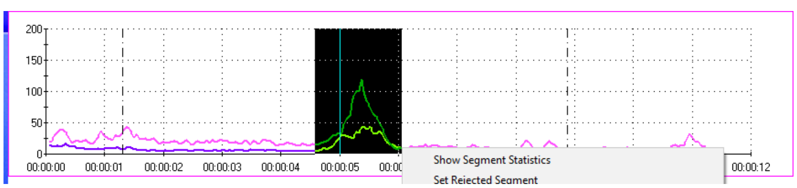


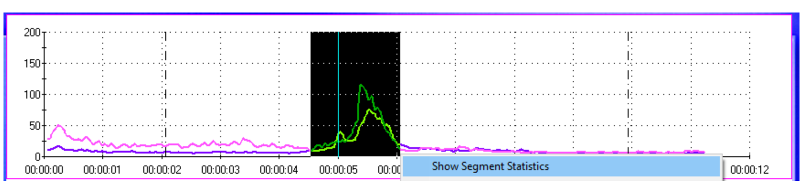
Treatment week 3 trial 3: PTT: 3.30



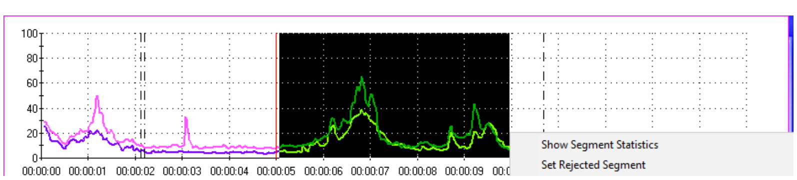
Treatment week 4 trial 1: PTT: 1.46



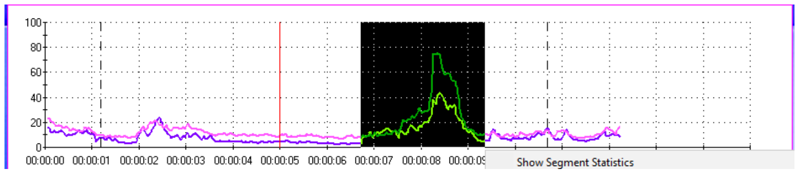
Treatment week 4 trial 2: PTT: 1.47



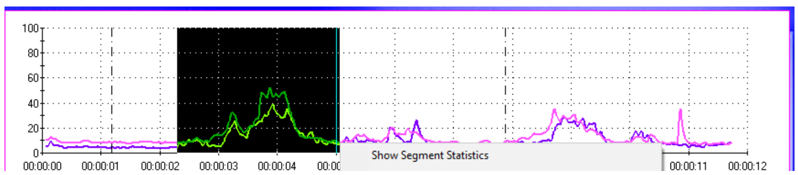
Treatment week 4 trial 3: PTT: 1.52



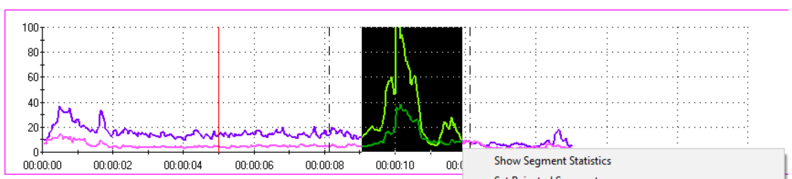
Treatment week 5 trial 1: PTT: 4.90



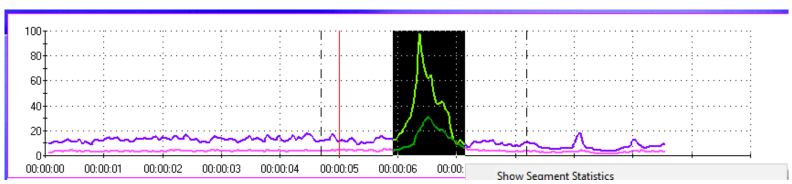
Treatment week 5 trial 2: PTT: 2.65



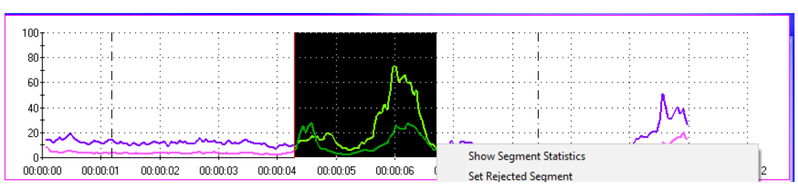
Treatment week 5 trial 3: PTT: 2.77



