Use Authorization

In presenting this thesis in partial fulfillment of the requirements for an advanced degree at Idaho State University, I agree that the Library shall make it freely available for inspection. I further state that permission to download and/or print my thesis for scholarly purposes may be granted by the Dean of the Graduate School, Dean of my academic division, or by the University Librarian. It is understood that any copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Signature ___________________________________

Date _______________________________________

Instrumental Investigation of the Effects of Tongue Thrust on Swallow Function

Shelly Elliott

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science in the Department of
Communication Sciences and Disorders
Idaho State University
August 2016

Committee Approval

To the Graduate Faculty:

The members of the committee appointed to examine the thesis of Shelly L. Elliott find it satisfactory and recommend that it be accepted.

____

J. Anthony Seikel, Ph.D.
Thesis Advisor

____

Joni Loftin, MSP-CCC-SLP, COM
Committee Member

____

Bryan M. Gee, OT, Ph.D.
Graduate Faculty Representative

HUMAN SUBJECTS LETTER

Idaho State UNIVERSITY

Office for Research Integrity
921 South 8th Avenue, Stop 8046 • Pocatello, Idaho 83209-8046

December 23, 2014

Lindsay Evans
6171 Indian Tree Lane
Pocatello, ID 83204

RE: Your application dated 12/23/2014 regarding study number 4178: Instrumental Investigation of the Effects of Tongue Thrust on Swallow Function

Dear Ms. Evans:

Thank you for your response to requests from a prior review of your application for the new study listed above. Your response is eligible for expedited review under FDA and DHHS (OHRP) designation.

This is to confirm that your application is now fully approved. The protocol is approved through 12/23/2015.

You are granted permission to conduct your study as most recently described effective immediately. The study is subject to continuing review on or before 6/23/2015, unless closed before that date.

Please note that any changes to the study as approved must be promptly reported and approved. Some changes may be approved by expedited review; others require full board review. Contact Tom Bailey (208-282-2179; fax 208-282-4723; email: humsubj@isu.edu) if you have any questions or require further information.

Sincerely,

Ralph Baergen, PhD, MPH, CIP
Human Subjects Chair

Phone: (208) 282-2179 • Fax: (208) 282-4723 • www.isu.edu/research
ISU is an Equal Opportunity Employer

ACKNOWLEDGEMENTS

Foremost, I would like to express my sincere gratitude to my thesis advisor Dr. Tony Seikel for his continuous support and encouragement. I could not imagine completing this process without his enthusiasm and kind words. I would also like to thank the other members of my committee, Professor Joni Loftin and Dr. Bryan Gee, for all their encouragement, availability, and thought-provoking questions.

To my beloved husband Shane, I couldn't have done it without your help and humor. Thank you! And finally, my gratitude to the power metal band Gloryhammer whose albums motivated me through many late nights.

Table of Contents

List of Tables

List of Figures

Abstract

This replication study analyzed data from five female subjects, aged 12 to 27 years. Prior to participation in the study participants were diagnosed with tongue thrust through the use of the Stone Tongue Thrust Protocol (STTP). Once diagnosed, subjects were evaluated using clinical measured of oromyofunctional disorder (OMD) and oropharyngeal dysphagia (OPD). Masseter activity was assessed using electromyography (EMG), oral muscle strength through the use of the Iowa Oral Performance Instrument (IOPI), and oropharyngeal swallow timing through a combination of EMG and the four finger method of palpation. Subjects were compared with normative data of Holzer, et al. (2011). Raw scores obtained during the study were converted into *T*-scores and *p*-values to determine if significant differences exist between the present study data and the normative data. Significant differences were found on IOPI tongue dorsum strength, EMG oropharyngeal transit time, and subjective variable measurements.

Key words: tongue thrust, oromyofunctional disorder, oropharyngeal dysphagia, swallowing, clinical assessment

Chapter 1: Review of Literature

Introduction to swallowing

Swallowing is a complex and essential process of living: the process by which hydration and nutrition are introduced to the body. This process requires the cranial nerves as well as the muscles of the face, mandible, velum, tongue, pharynx and larynx (Seikel, King, & Drumright, 2010). Both mastication, or chewing, and deglutition, the movement of the bolus down to the digestive system, are part of the swallowing process.

The swallow is usually classified into two different categories: somatic and visceral. Somatic swallowing is the expected adult swallowing pattern (Seikel et al., 2010). Visceral swallowing, also referred to as reverse or immature swallowing, is when the infantile swallow does not develop into a somatic swallow by adulthood. A persistent visceral swallow can lead to an orofacial myofunctional disorder (American Speech-Language and Hearing Association, 2015).

Somatic swallowing

The stages of the somatic swallow are classified differently based on varying sources. However, the four-stage model is considered effective at describing the biomechanics and bolus manipulation of liquids (Matsuo & Palmer, 2008) and is frequently taught to students of Speech-Language Pathology. The four stages of the somatic swallow include the oral preparatory stage, the oral phase, the pharyngeal stage, and the esophageal stage (Logemann, 1998).

The first stage, known as the oral preparatory stage, begins even before food is placed inside the oral cavity. The sensory perception that follows the presentation of food is vital to trigger the physiological changes that accompany the swallowing process.

Olfactory involvement and salivation begin and the lips are utilized to maintain a labial seal and prevent food and saliva from falling from the mouth (Logemann, 1998).

After the food is introduced to the mouth it is moved onto the grinding surfaces of the teeth and masticated until sufficiently broken down for the next stage. Mastication requires significant oral dexterity as the tongue and teeth work together to position food for chewing using a rotary lateral movement (Seikel, King, & Drumright, 2010). After the food has reached the desired consistency the tongue is used to pull the residue together into a rough ball, called a bolus (Logemann, 1998).

The primary goal of the second, or oral, phase is to move the bolus posteriorly to the back of the throat in order to trigger the pharyngeal swallow. In order to accomplish this, the tongue must sequentially elevate along the midline to strip the bolus backward while the tip of the tongue remained anchored against the alveolar ridge. This stage typically takes from one to one and a half seconds to complete (Logemann, 1998).

The triggering and completion of the pharyngeal swallow makes up the third stage. The triggering of the pharyngeal swallow is an automatic response to stimulation of the back of the throat and causes a chain reaction of physiological actions. First, the velum will retract and elevate and the velopharyngeal port will close in order to seal off the nasal cavity. The external laryngeal muscles will contract and elevate the larynx by pulling on the hyoid bone. Protection of the airway is accomplished by the closure of the laryngeal sphincters: the true vocal folds, the false vocal folds and surrounding structures and the epiglottis. Pharyngeal wall constriction and tongue base contraction serve to propel the bolus downward while the opening of the cricopharyngeal sphincter allows the bolus to pass into the esophagus (Logemann, 1998).

When the bolus reaches the esophageal orifice, the fourth stage is considered to have begun (Seikel, King, & Drumright, 2010). During the fourth stage the bolus passes into the stomach (Logemann, 1998). Only the first three stages have a direct relation to orofacial myofunctional disorders.

Visceral swallowing

Visceral swallowing is crucial early in life because this pattern allows infants to breastfeed by using the protruded tongue to stimulate the mother's nipple to release milk. Continued pumping with the tongue and maxillary structure draws the milk into the oral cavity (Seikel, King, & Drumright, 2010). As an infant grows the visceral swallow gradually shifts to a somatic swallow. Visceral swallowing is only considered disordered when it persists into school age (American Speech-Language and Hearing Association, 2015).

Visceral swallowing differs from the somatic swallow mainly in the second stage of swallowing. The tongue, rather than pumping to move the bolus up and back, pushes forward against the front teeth. This pumping action of the tongue is also known as lingual propulsion. The process of lingual propulsion consists of sequential elevation of the anterior, middle, and dorsal regions of the tongue and requires significant coordination (Bosma, Hepburn, Josell, & Baker, 1990). Due to the intricate nature of this movement, it is not surprising that some individuals cannot execute the movements perfectly.

Normal variability in swallowing

As stated above, what is considered a "normal" swallow changes throughout an individual's lifespan. A visceral swallow is the expected swallowing pattern for an infant, but requires intervention when still present in an adult patient (American Speech-Language and Hearing Association, 2015). Oromandibular coordination among infants has been examined in both 15-month-old (Green et al., 1997) and 9-month-old subjects (Steeve, Moore, Green, Reilly & McMurtrey, 2008). Additional research on these age groups found that refinement and rescaling of skills is the only difference between adults and infants when it comes to chewing and speech behavior (Moore, 1993).

Somatic swallowing is fairly constant among adults until the aging process begins. “Normal aging prolongs the oral-pharyngeal swallow that impairs upper esophageal sphincter (UES) opening but does not influence pharyngo-sphincteric coordination” (Shaw et al., 1995). For this reason, clinicians must be careful not to diagnose elderly patients with a swallowing disorder solely based on a prolonged oral-pharyngeal swallow without first ensuring that it is not within normal limits for that age group.

Another concern in geriatric patients is the inability of the swallowing mechanism to compensate as well as it once did. Nicosia et al. (2000) stated that “this decline in pressure reserve has important clinical implications in that older individuals may be at risk for dysphagia due to perturbations in the swallowing system for which younger individuals would be able to compensate” (Nicosia et al., 2000, p. 635). It is important to note that there are no significant differences for timing of the swallow between the genders (Kim, McCullough, & Asp, 2005).

Variability is also caused by differences in the bolus itself. Whereas a small bolus (from 1 to 3 ml) will follow the normal four-stage pattern, a large volume swallow (from 10 to 20 ml) will result in simultaneous oral and pharyngeal activity (Logemann, 1998).

Viscosity of the bolus will also affect the swallow. As viscosity increases, so too does the force generated by oral structures. For example, muscle activity as measured by electromyography will also increase as viscosity does (Dantas et al., 1990). This study illustrated that some boluses require increased coordination and strength to swallow properly. In order to follow evidence-based practice guidelines, diagnosis of an abnormal swallow must take into account bolus size, as well as type. Kendall (2002), who researched normal variation within a somatic swallow, concluded that professionals should not rely solely on general guidelines when evaluating the coordination of swallowing gestures.

Dysphagia

Although there is a fairly wide range of normal variability in swallowing, any swallowing process that is unable or struggles to move a bolus from the mouth to the stomach is considered to be disordered (Logemann, 1998). Dysphagia is the medical term for a disordered swallow. Dysphagia can occur in any age group and for any number of reasons. Onset may be either acute or progressive (Logemann, 1998).

Oropharyngeal dysphagia has four specific signs that can be observed during diagnostic assessment as identified by Logemann. Aspiration is defined as the entry of food or liquid into the airway below the true vocal folds. The second sign, penetration, is the entry of the bolus into the larynx up to the level of the vocal folds. Food residue left in the oral or pharyngeal cavity following a swallow is also a sign of oropharyngeal dysphagia. The final sign is backflow of food into the nasal or pharyngeal cavities (1988). Oropharyngeal dysphagia is often a sign of an overarching orofacial myofunctional disorder.

Introduction to orofacial myofunctional disorders

Orofacial myofunctional disorders include any consistent behavior where the tongue moves forward during speech, swallowing and/or at rest. The tongue may either lie too far forward or protrude between the upper and lower teeth (American Speech-Language and Hearing Association, 2015). OMD disorders persisting into childhood can result in permanent changes to both structure and function (American Speech-Language and Hearing Association, 2015).

Changes to facial structure are often the most noticeable impacts of OMD (Seikel, King, & Drumright, 2010). Andrianopoulos and Hanson (1987) found that actions of the tongue and orofacial muscles had a direct influence on the shape of the jaw and dental arches. This finding was further supported by a 2004 study, which found a strong etiological link between tongue dysfunction and the development of dental malocclusions (Horn, Kühnast, Axmann-Krcmar, & Göz). Malocclusions, though often considered aesthetic problems, can create obligatory and compensatory speech errors that can persist for a lifetime (Kummer, 2014). Chronic open posture of the mouth is also associated with OMD (Knösel, Klein, Bleckmann, & Engelke, 2012). The connection between structure and function is also evidenced in development; the pressure of the tongue rest found with a mature swallow is necessary for proper development of the hard palate and dental arches. Without this pressure “the maxillary dental arch will collapse medially and a vaulted palate will develop” (Seikel, King, & Drumright, 2010, p. 408).

What is tongue thrust?

Tongue thrust, also called reverse swallow or immature swallow, is the most common form of orofacial myofunctional disorder. A tongue thrust occurs when an individual over school age routinely uses a visceral swallowing pattern rather than using the adult somatic swallow (Seikel, King, & Drumright, 2010). A diagnosis requires that:

> "when in resting position, the anterior or lateral portions of the tongue contact more than half the surface of either the upper or lower incisors, cuspids, or bicuspids, or protrude between them; or when, during the moving or swallowing of any two of the three media (liquids, solids and saliva) there is an observable increase of (1) force, (2) degree of protrusion, or (3) amount of surface area of the teeth contacted by the tongue" (Hanson & Mason, 2003, p. 3).

Signs of tongue thrust

Tongue thrust does not have as clear a definition for common signs as it does for diagnosis. Rather, behaviors are judged to be abnormal or normal and are correlated with the presence of an orofacial myofunctional disorder (Hanson & Mason, 2003). This means both that a tongue thrust can occur without all of the abnormal behaviors and that these behaviors can occur without a tongue thrust being present.

Reduced tongue force both laterally (Reddy, Costarella, Grotz, & Canilang, 1990) and horizontally (Robinovitch, Hershler, & Romilly, 1991) has been strongly associated with a diagnosis of tongue thrust. Tongue weakness is usually measured using an Iowa Oral Performance Instrument (IOPI) and this is often required as part of a diagnosis (Robin & Luschei, 1992).

The presence of oral habits such as thumb or finger sucking, lip licking, cheek biting and teeth grinding as well as abnormal rest postures, handling of saliva and inefficient chewing patterns have all been correlated with tongue thrust (Hanson & Mason, 2003).

Prevalence/ Etiology of tongue thrust

Prevalence of tongue thrust is difficult to determine since many cases go unnoticed by patients. Orthodontists often identify tongue thrust in young adults and refer them to Speech-Language Pathologists for services (Stone, 2015). Because self-reporting among the populace is unreliable, studies that identify incidence rates are very valuable for diagnostic purposes. Christensen and Hanson (1981) found that tongue thrust occurs in five-year olds about 50% of the time. Rates of tongue thrust gradually decrease from 50% in children to about 30% in adulthood (Hanson & Mason, 2003).

Although tongue thrust commonly occurs across all populations (Hanson & Mason, 2003), etiologies remain uncertain. The American Speech-Language and Hearing Association identifies four likely causes which include allergies, enlarged tonsils or adenoids, excessive negative oral habits, and family heredity (2015). Hanson and Mason (2003) identify additional etiologies such as mouth breathing, tongue size, posture, oral sensory deficiencies, and orthodontic treatment.

Measurement of Tongue Thrust

Historically, objective measures of strength have been considered more reliable than subjective measures, but much of the available literature about tongue thrust is based on subjective findings (Clark, Henson, Barber, Stierwalt & Sherrill, 2003). For this reason, Clark et al. (2003) performed a direct comparison of the two. The data showed that both subjective and objective measures were a good indicator of oral phase swallowing impairments, although the more experienced examiners provided more accurate subjective estimates than inexperienced examiners. Subjective estimates generally consist of a rating scale based on the physical observation of the swallow following an orofacial examination (Stone, 2015).

Common subjective instruments

An oral peripheral examination requires visualization of the major anatomical structures of the oral cavity as well as an assessment of function. The structures of the lip, hard and soft palate, uvula, facial arches and sulci and tongue as well as the overall dimensions of the oral cavity are closely assessed. Emphasis should be placed on overall tone and symmetry of anatomy. Following the anatomical review, the range, rate and accuracy of movement of the articulators and structures of swallowing must be determined. In particular, the patient must be able to open their mouth voluntarily, manage appropriate levels of oral-sensory stimuli and test negative for abnormal oral reflexes (Logemann, 1998).

When dysphagia is suspected, a bedside evaluation of the swallow is generally the first swallowing-specific assessment to be performed. It is important to note that bedside evaluations, also known as clinical evaluations, give the examiner information about the need for further assessment, diet modifications, and the overall likelihood that a swallowing disorder is present (Weinhardt, Hazelett, Barrett, Lada, Enos, & Keleman, 2008). A bedside evaluation alone cannot reliably be used to diagnose dysphagia.

Before the start of a bedside swallow evaluation, an oral peripheral exam as well as a thorough case history and patient interview should be completed. This information should be used to determine whether or not this assessment is beneficial and safe for the patient (Logemann, 1998). Bedside evaluations are designed to assess the patient’s success with various textures, presentations and consistencies of food and liquid and can therefore present a risk of aspiration. Individual client severity, medical complications, and cognitive state may necessitate deviations from the standard assessment. If difficulty is present during a trial, the clinician can determine which stage of the swallow is of concern (Logemann, 1998).

The standard format for bedside swallowing evaluations begin with thin liquids presented with a spoon, cup, and straw. If thin liquid is unrealistic for the client it may be thickened, known as a honey or nectar thick consistency, to allow for increased pharyngeal swallow trigger time. The clinician must carefully observe the client for signs of aspiration or penetration, both overt and silent. Following each trial, the patient should be instructed to phonate in order to detect a gurgly or “wet” vocal quality. Signs of silent aspiration include watery eyes and a reddened face and should also be watched for. If liquid trials are tolerated by the patient, the clinician will then move on to various solid consistencies. In order from least to most advanced these consist of: pureed solids, neurosoft, mechanical soft, and then regular solids. These are generally presented with a spoon or fork and, if possible, the patient is asked to feed themselves with a bolus size they consider natural. Just as in liquid trials, signs of aspiration are noted by the clinician after each trial. Additionally, with solid trials the clinician must examine the oral cavity, particularly the sulci to detect residue (Logemann, 1998).

Laryngeal palpation is another valuable tool used to assess swallowing in conjunction with other assessments. By using their four fingers to feel for tongue movement, the extent of laryngeal excursion, and hyoid bone movement, the clinician can get additional information about the duration and muscular involvement of each swallow. Each finger is placed lightly on the throat with just enough pressure to feel structures and movement without causing any discomfort. The index finger is positioned immediately behind the mandible, the middle finger is placed directly on the hyoid bone, the ring finger is placed on the thyroid cartilage, specifically over the thyroid notch and the little finger is positioned right above the cricoid cartilage (Logemann, 1998).

Subjective methods of assessment rely on sound clinical observation and judgment. Often, subjective measures cannot conclusively determine diagnosis and require further objective testing (Logemann, 1998).

Common objective instruments

The Iowa Oral Performance Instrument (IOPI) works by measuring the force that the tongue exerts against an air filled plastic pressure sensor (Clark et al., 2003). This sensor is pressed between the tongue and the hard palate (Logemann, 1998). Normative data for this device have been reported by Robin and Luschei (1992) and provides standardized comparisons for clinical use. Availability of normative data is crucial for making evidence-supported clinical judgments. This is particularly true when the alternative measure for tongue strength is a subjective clinician assessment of force asserted against a tongue depressor.

An alternative measurement system is electromyography, which measures the action potential of skeletal muscles (Seikel, King, & Drumright, 2010). EMGs can detect myoelectrical activity at some distance through electrodes placed on the skin (Stepp, 2012). This system is typically used to measure the action potential of the muscles involved in the oral and pharyngeal phases of swallowing such as the masseter and suprahyoid muscles (Seikel, King, & Drumright, 2010). Electromyography can be used to judge the timing of a swallow since several muscles generate electrical activity when the pharyngeal swallow is triggered (Logemann, 1998).

Videofluoroscopy (VFSS) is the most commonly used technique for assessing the oropharyngeal swallow. Also known as a modified barium swallow study, this assessment requires the use of radiographic analysis, which clearly shows the path of barium-laced food. Differing amounts and consistencies of food are given to the patient and the effect on the swallow is noted. Radiation exposure, albeit at a very low dose, is part of this assessment. Videofluroscopic swallowing studies provide valuable information about bolus transit time, etiology and extent of aspiration and the reduction of movement in certain structures. The equipment can easily be connected to a recording device and the assessment can be analyzed in slow motion to obtain further details.

VFSS imaging provides a detailed view of oral mastication, the position of the bolus when the pharyngeal swallow is triggered and the ensuing motor movements of the pharyngeal swallow. It can also be used to determine efficacy of treatment strategies for prevention of aspiration and residue (Logemann, 1998).

Videoendoscopy, also known as flexible fiberoptic examination of swallowing (FEES) is another useful imaging procedure. A flexible scope is inserted through the nose of the client and is positioned around the level of the soft palate. Dynamics of pharyngeal closure can be observed with this method, as well as the presence and location of residue post swallow.

As with any diagnostic procedure there are some drawbacks to FEES. Topical anesthesia may be required to make the client comfortable for the insertion and placement of the scope and a willing participant is required. Additionally, endoscopy does not show the oral stage of the swallow because the walls of the pharynx close around the endoscopic tube when the swallow is triggered, obscuring the camera. Any diagnosis generated from FEES must therefore be indirect and based on the location of residue directly after the swallow, which is far from ideal (Logemann, 1998).

Interprofessional Diagnosis and Evidence-Based Practice

Under the Preferred Practice Patterns for the Profession of Speech-Language Pathology that were approved by the ASHA Legislative Council in November 2004, Speech-Language Pathologists have a recognized role in providing services to individuals with tongue thrust and other orofacial myofunctional disorders. However, ASHA officially advocates training beyond the level of course work and clinical experience in a typical master's degree program to better prepare the clinician for such specialized patients (American Speech-Language and Hearing Association, 2004). For this reason, individuals diagnosed with tongue thrust should only see a Speech-Language Pathologist, or orofacial myologist, specializing in oral myofunctional therapy (Seikel, King, & Drumright, 2010).

Speech-Language Pathologists generally diagnose tongue thrust as part of a team of professionals, which may include a dentist, orthodontist, physician or other health care provider in addition to the SLP (American Speech-Language and Hearing Association, 2015). This multidisciplinary approach allows the patient to be simultaneously treated for the many etiologies and symptoms associated with tongue thrust. For example:

> Both dentists and orthodontists may be involved when constant, continued tongue pressure against the teeth interferes with normal tooth eruption and alignment of

the teeth and jaws. Physicians rule out the presence of a blocked airway (e.g., from enlarged tonsils or adenoids or from allergies) that may cause forward tongue posture. SLPs assess and treat the effects of OMD on speech, rest postures, and swallowing (American Speech-Language and Hearing Association, 2015).

This team approach is an important tool for the SLP in following evidence-based practice protocols.

Another important evidence-based practice consideration is the presence of OMD in research studies and treatment trials. Tongue thrust is underrepresented in the literature and there is little available research about tongue position and function in those with orofacial dysfunctions, particularly regarding the position of the tongue directly following a swallow (Costa & Lemme, 2010). Because new research is currently being done in this area, it is crucial that clinicians follow best practice guidelines and carefully weigh the applications of new findings.

Relation between OMD and OPD

Traditionally, OMD and OPD have been classified as unrelated disorders (Logemann, 1998). However, Holzer et al. hypothesized that children with orofacial myofunctional disorders were at risk for developing oropharyngeal dysphagia later in life due to the inability of aging muscles to compensate for OMD as well as they once did. Their study, which included more than 400 individuals, did indeed show that the presence of indicators of tongue thrust predicted signs of oropharyngeal dysphagia (2011).

Recent research from Evers (2013) and Evans (2014), who utilized the normative data developed by Holzer (2011) in their comparison, found significant differences in lip strength, tongue strength, masseter contraction and oropharyngeal transit time in individuals diagnosed with tongue thrust. In order to further substantiate the link between OMD and OPD this replication study aims to include additional subjects.

Chapter 2: Methodology

This study is a replication of two previous studies (Evans, 2015; Evers, 2013). Due the replication nature of this study, this methodology is largely adapted from the Evans (2015) study. The current study is being conducted to increase the evidence regarding whether or not individuals with tongue thrust vary from the norm in oral pharyngeal dysphagia measures. The following measures were used to assess those diagnosed with tongue thrust: tongue tip strength, tongue dorsum strength, lip strength, masseter contraction, and oropharyngeal transit time. Normative data from a previous study (Holzer et al., 2011) was the comparison point used to determine whether or not these differences are statistically significant. Data from the current study were matched to same age and gender groups of individuals without tongue thrust. The current study included four subjects, who ranged in age from 12-27 years. This study is part of a larger group of studies, which are building upon evidence of lip strength, tongue strength, masseter contraction, and oropharyngeal transit time differences across the lifespan.

Research Hypotheses

H_{0a}: No significant difference exists in masseter contraction as measured by EMG between individuals diagnosed with tongue thrust and normative data.

H_{1a}: A significant difference exists in masseter contraction as measured by EMG between individuals diagnosed with tongue thrust and normative data.

H_{0b}: No significant difference exists in force, as measured by IOPI, based on location or between individuals diagnosed with tongue thrust and normative data.

H_{1b}: A significant difference exists in force, as measured by IOPI, based on location or between individuals diagnosed with tongue thrust and data.

H_{0c}: No significant difference exists in oropharyngeal transit time based on bolus type, and/or measurement type between individuals in the experimental and normative data.

H_{1c}: A significant difference exists in oropharyngeal transit time based on bolus type, and/or measurement type between individuals diagnosed with tongue thrust and normative data.

Subjects

The study consisted of four subjects identified with tongue thrust, with the individuals ranging in age from 12-27. Detailed demographic data are reported for each subject in Chapter 3. Participants were recruited through participant networks and word of mouth (recruitment letter located in Appendix A).

The Stone Tongue Thrust Protocol (refer to Appendix B) was used to confirm the presence of tongue thrust in all participants before further involvement in the study. By using the same inclusion procedure for each participant, the researcher ensured that identical criteria were used to qualify participants as having tongue thrust. The STTP was also used to gather case history information for each participant. Each subject was also given a medical history form (Appendix C), which included: date of birth, gender, ethnicity, medical conditions and/or disorders, OMD risks and/or conditions, surgeries, medications, alcohol consumption, tobacco use, food preferences, and food avoidances. Any additional information provided by the clients during the course of data collection was be audio recorded and reported by the researcher.

Exclusion criteria for the study was gathered through the medical history form filled out by each subject. Subjects with a history of structural or neurogenic impairments of the head or neck, not resulting from tongue thrust, were excluded from the study. If subjects reported a concussion resulting in a loss of consciousness for less than 5 minutes, with no associated motor or cognitive deficits, they were not be excluded from the study. However, no participants reported loss of consciousness.

Variables

Independent variables for this study include: subject age and gender, protocol group assignment, and bolus characteristics. Food and liquids that were used were replicated exactly from previous studies: a ½ teaspoon and 1½ -teaspoon measurements of chocolate pudding, a subject-determined “typical” bite of Triscuit cracker, and 10cc of water served in a cup.

The researcher used clinical observation and professional judgment to measure subjective variables. Subjective variables included: dental occlusions or malocclusions, the presence or absence of a vaulted palate, open or closed mouth posture at rest, the absence or presence of residue in the sulci or on the tongue following a swallow, and a “gurgly” voice quality post swallow. During each trial, which consisted of a ½ tsp of pudding, 10 cc of water, and a Triscuit cracker, subjects were assessed for tongue protrusion, as noted by the researcher, through pulling downward on the lower lip during a swallow. Pre-swallow bolus cohesion was also assessed for the Triscuit cracker trials, using a 1-3-5 rating scale (1= organized ball or tube in middle of tongue, 3= some evidence of cohesion/some scattering, 5= disorganized or scattered on tongue), as well as post-swallow residue on a similar 1-3-5 rating scale (1= minimal/no residue, 3= some evidence of residue, 5= significant amount of residue). Other characteristics, such as: open mouth posture, coughing, clavicular breathing, forward posture, chin-tuck, neck tension, and tongue protrusion were also be recorded as being present or absent during swallow trials. Any additional observations made by the researcher were noted on the study protocol.

Instruments and Materials

Before each session with the individual subjects, a video recorder was set up to allow for videotaping of all the sessions from beginning to end. Upon their arrival, the recording began and each subject, or his or her guardian if subject was a minor, was asked to complete and sign both the consent form, verifying their consent to participate in the study (Appendix D), and the medical history form (Appendix C). The Stone Tongue Thrust Protocol (STTP) created by Callie Stone, is a protocol used to determine the presence or absence of tongue thrust, including the procedure and swallow trials for determining the diagnosis. This protocol was used to assess all of the subjects in this study for consistently determining tongue thrust. As outlined in the STTP protocol, trials of water, diced peaches, chocolate pudding, and Triscuit crackers were consumed while the researcher observed and made note of accompanying characteristics, as previously mentioned, for each of the given consistencies. Along with the STTP, the researcher asked subjects to participate in “smile swallows,” a common practice performed by other OMD professionals in assessing for the presence of tongue thrust. A “smile swallow” is a procedure in which the subjects are asked to smile with the lips open while swallowing a small sip of water, which allows the professional to have an improved view of the forward movement of the tongue during the swallow. In previous studies, the results from the STTP swallow trials, as seen in the protocol, and the “smile swallows” have been in agreement in confirming the presence or absence of tongue thrust.

Following the diagnosis of tongue thrust, the researcher proceeded to follow the study protocol (see Appendix E). The Iowa Oral Performance Instrument (IOPI) (Model 2.2) was be used to measure tongue tip, tongue dorsum, and lip strength. A two channel Myotrac Infiniti EMG was used to measure masseter contraction and oropharyngeal transit time, using surface electrodes. EMG data were recorded on an HP Pavilion laptop running Windows 7. Foods and liquids that were administered to each subject during the study protocol included Snack Pack chocolate pudding, water, and Triscuit crackers. Sets of syringes, calibrated for volume measured in cubic centimeters, were used to measure amounts of pudding and water. Water was presented to subjects in a cup, pudding presented on a spoon, and subjects were instructed to take a “typical” bite of Triscuit cracker. Other clinical materials used by the researcher include the following: gloves, tongue depressors, straws, cups, spoons, paper towels, a flashlight, alcohol swabs, gauze pads, hand sanitizer, skin prepping gel, and conductive gel.