Post-treatment week 7 trial 1: PTT: 2.85

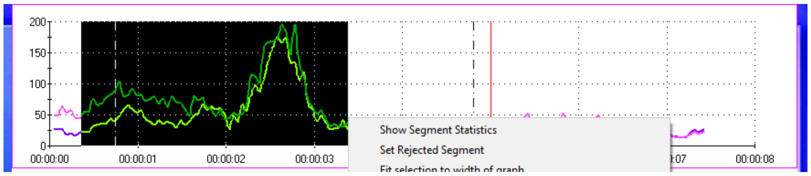


Post- treatment week 7 trial 2: PTT: 1.23



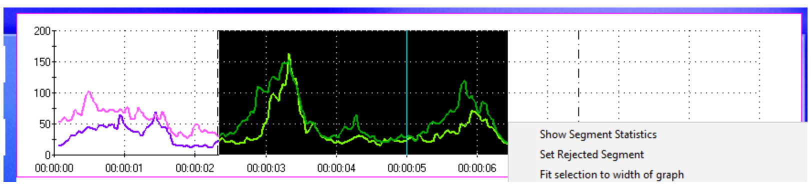
Post-treatment week 7 trial 3: 2.41

Appendix F: sEMG Graphics Participant 2

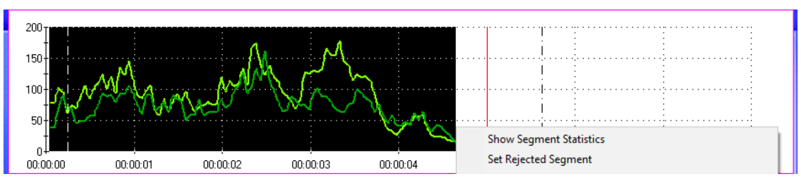


Assessment session 1 trial 1: PTT:4:30

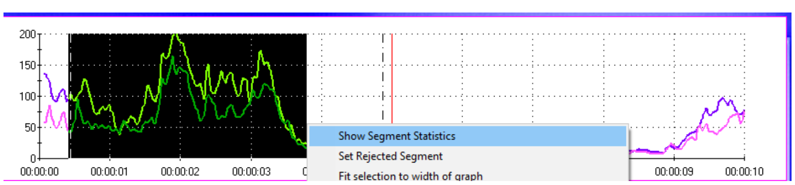
Assessment session 1 trial 2: PTT: 3.20



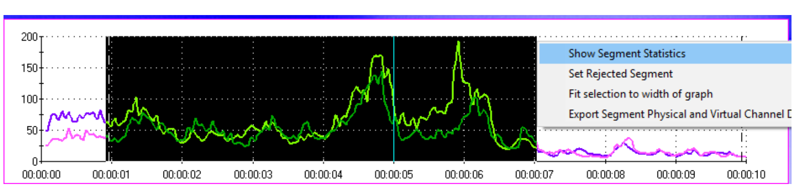
Assessment session 1 trial 3: PTT: 4:10



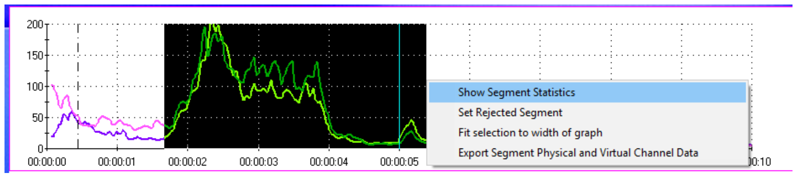
Assessment session 2 trial 1: PTT: 4.61



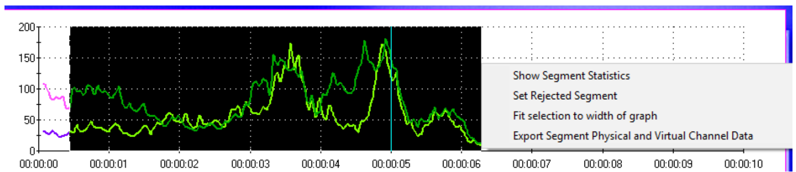