Procedures

The study included four individuals who were either previously diagnosed with tongue thrust, had a history of signs of tongue thrust, or were believed to have tongue thrust. The researcher recorded all sessions with a video recorder. All subjects, and guardians in cases in which the subjects are minors, were asked to sign consent forms to participate in medical research (see Appendix D). In the case of a minor subject, the caregiver remained present and assisted in the completion of consent and history forms. Next, the researcher evaluated all subjects using the STTP (see Appendix B) in order to evaluate and diagnose each subject as either having tongue thrust or not having tongue thrust.

All subjects were consecutively assigned to one of three different protocol groups, based on subject number assignments. The researcher rotated subjects through protocols A, B, and C. Based on the group assignments, the researcher measured IOPI tongue and lip strength, EMG masseter contraction, and EMG oropharyngeal transit time in different sequences. Table 2.1 outlines the three protocol groups of the study and the sequence of measurements for each group:

Table 2.1

Protocol Groups

Group A	Group B	Group C
IOPI force	EMG masseter contraction	EMG swallow timing
EMG masseter contraction	EMG swallow timing	IOPI force
EMG swallow timing	IOPI force	EMG masseter contraction

All subjects were seated comfortably in upright positions. Subjects were first asked to read and sign the consent forms, and then asked to complete the medical history forms. Caregivers were present for evaluations that included minors; the caregivers were allowed to assist the subjects in completing the medical history forms and answering questions related to their case histories. Upon completion of the aforementioned paperwork, all subjects were informed that an IOPI bulb would be placed between their lips and in their mouth, as well as electrodes on their throat and jaw. Subjects were told that they should not experience any pain or discomfort and that they may end their participation during the study at any time.

Oral peripheral examination. The oral peripheral examination, which follows the protocol found in the STTP, was used to evaluate the structure and function of the oral mechanism. The researcher noted any deviations of the teeth, tongue, tonsil, palate and lips. Palate height was recorded, as well as the presence of any the following features: crossbite, labioverted teeth, normal occlusion, class I malocclusion, class II malocclusion, or class III malocclusion.

Tongue tip, tongue dorsum, and lip strength. Objective measures of lip, tongue tip, and tongue dorsum strength were all gathered using the Iowa Oral Performance Instrument (IOPI). The strength of the tongue tip was measured first. In order to localize the measurements to the tongue tip, the IOPI bulb was placed anteriorly on the tip of the tongue. The subjects were directed to keep their lips and teeth closed, without biting down on the tubing, and compress the bulb against the alveolar ridge with as much force as possible for approximately two seconds. Each subject repeated this measurement for three trials, while the researcher recorded the force reported by the IOPI. At the start of each new attempt, the researcher repositioned the IOPI bulb on the tongue.

Next, the dorsal strength of the tongue was measured. For this task, the IOPI bulb needed to be placed further back in the mouth on the tongue dorsum. The researcher, by referencing the juncture of the hard and soft palates, identified the precise location for bulb placement. This was facilitated by having the subjects sustain phonation of the vowel /a/. Each subject was asked to occlude his or her teeth and lips while pushing upward against the bulb with maximal force and without biting down on the IOPI's tubing. As with the previous measure, subjects repeated this action in two-second intervals for a total of three trials. The researcher dried and repositioned the bulb after each attempt, and recorded results on the protocol form following each trial.

Lastly, lip strength was measured by placing the IOPI bulb parallel to the lips and instructing the subjects to press their lips closed against the bulb with as much force as possible. Before the first trial, subjects were asked to wipe their lips with a tissue so that saliva or chapstick did not interfere with their ability to grip the bulb with their lips. To prevent subjects from utilizing their teeth, specific instruction and monitoring was given to keep the back teeth clenched. Subjects were also instructed not to bite down onto the tubing, as this would invalidate the IOPI measurement. Lip strength measurements were broken into three, two-second trials. The IOPI bulb was dried of saliva and repositioned between each new attempt. Readings were recorded between each trial by the researcher.

EMG masseter contraction. Electromyography measurements for masseter contraction were collected through electrodes placed along the belly of the masseter in a vertical plane. Prior to skin preparation for placing electrodes, all subjects were interviewed about skin allergies or sensitivities. If none were reported, the researcher prepared the skin for electrode placement by using NuPrep skin prepping gel. Gel was applied using a gauze pad or disposable towel and was rubbed into the skin for approximately 30 seconds. Alcohol swabs were used to remove residue from the skin. If subjects presented with allergies/skin sensitivity, only alcohol swabs were used to prepare the skin for electrode placement. This was noted by the researcher and is reported in Chapter 3.

Correct placement over the belly of the masseter was determined by instructing subjects to clench their back teeth during palpation by the researcher. Marks were made on the skin with a nontoxic pen to ensure proper placement following subject permission. Channel A was assigned to the right masseter and Channel B to the left masseter. Ground electrodes for both channels were positioned over the left clavicle.

A baseline for the masseter was recorded before the onset of trials by instructing the subjects to bite down with their back teeth as forcefully as possible for three seconds. The researcher directed the subjects when to begin and when to relax. This baseline was repeated for a total of three trials. Trials with ½ tsp pudding, 1 ½ tsp pudding, 10cc water and a subject-determined bite of Triscuit cracker were then performed. Each stimulus presentation received three trials. Subjects were instructed to hold the bolus in his or her mouth until instructed to swallow. The five-finger laryngeal palpation method, developed by Logemann, was utilized to detect initiation and termination of the swallow (1998). The researcher used her free hand to depress the spacebar of the laptop computer as soon as initiation and termination of the swallow were detected. This placed timing markers on the EMG readings, which was displayed on the laptop screen, and was recorded by the researcher throughout the trials.

The swallow trial that included the Triscuit cracker required a slightly different process in order to be minimally disruptive to the natural timing of the swallow. Subjects were instructed to chew until ready to swallow, and then signal to the researcher. After being signaled, the researcher examined the Triscuit bolus for cohesion. Pre-swallow cohesion was rated using a 1-3-5 rating scale (1= organize ball or tube in middle of tongue, 3=some evidence of cohesion/some scattering, 5= disorganized or scattered on tongue). Post-swallow residue was also rated using a 1-3-5 rating scale (1= minimal/no residue, 3= some evidence of residue, 5= significant amount of residue).

After each trial, the researcher recorded subjective findings. Subjective information that was collected for each participant consists of the following: the presence or absence of a gurgly voice post-swallow, coughing, clavicular breathing, forward posture, chin-tuck posture, neck tension, open-mouth posture, tongue protrusion, and any additional findings. The presence or absence of tongue protrusion was determined by using the lip pull-down method for all stimulus presentations except the 1 ½ tsp pudding trial. Due to the multitasking required of the researcher, obvious signs were noted in real-time, while less obvious findings were noted upon viewing the recordings of each participant.

EMG and behavioral swallow timing. Oropharyngeal transit time was measured both behaviorally and instrumentally. The researcher defined the moment of swallow initiation as the upward movement of the larynx, as recorded by the EMG of the submental region. Termination of the swallow was determined through palpation of the throat and defined as the depression of the larynx. This was marked in the measurement system by the researcher as soon as depression was detected.

The same skin preparation procedure as were implemented for masseter contraction were utilized for oral-pharyngeal transit time. Channel A was placed on the submental region, approximating the mylohyoid muscle, with the first electrode being placed two centimeters posterior from the chin point, and the second electrode placed two centimeters posterior to the first, as measured with a ruler. Channel B electrodes were placed vertical to the thyroid lamina on the left side. Ground electrodes remained on the collarbone.

Subjects were be given ½ tsp pudding, 1 ½ tsp pudding, 10cc water and a participant-determined bite of Triscuit, just as in the masseter contraction portion of the study, with each stimulus being presented three times. Each time the subjects were instructed to hold the bolus in the oral cavity until told to swallow by the researcher for both the pudding and the water trials. They were instructed to chew until ready to swallow, then signal the researcher directly before swallowing, which allowed the researcher to check for cohesion of the pre-swallow bolus and remaining residue post-swallow of the Triscuit cracker trial. The researcher marked initiation and termination of the swallow by depressing the spacebar on the laptop to place marks on the EMG recordings.

The researcher recorded subjective findings following each trial. Subjective information that was collected for each participant consisted of the following: the presence or absence of a gurgly voice post-swallow, coughing, clavicular breathing, forward posture, chin-tuck posture, neck tension, open-mouth posture, tongue protrusion, and any additional findings. The presence or absence of tongue protrusion was determined by using the lip pull-down method for all stimulus presentations, aside from the 1½ tsp pudding trial. Due to the multitasking required of the researcher, obvious signs were noted in real-time, while less obvious findings were noted upon viewing the recordings of each participant.

Reliability

Inter-judge reliability: inter-judge reliability was be ensured through the use of consensus coding. The researcher, and a colleague trained in the tests, examined all subjects’ oropharyngeal transit time data, including all EMG oropharyngeal transit time graphs, together. Both researchers came to consensus for each trial of oropharyngeal transit time.

Intra-judge reliability: to safeguard intra-judge reliability the researcher re-measured all EMG oropharyngeal transit time graphs for 30% of trials.

Data Analysis

Subjects of the present study were compared with normative data. Following descriptive and graphic comparison, if the data were greater than one standard deviation from the norm the data are considered to be significant.

Chapter 3: Results

In order to determine whether or not individuals with tongue thrust differ from individuals without tongue thrust the researcher utilized the following OPD measures: tongue tip strength, tongue dorsum strength, lip strength, masseter contraction, and oropharyngeal transit time. Measurements were collected through the use of an IOPI and EMG system and were compared to normative data of individuals without tongue thrust which was gathered in a previous study (Holzer et al., 2011). The replication study included four subjects diagnosed with tongue thrust through the use of the Stone Tongue Thrust Protocol and clinical observation. Raw scores obtained during the study were converted into *T*-scores and *p*-values to determine if significant differences exist between the present study data and the normative data. The data was considered to be statistically significant for measures in which the *p*-value was .05 or smaller. Significant differences were found on IOPI tongue dorsum strength, EMG oropharyngeal transit time, and subjective variable measurements.

Medical History Form

The current study included four subjects, all females. The subjects ranged from 12-27 years of age. The mean age of the subjects was 18.68 years. All four of the subjects self-identified as European American.

The following noxious oral habits were reported: one subject indicated that she was a habitual mouth breather and one marked a history of cheek biting. Reported oral surgeries included one removal of a blocked salivary gland and wisdom teeth removal. Two of the participants reported having their tonsils and adenoids removed. One subject reported sensitive skin and allergies to certain chemicals found in laundry detergent. Oral sores and occasional alcohol consumption (one glass per month) were reported by the same subject. Previous tongue thrust therapy was indicated by subject number two. When asked for further details, she reported that therapy lasted approximately 8 weeks at a local private practice facility and consisted of tongue strengthening exercises and speech therapy to reduce lisping on fricative sounds, particularly /s/.

Results from the medical history form are summarized in Table 3.1. All other areas listed in the demographic survey (see Appendix C) were not indicated as present in any of the participants.

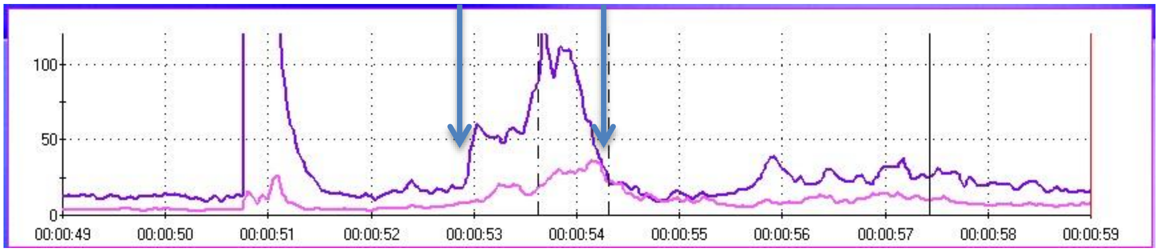
Table 3.1, *Medical History Form Results.*

	Subject Number	**Total**
European American	1, 2, 3, 4	4
Mouth breather	2	1
History of cheek biting	4	1
Tonsils/adenoids removed	1, 2	2
Oral surgery	2, 3	2
Allergies	4	1
Oral sores	4	1
Alcohol consumption	4	1
Participated in tongue thrust therapy	1	1

Oropharyngeal Transit Time Trends

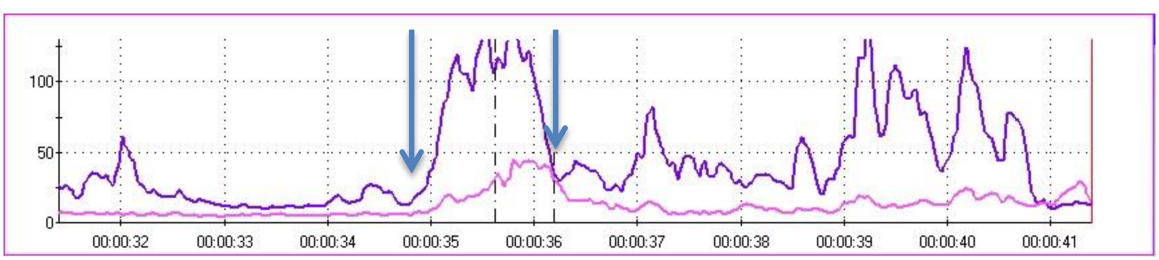
Just as noted by Evers (2013) and Evans (2015) variation in swallowing activity was observed between subjects. One participant in particular, Subject 4, exhibited both pre-swallow activity and multiple swallows depending on bolus consistency. Pre-swallow activity occurred during pudding and water trials and multiple swallows were recorded during the 1½ teaspoon pudding and Triscuit cracker boluses. Typical pre-swallow activity is shown in Figure 3.1 and occurs at approximately 50.8 seconds on the trace. In these cases, oropharyngeal transit time was measured from the physiological initiation of the main swallowing event, not from the beginning of pre-swallow activity.

Figure 3.1, *Pre-Swallow Activity for Subject 4 on Second Trial of ½ tsp. Pudding. Note that arrows indicate decision points for onset and termination of swallowing.*



Multiple secondary swallows were detected by the researcher but did not interfere with the initial marking of the swallow through the depression of the spacebar on the EMG system. For comparison purposes, laryngeal elevation measurements began at the initial physiological swallow initiation and were ended at the termination of the initial swallow's EMG activity and the closest dip toward baseline. Figure 3.2 shows multiple swallow activity for Subject 4. In this case, measurement began before the initial spacebar mark (around 34.75 seconds) and was ended at approximately the second spacebar depression line (around 36.2 seconds).

Figure 3.2, *Multiple Swallows for Subject 4 on Second Trial of Triscuit Cracker. Note that arrows indicate onset and termination of the swallow.*



Detailed data results will be reported for each participant. Table 3.2 lists the abbreviations used in the results tables for observed data in all subjects:

Table 3.2, *Abbreviations Used in Results.*

Abbreviation	**Description**
iopitipavg	average force for IOPI tongue tip measure
iopidorsavg	average force for IOPI tongue dorsum measure
iopilipsavg	average force for IOPI lips measurement
mcbARMSav	right masseter contraction baseline average
mcbBRMSav	left masseter contraction baseline average
mcpud1ARMS	right masseter contraction for ½ tsp pudding trials
mcpud1BRMS	left masseter contraction for ½ tsp pudding trials
mcpud2ARMS	right masseter contraction for 1 ½ tsp pudding trials
mcpud2BRMS	left masseter contraction for 1 ½ tsp pudding trials
mc10ccARMS	right masseter contraction for 10 cc water trials
mc10ccBRMS	left masseter contraction for 10 cc water trials
mccrackARMS	right masseter contraction for Triscuit cracker trials
mccrackBRMS	left masseter contraction for Triscuit cracker trials
stcpud1avg	average swallowing timing with contraction for ½ tsp pudding trials
stcpud2avg	average swallowing timing with contraction for 1 ½ tsp pudding trials
stc10ccavg	average swallowing timing with contraction for 10cc water trials
stccrackavg	average swallowing timing with contraction for Triscuit cracker trials
tppud1	tongue protrusion for ½ tsp pudding trials
tp10cc	tongue protrusion for 10 cc water trials
Tpcrack	tongue protrusion for Triscuit cracker trials
boluscoh	bolus cohesion during Triscuit cracker trials
bolusres	bolus residue following Triscuit cracker trials
ope_p	oral peripheral exam of palate (1= presence of high vaulted palate, 0= absence of high vaulted palate)
Cough	any cough during bolus trials
CB	indicates clavicular breathing during bolus trials
FP	forward posture during bolus trials
CTP	chin tuck position
NT	neck tension during bolus trials
OMP	open mouth posture during bolus trials
TP	tongue protrusion during bolus trials

Subject 1

Subject 1 was a 12-year-old female who participated over the course of two sessions at the Idaho State University Speech, Language and Hearing Clinic. The initial session consisted of explaining the study, acquiring parent and participant consent and medical history, IOPI measures and the masseter contraction portion of the EMG measures. Due to participant time constraints, the laryngeal elevation EMG measures had to be collected two days later. Her mother was present for both sessions. Behavioral and clinical indicators of oromyofacial disorder along with secondary tongue thrust as reported and observed during these sessions are shown below in Table 3.3.

The subject had been previously diagnosed with tongue thrust by a Speech-Language Pathologist during articulation treatment for a frontal lisp over a year before. The subject's mother reported that therapy for the frontal lisp and tongue thrust was conducted over eight weeks and primarily focused on tongue-strengthening exercises. The subject denied any current noxious oral habits but reported that she used a pacifier until approximately 2½ years of age.

During the oromyofunctional examination the researcher noted a central open bite and class II malocclusion as well as the presence of a high, sharply vaulted palate. Labial seal was insufficient to hold in air when moderate pressure was applied to the cheeks. The subject had completed an orthodontic treatment program a year prior; the program lasted one year and was free of complications. Tonsils and adenoids had been removed when the subject was approximately four years of age due to frequent sickness. When asked by the researcher the subject reported that her tongue generally rested against the upper teeth.

A slight frontal lisp was noted by the researcher, both when the subject was asked to count from 60 to 70 and during conversational speech. The tongue tip did not protrude between the teeth abnormally during productions of /t, l, d, n/.

During the bolus trials of the Stone Tongue Thrust protocol, the tongue protruded to presentation of puree. A rotational chewing pattern was consistently observed during solid bolus trials. When asked about her back teeth during trials, the subject reported that they were apart for liquid, puree, and soft solid consistencies. Limited chewing was observed for all solid boluses; the subject reported that this was how she normally ate. The researcher observed extraneous head movements during swallow initiation for all solid bolus trials. An audible swallow was present for liquid and soft solid consistencies. Objective and observational data collected during IOPI and EMG trials are reported below in Table 3.3.

Table 3.3, *Indicators of OMD for Subject 1, a 12-year-old Female.*

OMD Indicators	**Results**
Use liquid to wash foods down	Yes, especially when swallowing dry foods.
Noxious oral habits	Reported pacifier use until approximately 2½ years of age.
Open bite	Slight central open bite.
Malocclusion	Slight class II.
Tongue rest posture	Reported to be pressed against upper teeth.
Orthodontic treatment	One year of braces.
Tonsils	Removed when the subject was approximately four years old.
Speech	Slight frontal lisp.
Tongue protrudes to presentations of foods and liquids	Noted in puree trials.
Back teeth apart	Reported back teeth were apart across all but regular solid (Triscuit) trials.
Audible swallow	Was noted on liquid and soft solid trials.
Rotational chew	Observed during regular solid trials.

Table 3.4 lists objective data obtained via the IOPI and EMG as well as the normative data reported by Holzer et al. (2011). Observational data collected during EMG trials is also recorded and consists of specific tongue protrusion trials, post-swallow residue, and the incidence of cough, clavicular breathing, forward posture, chin-tuck posture, neck tension, open mouth posture, and incidental tongue protrusion. As can be seen in Table 3.4, all of this participant's oropharyngeal transit times were statistically significant compared to the normative data. It is also of note that differences in her rates of tongue protrusion, bolus residue post swallow and palate structure were significant.

Table 3.4, *Instrumental and Observational Data for Subject 1, a 12-year-old Female.*

Subject 1	**Observed Score**	**Norm Group Mean**	**Norm Group SD**	***T*-score**	***p*-value**
Iopitipavg	34	42.64583333	14.16692219	43.8971689	NS
iopidorsavg	41.33	38.91666667	12.23325314	51.97276498	NS
iopilipsavg	3	17.25	5.050805708	21.78667954	NS
mcbARMSav	128	287.42	192.8563742	41.73358279	NS
mcbBRMSav	107.87	248.09	160.6135753	41.26980707	NS
mcpud1ARMS	40.74	123.83	109.3699217	42.40284726	NS
mcpud1BRMS	41.56	112.460625	87.2395105	41.8728768	NS
mcpud2ARMS	49.61	164.2475	235.78213	45.13799031	NS
mcpud2BRMS	26.98	168.914375	262.5018011	44.59301329	NS
mc10ccARMS	9.96	128.0475	119.5880463	40.12547627	NS
mc10ccBRMS	10.44	132.24125	135.6133107	41.01848857	NS
mccrackARMS	115.24	175.928125	122.5282034	45.04700768	NS
mccrackBRMS	82.97	128.753125	95.22737287	45.19223059	NS
stcpud1avg	2.13	0.982291667	0.146523393	128.3293583	.01
stcpud2avg	1.71	0.9925	0.093159666	127.0183095	.01
stc10ccavg	1.46	0.826041667	0.108328491	108.5218464	.01
stccrackavg	2.15	1.027291667	0.088070078	177.4789756	.01
tppud1	3	0	0.75	87.5	.01
tp10cc	3	0.3125	0.87321246	80.77716047	.01
tpcrack	2	0.25	0.774596669	72.59240285	.01
bolusres	3.67	1.541875	0.653413792	82.5693309	.01
ope_p	1	0.125	0.341565026	75.61737691	.01
ope_d	2	0.625	0.806225775	67.05477601	.01
cough	1	0.1875	0.403112887	[1]	[1]
CB	0	0	0	[1]	[1]
FP	3	0	0	[1]	[1]
CTP	2	1	2.75	54.77272727	NS
NT	5	0	0	[1]	[1]
OMP	0	0	0	[1]	[1]
TP	0	0	0	[1]	[1]

[1] no data available from normative sample

Normative data were not available for comparison purposes on observational swallowing findings. For this reason, standard deviations away from the mean was used to describe findings. Standard deviation data are listed in Table 3.5. Subject 1 was found to exhibit coughing, forward posture and neck tension during swallowing trials with frequency more than two standard deviations above the norm.

Table 3.5, *Observational Data Standard Deviations for Subject 1, a 12-year-old Female.*

	Normative Mean	**Std Dev**	**Observed Score**	**1 SD**	**2 SD**
cough	0.19	0.40	1		above
CB	0.00	0.00	0		
FP	0.00	0.00	3		above
CTP	0.69	2.75	2		
NT	0.00	0.00	5		above
OMP	0.00	0.00	0		
TP	0.00	0.00	0		

Subject 2

Subject 2 was a 12-year-old female whose participation in the study was conducted during one evaluation at the Idaho State University Speech, Language and Hearing clinic. The subject's mother was present for most of the session. All IOPI and EMG data, as well as consent and medical history forms, were collected during a single session. Table 3.6 lists the clinical and behaviors indicators of oromyofacial disorder found during assessment and data collection.

The subject's mother identified her as having tongue thrust and referred her to the researcher upon hearing about the study. The subject reported that she frequently uses liquids to wash down food, particularly dry food. She also indicated that it is difficult for her to swallow pills.

Orofacial examination revealed a high palate with abnormally defined rugae and a slight central open bite. The subject has worn braces for two years and treatment is still ongoing to repair her open bite. She reported herself to be a mouth breather with habitual open-lip posture, both were observed by the researcher during assessment. Only seasonal allergies were reported and the subject's tonsils had been removed two years prior.

The Stone Tongue Thrust Protocol swallowing trials revealed significant tongue protrusion across all presentations and swallows of bolus consistencies. The subject reported that her back teeth were open during all trials. Both excessive and rotational chewing was observed during soft and regular solid trials. Liquid boluses resulted in audible swallows during all trials.

Table 3.6, *Indicators of OMD for Subject 2, a 12-year-old Female.*

OMD Indicators	**Results**
Use liquid to wash foods down	Yes, especially when swallowing dry foods.
Difficulty swallowing pills	Yes.
Open bite	Slight central open bite.
Palatal structure	High with sharply defined rugae.
Orthodontic treatment	Subject was fitted with braces two years ago. Treatment is ongoing.
Lip rest posture	Lips open.
Mouth breather	Yes.
Allergies	Subject reported seasonal allergies.
Tonsils	Removed March 2014.
Tongue protrusion	Noted across saliva swallows and food and liquid trials.
Tongue protrudes to presentations of foods and liquids	Noted across all liquid and food presentations.
Back teeth apart	Reported back teeth were apart across trials.
Audible swallow	Was noted on liquid trials.
Rotational chew	Observed during soft and regular solid trials.
Excessive chewing	Observed during soft and regular solid bolus trials.

Normative findings and objective data obtained via the IOPI and EMG as well as observational data collected by the researcher is reported below in Table 3.7.

Observational findings of interest to the researcher included specific tongue protrusion trials, post-swallow residue, and the incidence of cough, clavicular breathing, forward posture, chin-tuck posture, neck tension, open mouth posture, and incidental tongue protrusion. As can be seen in the table below, all of this participant's oropharyngeal transit times, tongue protrusion trials, and bolus residue trials differed significantly from the age-equivalent normative data. Another measure of note is the IOPI tongue dorsum strength measure; the participant's *T*-score was found to be significantly different from the normative data.

Table 3.7, *Instrumental and Observational Data for Subject 2, a 12-year-old Female.*

Subject 2	**Observed Score**	**Norm Group Mean**	**Norm Group SD**	***T*-score**	***p*-value**
iopitipavg	33	42.64583333	14.16692219	43.19129928	NS
iopidorsavg	54	38.91666667	12.23325314	62.3297811	.01
iopilipsavg	6	17.25	5.050805708	27.72632596	NS
mcbARMSav	32.61	287.42	192.8563742	36.78741493	NS
mcbBRMSav	25.84	248.09	160.6135753	36.16251773	NS
mcpud1ARMS	14.51	123.83	109.3699217	40.00456448	NS
mcpud1BRMS	15.07	112.460625	87.2395105	38.83640859	NS
mcpud2ARMS	20.02	164.2475	235.78213	43.88301819	NS
mcpud2BRMS	18.67	168.914375	262.5018011	44.27644403	NS
mc10ccARMS	23.37	128.0475	119.5880463	41.24682581	NS
mc10ccBRMS	12.36	132.24125	135.6133107	41.16006759	NS
mccrackARMS	18.38	175.928125	122.5282034	37.14188892	NS
mccrackBRMS	17.77	128.753125	95.22737287	38.34545975	NS
stcpud1avg	2.41	0.982291667	0.146523393	147.438935	.01
stcpud2avg	1.94	0.9925	0.093159666	151.7071055	.01
stc10ccavg	1.94	0.826041667	0.108328491	152.8315191	.01
stccrackavg	2.02	1.027291667	0.088070078	162.7180031	.01
tppud1	3	0	0.75	87.5	.01
tp10cc	3	0.3125	0.87321246	80.77716047	.01
tpcrack	3	0.25	0.774596669	85.50234734	.01
bolusres	3.67	1.541875	0.653413792	82.5693309	.01
ope_p	1	0.125	0.341565026	75.61737691	.01
ope_d	1	0.625	0.806225775	54.65130255	NS
cough	2	0.1875	0.403112887	[1]	[1]
CB	0	0	0	[1]	[1]
FP	1	0	0	[1]	[1]
CTP	2	1	2.75	54.77272727	NS
NT	5	0	0	[1]	[1]
OMP	3	0	0	[1]	[1]
TP	0	0	0	[1]	[1]

[1] no data available from normative sample

Although there were no normative data available the frequency of cough, forward posture, neck tension, and open mouth posture during swallowing trials were noted to occur more than two standard deviations above the mean. Specific standard deviation data is shown below in Table 3.8.

Table 3.8, *Observational Data Standard Deviations for Subject 2, a 12-year-old Female.*

	Normative Mean	**Std Dev**	**Observed Score**	**1 SD**	**2 SD**
cough	0.19	0.40	2		above
CB	0.00	0.00	0		
FP	0.00	0.00	1		above
CTP	0.69	2.75	2		
NT	0.00	0.00	5		above
OMP	0.00	0.00	3		above
TP	0.00	0.00	0		

Subject 3

Subject 3 was a 27-year-old female who was referred to the researcher by her husband, a student in the same Speech-Language Pathology graduate program. EMG and IOPI data were collected by another researcher and then shared along with video of all data collection, so repeat EMG measures were not performed. Additional measures were collected during one session at the Idaho State University Speech, Language and Hearing Clinic. The session consisted of explaining the study to the participant, collecting consent and medical history, and administering the STTP to confirm the presence of tongue thrust. Clinical and behavioral indicators are listed in Table 3.9.

The subject reported difficulty swallowing pills, gargling, and eating meals without using liquids to wash down boluses. She stated that she is currently a fast eater and feels she used to be a messy eater but that her husband still considers her one. When asked about her tongue's resting position she consistently reported it to be pressed against her upper teeth. The subject has completed two years of orthodontic treatment.

Orofacial examination revealed an abnormally high and narrow palate, ankyloglossia, open lip resting posture, and habitual mouth breathing.

The liquid and food trials of the Stone Tongue Thrust Protocol confirmed the presence of tongue thrust. The subject was observed to protrude her tongue to the presentation of food or liquid across all trials, require excessive chewing time before swallowing solid boluses, and suck in her lips to prevent the anterior spillage of liquids. Rotational chew was observed during all solid trials. The subject reported lateralization of all solid boluses and open back teeth during liquid and regular solid trials. All swallows were audible to the researcher and the subject was observed to require multiple swallows for all solid trials. Frequent cleaning with the tongue of the buccal pockets and lips was also noted. During the assessment the subject reported that her normal swallowing pattern consist of multiple swallows which she termed “little, big, little.”