Assessment session 2 trial 2: PTT: 3.39



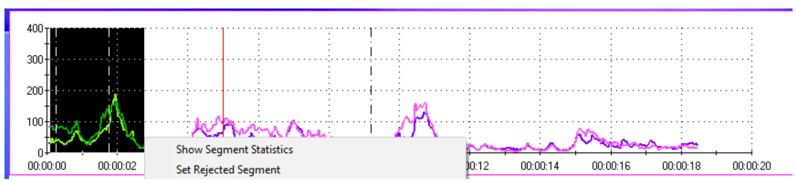
Assessment session 2 trial 3: PTT: 6.11



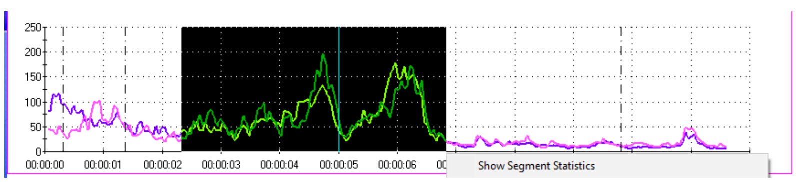
Assessment session 3 trial 1: PTT: 5.31



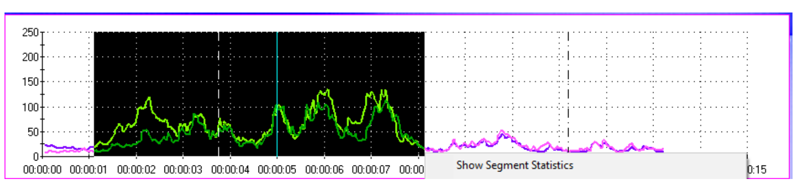
Assessment session 3 trial 2: PTT: 5.84



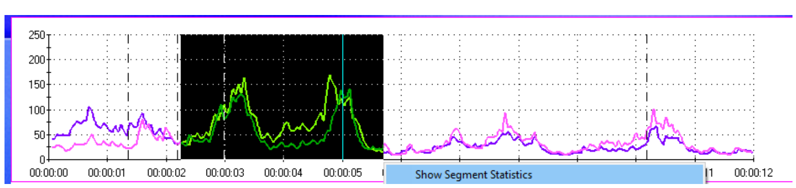
Assessment session 3 trial 3: PTT: 2.87



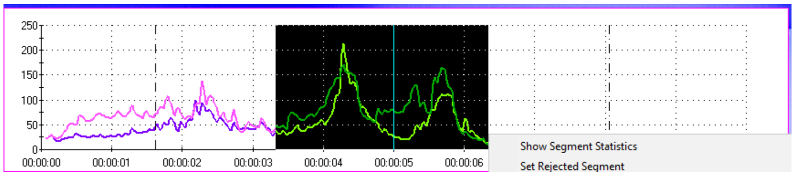
Assessment session 4 trial 1: PTT: 4.61



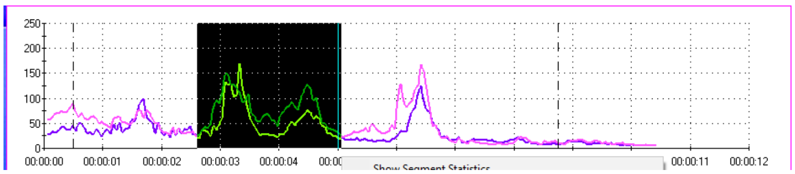
Assessment session 4 trial 2: PTT: 7.03



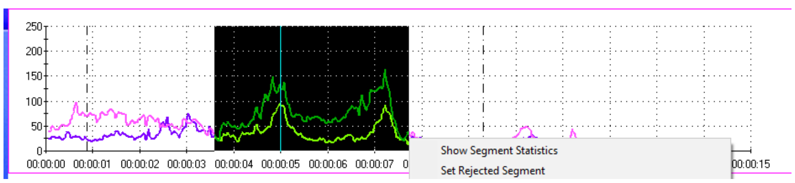
Assessment session 4 trial 3: PTT: 3.45



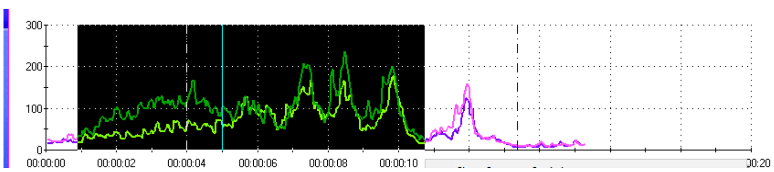
Treatment week 1 trial 1: PTT: 3.02



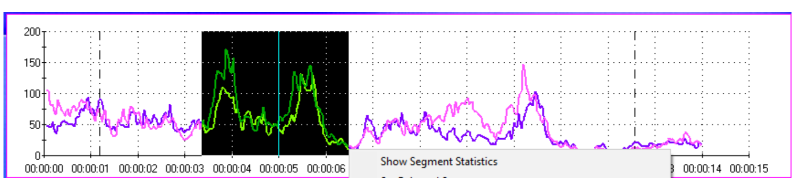
Treatment week 1 trial 2: PTT:2.46



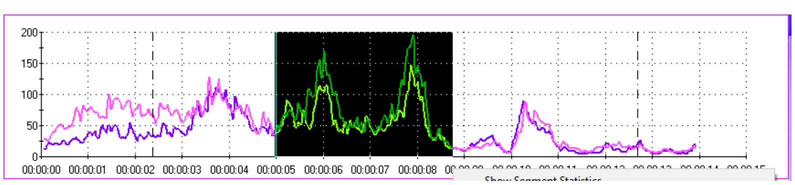
Treatment week 1 trial 3: PTT: 4.14



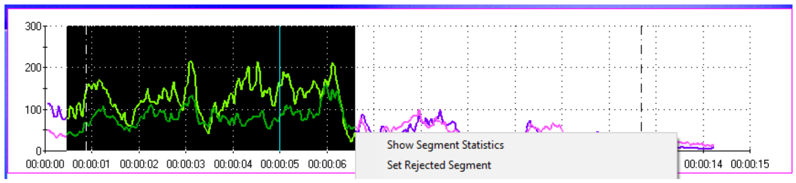
Treatment week 3 trial 1: PTT: 9.84



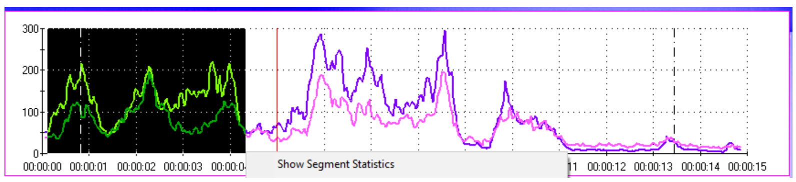
Treatment week 3 trial 2: PTT: 3.13



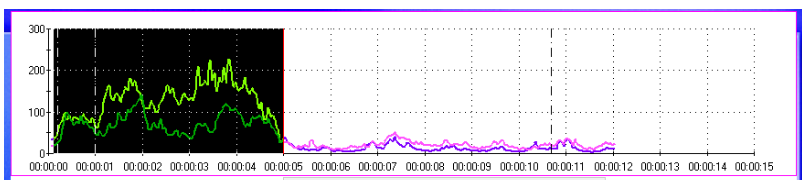
Treatment week 3 trial 3: PTT: 3.79



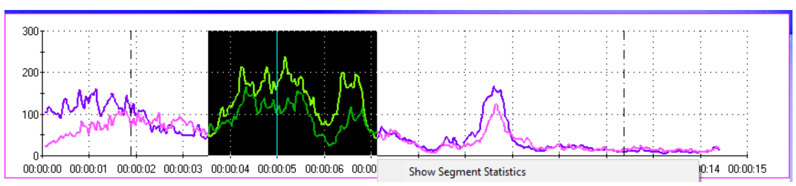
Treatment week 4 trial 1 PTT: 6.03



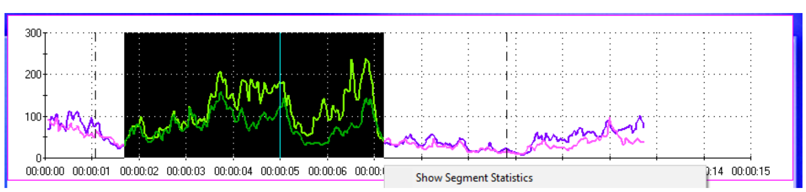
Treatment week 4 trial 2 PTT: 4.21