Table 3.9, *Indicators of OMD for Subject 3, a 27-year-old Female.*

OMD Indicators	**Results**
Use liquid to wash foods down	Yes.
Rate of eating	Subject reported that she is a fast eater.
Difficulty swallowing pills	Yes.
Messy eater	Subject stated that she feels she used to be but that her husband tells her she still is.
Orthodontic treatment	Completed two years of braces.
Ankyloglossia	Yes.
Tongue rest posture	Reported to be pressed against upper teeth.
Palatal vault	Abnormally high and narrow.
Gargling	Experiences difficulty.
Lip rest posture	Reported lips apart. Researcher observation corroborated.
Mouth breather	Yes.
Tongue protrusion	Noted across saliva swallows and food and liquid trials.
Tongue protrudes to presentations of foods and liquids	Noted across all liquid and food presentations.
Back teeth apart	Reported back teeth were apart across all liquid and regular solid trials.
Pursing lips	Was noted during liquid trials.
Audible swallow	Was noted across food and liquid trials.
Chewing behaviors	Subject was noted to lick her lips frequently to clean them while chewing. Excessive chewing was present during solid trials.
Multiple swallows	Observed during solid food trials. Subject reported a habitual “little, big, little” pattern of swallowing.
Rotational chew	Observed during solid food trials.
Labial leakage	Observed during cup liquid trials.

Objective and observational data obtained for Subject 3 is listed below in Table 3.10. Objective data were collected through the use of IOPI and EMG and is compared in the table with the normative data reported by Holzer et al. (2011). Observational data consists of specific tongue protrusion trials, post-swallow residue, and the incidence of cough, clavicular breathing, forward posture, chin-tuck posture, neck tension, open mouth posture, and incidental tongue protrusion. As can be seen in Table 3.10, data for Subject 3 were significant in the areas of right masseter contraction during Triscuit cracker bolus trials, all oropharyngeal transit time trials, all tongue protrusion trials, and bolus residue measures.

Table 3.10, *Instrumental and Observational Data for Subject 3, a 27-year-old Female.*

Subject 3	**Observed Score**	**Norm Group Mean**	**Norm Group SD**	***T*-score**	***p*-value**
iopitipavg	28	38.18181818	12.61245915	41.9271745	NS
iopidorsavg	36.33	37.07575758	13.55934036	49.45000453	NS
iopilipsavg	3	20.33333333	12.77778521	36.4347905	NS
mcbARMSav	57.71	282.93	233.7016577	40.3630337	NS
mcbBRMSav	42.84	470.66	306.952717	36.06234849	NS
mcpud1ARMS	12.19	42.73954545	33.42872638	40.86128945	NS
mcpud1BRMS	15.37	85.42666667	104.398368	43.28948641	NS
mcpud2ARMS	17.45	68.44181818	88.15941225	44.21595302	NS
mcpud2BRMS	21.04	136.7386364	171.5103234	43.25412989	NS
mc10ccARMS	13.08	29.44909091	29.20665073	44.39542347	NS
mc10ccBRMS	28.03	100.1609091	142.825321	44.9497114	NS
mccrackARMS	187.51	125.0380952	121.9163393	55.12416179	.05
mccrackBRMS	110.29	159.864	149.0812532	46.67469927	NS
stcpud1avg	2.33	1.151136364	0.614837937	69.17356697	.01
stcpud2avg	2.36	1.292863636	1.335218391	57.99222338	.05
stc10ccavg	1.52	0.910878788	0.424957573	64.33369472	.01
stccrackavg	1.79	1.03630303	0.549417537	63.71810907	.01
tppud1	3	0	0.646334989	91.49269695	.01
tp10cc	2	0.909090909	1.108799905	59.83864704	.05
tpcrack	3	0.409090909	0.796366206	82.53414159	.01
bolusres	3.67	1.499090909	0.614986714	85.30009743	.01
ope_p	1	0.181818182	0.394771017	70.72547839	.01
ope_d	1	0.636363636	1.176979773	53.0895719	NS
cough	0	[1]	[1]	[1]	[1]
CB	0	[1]	[1]	[1]	[1]
FP	0	[1]	[1]	[1]	[1]
CTP	0	[1]	[1]	[1]	[1]
NT	3	[1]	[1]	[1]	[1]
OMP	7	[1]	[1]	[1]	[1]
TP	2	[1]	[1]	[1]	[1]

[1] no data available from normative sample

Neck tension, open mouth posture, and tongue protrusion were all observed in this client at rates more than two standard deviations greater than the normative mean as can be seen in table 3.11.

Table 3.11, *Observational Data Standard Deviations for Subject 3, a 27-year-old Female.*

	Normative Mean	**Std Dev**	**Observed Score**	**1 SD**	**2 SD**
cough	0.05	0.21	0		
CB	0.05	0.21	0		
FP	0.05	0.21	0		
CTP	0.09	0.43	0		
NT	0.00	0.00	3		above
OMP	0.09	0.29	7		above
TP	0.09	0.29	2		above

Subject 4

Subject 4 was a 21-year-old female whose participation in the study consisted of one session held in the Idaho State University Speech, Language, and Hearing Clinic. All IOPI and EMG data, as well as consent and medical history forms, were collected during this session. Table 3.12 lists the clinical and behaviors indicators of oromyofacial disorder found during assessment and data collection.

This subject was self-identified with tongue thrust and reported that her tongue is habitually pressed against her lower teeth. Noxious oral habits observed by the researcher included habitual open-lip and open-mouth posture and lip licking. The subject reported pacifier use until 1½ years of age.

During the oromyofunctional examination the researcher noted a central open bite and class II malocclusion as well as the presence of an abnormally high palate and bifurcated uvula. The upper canines and lower incisors were noted to protrude forward slightly. The subject reported the following behavioral indicators of tongue thrust: messy eating habits, hyperactive gag reflex and difficulty gargling liquids.

The observed swallow portion of the Stone Tongue Thrust protocol was used to gather additional information about habitual swallowing patterns. The subject's tongue was observed to protrude to the presentation of water, peaches, and Triscuits. A rotational chewing pattern was consistently observed during solid bolus trials. The participant was observed to take large bites of solid food trials and required excessive time to chew regular solid boluses. Tongue protrusion and poor labial seal resulting in slight frontal leakage was observed during water and saliva trials. The researcher noted that liquid trials resulted in clearly audible swallows. The subject consistently raised her chin before the initiation of the swallow to aid in bolus transfer to the back of the throat and prevent anterior spillage. Habitual lip licking was noted, particularly when spillage or residue was evident. When asked by the researcher, Subject 4 reported that observed swallow trials were representative of how she normally eats.

When asked about her back teeth during trials, the subject reported that they were apart for all consistencies. She also reported lateralization of the bolus during soft and regular solids.

Table 3.12, *Indicators of OMD for Subject 4, a 21-year-old Female.*

OMD Indicators	Results
Use liquid to wash foods down	Yes.
Rate of eating	Subject reported that she is a slow eater.
Noxious oral habits	Reported to have used a pacifier until 1½ years of age.
Open bite	Yes, central.
Malocclusion	Class II.
Protruding teeth	Yes, the upper canines and lower incisors.
Tongue rest posture	Reported to be habitually pressed against the lower teeth.
Messy eater	Reported that she used to be but has gotten better.
Orofacial Examination	High palate is present. Bifurcated uvula.
Gag reflex	Subject reported that she gags every time she brushes her teeth.
Lip rest posture	Lips open.
Gargling	Experiences difficulty. Reported that liquids come out her nose frequently.
Allergies	Allergic to scented laundry detergent and grass. Also reported a recent allergic reaction, which left irritated patches on her neck. Due to the skin irritation the researcher did not use skin prepping gel during evaluation.
Speech	No audible frontal lisping or interdental productions of speech sounds noted. Researcher did note the tongue was visibly forward during speech.
Tongue protrudes to presentations of foods and liquids	Noted across liquid and food presentations.
Tongue protrusion	Noted on liquid and food presentations.
Open lips	Was noted across food and liquid trials; subject tilted her head back while swallowing to compensate.
Audible swallow	Was noted on liquid trials.
Post-swallow behaviors	Subject was note to clean her teeth and lips.
Back teeth apart	Reported during all trials.
Rotational chew	Observed during solid food trials.

Table 3.13 lists objective data obtained via the IOPI and EMG as well as the comparative norms (Holzer et al., 2011). Observational data collected during EMG trials is also recorded and consists of specific tongue protrusion trials, post-swallow residue, and the incidence of cough, clavicular breathing, forward posture, chin-tuck posture, neck tension, open mouth posture, and incidental tongue protrusion.

Statistically significant differences were found between Subject 4 and the normative data in the following areas: average left masseter contraction baseline, left masseter swallowing trials of water, left and right masseter contraction of Triscuit cracker, pharyngeal transit time of all bolus consistencies, bolus residue trials, and rates of tongue protrusion.

Table 3.13, *Instrumental and Observational Data for Subject 4, a 21-year-old Female.*

Subject 4	**Observed Score**	**Norm Group Mean**	**Norm Group SD**	***T*-score**	***p*-value**
iopitipavg	23.67	37.18	15.75	41.42222222	NS
iopidorsavg	38.33	33.75	10.6	54.32075472	NS
iopilipsavg	4.33	23.33	13.66	36.09077599	NS
mcbARMSav	195.39	152.86	107.29	53.96402274	NS
mcbBRMSav	241.70	168.38	108.95	56.72969252	.05
mcpud1ARMS	24.55	29.12	15.85	47.11671924	NS
mcpud1BRMS	52.52	55.92	77.29	49.56009833	NS
mcpud2ARMS	28.66	44.66	36.30	45.5922865	NS
mcpud2BRMS	86.49	49.62	82.78	54.45397439	NS
mc10ccARMS	24.32	22.44	8.73	52.1534937	NS
mc10ccBRMS	70.60	30.73	30.06	63.26347305	.01
mccrackARMS	179.91	108.9	79.56	58.92533937	.05
mccrackBRMS	243.05	151.99	140.59	56.47698983	.05
stcpud1avg	2.43	1.39	0.48	71.66666667	.01
stcpud2avg	1.78	1.32	0.37	62.43243243	.01
stc10ccavg	1.80	1.03	0.2	88.5	.01
stccrackavg	1.60	1.2	0.28	64.28571429	.01
tppud1	3	0.2	0.7	90	.01
tp10cc	3	1	1.3	65.38461538	.01
tpcrack	3	0.35	0.81	82.71604938	.01
bolusres	5	1.27	.55	117.8181818	.01
ope_p	1	0.2	0.41	69.51219512	.01
ope_d	2	0.7	1.53	58.49673203	.05
cough	0	[1]	[1]	[1]	[1]
CB	0	[1]	[1]	[1]	[1]
FP	0	[1]	[1]	[1]	[1]
CTP	0	[1]	[1]	[1]	[1]
NT	7	[1]	[1]	[1]	[1]
OMP	4	[1]	[1]	[1]	[1]
TP	1	[1]	[1]	[1]	[1]

[1] no data available from normative sample

Observational data of note for this subject included the occurrence of neck tension, open mouth posture, and tongue protrusions, which all occurred during swallowing trials with a frequency greater than two standard deviations above the norm. Standard deviation data is listed below in Table 3.14.

Table 3.14, *Observational Data Standard Deviations for Subject 4, a 21-year-old Female.*

	Normative Mean	**Std Dev**	**Observed Score**	**1 SD**	**2 SD**
cough	0	0	0		
CB	0	0	0		
FP	0	0	0		
CTP	0.05	0.22	0		
NT	0	0	7		Above
OMP	0	0	4		Above
TP	0	0	1		Above

Group Results

Data for the group were examined to determine overall trends in comparison to the normative data (Holzer et al., 2013). Figures 3.3, 3.4, 3.5 and 3.6 show average oropharyngeal transit times graphed for both the normative sample and the participant data gathered during this study. The participants are sorted by age (from youngest to oldest) along the horizontal axis so trends according to age are easily seen.

Figure 3.3, *Oropharyngeal Transit Time- ½ tsp. Pudding.*

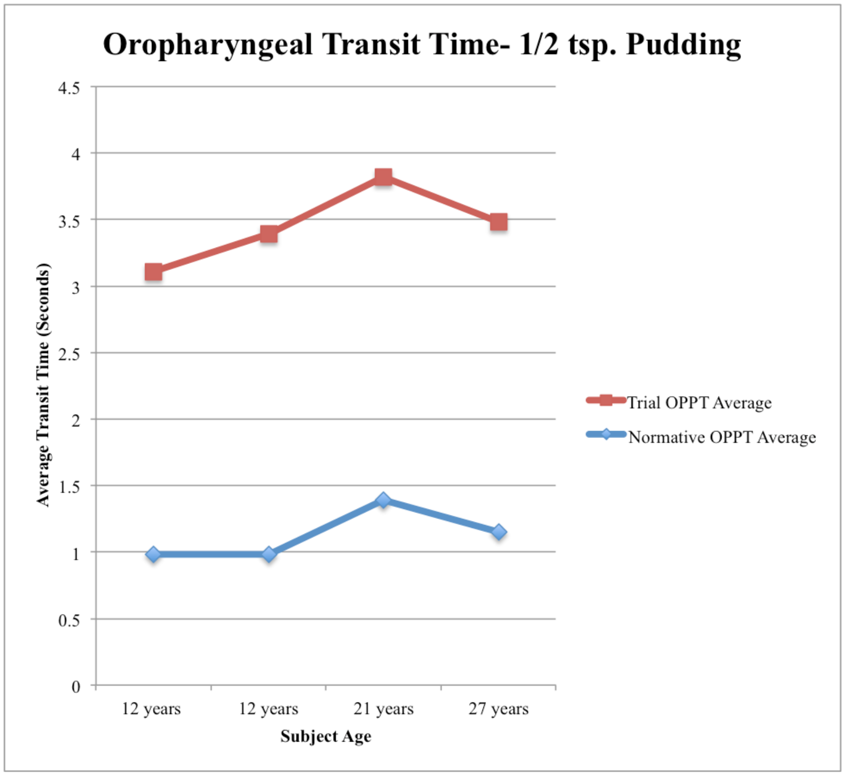


Figure 3.4, *Oropharyngeal Transit Time- 1½ tsp. Pudding.*

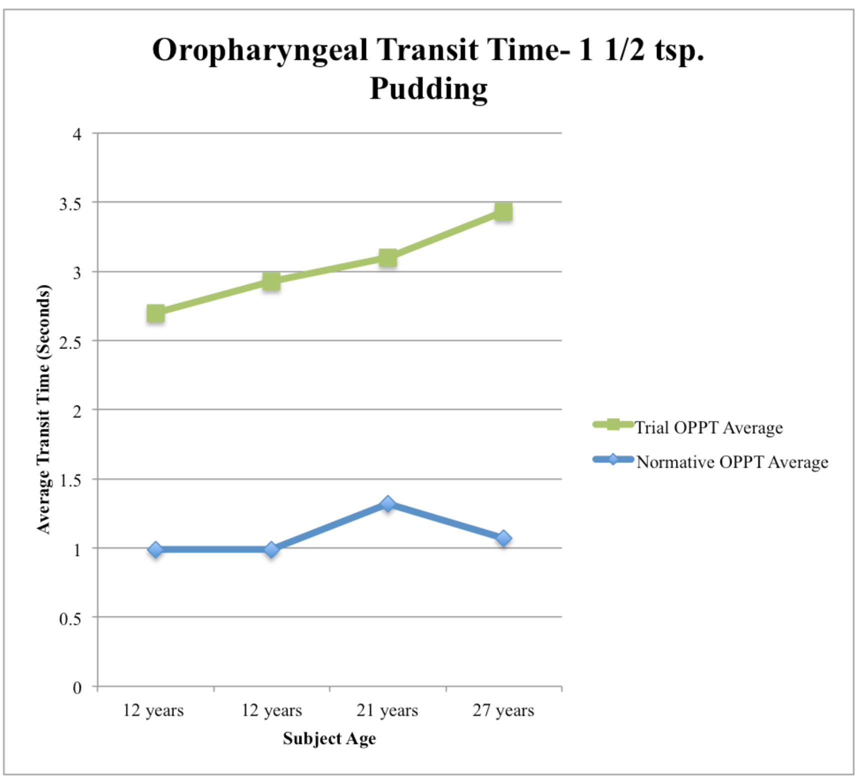


Figure 3.5, *Oropharyngeal Transit Time- Water.*

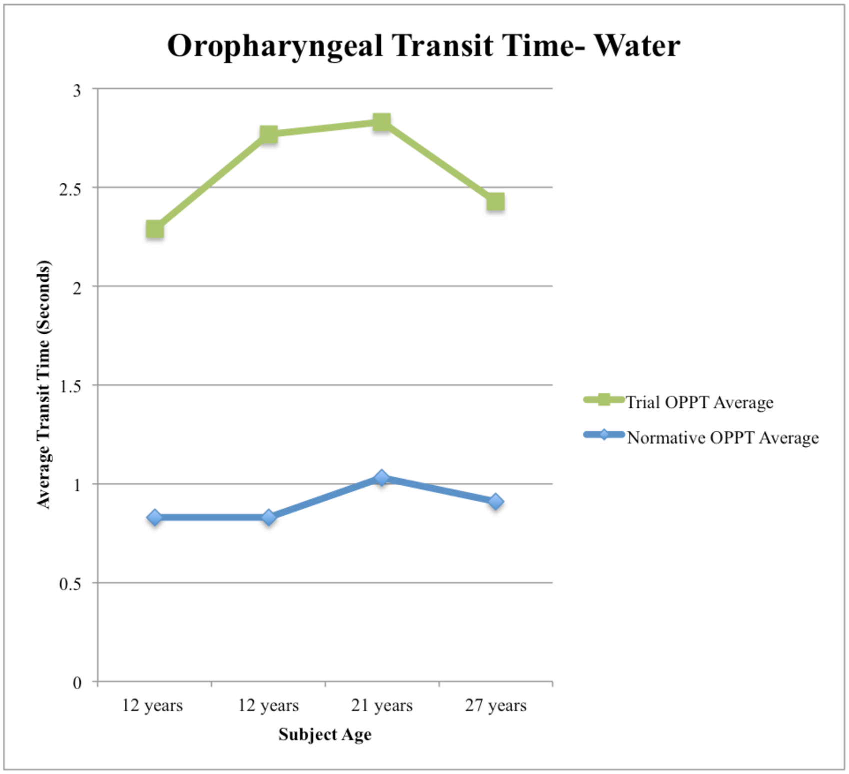
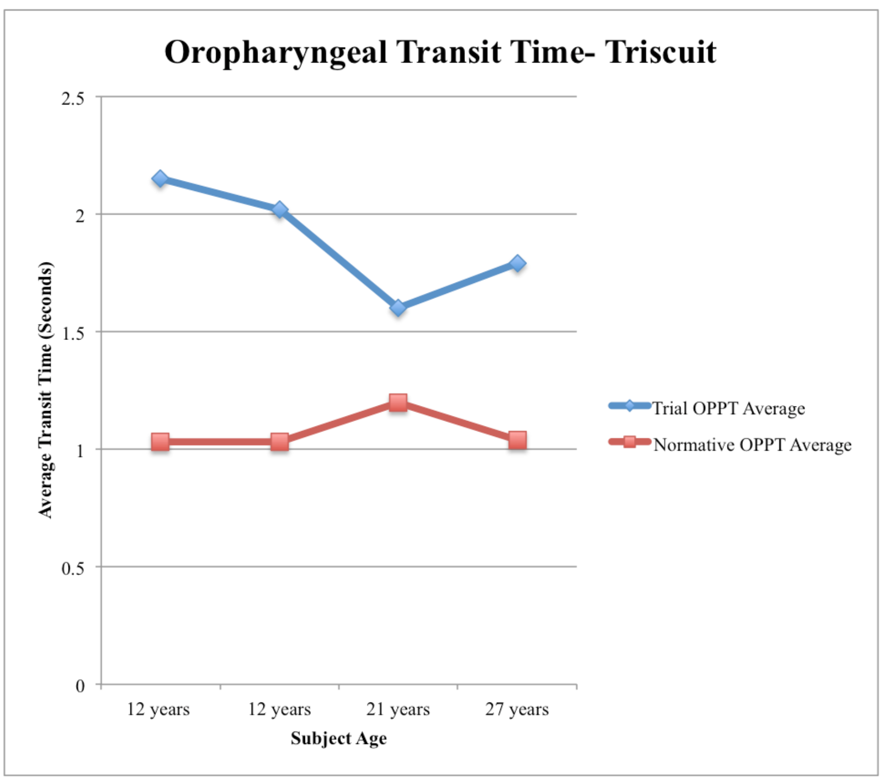


Figure 3.6, *Oropharyngeal Transit Time- Triscuit.*



These figures clearly indicate that oropharyngeal transit times of participants diagnosed with tongue thrust in the present study all show prolonged oropharyngeal transit times relative to the normative data. The data also show similar trends based on subject age.

Reliability

Inter-judge reliability: inter-judge reliability was ensured through the use of consensus coding. The researcher, and a colleague trained in the tests, examined all subjects' oropharyngeal transit time data, including all EMG oropharyngeal transit time graphs, together. Both researchers came to a consensus for each trial of oropharyngeal transit time.

Intra-judge reliability: to safeguard intra-judge reliability the researcher re-measured all EMG oropharyngeal transit time graphs for 30% of trials.

Summary

All raw scores obtained during the study were compared with normative data. Statistical, descriptive and graphic comparisons were utilized to determine significance. *T*-scores and p-values were used to determine if statistically significant differences were present for objective and some subjective data measures. For observational findings where norms were unavailable the method of comparison was the number of standard deviations away from the norm; if the data were greater than one standard deviation from the norm the data was considered to be significant and was reported.

Chapter 4: Discussion

Research Findings

This study protocol was developed to determine whether or not individuals with tongue thrust consistently exhibit diagnostic indicators of oropharyngeal dysphagia. In the interest of increasing the basis of support for the research, this replication study included four more participants. All participants were females between the ages of 12-27. All four subjects were diagnosed with tongue thrust prior to inclusion in the study. OMD and OPD measures were collected through the use of IOPI, EMG, observation and participant report. All collected data was compared to the norms developed by Holzer et al. in 2011. Inferential statistics, including *p*-values and *T*-scores, were calculated for IOPI measures, masseter contraction, oropharyngeal transit times, tongue protrusion, bolus residue, and orofacial examination findings. Observational data taken during swallowing trials such as the frequency of cough, forward posture, clavicular breathing, neck tension, and tongue protrusion were examined to determine degree of variation from the mean. Data are examined as to the degree (one or two standard deviations) that they deviate from the norms. Findings from these comparisons will be reported below. Research hypotheses for this study are as follows:

H_{0a}: No significant difference exists in masseter contraction as measured by EMG between individuals diagnosed with tongue thrust and normative data.

H_{1a}: A significant difference exists in masseter contraction as measured by EMG between individuals diagnosed with tongue thrust and normative data.

H_{0b}: No significant difference exists in force, as measured by IOPI, based on location or between individuals diagnosed with tongue thrust and normative data.

H_{1b}: A significant difference exists in force, as measured by IOPI, based on location or between individuals diagnosed with tongue thrust and data.

H_{0c}: No significant difference exists in oropharyngeal transit time based on bolus type, and/or measurement type between individuals in the experimental and normative data.

H_{1c}: A significant difference exists in oropharyngeal transit time based on bolus type, and/or measurement type between individuals diagnosed with tongue thrust and normative data.

Question 1: Are there significant differences between masseter contraction, as measured by EMG, between individuals diagnosed with tongue thrust and the normative data?

Masseter contraction data are considered a variable for oromyofunctional disorder and were collected through the use of an EMG system. Specifically, the researcher collected baselines before proceeding with swallowing trials for ½ t. pudding, 1½ t. pudding, 10cc water, and Triscuit cracker. Subjective evaluation of the subject's masseter contraction strength during assessment did not reveal any subject to have a weakened masseter.

Statistical significance was determined through the use of *T*-scores and *p*-values. Table 4.1 shows the spread of participant performance in terms of *p*-value findings. In the case of masseter contraction only two participants, Subject 3 and Subject 4, were significantly below the normative data. Due to the inconsistent nature of the findings the researcher fails to reject the null hypothesis.

Table 4.1, *Masseter Contraction Findings. Number in table denotes subject number.*

Measure	***p*-value of .05**	***p*-value of .01**
mcbBRMSav	4	
mc10ccBRMS		4
mccrackARMS	3, 4	
mccrackBRMS	4	

Question 2: Are there significant differences in force, as measured by the IOPI, based on location or between individuals diagnosed with tongue thrust and the normative data?

The Iowa Oral Performance Instrument (IOPI) was used to measure tongue tip strength, tongue dorsum strength, and lip strength among all participants. Subjective clinical findings did not reveal any of the subjects to have weakened tongue strength. However, subjective findings in this area are not considered to be accurate grounds for diagnosis.

Statistically significant differences from the normative data were not found for tongue tip or lip strength. One subject, Subject 2, was found to have significantly increased tongue dorsum strength (*T*-score: 62.33; *p*-value: .01) when compared to the normative data. Due to the inconsistent nature of the findings the researcher fails to reject the null hypothesis.

Question 3: Are there significant differences in oropharyngeal transit time based on bolus type between individuals diagnosed with tongue thrust and the normative data?

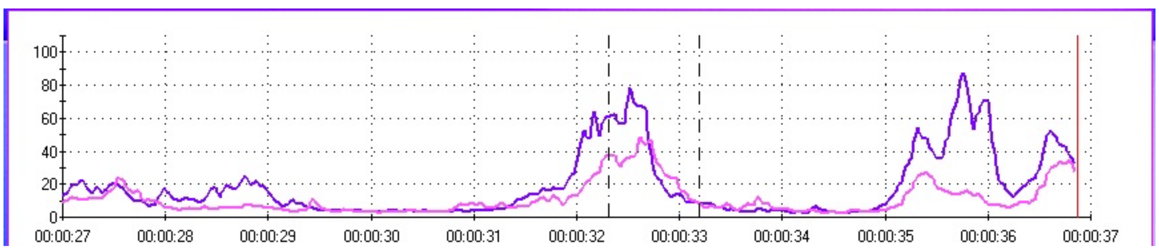
Increased oropharyngeal transit time is associated with oropharyngeal dysphagia. This is the variable that correlates OPD with OMD and is central to this study. This study found that all participants had a statistically significantly increased transit time across all bolus types. *p*-value findings across specific bolus types are listed below in Table 4.2. Based on these findings, the null hypothesis is rejected.

Table 4.2, *Oropharyngeal Transit Time Standard Deviation Findings. Number in table denotes subject number.*

Measure	***p*-value of .05**	***p*-value of .01**
stcpud1avg		1, 2, 3, 4
stcpud2avg	3	1, 2, 4
stc10ccavg		1, 2, 3, 4
stccrackavg		1, 2, 3, 4

Increased oropharyngeal transit time was evident across all subjects. Figure 4.2 shows a typically EMG reading for Subject 1.

Figure 4.1, *Typical Oropharyngeal Transit Time for Subject 1: Third Trial of 1 ½ t. Pudding*



Additional Findings

Several observational measures were included in the protocol for this study. The researcher carefully noted tongue protrusion trials, the amount of bolus residue, palatal structure, and post-swallow behaviors. These observational findings were also compared to the norms developed by Holzer et al. (2011).

Statistical significance as determined by *T*-scores and *p*-values was present in all subjects for tongue protrusion, bolus residue and palate structure findings. Post-swallow behaviors could not be compared using inferential statistics. For this reason standard deviation findings in comparison to these norms are reported below in Table 4.3.

Table 4.3, *Observational Data Standard Deviation Findings. Number in table denotes subject number.*

Measure	**Within 1 SD**	**Within 2 SD**
cough		1, 2
FP		1, 2
NT		1, 2, 3, 4
OMP		2, 3, 4
TP		3, 4

Tongue protrusion trials were performed as part of the oropharyngeal transit time section of the protocol. The researcher tested ½ t. pudding, 10cc water, and a subject-determined bite of Triscuit cracker while pulling down on the bottom lip to better determine the presence or absence of tongue protrusion. Findings for all four of the subjects revealed a *p*-value of .01 for tongue protrusion trials of pudding and Triscuit cracker boluses. While trials of water showed p-values of .01 for all subjects except for subject 3 who was found to have a p-value of .05. All participants had data with a *p*-value of .01 for bolus residue scores. Post-swallow behaviors, when present in the participants, were all more than two standard deviation above the mean; meaning that they occurred more often than approximately 95% of the individuals used in the norming sample.

Clinical Applications

This study further supports the importance of treating the underlying cause of tongue thrust. Currently in the field of speech-language pathology the consequences of orofacial myofunctional disorders are not considered to be dire, instead being taken as potential cosmetic or minor articulation concerns (American Speech-Language and Hearing Association, 2015; Hanson & Mason, 2003). When compared with justified concern given to oral pharyngeal dysphagia as a potentially life-threatening finding

(Logemann, 1998) orofacial myofunctional disorders such as tongue thrust are not considered priority by most speech-language pathologists.

The results of the present study, which further add to the body of research developed by Evers (2013) and Evans (2015), suggest that individuals with tongue thrust are potentially more likely to develop oral pharyngeal dysphagia, as indicated by a significantly increased oropharyngeal transit time.

Due to the serious nature of this link between tongue thrust and oropharyngeal dysphagia, it is our hope as researchers that screening and treatment of tongue thrust and other orofacial myofunctional disorders will be given more weight by the medical community involved with affected individuals.

Limitations

This study was designed to add additional research support to the work of Evers (2013) and Evans (2015). Although the overall number of subjects was increased by four, the diversity of the subjects is still of concern. All four subjects in this study were female and identified themselves as being of European American decent. For this reason, application of this study is limited to population subgroups.

Another limitation of this study is the variability between subjects in severity of indications of tongue thrust. The Stone Tongue Thrust Protocol used to qualify participants for the study does not provide a rating of severity, only a positive or negative identification. Some subjects subjectively appeared to display tongue thrust indicators to a greater degree; however, there are no current severity ratings for tongue thrust approved for clinical use. It is possible that the differing degrees of severity observed by the researcher affected results.

Another significant limitation in the diagnosis of tongue thrust among participants is that the underlying cause was not determined or reported as part of assessment. There is the potential that if the underlying cause was treated or corrected that that individual would no longer display indications of tongue thrust. Future studies are required to determine the effect of tongue thrust treatment on improving oropharyngeal transit time, lip strength and masseter contraction.

Implications for Further Research

As discussed above, additional research to confirm the link between oropharyngeal dysphagia and orofacial myofunctional disorders is needed. Although the data collected in this study supports previous research in this area, the addition of subjects of varied ages and demographic backgrounds would allow the results to be more widely interpreted and could provide valuable information about the progression of oropharyngeal dysphagia indicators in individuals with tongue thrust.

The importance of additional treatment studies to examine areas of limitation within this study cannot be overstated. Tongue thrust is generally a sign that something else is occurring and necessitating an adapted swallowing pattern. By taking the underlying cause of tongue thrust into account and assessing individuals both pre and post treatment, researchers would be able to determine if the link and probably oropharyngeal dysphagia can be mitigated.

Conclusions

The present study replicated past studies by Evers (2013) and Evans (2015) in order to provide further support for a hypothesized relationship between tongue thrust, a form of OPD, and oropharyngeal dysphagia. This study included four participants from

12-27 years of age who were all identified as having tongue thrust. Objective data was collected using EMG and IOPI systems and subjective data was gathered through clinical observation. Specifically, the following measures were collected for each subject: tongue dorsum strength, tongue tip strength, lip strength, masseter contraction, and oropharyngeal transit time. Findings were analyzed and reported using both inferential statistical analysis and in terms of distance from the normative mean in standard deviations when statistical comparisons were unavailable to determine if significant differences were present.

Differences of statistical significance were shown in the areas of masseter contraction, IOPI tongue dorsum strength, oropharyngeal transit time, and observational findings. The findings from this study should be taken into account by professionals working with individuals identified as having an oromyofunctional disorder, given the evidence supporting the relationship between OMD and OPD.

References

American Speech-Language and Hearing Association. (2015). *Orofacial Myofunctional Disorders (OMD).* Retrieved from http://www.asha.org/public/speech/disorders/OMD/

American Speech-Language-Hearing Association. (2004). *Preferred practice patterns for the profession of speech-language pathology* [Preferred Practice Patterns]. Retrieved from www.asha.org/policy.

Andrianopoulos, M. V., & Hanson, M. L. (1987). Tongue-thrust and the stability of overjet correction. *The Angle Orthodontist*, *57*(2), 121-135.

Bosma, J. F., Hepburn, L. G., Josell, S. D., & Baker, K. (1990). Ultrasound demonstration of tongue motions during suckle feeding. *Developmental Medicine & Child Neurology*, *32*(3), 223-229.

Christensen, M. S., & Hanson, M. L. (1981). An investigation of the efficacy of oral myofunctional therapy as a precursor to articulation therapy for pre-first grade children. *Journal of Speech and Hearing Disorders*, *46*(2), 160-167.

Clark, H. M., Henson, P. A., Barber, W. D., Stierwalt, J. A., & Sherrill, M. (2003). Relationships among subjective and objective measures of tongue strength and oral phase swallowing impairments. *American Journal of Speech-Language Pathology*, *12*(1), 40-50.

Costa, M. M. B., & Lemme, E. M. D. O. (2010). Coordination of respiration and swallowing: Functional pattern and relevance of vocal folds closure. *Arquivos de gastroenterologia*, *47*(1), 42-48. http://dx.doi.org/10.1590/S0004-28032010000100008

Dantas, R. O., Kern, M. K., Massey, B. T., Dodds, W. J., Kahrilas, P. J., Brasseur, J. G., & Lang, I. M. (1990). Effect of swallowed bolus variables on oral and pharyngeal phases of swallowing. *American Journal of Physiology-Gastrointestinal and Liver Physiology*, *258*(5), 675-681.

Evers, D.L. (2013). *Comparison of Individuals with Oromyofunctional Disorders on Oropharyngeal Measures Ages 7-51* (Master's thesis). Idaho State University, Pocatello/Meridian, ID.

Evans, L. (2015). Instrumental Investigation of the Effects of Tongue Thrust on Swallow Function (Master's thesis). Idaho State University, Pocatello/Meridian, ID

Green, J. R., Moore, C. A., Ruark, J. L., Rodda, P. R., Morvée, W. T., & Vanwitzenburg, M. J. (1997). Development of chewing in children from 12 to 48 months: Longitudinal study of EMG patterns. *Journal of Neurophysiology*, *77*(5), 2704-2716.

Hanson, M. L., Mason, R. M. (2003). *Orofacial myology: International perspectives*. Springfield; IL: Charles C. Thomas Publisher, Ltd.

Holzer, K., Fish, R., Lomen, H., Calley, K., Devine, N., Eakman, A., Loftin, J., Seikel, J., Sorensen, D., Peterson, T. (2011). Lifespan indicators of oromyofunctional disorder and oropharyngeal dysphagia: Preliminary Results. Poster presented at the Annual Convention of the American Speech-Language Hearing Association, San Diego, CA.

Horn, O. D. H., Kühnast, K., Axmann-Krcmar, D., & Göz, G. (2004). Influence of orofacial dysfunctions on spatial and temporal dimensions of swallowing movements. *Journal of Orofacial Orthopedics/Fortschritte der Kieferorthopädie*, *65*(5), 376-388.

Kendall, K. A. (2002). Oropharyngeal swallowing variability. *The Laryngoscope*, *112*(3), 547-551.

Kim, Y., McCullough, G. H., & Asp, C. W. (2005). Temporal measurements of pharyngeal swallowing in normal populations. *Dysphagia*, *20*(4), 290-296.

Knösel, M., Klein, S., Bleckmann, A., & Engelke, W. (2012). Coordination of tongue activity during swallowing in mouth-breathing children. *Dysphagia*, *27*(3), 401-407. doi: 10.1007/s00455-011-9383-8

Kummer, A. (2014). *Oropharyngeal abnormalities: Effects on speech and resonance* [PDF document]. Retrieved from Cincinnati Children's Hospital Medical Center online lecture series: http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CB4QFjAA&url=http%3A%2F%2Fwww.asha.org%2FEvents%2Fconvention%2Fhandouts%2F2010%2F1371-Kummer-Ann%2F&ei=GXIpVfOELsG5ggTAxYOYAQ&usg=AFQjCNEVp3F4cmjOsi1OCVbCEJ8swplDUg&sig2=Fab-7NN_TKCWdktPEcFBHg

Logemann, J. A. (1998). *Evaluation and treatment of swallowing disorders*. Austin, TX: Pro Ed.

Matsuo, K., & Palmer, J. B. (2008). Anatomy and physiology of feeding and swallowing: Normal and abnormal. *Physical Medicine and Rehabilitation Clinics of North America*, *19*(4), 691–707. doi:10.1016/j.pmr.2008.06.001

Moore, C. A. (1993). Symmetry of mandibular muscle activity as an index of coordinative strategy. *Journal of Speech, Language, and Hearing Research*, *36*(6), 1145-1157.

Nicosia, M. A., Hind, J. A., Roecker, E. B., Carnes, M., Doyle, J., Dengel, G. A., & Robbins, J. (2000). Age effects on the temporal evolution of isometric and swallowing pressure. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *55*(11), 634-640.

Reddy, N. P., Costarella, B. R., Grotz, R. C., & Canilang, E. P. (1990). Biomechanical measurements to characterize the oral phase of dysphagia. *Biomedical Engineering, IEEE Transactions on*, *37*(4), 392-397.

Robin, D. A., & Luschei, E. S. (1992). *Reference manual for the Iowa Oral Performance Instrument.* Oakdale, IA: Breakthrough.

Robinovitch, S. N., Hershler, C., & Romilly, D. P. (1991). A tongue force measurement system for the assessment of oral-phase swallowing disorders. *Archives of Physical Medicine and Rehabilitation*, *72*(1), 38-42.

Seikel, J. A., King, D. W., Drumright, D. G. (2010). *Anatomy and physiology for speech, language, and hearing*. Clifton Park, NY: Delmar.

Shaw, D. W., Cook, I. J., Gabb, M., Holloway, R. H., Simula, M. E., Panagopoulos, V., & Dent, J. (1995). Influence of normal aging on oral-pharyngeal and upper esophageal sphincter function during swallowing. *American Journal of Physiology-Gastrointestinal and Liver Physiology*, *268*(3), G389-G396.

Stepp, C. E. (2012). Surface electromyography for speech and swallowing systems: Measurement, analysis, and interpretation. *Journal of Speech, Language, and Hearing Research*, *55*(4), 1232-1246. doi: 10.1044/1092-4388

Steeve, R. W., Moore, C. A., Green, J. R., Reilly, K. J., & McMurtrey, J. R. (2008). Babbling, chewing, and sucking: Oromandibular coordination at 9 months. *Journal of Speech, Language, and Hearing Research*, *51*(6), 1390-1404. doi: 1092-4388/08/5106-1390

Stone, C. R. (2015). *Treatment of tongue thrust* [PowerPoint File] Retrieved from a broadcast lecture at Idaho State University: http://elearning.isu.edu/moodle2/mod/resource/view.php?id=784555

Weinhardt, J., Hazelett, S., Barrett, D., Lada, R., Enos, T., & Keleman, R. (2008). Accuracy of a bedside dysphagia screening: A comparison of registered nurses and speech therapists. *Rehabilitation Nursing*, *33* (6), 247-252.

Appendix A: Stone Tongue Thrust Protocol (STTP) Oral Evaluation

Stone Tongue Thrust Protocol (STTP)

Oral Evaluation

Name: ____________________ **Parents:** ____________________

Date of Evaluation: ____________ **DOB:** __________ **Age:** ______

Orthodontist/Dentist: ________________________________

I. History	Yes	No
Does patient to use liquid to wash down food?		
Is it difficult to swallow dry foods without washing them down?		
Is patient a fast/slow eater? *(circle which)*		
Does patient resist foods that are hard to chew?		
Is it difficult for patient to swallow pills?		
Is the patient a messy eater?		
Did patient suck his/her thumb? (*If so, how long?* ____________________)		
Did patient use pacifier? (*if so, how long?* __________________)		
II. Oral/Motor Exam	**Yes**	**No**
Teeth:		
Is there an open bite?		
Is there protrusion of teeth?		
Is there an overbite?		
Is there a crossbite?		
Is there jumbled dentition?		
Are there any teeth missing?		
Has the person been, or is patient now, in an active orthodontic treatment program? *(Circle which)* Notes: ______________________________		
Tongue:		
Is the tongue large in relation to the oral cavity?		

Does patient have difficulty with tongue-tip elevation?		
Is there any weakness in the tip or back of the tongue? *(Circle which)*		
Is there weakness in the lateral borders of the tongue?		
When tongue is in resting position, is it pressed against the upper teeth, lower teeth, or between the teeth? *(Circle which)*		
Does the tongue rely on the mandible to move it?		
Does the patient have ankyloglossia (tongue tied)? If yes, has patient had surgery to fix it? ______________________		
Palate:		
Is the palatal vault high and/or narrow?		
Is mobility of the soft palate decreased?		
Does the patient have a normal gag reflex?		
Are the rugae sharply defined (bumps on the alveolar ridge)?		
Is it difficult for patient to gargle?		
What is patient's habitual resting oral posture? Lips open or Lips closed *(Circle which)*		
II. Oral/Motor Exam (Continued)	**Yes**	**No**
Lips (ROM/Strength/Coordination):		
Is the patient able to retract lips?		
Is the patient able to protrude lips?		
Is lip movement smooth, coordinated and symmetrical?		
Can the patient seal lips to hold air in oral cavity?		
Breathing:		
Is patient a mouth breather?		
Can patient breathe through his nose?		
Does the patient have allergies, sinus problems, etc.?		
Does the patient still have tonsils? If no, when was surgery performed? ____		
Are tonsils enlarged?		
Speech:		
When counting from 60-70, is there a frontal lisp?		
Is there interdental production of t, l, d, and/or n?		

Has the patient been enrolled in speech therapy? How long? __________ For what? ____						
III. Clinical Swallow Eval Oral Prep Phase	**Liquids**		**Solids**			**Saliva**
	Straw	**Cup**	**Puree**	**Soft**	**Reg.**	
+ = Yes - + No / = Inconsistent						
Oral Prep Phase:						
Tongue protrudes to presentation						
Large presentation/stuffing mouth						
Oral Phase:						
Rotational Chew						
Anterior munching						
Lateralization of bolus						
Excessive and/or /limited chewing (*Circle which*)						
Poor labial seal/anterior leakage/drooling						
Back teeth apart						
Does tongue protrude from mouth during swallow?						
Does patient suck lips in during swallow to keep liquid from escaping?						
Does patient burp during or after swallow?						
Is swallow audible?						
Does patient have history of GERD or complain of heartburn?						
Pharyngeal Phase:						
Timely swallow trigger (< / sec)						
Base of tongue movement/laryngeal elevation						
Multiple swallows						

IV. Comments / Impressions

V. Recommendations			
☐	Tongue Thrust Therapy	☐	Articulation Therapy
☐	ENT Referral	☐	Eliminate Oral Habits
☐	Orthodontic Referral		

Appendix B: Recruitment Materials

Do you have tongue thrust?!

What is tongue thrust?

Tongue thrust is the forward movement of the tongue during swallowing, eating, and/or speech. A typical swallow consists of the up and back movement of the tongue. But how do you know if you have it? As a quick screener, answer the following questions while swallowing food or liquid:

1. Did your tongue push forward against your teeth?
2. Was your tongue up in your palate? Or low in your mouth?
3. Did you need to make extra effort to close your lips when you swallowed?

Common causes include the following, which may be current or past conditions: malocclusions of the teeth, open mouth while breathing, tongue in the bottom of your mouth while at rest, allergies/airway obstruction, and current or past oral habits (sucking on objects-thumb, pens, etc).

If any of these apply to you, I would love to assess your swallow for tongue thrust. If you do have tongue thrust, you would qualify to be in my thesis study. I would really appreciate any and all participation in my study. If you're not sure, or you have questions, feel free to call or email me. Thank you!

Shelly Elliott ellishel@isu.edu; 435-938-8184

Appendix C: Medical History Form

Subject ID#______________

Medical History Form

1. Birth Date: ________________________

2. Circle One: MALE FEMALE

3. Ethnicity (check one):

☐ (1) European American (not Hispanic)

☐ (2) White Hispanic

☐ (3) Latino

☐ (4) Asian

☐ (5) African American

☐ (6) Native American

☐ (7) Other / Multi-racial

Health Status

4. Do you have or have you experienced any of the following? (check yes or no)

Heart & Blood

a. Heart & Blood Problems (including chest pain due to heart problems, irregular heart beat, high blood pressure, blood clots, anemia, hypertension, blood transfusion, high cholesterol, heart failure, or heart bypass surgery)

   ☐ Yes ☐ No

b. COPD (Chronic Obstructive Pulmonary Disorder)

☐ Yes ☐ No

c. Bleeding GI (stomach, throat, intestines)

☐ Yes ☐ No

Psychiatric

d. Psychiatric Treatment for depression or anxiety

☐ Yes ☐ No

Illness

e. Cancer (what kind ________________________?)

☐ Yes ☐ No

f. Rheumatologic Disease (Sjogren's, Lupus, Arthritis)

☐ Yes ☐ No

Neuromedical Risks/Condition

g. Head injury (describe and include point of impact)

____

____

☐ Yes ☐ No

h. Loss of consciousness (how long?) _______________________________

☐ Yes ☐ No

i. Seizures

☐ Yes ☐ No

j. Stroke/TIA

☐ Yes ☐ No

k. Sleep Apnea

☐ Yes ☐ No

l. Toxin/Chemical Exposure (what kind?) ____________________________________

☐ Yes ☐ No

m. Parkinson’s Disease (when diagnosed?)_____________________________________

☐ Yes ☐ No

n. Huntington’s Disease (when diagnosed?) ___________________________________

☐ Yes ☐ No

o. Brain Masses (location) ____

☐ Yes ☐ No

p. Multiple Sclerosis (when diagnosed?) ______________________________________

☐ Yes ☐ No

q. Cerebral Palsy

☐ Yes ☐ No

r. Dementia /Alzheimer's (when diagnosed?) __________________________________

☐ Yes ☐ No

s. Oral Apraxia (when diagnosed?) ____

☐ Yes ☐ No

t. Spinal Injury (describe) ____

☐ Yes ☐ No

u. Brain Surgery (describe) ____

☐ Yes ☐ No

☐

v. Poliomyelitis (when diagnosed?) ____

☐ Yes ☐ No

w. Guillain-Barre (when diagnosed?) ____

☐ Yes ☐ No

aa. Riley-Day Syndrome or Dysautonomia (when diagnosed?)

____

☐ Yes ☐ No

bb. ALS (when diagnosed?) ____

☐ Yes ☐ No

cc. Werdig- Hoffmann Disease (when diagnosed?) ______________________________

☐ Yes ☐ No

dd. Myasthenia Gravis (when diagnosed?) _____________________________________

☐ Yes ☐ No

ee. Muscular Dystrophy (when diagnosed?) ____________________________________

☐ Yes ☐ No

ff. Dystonia (when diagnosed?) ____

☐ Yes ☐ No

Oromyofunctional Risks/Conditions

gg. Recurrent Pneumonia

☐ Yes ☐ No

hh. Frequent Temperature Spikes

☐ Yes ☐ No

☐

ii. History of Artificial Airway

☐ Yes ☐ No

jj. Mouth Breather

☐ Yes ☐ No

kk. History of Finger Sucking

☐ Yes ☐ No

ll. History of Cheek Biting

☐ Yes ☐ No

mm. Deviated Septum

☐ Yes ☐ No

nn. Enlarged Tonsils/Adenoids

☐ Yes ☐ No

oo. Tonsils/Adenoids Removed

☐ Yes ☐ No

pp. Open Spaced During Mixed Dentition

☐ Yes ☐ No

qq. Current Open Spaces in Dentition

☐ Yes ☐ No

rr. Allergies (explain) ____

☐ Yes ☐ No

ss. TMJ Syndrome

☐ Yes ☐ No

☐

tt. Eating Disorders

☐ Yes ☐ No

uu. Oral Surgery (explain) ____

☐ Yes ☐ No

vv. Neck Surgery (explain) ____

☐ Yes ☐ No

ww. Oral Sores

☐ Yes ☐ No

Other

xx. Other Surgery (explain) ____

☐ Yes ☐ No

5. List and describe any serious accidents that required hospitalization.

____
____
____

Medications

6. Have you taken any medication today? ☐ Yes ☐ No

If yes, list medication, dose, time taken, and reason for taking it. (Use back of page for more room)

Name of medication Time Taken Dose Reason for Taking

________________________ ______mg ______________

________________________ ______mg ______________

________________________ ______mg ______________

_________________________ _____mg _____________

_________________________ _____mg _____________

_________________________ _____mg _____________

_________________________ _____mg _____________

_________________________ _____mg _____________

_________________________ _____mg _____________

_________________________ _____mg _____________

Alcohol and Tobacco

7. Do you consume alcohol? ☐ Yes ☐ No

8. If you answered yes to question 7, how much alcohol do you typically consume in 1 month? ______ glasses/month

9. Do you chew tobacco? ☐ Yes ☐ No

10. If you answered yes to question 9, how much do typically use in a month?

_______ cans/month

11. Do you smoke? ☐ Yes ☐ No

12. If you answered yet to question 11, how much do you smoke in a month?

_______ packs/month

Food Information

13. What are your three favorite foods? ____

14. What are your three least favorite foods? ____________________________________

15. Are there any foods that you avoid?

____

16. How often do you chew gum? ____

17. Have you ever participated in tongue thrust therapy? ☐ Yes ◻ No

Appendix D: Study Protocol

Subject number __________ Group ___________ Date____________

1. Set up videocamera. Press record.
2. Open Biograph Infiniti Program
3. Select Options and Notch Filters
4. Set them to EMG and 60 Hz and choose okay
5. Select Start Open Display Session
6. Select Add New Client and enter client number under Clinic ID & Name and select OK (see Table of Subjects and Researchers to determine client number)
7. Choose desired client from subjects and Define New session
8. Select Skeletal Muscle Rehab and M1revw- 2 ch Open Display.scr (be sure you have selected MyoTrac Infiniti as encoder type).
9. Make sure the encoder is connected to the computer. Then turn on the encoder. On the encoder, under “New Session” select “Open.” A graph should display in Biograph Infiniti Program.
10. Once electrodes are in place, press record and instruct client to do desired task. The spacebar places event markers on the screen (used in swallow timing section/ LE and to mark swallow for masseter activity). Be sure that when you pause the session you press pause and not stop.
11. When you are done with the session, press stop and save it in an uncompressed version with the name being the task you just completed (ex. Masseter activity- 1 tsp pudding).
12. Choose not to review the session.
13. Continue recording with the same client set-up until you have completed the protocol for that client, following step 8-10.
14. Once you’ve recorded all the necessary sessions for the client and save as instructed in 9, close out the client. See the Biograph Infiniti program information for measuring data.

Group A	Group B	Group C
IOPI	EMG masseter (pg 10)	EMG swallow timing (pg 19)
EMG masseter	EMG swallow timing (pg 19)	IOPI (pg 2)
EMG swallow timing	IOPI (pg 2)	EMG masseter (pg 10)

GROUP A			
Task	Clinician’s Instructions to Subject	What Clinician Does	Record Data
1. Human Consent Form			
Human Consent	“Today I will be using different measures and foods to assess your swallow function. I will be placing the		

	IOPI (show them the instrument) on your lips and in your mouth, EMG electrodes (show them instrument) on your throat and jaw, and placing my hands on your face and throat. If at any time you feel uncomfortable please let me know. The IOPI measures how much force your tongue and lips can exert, and the EMG measures electrical activity of your muscles. Neither device should cause you any discomfort."		
2. Medical History Form			
Medical History Form (Appendix D)	"Please answer the following questions to the best of your knowledge. Please make sure to answer all of the questions. If you have any questions, please do not hesitate to ask me. This information will remain confidential. Here is a consent form for you to read as well. You do not need to sign it. It is strictly for your knowledge."	Give subject the medical history form and consent form.	
3. Stone Tongue Thrust Protocol: Oral Evaluation			
STTP: Oral Evaluation	"I am now going to evaluate you using the Stone Tongue Thrust	Perform oral evaluation following STTP protocol (see	Mark appropriate answers on record form. No names will be written on record form. Participant will be identified with their assigned number.

	Protocol: Oral Evaluation. This will allow me to determine the presense or absence of tongue thrust.”	attached).	
4. Oral Peripheral Exam (OPE)	Open your mouth	Look for vaulted palate	Circle for presence or absence of vaulted palate
OPE	Bite down on your teeth and smile	Look for molar classification (See picture on last page for malocclusion type)	Check for presence of each of the following: Crossbite _________ Labioversion ______ Normal malocclusion ________ Malocclusion I _____________ Malocclusion II _____________ Malocclusion III ____________
5. Iowa Oral Performance Instrument (IOPI) Tongue Tip			
IOPI Tongue Tip		Procedures for Clinician 1.Press“Peak” and then press “Reset.” 2.Check screen for low battery symbol. Change battery if needed. 3. Attach connecting tube to tongue bulb. IOPI is now ready to use. 4. Turn IOPI screen away from subject	
IOPI Tongue Tip		If at any time the bulb moves out of place or directions are not followed, re-administer the directions.	
IOPI Tongue Tip	“I’m going to place this bulb on the tip of your tongue.”		
IOPI Tongue Tip	“Open your mouth”		
IOPI Tongue Tip		Clinician places bulb in mouth, making sure	

		bulb is completely behind the front teeth.	
IOPI Tongue Tip		Make sure they are not biting on tubing.	
IOPI Tongue Tip	"Close your lips"		
IOPI Tongue Tip	"When I say go press with the tip of your tongue against the roof of your mouth as hard as you can, hold until you are told to stop."		
IOPI Tongue Tip – Trial 1	"Go"		
IOPI Tongue Tip – Trial 1		Have subject press until IOPI number stabilizes	
IOPI Tongue Tip – Trial 1	"Stop"		
IOPI Tongue Tip – Trial 1			______Record final number on screen
		Check positioning of bulb and reposition if needed.	
	"We are going to do it again."	Push "reset"	
IOPI Tongue Tip – Trial 2	"Go"		
IOPI Tongue Tip – Trial 2	"Stop"		
IOPI Tongue Tip – Trial 2			______Record second reading
		Check positioning of bulb and reposition if needed.	
	"We are going to do it again."	Push "reset"	
IOPI Tongue Tip – Trial 3	"Go"		
IOPI Tongue Tip – Trial 3	"Stop"		
IOPI Tongue Tip – Trial 3			______Record third reading
6. IOPI Dorsum			
IOPI Dorsum	"Now I'm going to place the bulb on a different part of your tongue. Open	Push "reset"	

	your mouth and say /a/”		
IOPI Dorsum		Look for the peak of the tongue dorsum when subject says /a/.	
IOPI Dorsum		Place the tip of the bulb at the peak.	
IOPI Dorsum – Trial 1	“Close your mouth and push as hard as you can against the bulb.”	Have subject press until IOPI number stabilizes	
IOPI Dorsum – Trial 1	“Stop”		
IOPI Dorsum – Trial 1			______Record reading
		Wipe bulb with tissue, reposition bulb & repeat Push “reset”	
IOPI Dorsum – Trial 2	“Go”		
IOPI Dorsum – Trial 2	“Stop”		
IOPI Dorsum – Trial 2			______Record reading
		Wipe bulb with tissue, reposition bulb & repeat Push “reset”	
IOPI Dorsum – Trial 3	“Go”		
IOPI Dorsum – Trial 3	“Stop”		
IOPI Dorsum – Trial 3		Wipe bulb	______Record reading
7. IOPI Lip strength		Push “reset”	
IOPI Lip Strength	“Bite down and clench your teeth together. Now I’m going to place this between your lips but be sure not bite the bulb directly”		
IOPI Lip Strength		Place bulb between lips (parallel with lips), but not between teeth.	
IOPI Lip Strength	“When I say go	Have subject	

	press your lips together”	press until IOPI number stabilizes	
IOPI Lip Strength – Trial 1	“Go”		
IOPI Lip Strength – Trial 1	“Stop”		
IOPI Lip Strength – Trial 1			_______Record reading
		Reposition bulb between lips parallel with lips & Repeat Push “reset”	
IOPI Lip Strength – Trial 2	“Go”		
IOPI Lip Strength – Trial 2	“Stop”		_______Record reading
		Reposition bulb between lips parallel with lips & Repeat Push “reset”	
IOPI Lip Strength – Trial 3	“Go”		
IOPI Lip Strength – Trial 3	“Stop”		_______Record reading
8. Masseter baseline			
Masseter Baseline		Select “start open display session” on computer. Add new client by number. Define new session and select “skeletal muscle rehab.” Choose screen M1revw-2ch open display screen. Then turn on the encoder.	
Masseter Baseline	“Clench your back teeth”	Palpate the Masseter, Feel for belly of masseter during contraction.	
Masseter Baseline	“Do you have skin allergies?” **(If subject has skin allergies don’t use Nuprep, use alcohol swabs).**	Use Nuprep to exfoliate skin (masseter and clavicle). Rub for 30 seconds on location of electrode placement. Remove excess Nuprep with alcohol. **(If**	

		subject has skin allergies don't use Nuprep, use alcohol swabs).	
Masseter Baseline	"Clench your back teeth"	Palpate masseter again and mark placement for electrodes with marker.	
Masseter Baseline	"Bite down for me while I place these electrodes on your muscle."	**Put conductive gel on electrodes**. Place EMG electrodes bilaterally on masseter belly in a vertical plane, **Channel A is on the subject's right masseter (yellow on superior/blue inferior) & Channel B is on the subject's left masseter (yellow superior/blue inferior). Place the ground electrode (black) on the subject's collar bone.** (Reference Figure 1 for specific placement). Clip electrode cables to subject's sleeve if needed.	
Masseter Baseline		Select record	
Masseter Baseline – Trial 1 (max contraction)	"Clamp down with your back teeth as hard as possible until I say stop and then relax."	Wait 3 seconds	
Masseter Baseline – Trial 1 (max contraction)	"Stop"		_____Check for EMG reading of contraction

Masseter Baseline – Trial 2 (max contraction)	"Clamp down with your back teeth as hard as possible until I say stop and then relax."	Wait 3 seconds	
Masseter Baseline – Trial2 (max contraction)	"Stop"		_____Check for EMG reading of contraction
Masseter Baseline – Trial 3 (max contraction)	"Clamp down with your back teeth as hard as possible until I say stop and then relax."	Wait 3 seconds	
Masseter Baseline – Trial 3 (max contraction)	"Stop"		_____Check for EMG reading of contraction
		Stop recording and save without reviewing in non compressed format and start new session with same client.	
9. Masseter Activity			
Masseter Activity		Electrodes will remain in the same placement. Select record	
Masseter Activity – Trial 1 (1/2 tsp pudding)		Measure 1/2 teaspoon of pudding with syringe and place on spoon.	
Masseter Activity – Trial 1 (1/2 tsp pudding)		Have subject place the pudding in their mouth	
Masseter Activity – Trial 1 (1/2 tsp pudding)	"Place the pudding in your mouth, cleaning the whole spoon, & swallow when I say swallow"	Watch for swallow initiation and press space bar to mark swallow time.	______ Cough (+/-) ______ Clavicle breathing (+/-) ______ Forward posture (+/-) ______ Chin tuck posture (+/-) ______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
Masseter Activity – Trial 1 (1/2 tsp pudding)		Press pause	______Check EMG for completion of task ______ Swallow initiation time