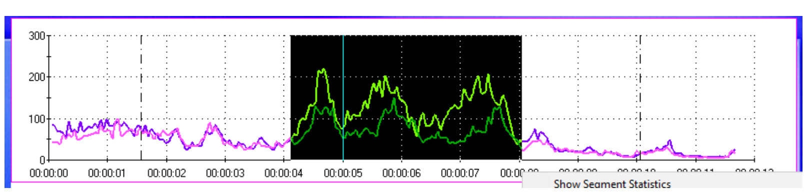
Treatment week 4 trial 3: PTT: 4.87



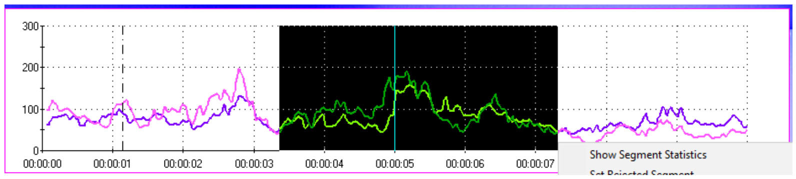
Treatment week 5 trial 1: PTT:3.59



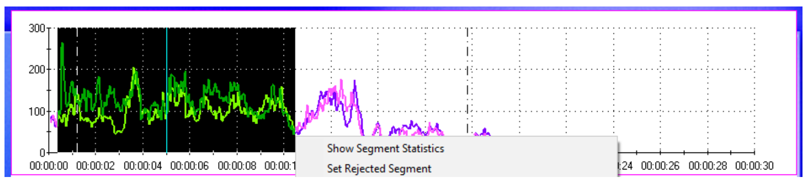
Treatment week 5 trial 2: PTT: 5.52



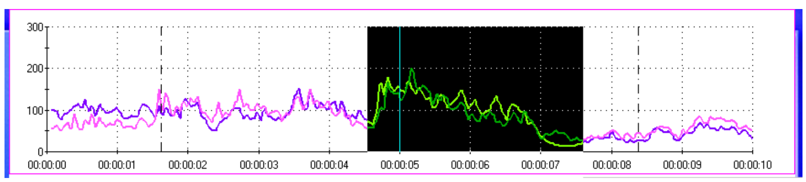
Treatment week 5 trial 3: PTT: 3.93



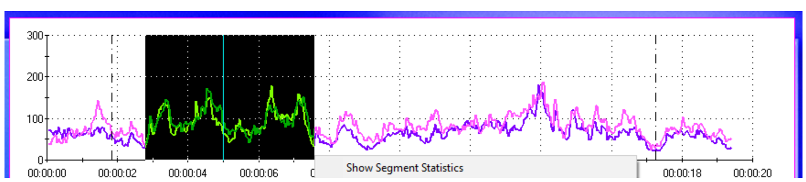
Treatment week 6 trial 1: PTT: 3.95



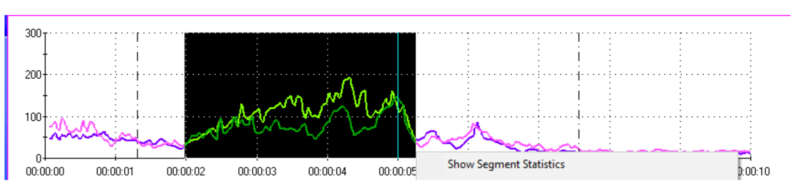
Treatment week 6 trial 2: PTT: 10:10



Treatment week 6 trial 3: PTT: 3:05



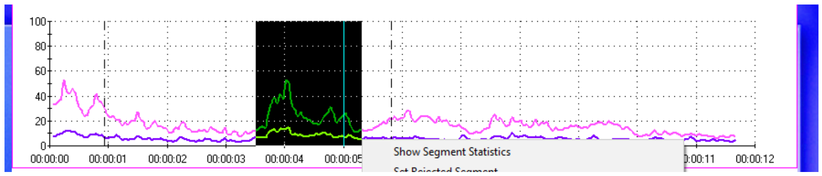
Post-treatment week 7 trial 1: PTT: 4.79