Masseter Activity – Trial 2 (1/2 tsp pudding)		Measure 1/2 teaspoon of pudding with syringe and place on spoon.	
Masseter Activity – Trial 2 (1/2 tsp pudding)		Have subject place the pudding in their mouth	
Masseter Activity – Trial 2 (1/2 tsp pudding)	"Place the pudding in your mouth, cleaning the whole spoon, & swallow when I say swallow"	Watch for swallow initiation and press space bar to mark swallow time.	______ Cough (+/-) ______ Clavicle breathing (+/-) ______ Forward posture (+/-) ______ Chin tuck posture (+/-) ______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
Masseter Activity – Trial 2 (1/2 tsp pudding)		Press pause	______Check EMG for completion of task ______ Swallow initiation time
Masseter Activity – Trial 3 (1/2 tsp pudding)		Measure 1/2 teaspoon of pudding with syringe and place on spoon.	
Masseter Activity – Trial 3 (1/2 tsp pudding)		Have subject place the pudding in their mouth	
Masseter Activity – Trial 3 (1/2 tsp pudding)	"Place the pudding in your mouth, cleaning the whole spoon, & swallow when I say swallow"	Watch for swallow initiation and press space bar to mark swallow time.	______ Cough (+/-) ______ Clavicle breathing (+/-) ______ Forward posture (+/-) ______ Chin tuck posture (+/-) ______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
Masseter Activity – Trial 3 (1/2 tsp pudding)		Press pause	______Check EMG for completion of task ______ Swallow initiation time
Masseter Activity – Trial 1 (1 ½ tsp pudding)		Stop recording and save without reviewing in non compressed format and start new session with same	

		client.	
Masseter Activity – Trial 1 (1 ½ tsp pudding)		Measure 1 ½ teaspoons of pudding with syringe and place on spoon. Press record.	
		Have subject place the pudding in their mouth	
Masseter Activity – Trial 1 (1 ½ tsp pudding)	"Place the pudding in your mouth, cleaning the whole spoon, & swallow when I say swallow"	Watch for swallow initiation and press space bar to mark swallow time.	______ Cough (+/-) ______ Clavicle breathing (+/-) ______ Forward posture (+/-) ______ Chin tuck posture (+/-) ______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
Masseter Activity – Trial 1 (1 ½ tsp pudding)		Press pause	______Check EMG for completion of task ______ Swallow initiation time
Masseter Activity – Trial 2 (1 ½ tsp pudding)		Measure 1 ½ teaspoons of pudding with syringe and place on spoon. Press record.	
		Have subject place the pudding in their mouth	
Masseter Activity – Trial 2 (1 ½ tsp pudding)	"Place the pudding in your mouth, cleaning the whole spoon, & swallow when I say swallow"	Watch for swallow initiation and press space bar to mark swallow time.	______ Cough (+/-) ______ Clavicle breathing (+/-) ______ Forward posture (+/-) ______ Chin tuck posture (+/-) ______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
Masseter Activity – Trial 2 (1 ½ tsp pudding)			______Check EMG for completion of task ______ Swallow initiation time
Masseter Activity – Trial 3 (1 ½ tsp pudding)		Measure 1 ½ teaspoons of pudding with syringe and place on spoon. Press record.	
		Have subject place the	

		pudding in their mouth	
Masseter Activity – Trial 3 (1 ½ tsp pudding)	"Place the pudding in your mouth, cleaning the whole spoon, & swallow when I say swallow"	Watch for swallow initiation and press space bar to mark swallow time.	______ Cough (+/-) ______ Clavicle breathing (+/-) ______ Forward posture (+/-) ______ Chin tuck posture (+/-) ______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
Masseter Activity – Trial 3 (1 ½ tsp pudidng)			______Check EMG for completion of task ______ Swallow initiation time
Masseter Activity – Trial 1 (10 cc water)		Stop recording and save without reviewing in non compressed format and start new session with same client.	
Masseter Activity – Trial 1 (10 cc water)		Measure 10 cc of water, to line marked on the syringe and squirt into cup.	
Masseter Activity – Trial 1 (10 cc water)	"I'm going to give you a small amount of water in a cup."	Press record	
Masseter Activity – Trial 1 (10 cc water)	"Drink the water from the cup but don't swallow until I say swallow."	Watch for swallow initiation and press space bar to mark swallow time.	______ Cough (+/-) ______ Clavicle breathing (+/-) ______ Forward posture (+/-) ______ Chin tuck posture (+/-) ______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
Masseter Activity – Trial 1 (10 cc water)		Press pause	______Check EMG for completion of task ______ Swallow initiation time
Masseter Activity – Trial 2 (10 cc water)		Measure 10 cc of water, to line marked on the syringe and squirt into cup.	
		Press record	
Masseter Activity – Trial 2 (10 cc water)	"Drink the water from the cup but don't swallow	Watch for swallow initiation and	______ Cough (+/-) ______ Clavicle breathing (+/-) ______ Forward posture (+/-)

	until I say swallow.”	press space bar to mark swallow time.	______ Chin tuck posture (+/-) ______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
Masseter Activity – Trial 2 (10 cc water)		Press pause	______Check EMG for completion of task ______ Swallow initiation time
Masseter Activity – Trial 3 (10 cc water)		Measure 10 cc of water, to line marked on the syringe and squirt into cup.	
		Press record	
Masseter Activity – Trial 3 (10 cc water)	“Drink the water from the cup but don’t swallow until I say swallow.”	Watch for swallow initiation and press space bar to mark swallow time.	______ Cough (+/-) ______ Clavicle breathing (+/-) ______ Forward posture (+/-) ______ Chin tuck posture (+/-) ______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
Masseter Activity – Trial 3 (10 cc water)			______Check EMG for completion of task ______ Swallow initiation time
		Stop recording and save without reviewing in non compressed format and start new session with same client.	
Masseter Activity – Trial 1 (Triscuit)			
Masseter Activity – Trial 1 (Triscuit)		Give subject whole Triscuit	
Masseter Activity – Trial 1 (Triscuit)	“Take a normal bite, chew it and open your mouth when you are ready to swallow. Signal to me when you are ready to swallow.”	Press record	
Masseter Activity – Trial 1 (Triscuit)		Look in mouth & rate bolus	
Masseter Activity – Trial 1 (Triscuit)			1 3 5 Organized Some Disorganized

			in ball or tube in middle of tongue evidence of cohesion, some scattering or scattered on tongue
Masseter Activity – Trial 1 (Triscuit)		Participant signals ready to swallow. Watch for swallow initiation and press space bar to mark swallow time.	______ Cough (+/-) ______ Clavicle breathing (+/-) ______ Forward posture (+/-) ______ Chin tuck posture (+/-) ______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
Masseter Activity – Trial 1 (Triscuit)	"Open your mouth"	Press pause	______Check EMG for completion of task ______ Swallow initiation time
Masseter Activity – Trial 1 (Triscuit)		Look for residue on sulci & tongue & rate residue	
Masseter Activity – Trial 1 (Triscuit)			1 3 5 Minimal/No residue (few to no parts of residue) Some evidence of residue Significant amount of residue
Masseter Activity – Trial 2 (Triscuit)	"We are going to repeat the process 2 more times"		
Masseter Activity – Trial 2 (Triscuit)	"Take another bite & open your mouth when you are ready to swallow. Signal to me when you are ready to swallow."	Press record.	
Masseter Activity – Trial 2 (Triscuit)		Look in mouth & rate bolus	
Masseter Activity – Trial 2 (Triscuit)			1 3 5 Organized in ball or tube in middle of tongue Some evidence of cohesion, some scattering Disorganized or scattered on tongue
Masseter Activity – Trial 2 (Triscuit)		Participant signals when ready to swallow.	______ Cough (+/-) ______ Clavicle breathing (+/-) ______ Forward posture (+/-) ______ Chin tuck posture (+/-)

		Watch for swallow initiation and press space bar to mark swallow time.	______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
Masseter Activity – Trial 2 (Triscuit)	"Open your mouth"	Press pause	______Check EMG for completion of task ______ Swallow initiation time
Masseter Activity – Trial 2 (Triscuit)		Look for residue on sulci with tongue depressor if needed & tongue & rate residue	
Masseter Activity – Trial 2 (Triscuit)			1 3 5 Minimal/No residue (few to no parts of residue) / Some evidence of residue / Significant amount of residue
Masseter Activity – Trial 3 (Triscuit)	"Take another bite & open your mouth when you are ready to swallow. Signal to me when you are ready to swallow."	Press record	
Masseter Activity – Trial 3 (Triscuit)		Look in mouth & rate bolus	
Masseter Activity – Trial 3 (Triscuit)			1 3 5 Organized in ball or tube in middle of tongue / Some evidence of cohesion, some scattering / Disorganized or scattered on tongue
Masseter Activity – Trial 3 (Triscuit)		Participant signals ready to swallow. Watch for swallow initiation and press space bar to mark swallow time.	______ Cough (+/-) ______ Clavicle breathing (+/-) ______ Forward posture (+/-) ______ Chin tuck posture (+/-) ______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
Masseter Activity – Trial 3 (Triscuit)	"Open your mouth"	Press pause	______Check EMG for completion of task ______ Swallow initiation time
Masseter Activity – Trial 3 (Triscuit)		Look for residue on sulci	

		& tongue & rate residue	
Masseter Activity – Trial 3 (Triscuit)			1 3 5 Minimal/No residue (few to no parts of residue) / Some evidence of residue / Significant amount of residue
10. Laryngeal elevation (LE)			
LE		Remove channel A & B electrodes	
LE		Prepare skin for electrode placement. **Get new electrodes and place conductive gel on electrodes.** Put Channel **A electrode to geniohyoid**. Measure **2 cm posterior from chin point and place first (yellow) electrode and place second electrode (blue) 2cm posterior** from the first. Place **channel B electrode just off lamina on left side.** Have subject perform dry swallow & feel for thyroid notch. Place electrodes 2cm apart in vertical alignment on left side of thyroid notch **with yellow electrode superior and blue electrode inferior.** (See Figure 2 for placement)	
LE – **<u>Trial 1</u>**		Measure 1/2	

(1/2 tsp pudding)		teaspoon of pudding with syringe and place on spoon	
		Press record	
LE – Trial 1 (1/2 tsp pudding)	"Place the pudding in your mouth, cleaning the whole spoon, & swallow when I say swallow"	Have subject place the pudding in their mouth	
LE – Trial 1 (1/2 tsp pudding)	"Swallow"	Feel for swallow initiation and press space bar to mark laryngeal elevation and depression	______ Cough (+/-) ______ Clavicle breathing (+/-) ______ Forward posture (+/-) ______ Chin tuck posture (+/-) ______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
LE – Trial 1 (1/2 tsp pudding)		Press pause	______Check EMG for completion of task ______ Swallow initiation time
LE – Trial 1 (1/2 tsp pudding)	"Say ah"		______ Gurgly voice (+/-)
LE – Trial 2 (1/2 tsp pudding)		Measure 1/2 teaspoon of pudding with syringe and place on spoon	
		Press record	
LE – Trial 2 (1/2 tsp pudding)	"Place the pudding in your mouth, cleaning the whole spoon, & swallow when I say swallow"	Have subject place the pudding in their mouth	
LE – Trial 2 (1/2 tsp pudding)	"Swallow"	Feel for swallow initiation and press space bar to mark laryngeal elevation and depression	______ Cough (+/-) ______ Clavicle breathing (+/-) ______ Forward posture (+/-) ______ Chin tuck posture (+/-) ______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
LE – Trial 2 (1/2 tsp pudding)		Press pause	______Check EMG for completion of task ______ Swallow initiation time
LE – Trial 2 (1/2 tsp pudding)	"Say ah"		______ Gurgly voice (+/-)
LE – Trial 2 (1/2 tsp pudding)		Measure 1/2 teaspoon of pudding with	

		syringe and place on spoon	
LE – Trial 3 (1/2 tsp pudding)		Press record	
LE – Trial 3 (1/2 tsp pudding)	"Place the pudding in your mouth, cleaning the whole spoon, & swallow when I say swallow"	Have subject place the pudding in their mouth	
LE – Trial 3 (1/2 tsp pudding)	"Swallow"	Feel for swallow initiation and press space bar to mark laryngeal elevation and depression	______ Cough (+/-) ______ Clavicle breathing (+/-) ______ Forward posture (+/-) ______ Chin tuck posture (+/-) ______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
LE – Trial 3 (1/2 tsp pudding)		Press pause	______Check EMG for completion of task ______ Swallow initiation time
LE – Trial 3 (1/2 tsp pudding)	"Say ah"		______ Gurgly voice (+/-)
LE – Trial 3 (1/2 tsp pudding)		Stop recording and save without reviewing in non compressed format and start new session with same client.	
LE – protrusion	"I'm going to pull down your lip when you swallow."		
LE/protrusion – Trial 1 (1/2 tsp pudding)		Measure 1/2 teaspoon of pudding with syringe and place on spoon	
LE/protrusion – Trial 1 (1/2 tsp pudding)	"Place the pudding in your mouth, cleaning the whole spoon, & swallow when ready"	Have subject place the pudding in their mouth Pull down lip while swallowing and watch for protrusion of tongue.	______ Tongue protrusion (+/-)
LE/protrusion – Trial 2 (1/2 tsp pudding)		Measure 1/2 teaspoon of	

		pudding with syringe and place on spoon	
LE/protrusion – Trial 2 (1/2 tsp pudding)	"Place the pudding in your mouth, cleaning the whole spoon, & swallow when ready"	Have subject place the pudding in their mouth Pull down lip while swallowing and watch for protrusion of tongue.	_______ Tongue protrusion (+/-)
LE/protrusion – Trial 3 (1/2 tsp pudding)		Measure 1/2 teaspoon of pudding with syringe and place on spoon	
LE/protrusion – Trial 3 (1/2 tsp pudding)	"Place the pudding in your mouth, cleaning the whole spoon, & swallow when ready"	Have subject place the pudding in their mouth Pull down lip while swallowing and watch for protrusion of tongue.	_______ Tongue protrusion (+/-)
LE – Trial 1 (1 ½ tsp pudding)		Measure 1 ½ teaspoons of pudding with syringe and place on spoon	
LE – Trial 1 (1 ½ tsp pudding)		Press record	
LE – Trial 1 (1 ½ tsp pushing)	"Place the pudding in your mouth, cleaning the whole spoon, & swallow when I say swallow"		
LE – Trial 1 (1 ½ tsp pushing)	"Swallow"	Feel for swallow initiation and press space bar to mark laryngeal elevation and depression	_______ Cough (+/-) _______ Clavicle breathing (+/-) _______ Forward posture (+/-) _______ Chin tuck posture (+/-) _______ Neck tension (+/-) _______ Open-mouth posture (+/-) _______ Tongue protrusion (+/-) Additional notes:
LE – Trial 1 (1 ½ tsp pudding)		Press pause	_______Check EMG for completion of task _______ Swallow initiation time

LE – Trial 1 (1 ½ tsp pudding)	"Say ah"		______ Gurgly voice (+/-)
LE – Trial 2 (1 ½ tsp pudding)		Measure 1 ½ teaspoons of pudding with syringe and place on spoon	
LE – Trial 2 (1 ½ tsp pudding)		Press record	
LE – Trial 2 (1 ½ tsp pudding)	"Place the pudding in your mouth, cleaning the whole spoon, & swallow when I say swallow"		
LE – Trial 2 (1 ½ tsp pudding)	"Swallow"	Feel for swallow initiation and press space bar to mark laryngeal elevation and depression	______ Cough (+/-) ______ Clavicle breathing (+/-) ______ Forward posture (+/-) ______ Chin tuck posture (+/-) ______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
LE – Trial 2 (1 ½ tsp pudding)		Press pause	______Check EMG for completion of task ______ Swallow initiation time
LE – Trial 2 (1 ½ tsp pudding)	"Say ah"		______ Gurgly voice (+/-)
LE – Trial 3 (1 ½ tsp pudding)		Measure 1 ½ teaspoons of pudding with syringe and place on spoon	
LE – Trial 3 (1 ½ tsp pudding)		Press record	
LE – Trial 3 (1 ½ tsp pudding)	"Place the pudding in your mouth, cleaning the whole spoon, & swallow when I say swallow"		
LE – Trial 3 (1 ½ tsp pudding)	"Swallow"	Feel for swallow initiation and press space bar to mark laryngeal elevation and depression	______ Cough (+/-) ______ Clavicle breathing (+/-) ______ Forward posture (+/-) ______ Chin tuck posture (+/-) ______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
LE – Trial 3 (1 ½ tsp pudding)		Press pause	______Check EMG for completion of task ______ Swallow initiation time
LE – Trial 3	"Say ah"		______ Gurgly voice (+/-)

(1 ½ tsp pudding)			
LE		Stop recording and save without reviewing in non compressed format and start new session with same client.	
LE – Trial 1 (10 cc water)		Measure 10 cc of water, to line marked on syringe.	
LE – Trial 1 (10 cc water)		Press record	
LE – Trial 1 (10 cc water)	"I'm going to give you a small amount of water in a cup. Place it all in your mouth but don't swallow until I say swallow"		
LE – Trial 1 (10 cc water)	"Swallow"	Feel for swallow initiation and press space bar to mark laryngeal elevation and depression	_______ Cough (+/-) _______ Clavicle breathing (+/-) _______ Forward posture (+/-) _______ Chin tuck posture (+/-) _______ Neck tension (+/-) _______ Open-mouth posture (+/-) _______ Tongue protrusion (+/-) Additional notes:
LE – Trial 1 (10 cc water)		Press pause	_______Check EMG for completion of task _______ Swallow initiation time
LE – Trial 1 (10 cc water)	"Say ah"		_______ Gurgly voice (+/-)
LE – Trial 2 (10 cc water)		Measure 10 cc of water, to line marked on syringe.	
LE – Trial 2 (10 cc water)		Press record	
LE – Trial 2 (10 cc water)	"I'm going to give you a small amount of water in a cup. Place it all in your mouth but don't swallow until I say swallow"		
LE – Trial 2 (10 cc water)	"Swallow"	Feel for swallow initiation and	_______ Cough (+/-) _______ Clavicle breathing (+/-) _______ Forward posture (+/-)

		press space bar to mark laryngeal elevation and depression	______ Chin tuck posture (+/-) ______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
LE – Trial 2 (10 cc water)		Press pause	______Check EMG for completion of task ______ Swallow initiation time
LE – Trial 2 (10 cc water)	"Say ah"		______ Gurgly voice (+/-)
LE – Trial 3 (10 cc water)		Measure 10 cc of water, to line marked on syringe.	
LE – Trial 3 (10 cc water)		Press record	
LE – Trial 3 (10 cc water)	"I'm going to give you a small amount of water in a cup. Place it all in your mouth but don't swallow until I say swallow"		
LE – Trial 3 (10 cc water)	"Swallow"	Feel for swallow initiation and press space bar to mark laryngeal elevation and depression	______ Cough (+/-) ______ Clavicle breathing (+/-) ______ Forward posture (+/-) ______ Chin tuck posture (+/-) ______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
LE – Trial 3 (10 cc water)		Press pause	______Check EMG for completion of task ______ Swallow initiation time
LE – Trial 3 (10 cc water)	"Say ah"		______ Gurgly voice (+/-)
LE		Stop recording and save without reviewing in non compressed format and start new session with same client.	
LE/protrusion	"I'm going to pull down your lip when you swallow."		
LE/protrusion – Trial 1 (10 cc water)		Measure 10 cc of water, to line	

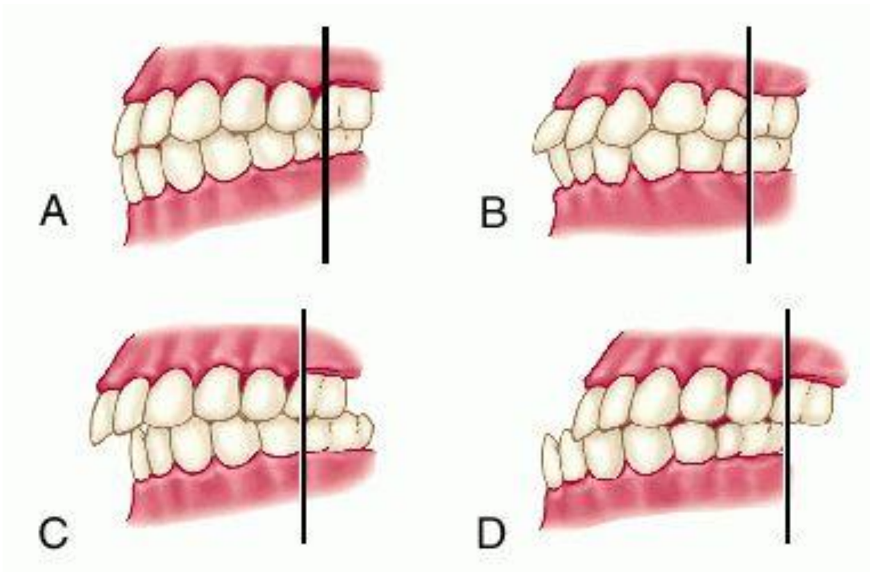
		marked on syringe.	
LE/protrusion – Trial 1 (10 cc water)	"Open your mouth(place syringe in) close mouth & swallow when ready"	Pull down lip while swallowing and watch for protrusion of tongue.	______ Tongue protrusion (+/-)
LE/protrusion – Trial 2 (10 cc water)		Measure 10 cc of water, to line marked on syringe.	
LE/protrusion – Trial 2 (10 cc water)	"Open your mouth(place syringe in) close mouth & swallow when ready"	Pull down lip while swallowing and watch for protrusion of tongue.	______ Tongue protrusion (+/-)
LE/protrusion – Trial 3 (10 cc water)		Measure 10 cc of water, to line marked on syringe.	
LE/protrusion – Trial 3 (10 cc water)	"Open your mouth(place syringe in) close mouth & swallow when ready"	Pull down lip while swallowing and watch for protrusion of tongue.	______ Tongue protrusion (+/-)
LE – Trial 1 (Triscuit)		Give subject Triscuit	
LE – Trial 1 (Triscuit)	"Take a normal bite of the cracker & signal to me when you are ready to swallow."	Press record	
LE – Trial 1 (Triscuit)		Participant signals ready to swallow. Feel for swallow initiation and press space bar to mark laryngeal elevation and depression	______ Cough (+/-) ______ Clavicle breathing (+/-) ______ Forward posture (+/-) ______ Chin tuck posture (+/-) ______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
LE – Trial 1 (Triscuit)		Press pause	______Check EMG for completion of task ______ Swallow initiation time
LE – Trial 1 (Triscuit)	"Say ah"		______ Gurgly voice (+/-)
LE – Trial 2 (Triscuit)	"Take a normal bite of the cracker & signal to me when you	Press record	

	are ready to swallow.”		
LE – Trial 2 (Triscuit)		Participant signals ready to swallow. Feel for swallow initiation and press space bar to mark laryngeal elevation and depression	______ Cough (+/-) ______ Clavicle breathing (+/-) ______ Forward posture (+/-) ______ Chin tuck posture (+/-) ______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
LE – Trial 2 (Triscuit)			______Check EMG for completion of task ______ Swallow initiation time
LE – Trial 2 (Triscuit)	“Say ah”		______ Gurgly voice (+/-)
LE – Trial 3 (Triscuit)	“Take a normal bite of the cracker & signal to me when you are ready to swallow.”	Press record	
LE – Trial 3 (Triscuit)		Participant signals ready to swallow. Feel for swallow initiation and press space bar to mark laryngeal elevation and depression	______ Cough (+/-) ______ Clavicle breathing (+/-) ______ Forward posture (+/-) ______ Chin tuck posture (+/-) ______ Neck tension (+/-) ______ Open-mouth posture (+/-) ______ Tongue protrusion (+/-) Additional notes:
LE – Trial 3 (Triscuit)		Press pause	______Check EMG for completion of task ______ Swallow initiation time
LE – Trial 3 (Triscuit)	“Say ah”		______ Gurgly voice (+/-)
LE		Stop recording and save without reviewing in non compressed format.	
LE/protrusion	“I’m going to have you chew the cracker. Let me know when you have finished chewing by raising your hand. Then I will pull your lip down. Then I	Give subject Triscuit	

	want you to signal when you are ready to swallow.”		
LE/protrusion – Trial 1 (Triscuit)		Pull lip down and watch for tongue protrusion. Participant signals ready to swallow.	_______ Tongue protrusion (+/-)
LE/protrusion – Trial 2 (Triscuit)	“Take another bite. Let me know when you have finished chewing by raising your hand. Then I will pull your lip down. Then I want you to signal when you are ready to swallow.”		
LE/protrusion – Trial 2 (Triscuit)		Pull lip down and watch for tongue protrusion. Participant signals ready to swallow.	_______ Tongue protrusion (+/-)
LE/protrusion – Trial 3 (Triscuit)	“Take another bite. Let me know when you have finished chewing by raising your hand. Then I will pull your lip down . Then I want you to signal when you are ready to swallow.		
LE/protrusion – Trial 3 (Triscuit)		Pull lip down and watch for tongue protrusion. Participant signals ready to swallow.	_______ Tongue protrusion (+/-)
		Stop recording and save without reviewing in non compressed	

		format and start new session with same client. Stop videorecorder.	

(A), Normal occlusion; *(B)*, Class I malocclusion; *(C)*, Class II malocclusion; *(D)*, Class III malocclusion. Note the position of the mesial cusp of the maxillary molar relative to the mandibular molar in each type of occlusion. http://medical-dictionary.thefreedictionary.com/_/viewer.aspx?path=dorland&name=malocclusion.jpg



- IOPI - tongue tip = 3 trials
- IOPI - dorsum = 3 trials
- IOPI - lip strength = 3 trials
- Masseter Baseline = 3 trials
- Masseter Activity - ½ tsp pudding = 3 trials
- Masseter Activity - 1 ½ tsp pudding = 3 trials
- Masseter Activity - 10 cc water = 3 trials
- Masseter Activity - bite of Triscuit = 3 trials
- LE - ½ tsp pudding = 3 trials
- LE protrusion - ½ tsp pudding = 3 trials
- LE - 1 ½ tsp pudding = 3 trials
- LE - 10 cc water = 3 trials
- LE protrusion - 10 cc water = 3 trials
- LE - bite of Triscuit = 3 trails
- LE protrusion - bite of Triscuit = 3 trials

Appendix E: Abbreviations Used in Results

Abbreviation	**Description**
iopitipavg	average force for IOPI tongue tip measure
iopidorsavg	average force for IOPI tongue dorsum measure
iopilipsavg	average force for IOPI lips measurement
mcbARMSav	right masseter contraction baseline average
mcbBRMSav	left masseter contraction baseline average
mcpud1ARMS	right masseter contraction for ½ tsp pudding trials
mcpud1BRMS	left masseter contraction for ½ tsp pudding trials
mcpud2ARMS	right masseter contraction for 1 ½ tsp pudding trials
mcpud2BRMS	left masseter contraction for 1 ½ tsp pudding trials
mc10ccARMS	right masseter contraction for 10 cc water trials
mc10ccBRMS	left masseter contraction for 10 cc water trials
mccrackARMS	right masseter contraction for Triscuit cracker trials
mccrackBRMS	left masseter contraction for Triscuit cracker trials
stcpud1avg	average swallowing timing with contraction for ½ tsp pudding trials
stcpud2avg	average swallowing timing with contraction for 1 ½ tsp pudding trials
stc10ccavg	average swallowing timing with contraction for 10cc water trials
stccrackavg	average swallowing timing with contraction for Triscuit cracker trials
tppud1	tongue protrusion for ½ tsp pudding trials
tp10cc	tongue protrusion for 10 cc water trials
tpcrack	tongue protrusion for Triscuit cracker trials
boluscoh	bolus cohesion during Triscuit cracker trials
bolusres	bolus residue following Triscuit cracker trials
ope_p	oral peripheral exam of palate (1= presence of high vaulted palate, 0= absence of high vaulted palate)
cough	any cough during bolus trials
CB	indicates clavicular breathing during bolus trials

FP	forward posture during bolus trials
CTP	chin tuck position
NT	neck tension during bolus trials
OMP	open mouth posture during bolus trials
TP	tongue protrusion during bolus trials

Appendix F: Raw Data

LE 1/2 PHYS DUR	TRIAL 1	TRIAL 2	TRIAL 3	AVG	STD
1	2.46	2.5	1.43	2.13	0.61
2	2.9	2.01	2.31	2.41	0.45
3	1.54	1.87	3.58	2.33	1.10
4	2.39	2.78	2.11	2.43	0.34

LE 1 1/2 PHYS DUR	TRIAL 1	TRIAL 2	TRIAL 3	AVG	STD
1	1.75	1.51	1.88	1.71	0.19
2	1.85	1.75	2.23	1.94	0.25
3	2.16	2.88	2.05	2.36	0.45
4	1.67	1.74	1.92	1.78	0.13

LE WATER PHYS DUR	TRIAL 1	TRIAL 2	TRIAL 3	AVG	STD
1	1.16	1.6	1.61	1.46	0.26
2	2.42	1.24	2.15	1.94	0.62
3	1.33	1.89	1.35	1.52	0.32
4	1.85	1.68	1.88	1.80	0.11

LE TRISCUIT PHYS DUR	TRIAL 1	TRIAL 2	TRIAL 3	AVG	STD
1	1.33	2.28	2.83	2.15	0.76
2	1.5	2.25	2.32	2.02	0.45
3	1.59	1.91	1.88	1.79	0.18
4	1.37	1.48	1.96	1.60	0.31

LE 1/2 PHYS DUR TO TICK	TRIAL 1	TRIAL 2	TRIAL 3	AVG	STD
1	0	0	0	0.00	0.00
2	2.3	1.28	1.62	1.73	0.52
3	1.35	1.6	1.31	1.42	0.16
4	1.89	2.28	1.7	1.96	0.30

LE 1 1/2 PHYS DUR TO TICK	TRIAL 1	TRIAL 2	TRIAL 3	AVG	STD
1	1.41	1	1.88	1.43	0.44
2	1.53	1.63	1.88	1.68	0.18
3	1.83	2.25	2.6	2.23	0.39
4	1.67	1.36	1.57	1.53	0.16

LE WATER PHYS DUR TO TICK	TRIAL 1	TRIAL 2	TRIAL 3	AVG	STD
1	1.01	1.26	1.04	1.10	0.14
2	1.89	0.88	1.56	1.44	0.52
3	1.26	1.71	1.17	1.38	0.29
4	1.18	0.83	1.09	1.03	0.18

LE TRISCUIT PHYS DUR TO TICK	TRIAL 1	TRIAL 2	TRIAL 3	AVG	STD
1	1.37	1.7	1.81	1.63	0.23
2	1.06	2.01	2.32	1.80	0.66

3	1.33	2.04	2.06	1.81	0.42
4	1.37	1.4	1.81	1.53	0.25
RIGHT MASSETER BASELINE	TRIAL 1	TRIAL 2	TRIAL 3	AVG	STD
1	128.67	115.94	139.4	128.00	11.74
2	25.46	34.19	38.19	32.61	6.51
3	57.43	63.26	52.44	57.71	5.42
4	190.59	195.74	199.83	195.39	4.63
RIGHT MASSETER 1/2	TRIAL 1	TRIAL 2	TRIAL 3	AVG	STD
1	26.72	49.17	46.35	40.75	12.23
2	12.94	16.17	14.42	14.51	1.62
3	11.06	15.01	10.5	12.19	2.46
4	35.09	19.06	19.51	24.55	9.13
RIGHT MASSETER 1 1/2	TRIAL 1	TRIAL 2	TRIAL 3	AVG	STD
1	43.83	56.5	48.49	49.61	6.41
2	28.16	16.16	15.74	20.02	7.05
3	8.71	15.05	28.58	17.45	10.15
4	21.75	39.44	24.79	28.66	9.46
RIGHT MASSETER WATER	TRIAL 1	TRIAL 2	TRIAL 3	AVG	STD
1	10.04	9.96	9.89	9.96	0.08
2	35.04	17.93	17.13	23.37	10.12
3	14.09	12.58	12.57	13.08	0.87
4	27.74	22.54	22.68	24.32	2.96
RIGHT MASSETER TRISCUIT	TRIAL 1	TRIAL 2	TRIAL 3	AVG	STD
1	45.4	88.97	211.36	115.24	86.04
2	17.61	16.4	21.13	18.38	2.46
3	98.01	227.59	236.93	187.51	77.65
4	16.22	496.49	27.01	179.91	274.22
LEFT MASSETER BASELINE	TRIAL 1	TRIAL 2	TRIAL 3	AVG	STD
1	103.15	99.59	120.87	107.87	11.40
2	17.91	28.68	30.92	25.84	6.96
3	43.79	46.99	37.75	42.84	4.69
4	238.06	229.17	257.87	241.70	14.69
LEFT MASSETER 1/2	TRIAL 1	TRIAL 2	TRIAL 3	AVG	STD
1	51.91	49.53	23.24	41.56	15.91
2	14.25	13.81	17.16	15.07	1.82
3	14.72	16.59	14.8	15.37	1.06
4	42.74	51.49	63.34	52.52	10.34
LEFT MASSETER 1 1/2	TRIAL 1	TRIAL 2	TRIAL 3	AVG	STD
1	28.53	26.52	25.9	26.98	1.37
2	22.24	21.66	12.11	18.67	5.69
3	18.89	22.62	21.62	21.04	1.93
4	64.03	99.82	95.62	86.49	19.56

LEFT MASSETER WATER	TRIAL 1	TRIAL 2	TRIAL 3	AVG	STD
1	11.76	9.42	10.13	10.44	1.20
2	15.55	10.4	11.14	12.36	2.78
3	27.9	30.65	25.55	28.03	2.55
4	63.46	81.83	66.51	70.60	9.84

LEFT MASSETER TRISCUIT	TRIAL 1	TRIAL 2	TRIAL 3	AVG	STD
1	14.32	98.67	135.91	82.97	62.30
2	17.53	18.82	16.97	17.77	0.95
3	50.46	149.96	130.46	110.29	52.73
4	44.13	597.08	87.93	243.05	307.38

IOPI TT	TRIAL 1	TRIAL 2	TRIAL 3	AVERAGE	STD
1	18	37	47	34.00	14.73
2	35	28	36	33.00	4.36
3	28	28	28	28.00	0.00
4	27	22	22	23.67	2.89

IOPI TD	TRIAL 1	TRIAL 2	TRIAL 3	AVERAGE	STD
1	49	30	45	41.33	10.02
2	55	48	59	54.00	5.57
3	36	32	41	36.33	4.51
4	32	38	45	38.33	6.51

IOPI LIP	TRIAL 1	TRIAL 2	TRIAL 3	AVERAGE	STD
1	2	5	2	3.00	2.08
2	5	6	7	6.00	1.00
3	5	2	2	3.00	1.73
4	6	3	4	4.33	1.53

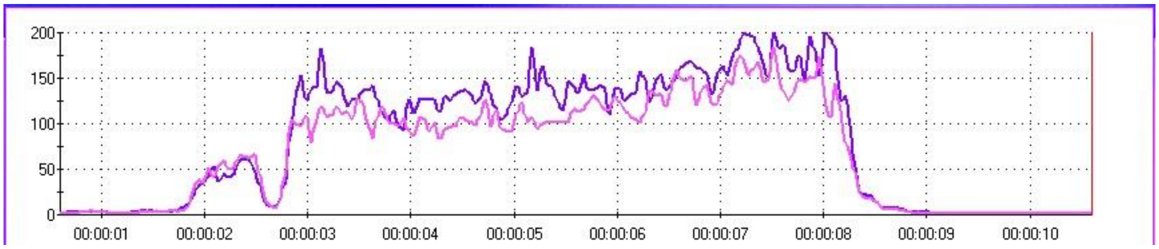
BOLUS ORGANIZATION	TRIAL 1	TRIAL 2	TRIAL 3	AVG
1	3	5	5	4.33
2	5	5	5	5.00
3	3	3	3	3.00
4	5	5	3	4.33

RESIDUE	TRIAL 1	TRIAL 2	TRIAL 3	AVG
1	3	3	5	3.67
2	5	3	3	3.67
3	1	5	5	3.67
4	5	5	5	5.00

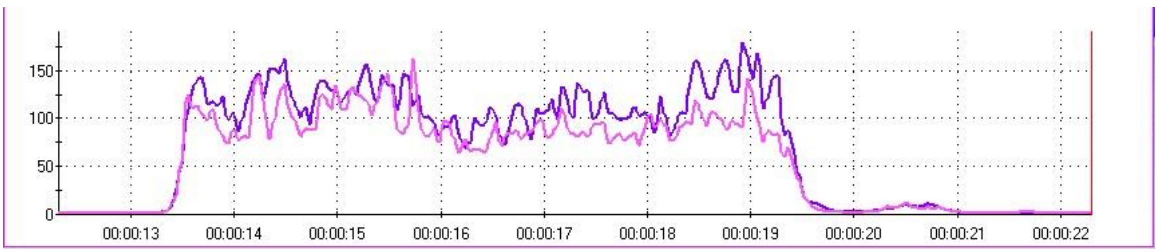
Appendix G: EMG Screenshots for Subject 1

Masseter Baseline:

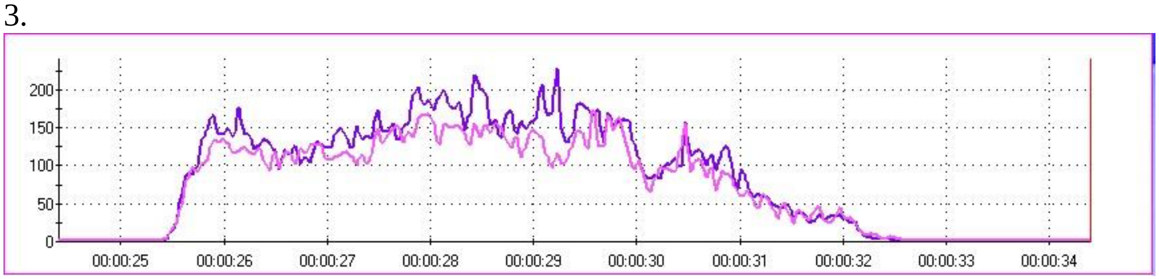
1.



2.

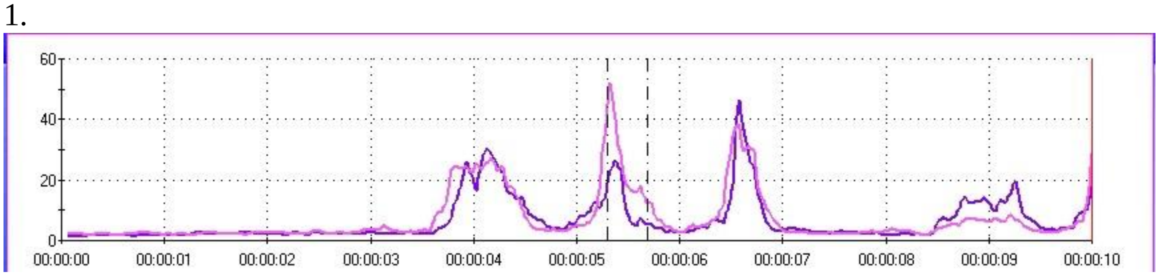


3.

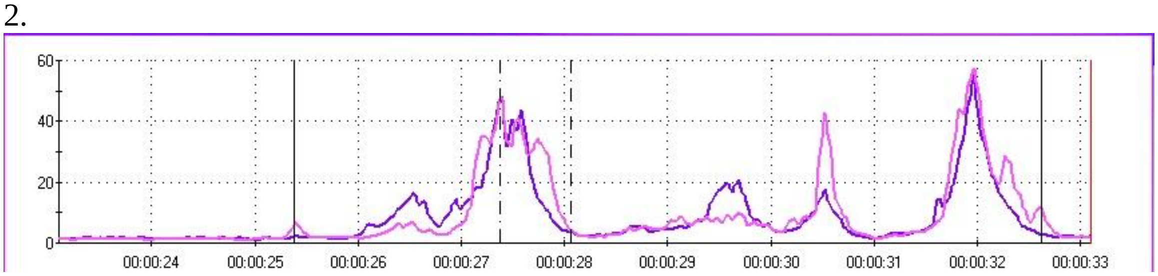


Masseter ½ t. pudding:

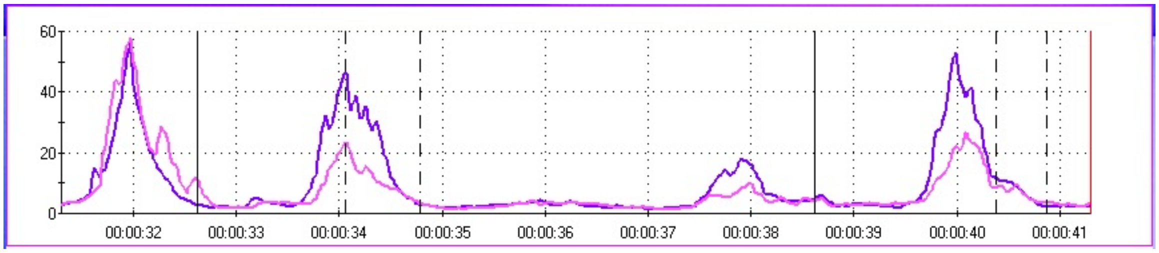
1.



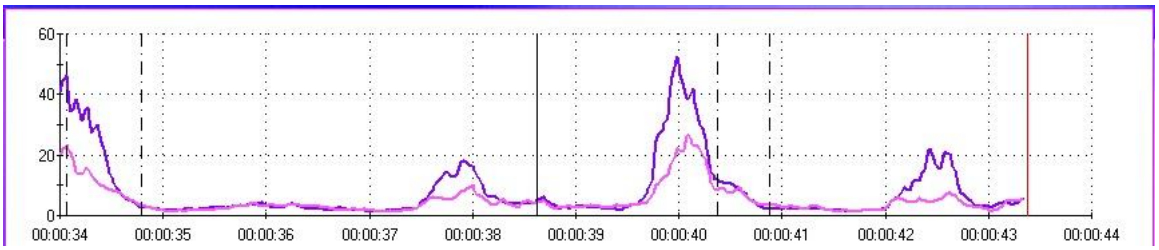
2.



3.

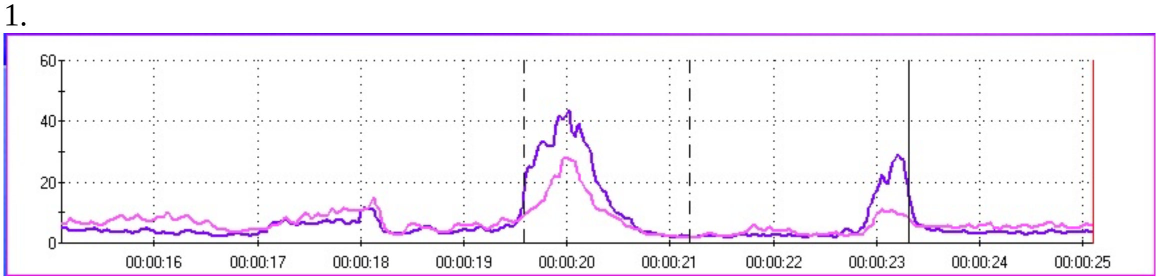


4.

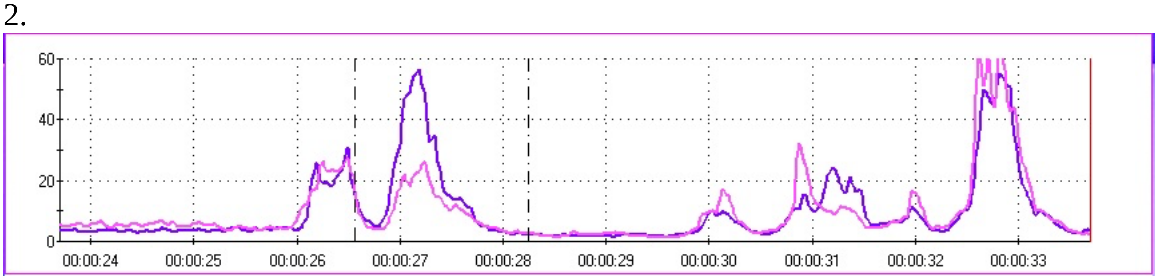


Masseter 1 ½ t. pudding:

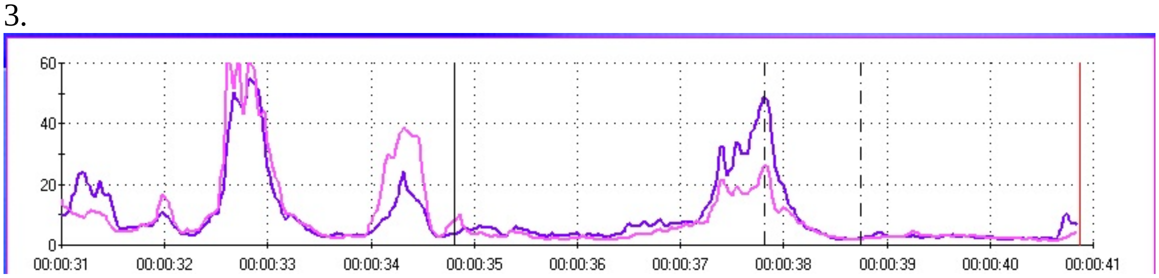
1.



2.

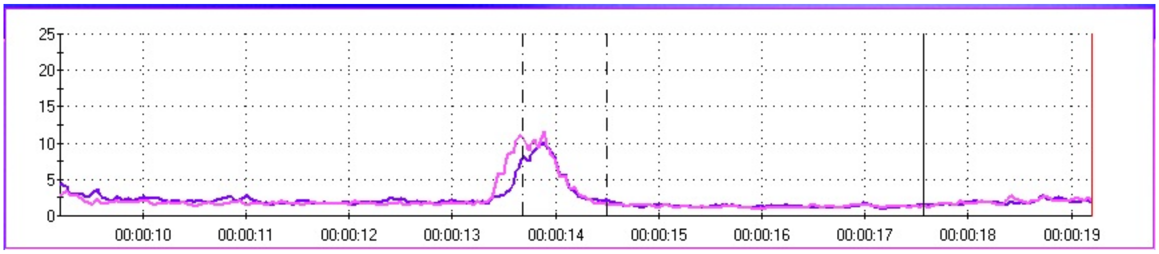


3.

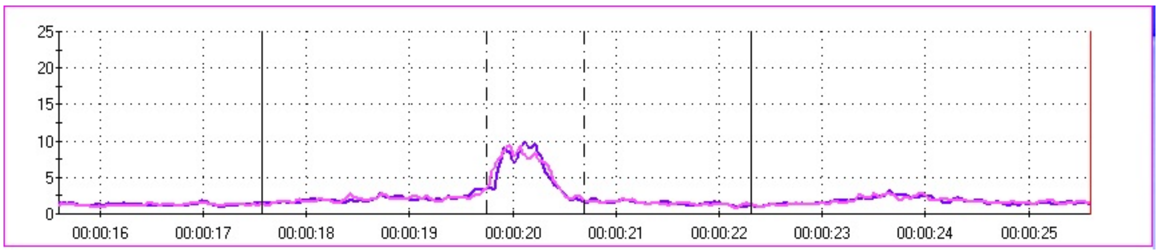


Masseter water:

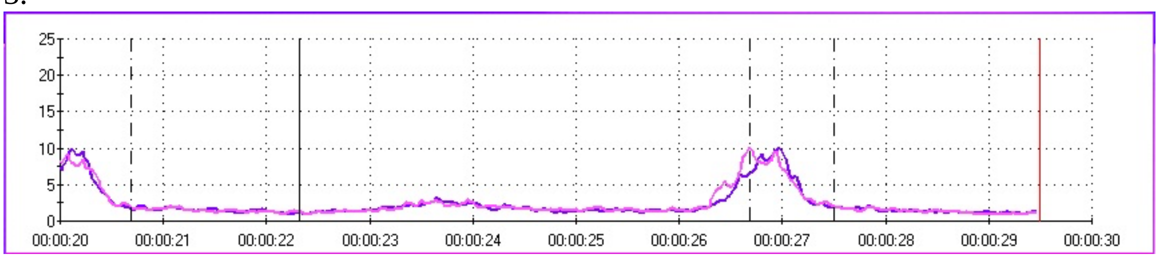
1.



2.

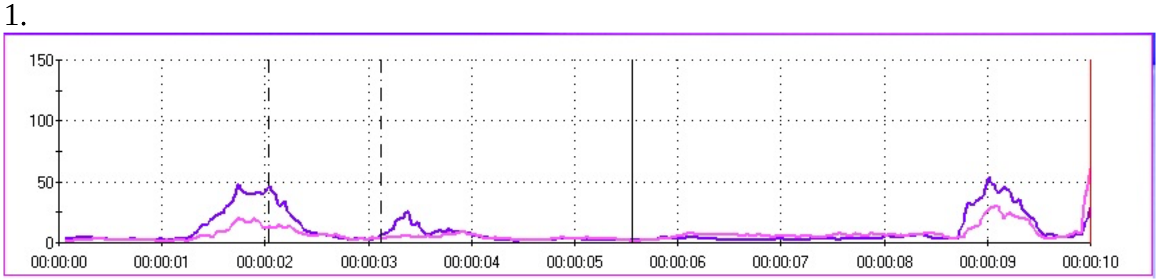


3.

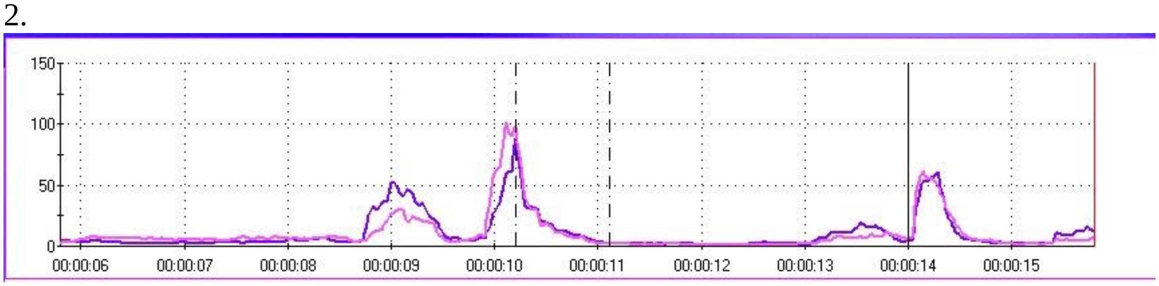


Masseter triscuit:

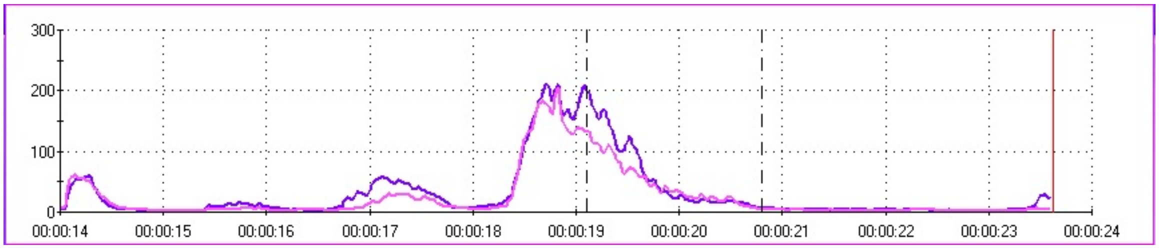
1.



2.

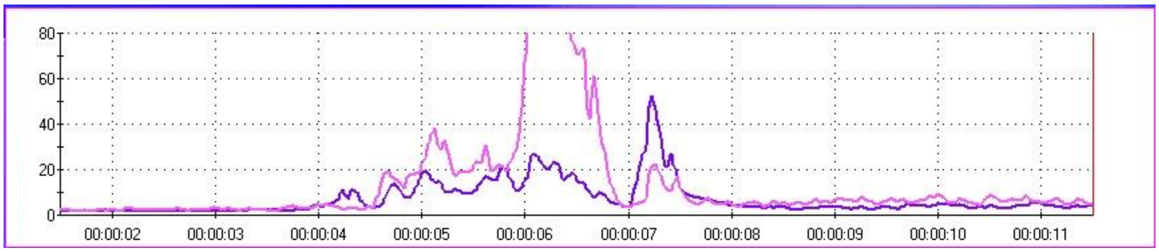


3.

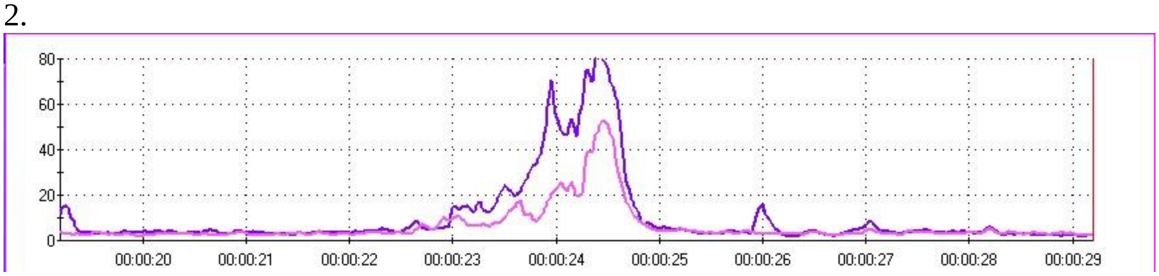


LE ½ t. pudding:

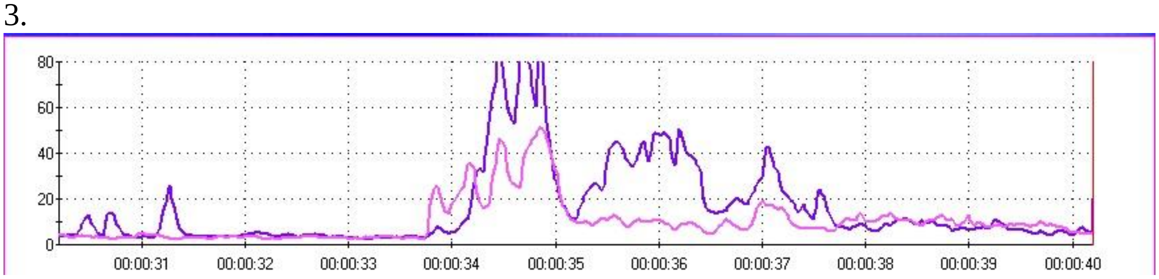
1.



2.

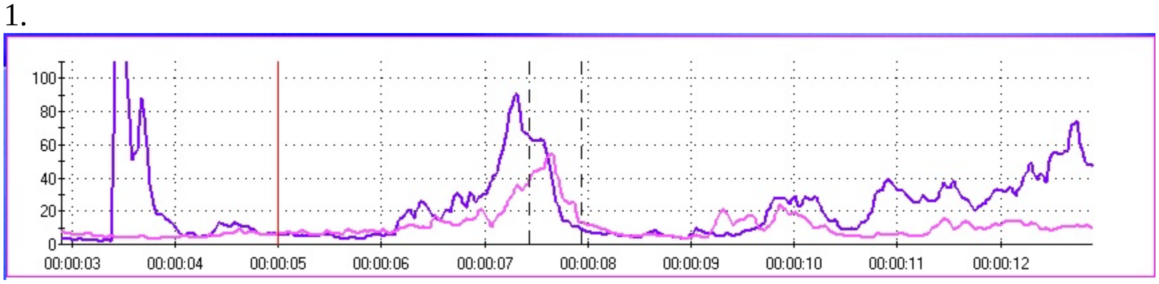


3.

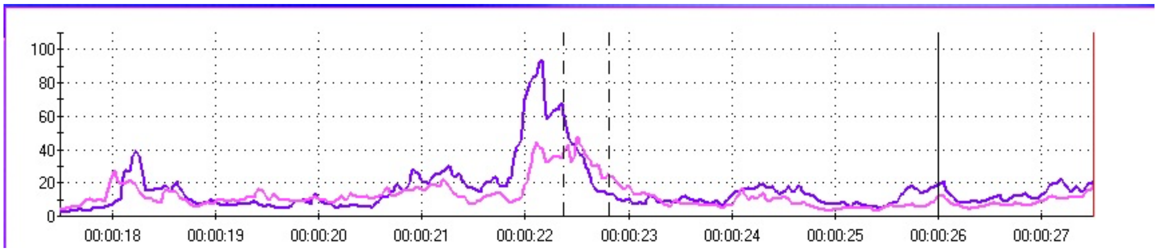


LE 1½ t. pudding:

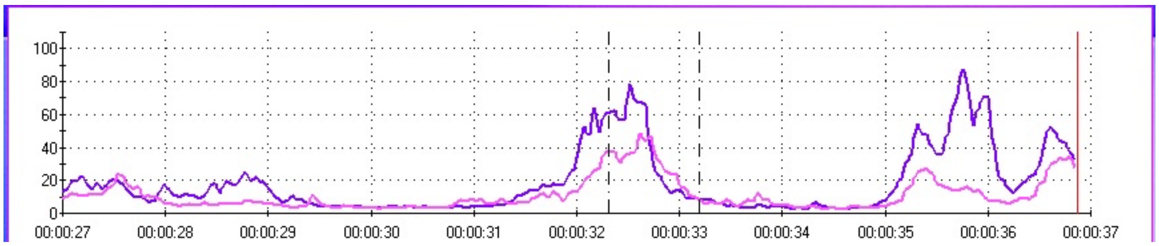
1.



2.

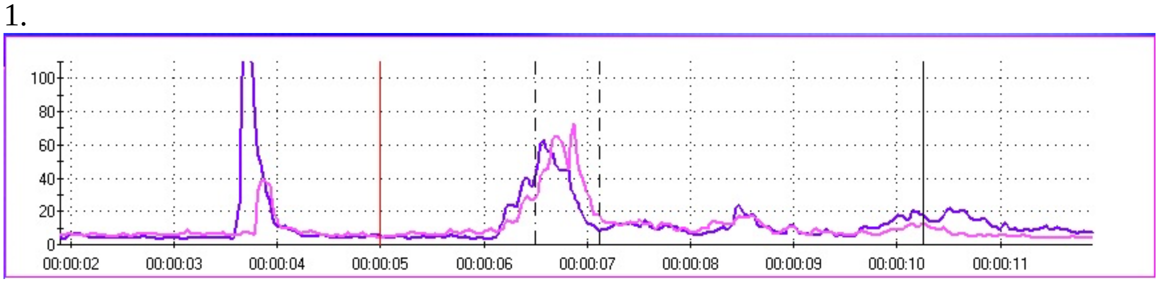


3.