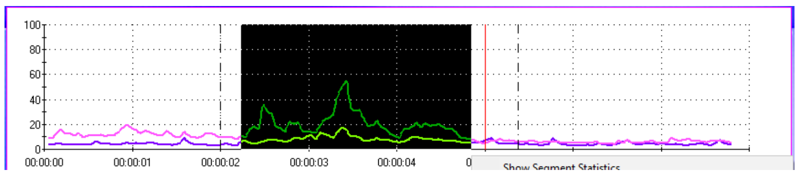
Post-treatment week 7 trial 2: PTT: 3.28

Appendix G: sEMG Graphics Participant 3

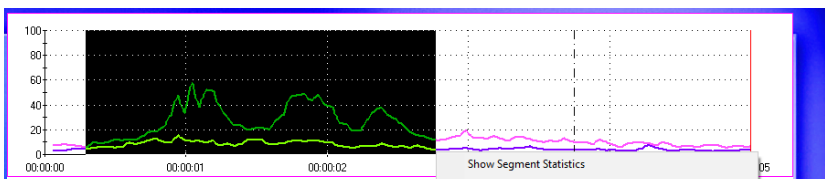
sEMG Images Participant 1



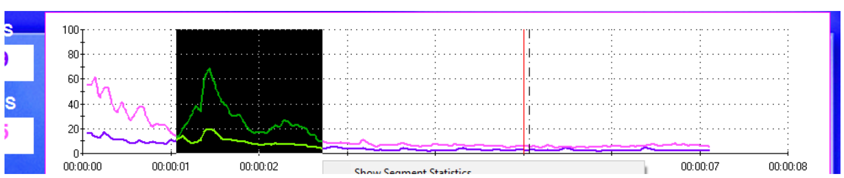
Assessment session 1 trial 1: PTT Assessment 1: 1.81



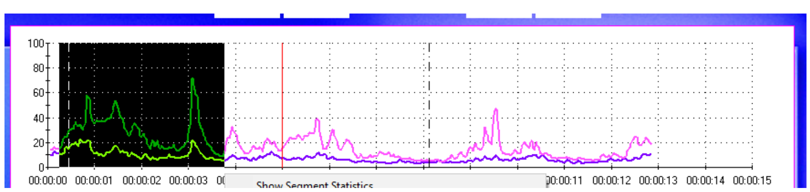
Assessment session 1 trial 2: PTT Assessment 2.61