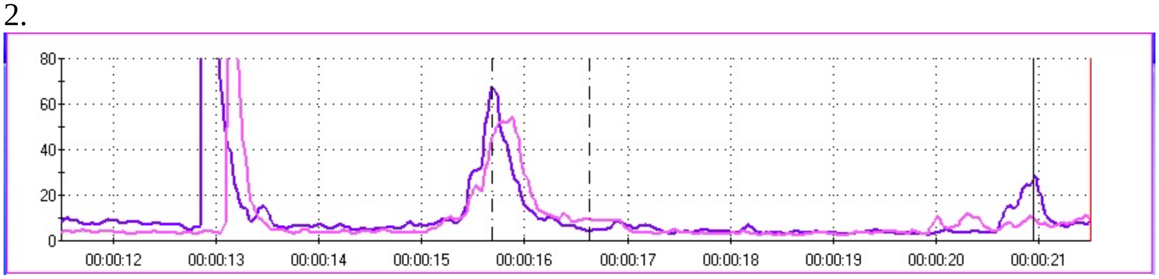


LE water:

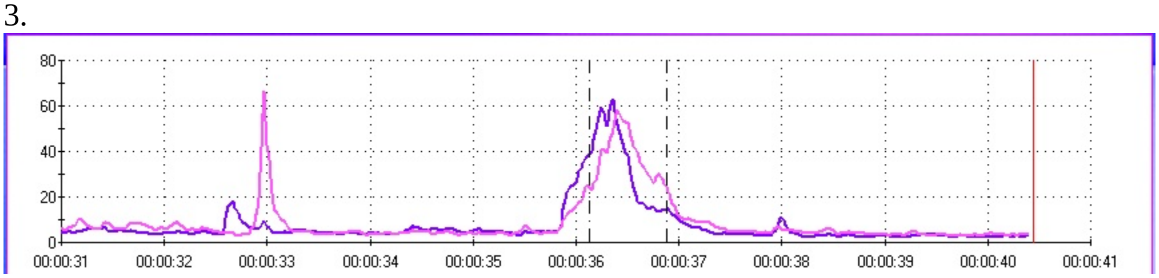
1.



2.

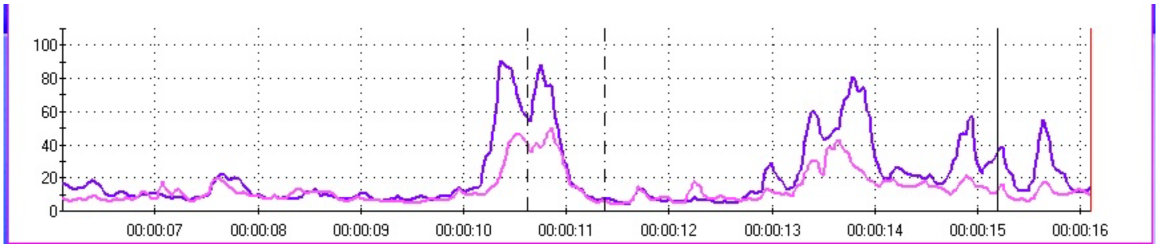


3.

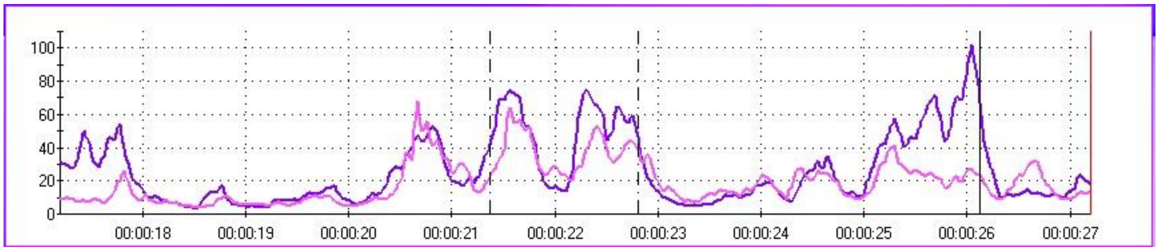


LE triscuit:

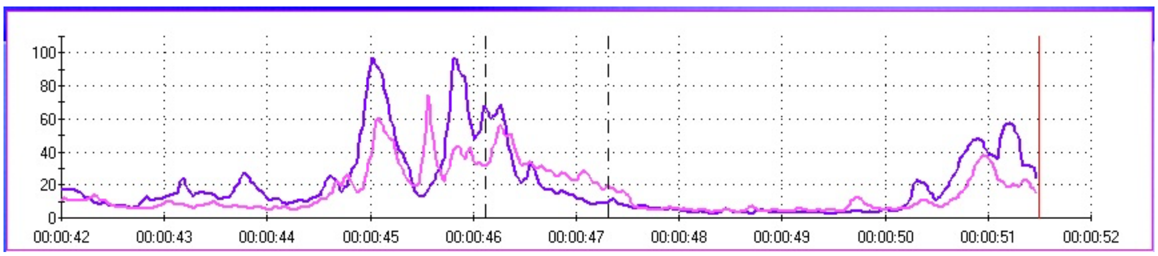
1.



2.



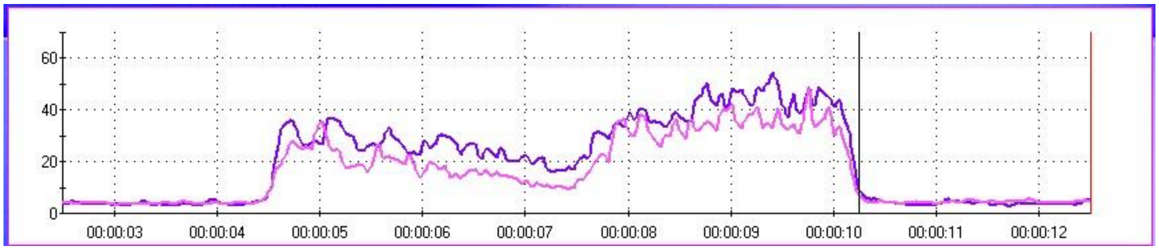
3.



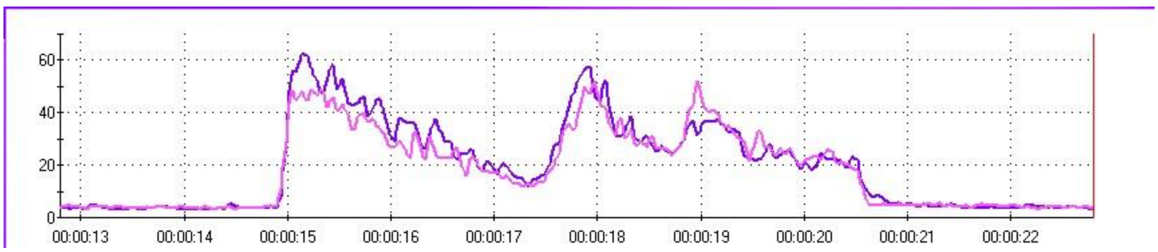
Appendix H: EMG Screenshots for Subject 2

Masseter Baseline:

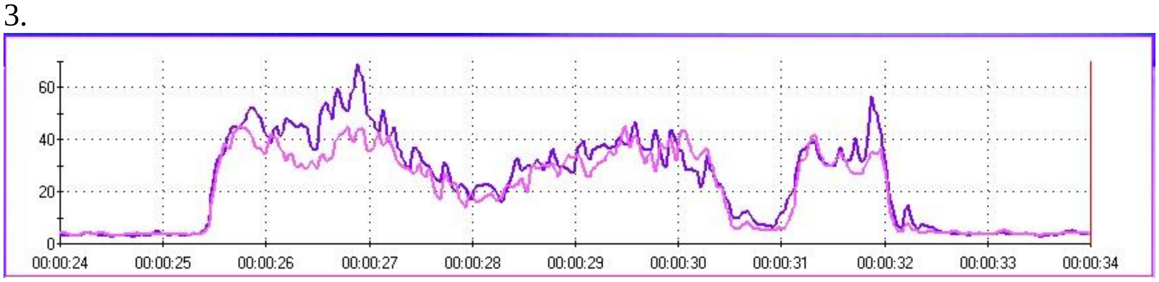
1.



2.

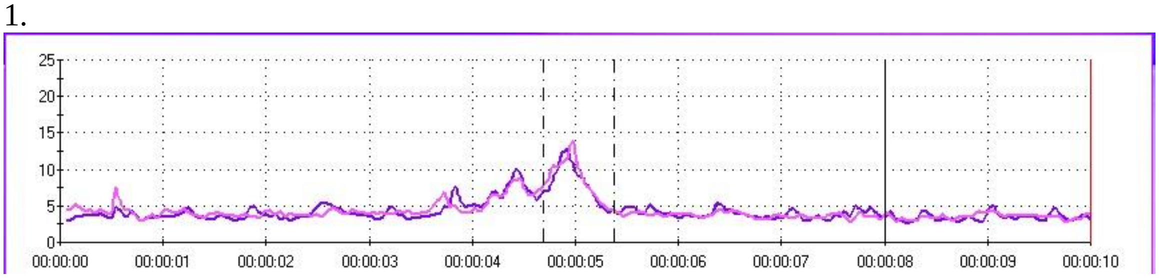


3.

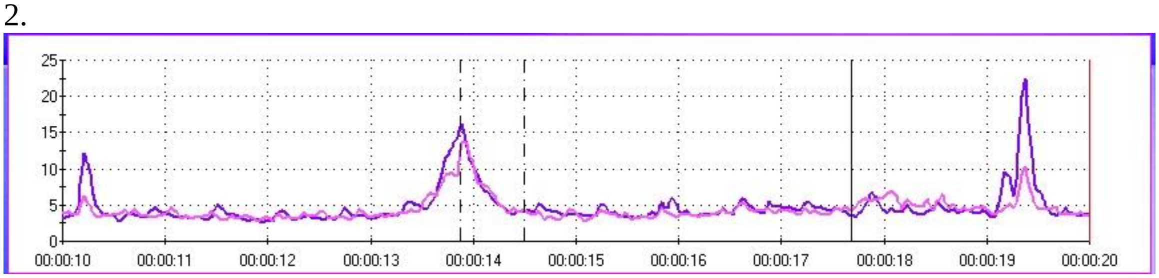


Masseter ½ t. pudding:

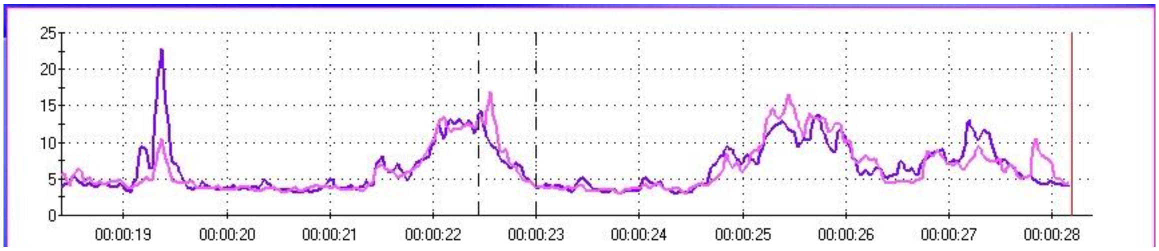
1.



2.

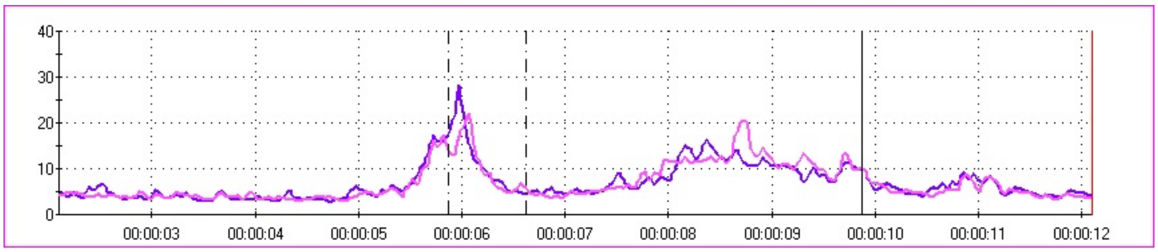


3.

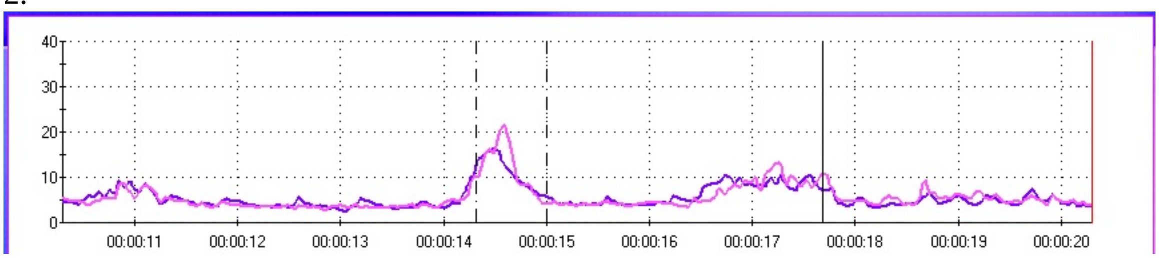


Masseter 1 ½ t. pudding:

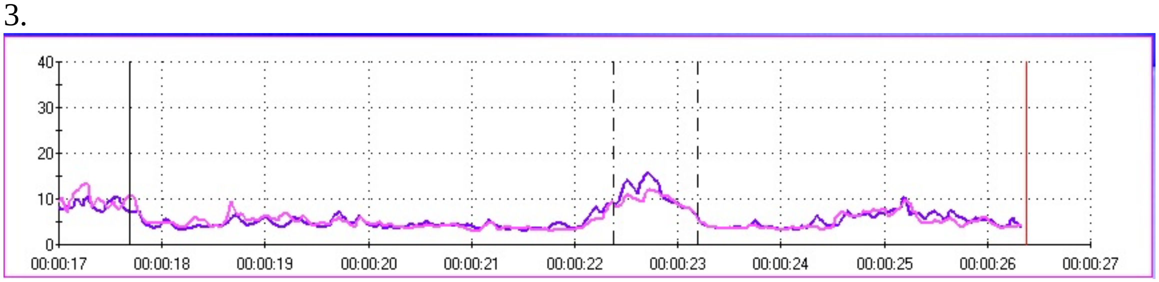
1.



2.

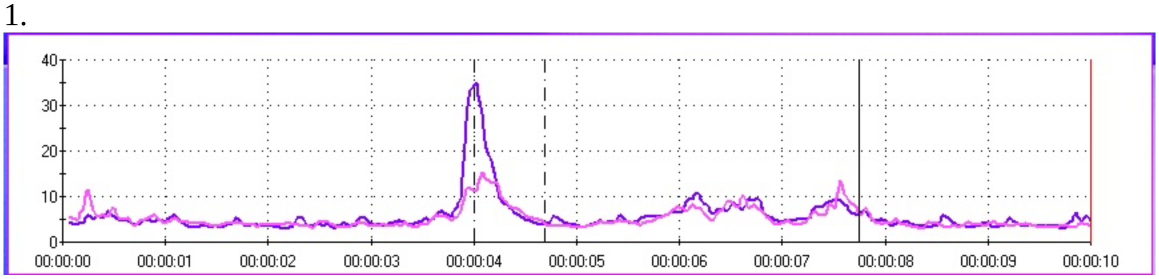


3.

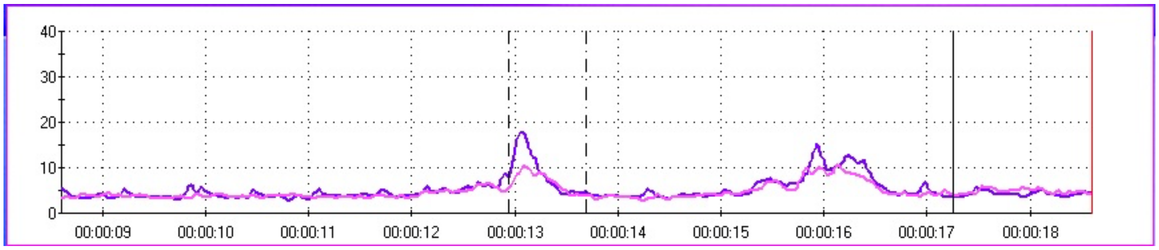


Masseter water:

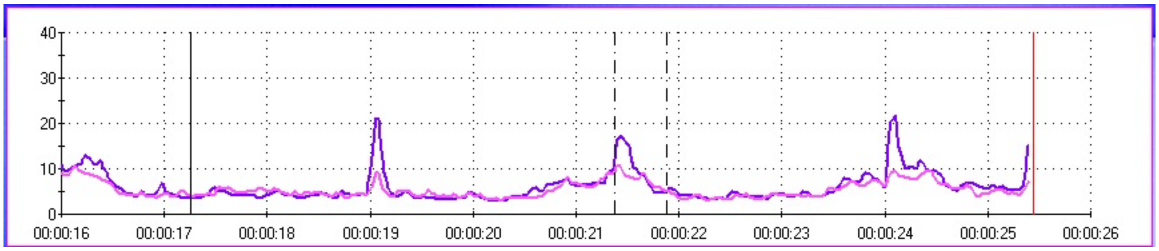
1.



2.

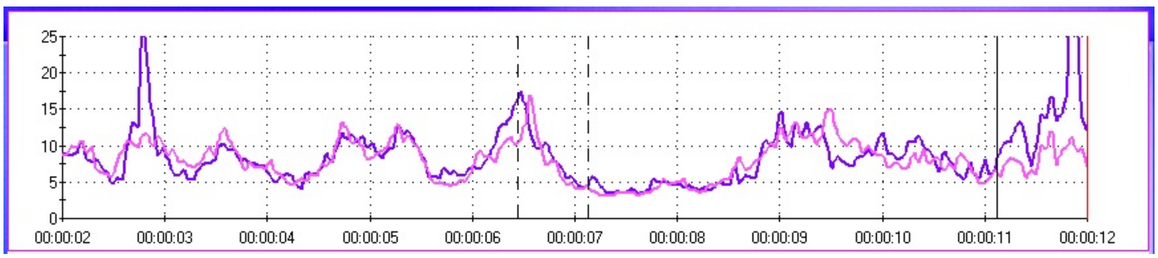


3.

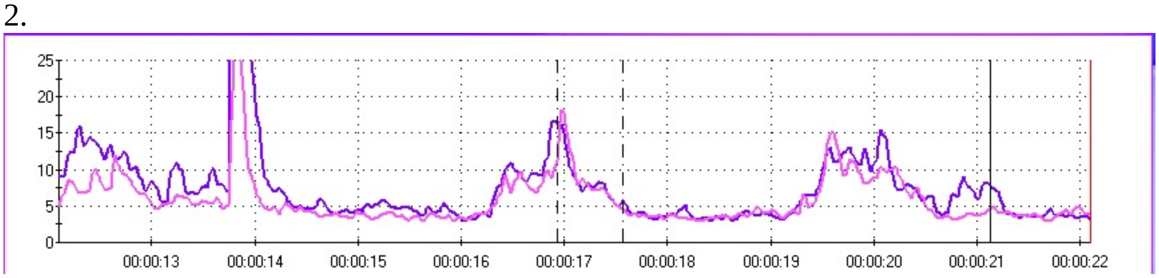


Masseter triscuit:

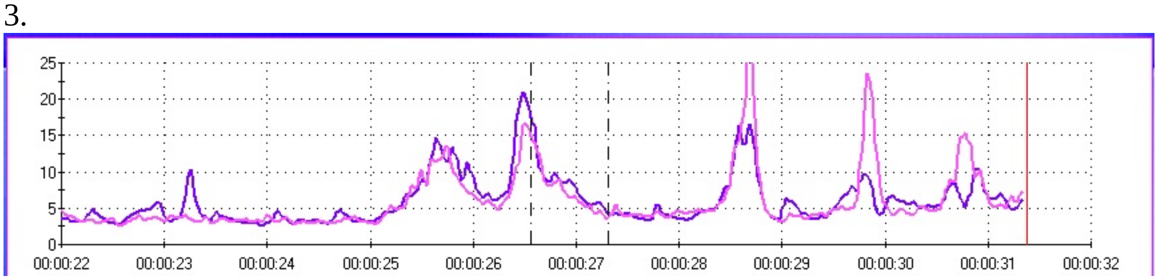
1.



2.

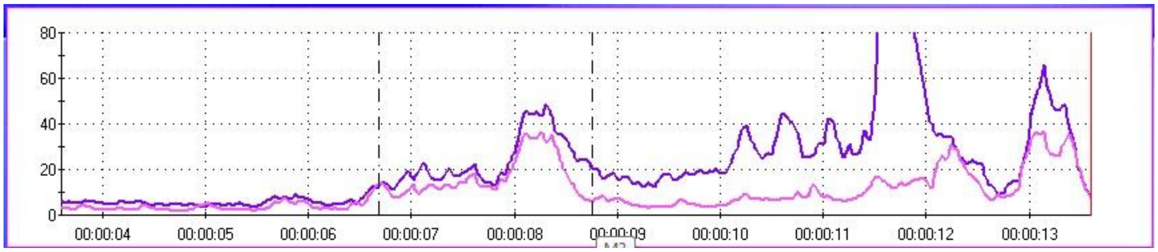


3.

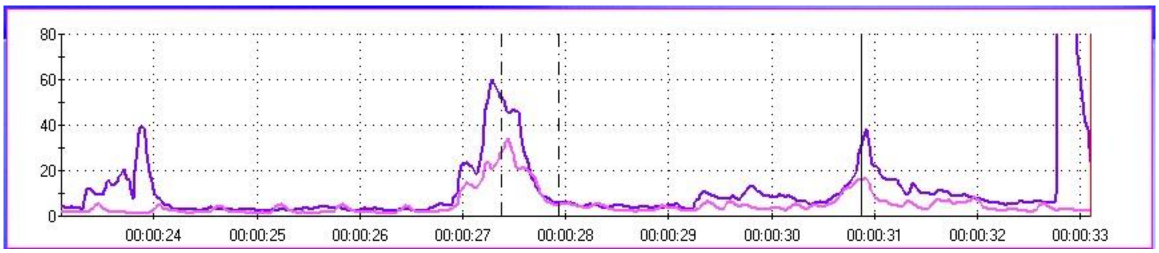


LE ½

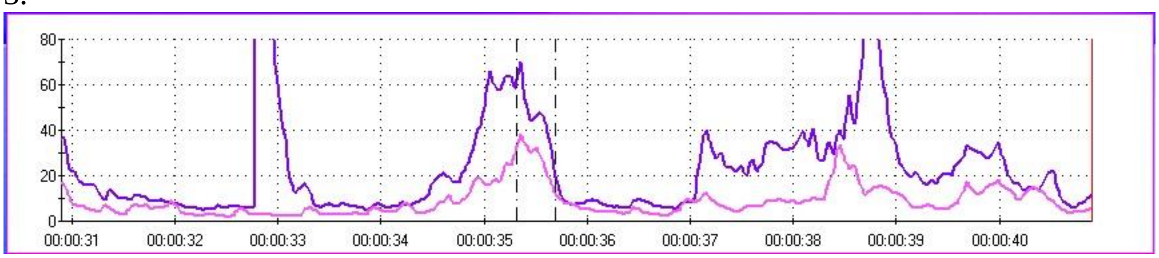
1.



2.

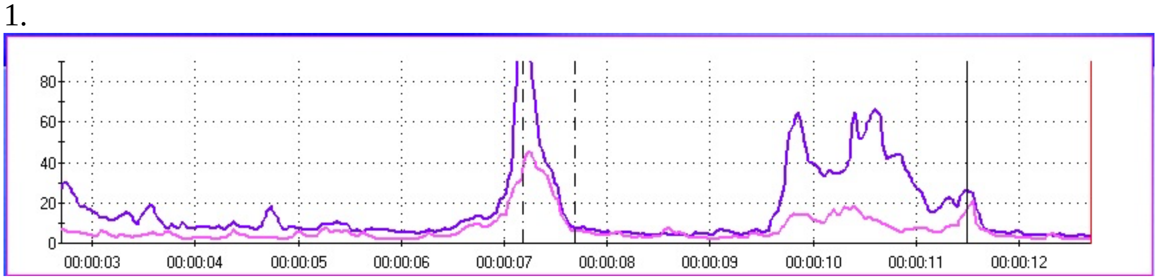


3.

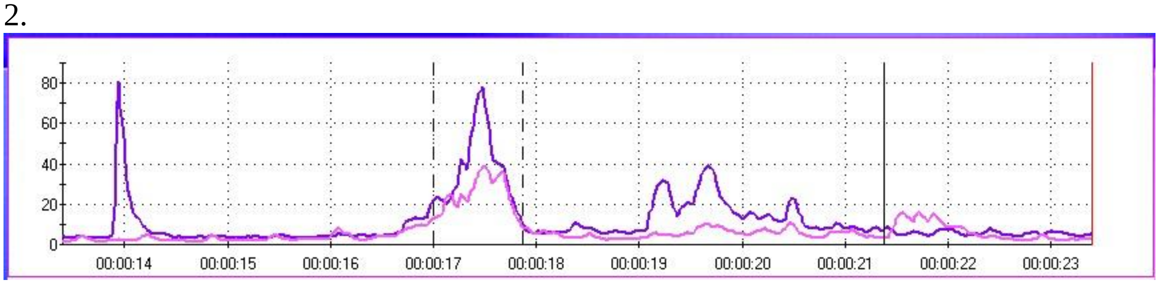


LE 1½:

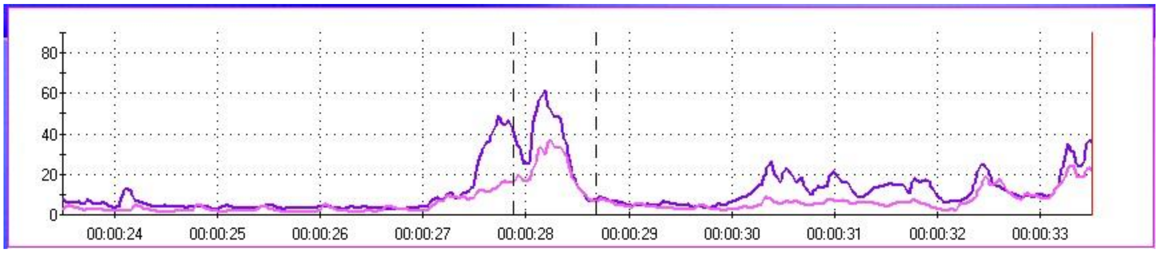
1.



2.

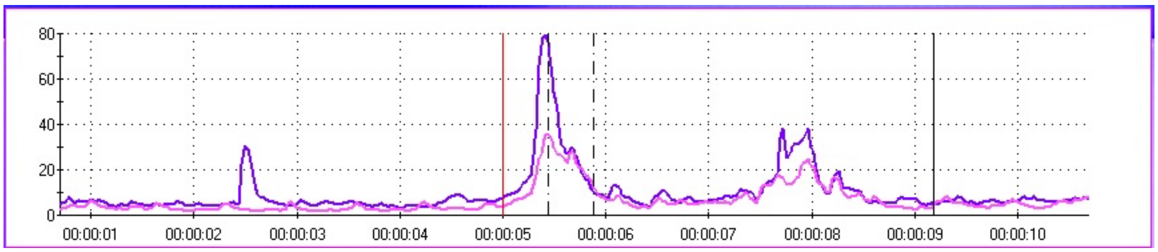


3.

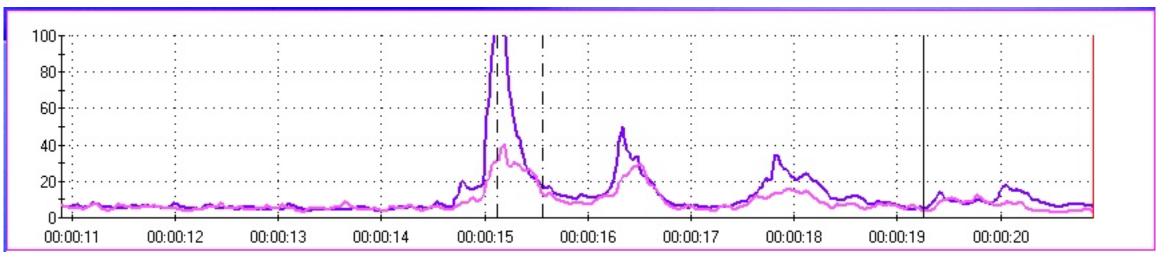


LE water:

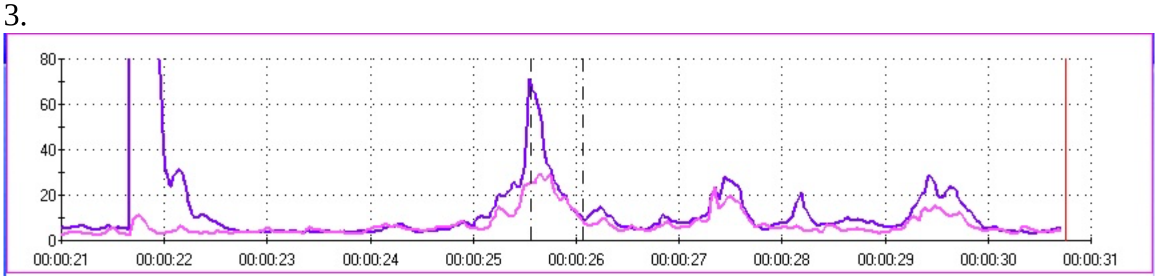
1.



2.

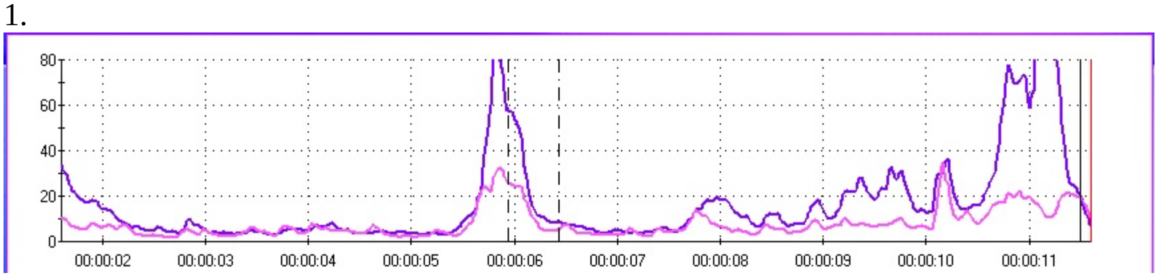


3.