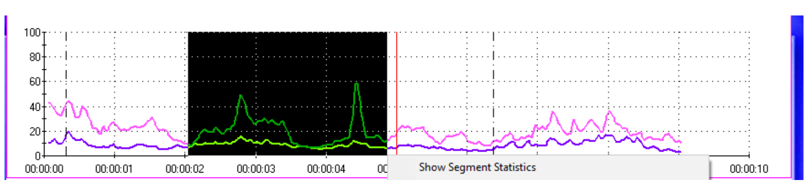
Assessment session 1 trial 3: PTT: 2.48



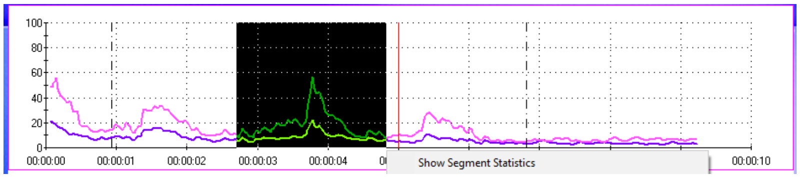
Assessment session 2 trial 1: PTT: 1.66



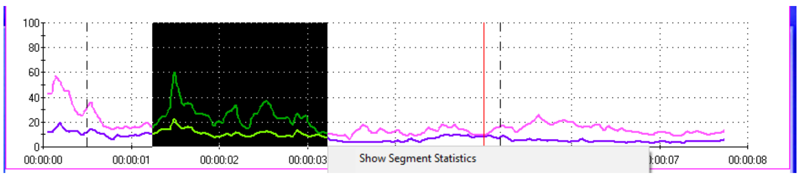
Assessment session 2 trial 2: PTT: 3.52



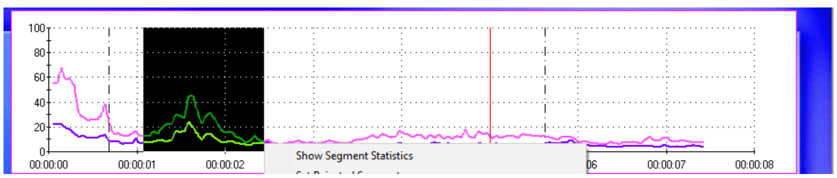
Assessment session 2 trial 3: PTT 2.82



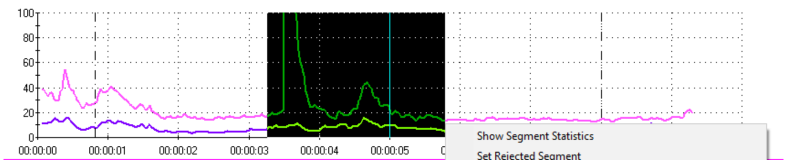
Assessment session 3 trial 1: PTT: 2.12



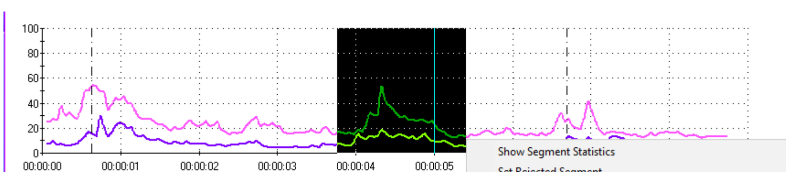
Assessment session 3 trial 2: PTT: 1.99



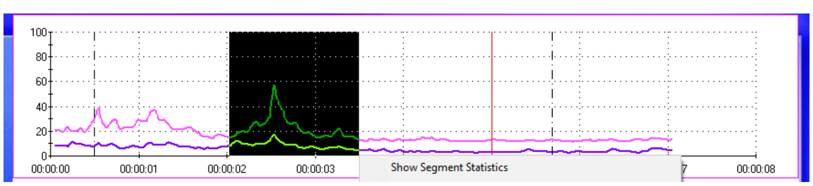
Assessment session 3 trial 3: PTT:1.37



Assessment session 4 trial 1: PTT:2.53



Assessment session 4 trial 2: PTT:1.64



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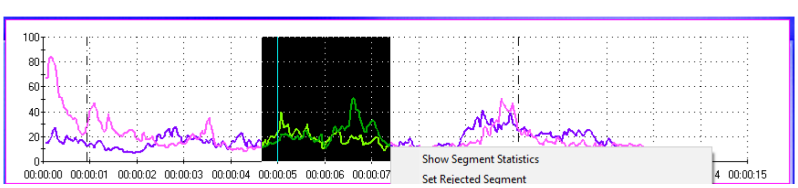
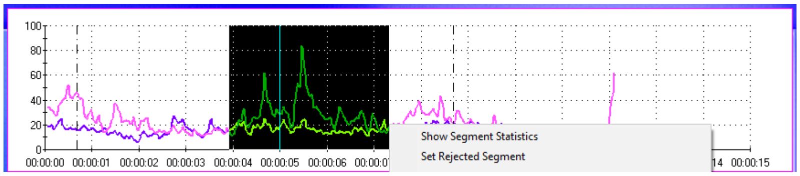
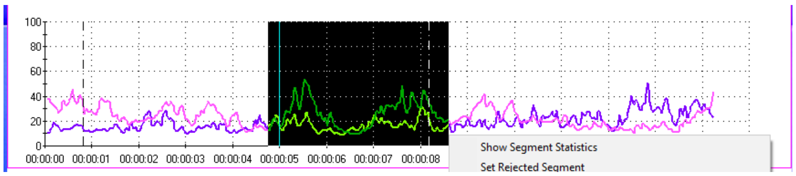


Treatment week 1 trial 1: PTT: 2.74



Treatment week 1 trial 2: PTT:3.41



Treatment week 1 trial 3: PTT:3.85