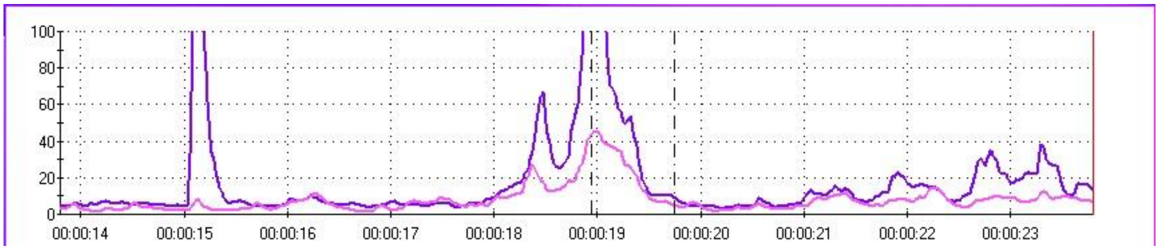


LE triscuit:

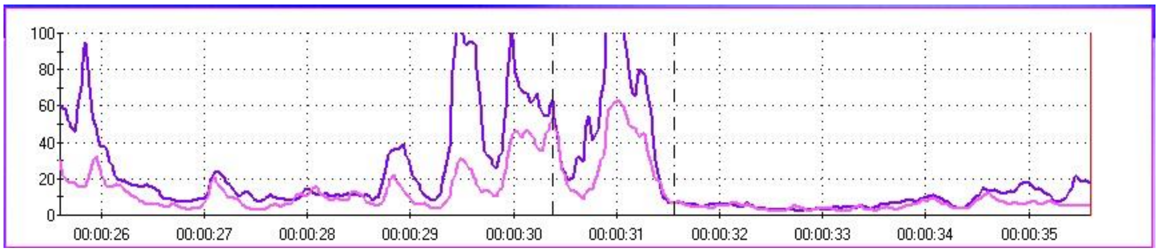
1.



2.


100
80
60
40
20
0
00:00:14
00:00:15
00:00:16
00:00:17
00:00:18
00:00:19
00:00:20
00:00:21
00:00:22
00:00:23

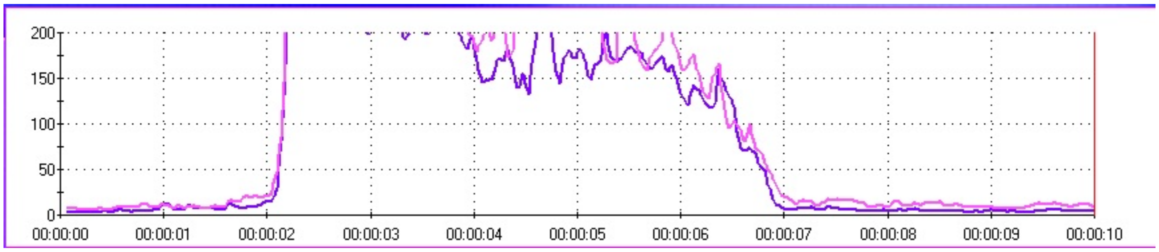
3.


100
80
60
40
20
0
00:00:26
00:00:27
00:00:28
00:00:29
00:00:30
00:00:31
00:00:32
00:00:33
00:00:34
00:00:35

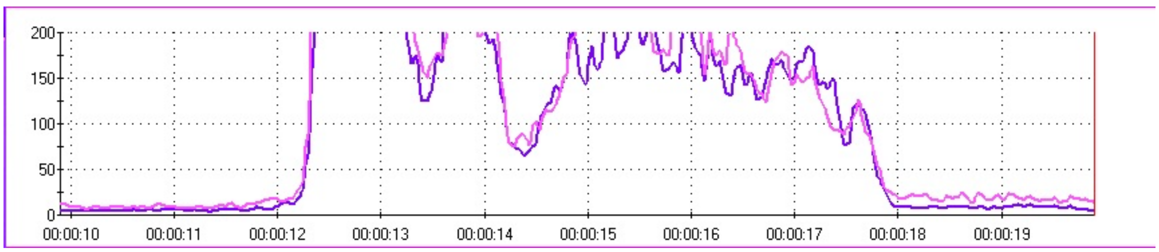
Appendix I: EMG Screenshots for Subject 4

Masseter Baseline:

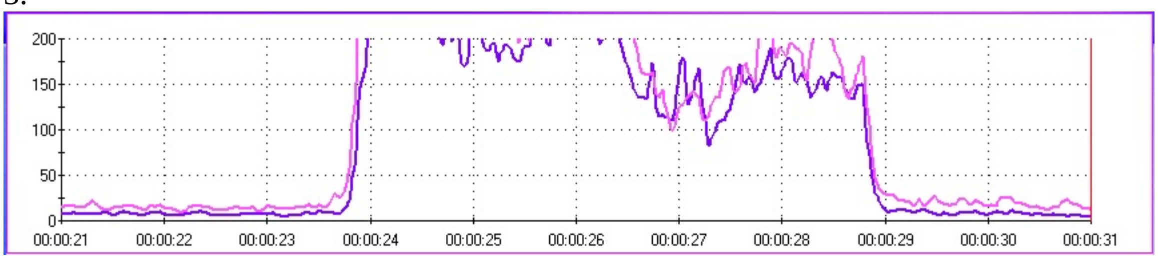
1.



2.

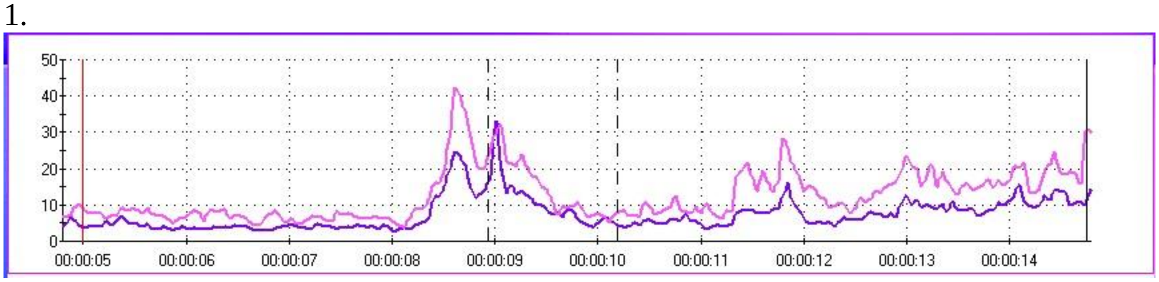


3.

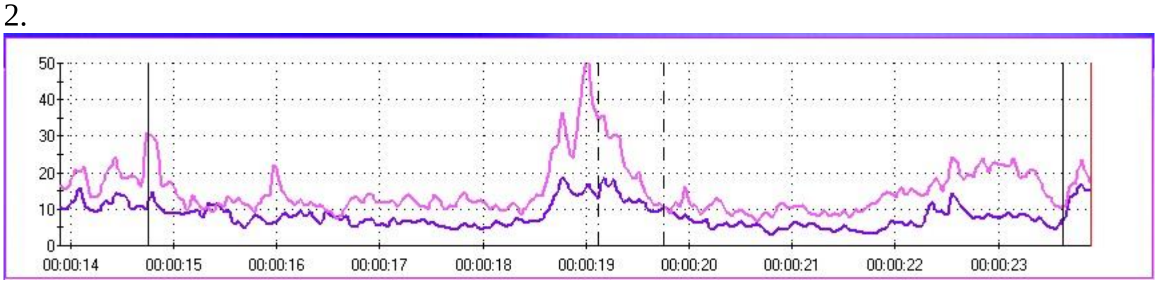


Masseter ½ t. pudding:

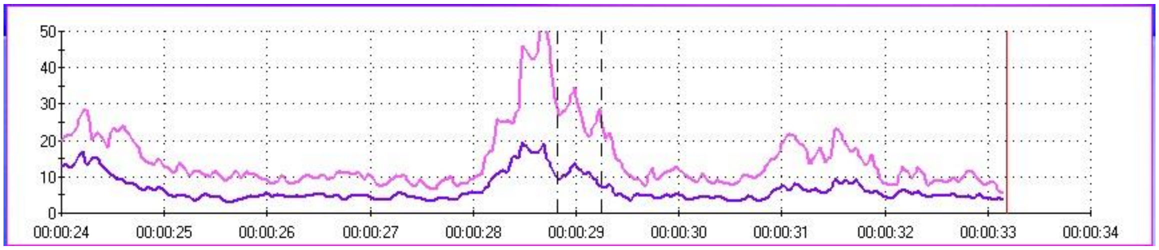
1.



2.

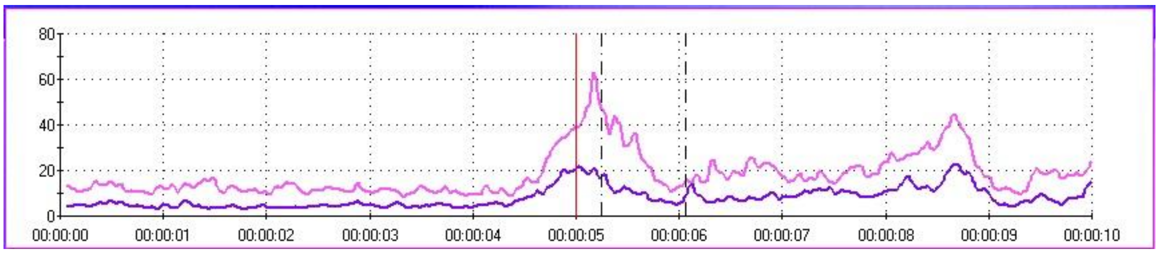


3.

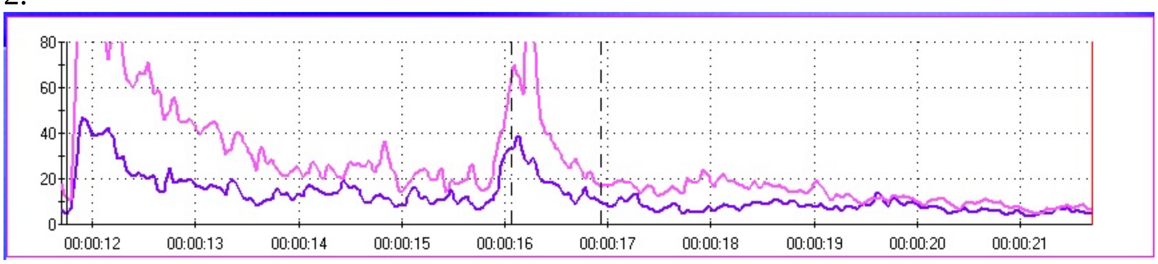


Masseter 1 ½ t. pudding:

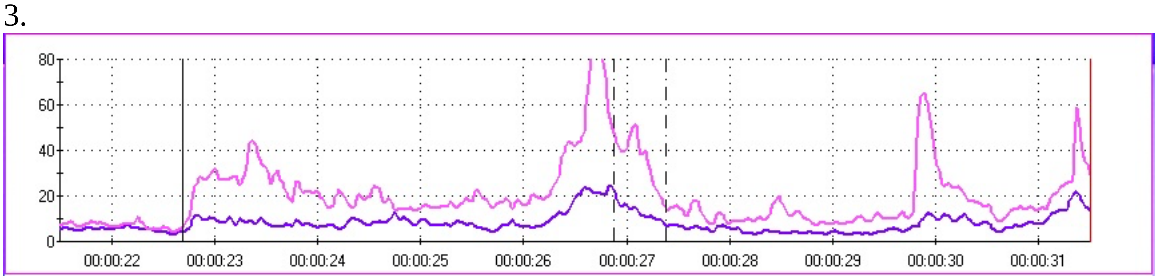
1.



2.

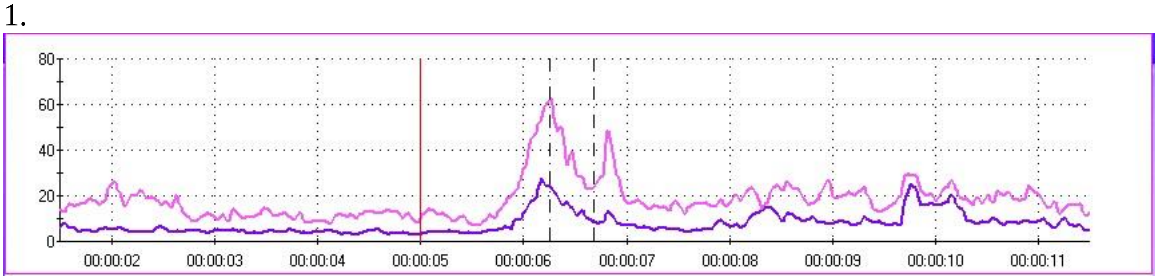


3.

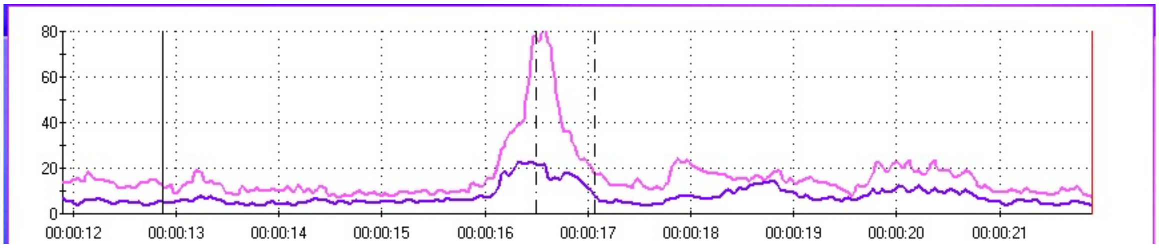


Masseter water:

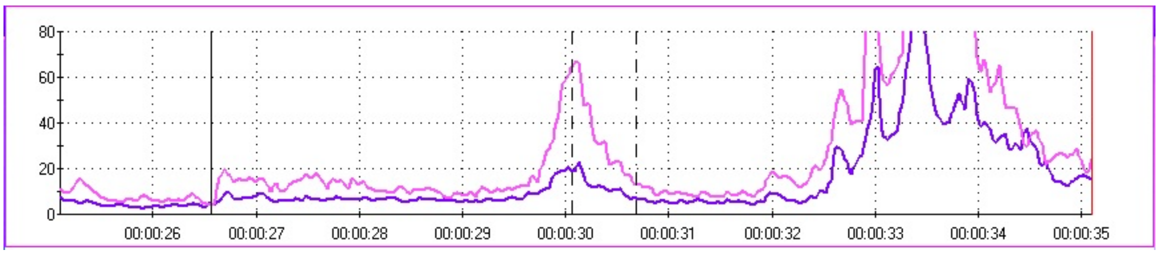
1.



2.

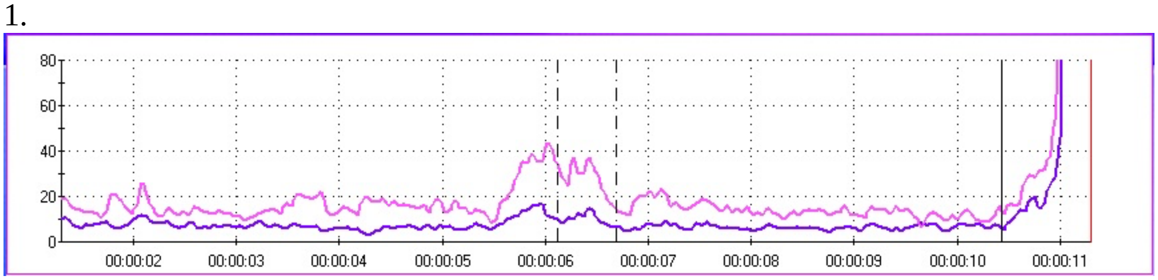


3.

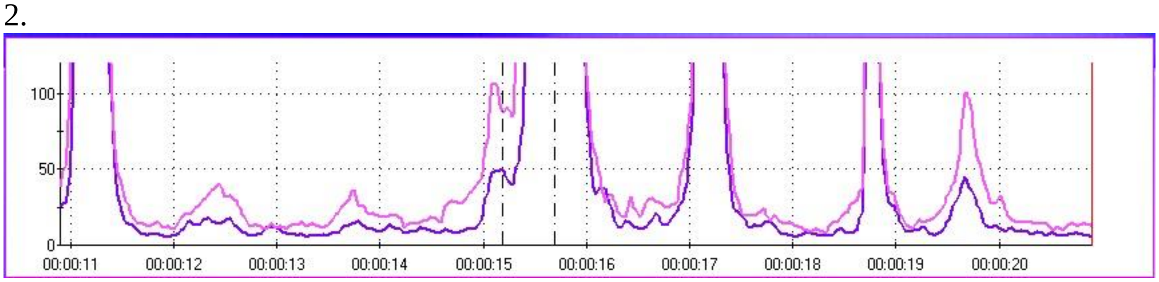


Masseter triscuit:

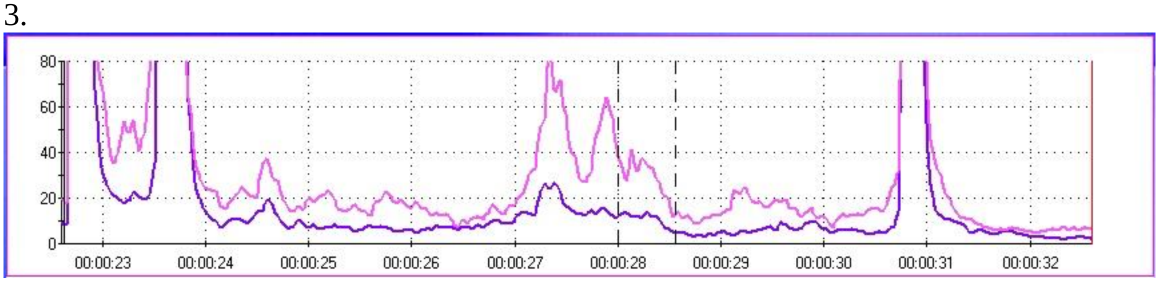
1.



2.

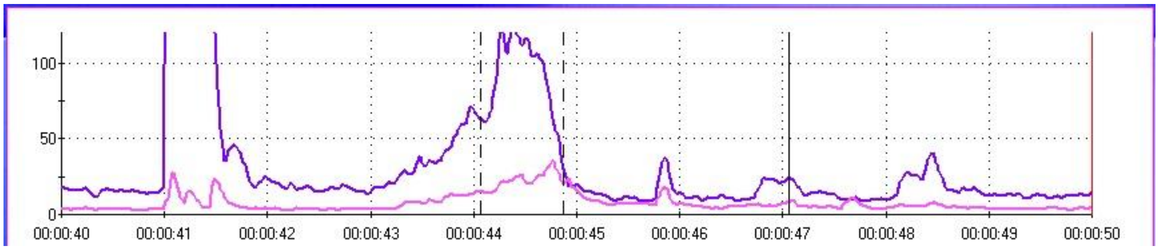


3.

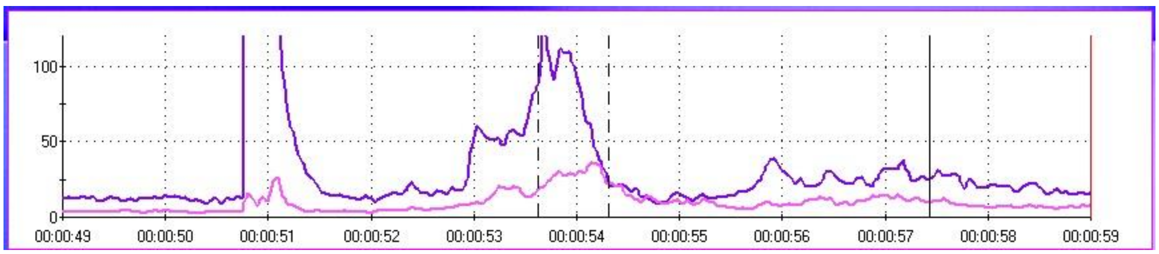


LE ½ t. pudding:

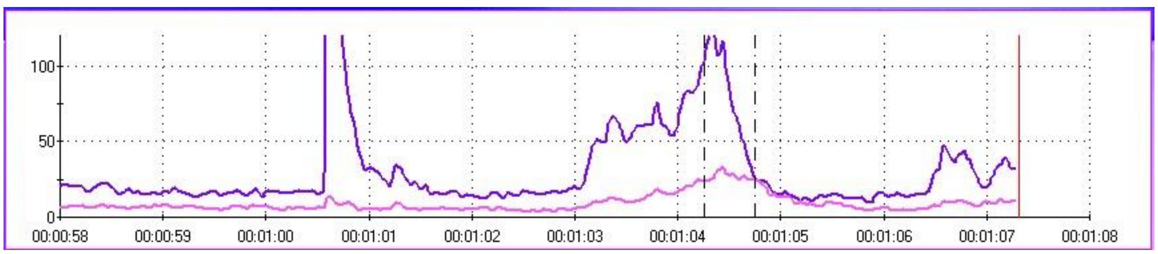
1.



2.

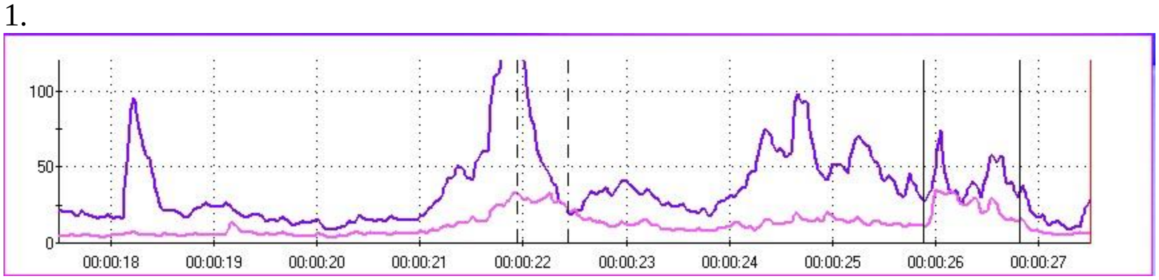


3.

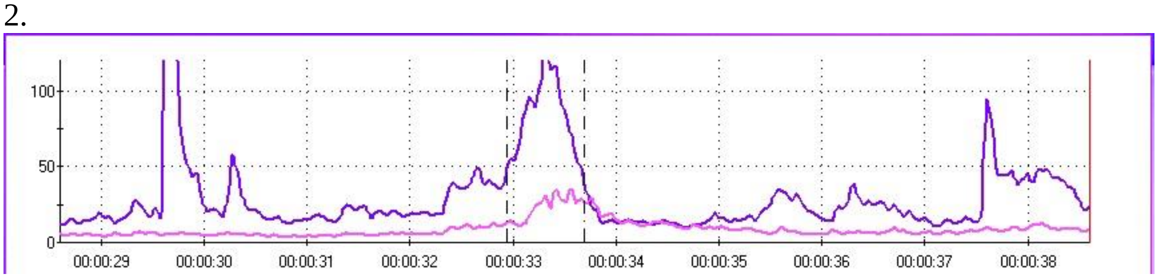


LE 1½ t. pudding:

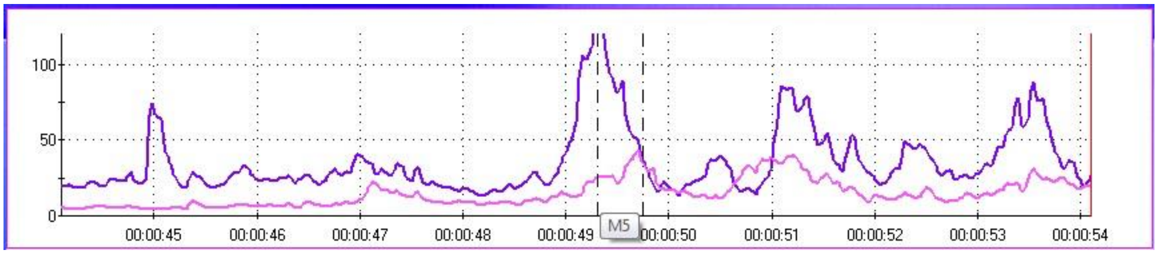
1.



2.

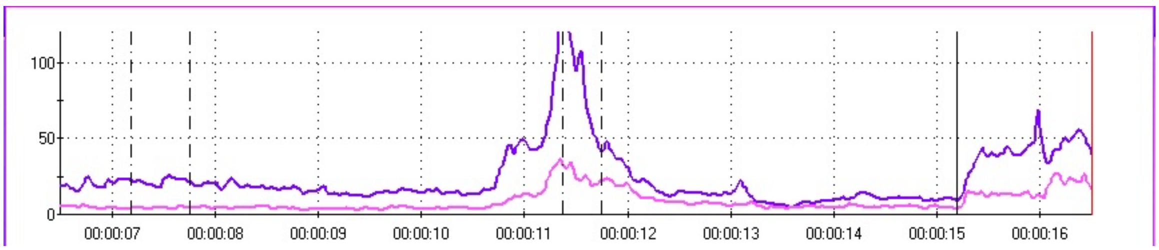


3.

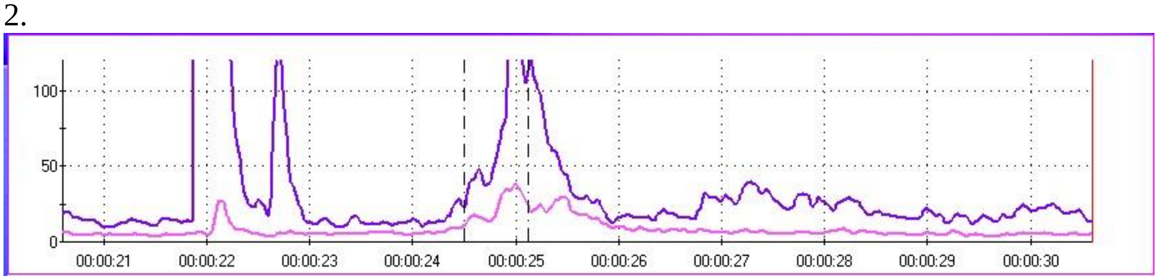


LE water:

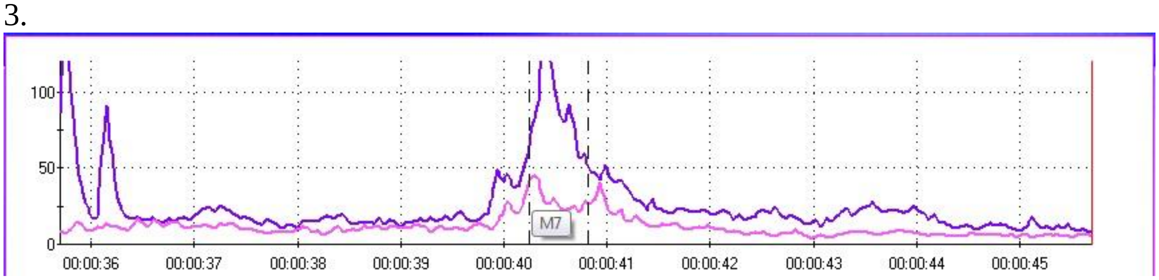
1.



2.

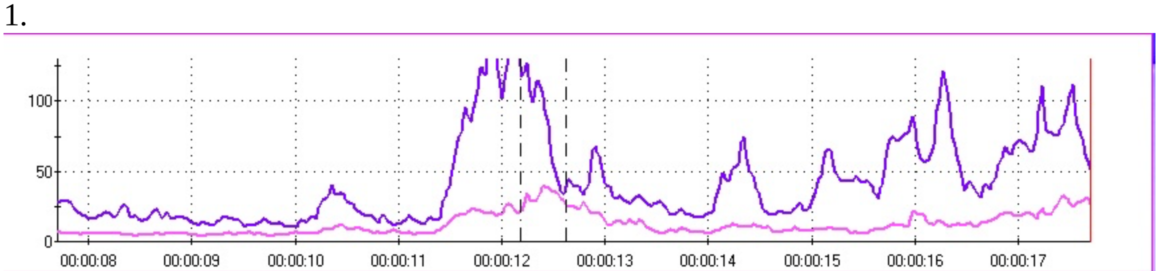


3.

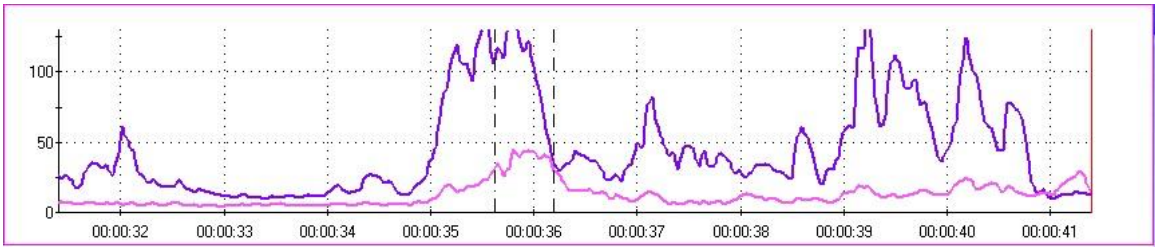


LE triscuit:

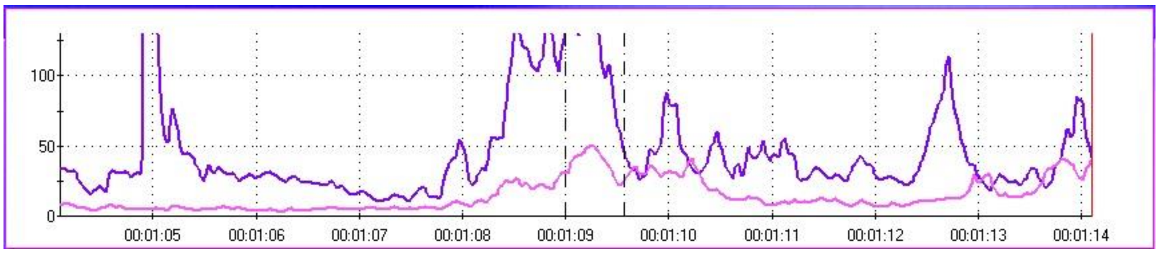
1.



2.


100
50
0
00:00:32
00:00:33
00:00:34
00:00:35
00:00:36
00:00:37
00:00:38
00:00:39
00:00:40
00:00:41

3.


100
50
0
00:01:05
00:01:06
00:01:07
00:01:08
00:01:09
00:01:10
00:01:11
00:01:12
00:01:13
00:01:14