**The Influence Of Food Texture And Liquid Consistency Modification On Swallowing Physiology And Function**

Steele 2015

- This systematic review identified major gaps in the understanding of the impact of liquid consistency and food texture on swallowing physiology, both in healthy and disordered populations.
- With respect to objective measures that might be used to guide the classification of thickened liquids and texture-modified foods, the review identified an absence of convention, particularly in terms of the shear rates that are used for reporting apparent viscosity.
- Exceptionally limited information is available for objective measurement of texture-modified foods.

**Changing Diet Texture**

Wright 2005

- Study evaluated dietary intake over the course of a day in hospitalized patients older than 60 years comparing intake in patients consuming a regular diet to those consuming a texture-modified diet.
- Patients on the modified diet had a significantly lower nutritional intake in terms of energy and protein.
- 54% of patients on a texture-modified diet were recommended a nutritional supplement, compared with 24% of patients on a regular diet.

**Changing Diet Texture**

Viganó 2011

- Compared with the normal diet the pureed and liquid diets were the ones with the most reduced:
  - energy (31.4% and 39.9%, respectively),
  - protein (45.4% and 79.8%, respectively)
  - lipid (41.0% and 76.0%, respectively) contents.

**Thickened Liquids**

- Despite the lack of evidence to support first-line use of thickened liquids, many clinicians continue to believe they are an effective intervention. (Wang 2016)
- In a 2005 survey of speech-language pathologists, respondents prescribed thickened liquids to 25% to 75% of patients with dysphagia. (Garcia 2005)
Thickened Liquids

**Steele 2015**

The Influence of Food Texture and Liquid Consistency Modification on Swallowing Physiology and Function: A Systematic Review

“Qualitative synthesis revealed two key trends with respect to the impact of thickening liquids on swallowing: Thicker liquids reduce the risk of penetration-aspiration, but also increase the risk of post-swallow residue in the pharynx.”

Thickened Liquids

- “No strong evidence is available supporting the use of thickened liquids as an intervention for patients with dysphagia.” Sura et al. 2012
- Dehydration occurred to a significant degree in the presence of thickened liquids. Logemann 2003

Thickened Liquids

Cicero 2013

Some complications that may arise from thickeners:
- Slow gastric emptying
- Increase risk of reflux
- Reduce appetite
- Hypotension
- Falls
- Constipation
- UTI
- Confusion
- Delirium
- Poor recovery from illness
- Delayed dissolution and disintegration of medications

Defining Physical Properties Of Fluids For Dysphagia Evaluation And Treatment

Robbins 2002

“The generally accepted clinical notion that manipulation of thicker (more viscous) substances reduces occurrence of aspiration, or modifies other bolus flow characteristics in dysphagic persons that produce an “improved swallow,” has little support, other than anecdotal, in the literature. Despite the paucity of data, the manipulation of thickness in the diet has become a cornerstone of dysphagia management practice.”

Thickening agents used for dysphagia management: effect on bioavailability of water, medication and feelings of satiety

Cicero 2013

- Dehydration may be due to physiological expectations that thick fluids will make them feel full
- Flavor suppression associated with increasing thickness provides little motivation to drink
- The muco-adhesive qualities of thickeners leave the mouth feeling sticky after a drink rather than wet, resulting in continuing unresolved feelings of thirst
- Administration of medication with thickened liquids needs careful consideration and consultation with a pharmacist as effects of delayed dissolution and disintegration have been demonstrated

The Horrible Taste Of Nectar And Honey

Inappropriate Use Of Thickened Liquids In Dementia

Wang 2016

“Use of thickened liquids reduces videofluoroscopic evidence of aspiration in older adults with dementia but does not reduce the 3-month risk of pneumonia in the same population.”
COMENSATORY TECHNIQUES

- Chin Tuck
- Chin Elevation
- Head Rotation to Weaker Side
- Head Tilt to Stronger Side
- Side lying
- Supraglottic Swallow
- Supero-Supraglottic Swallow

Chin Down/Chin Tuck

- Wheeler-Hegland 2009

- Collectively, evidence indicates that the chin tuck changes the anatomic relationships between structures involved in swallowing before the swallow and narrows the width of the airway entrance before the swallow.

- Therefore, the potential of the chin tuck to treat certain aspects of swallowing disorders is established and investigation into its efficacious value warranted.

- Leigh 2015

- Chin tuck facilitates airway protection and enhances tongue base retraction but possibly reduces UES opening.

- The effectiveness of chin tuck is related to the overall degree of dysphagia, the more severe the dysphagia, the less effective the maneuver. Saconato 2016

- Chin down position improved airway protection in patients with impaired swallowing safety during cup drinking with thin liquid barium in the upright position. The chin down maneuver did not lead to improved airway protection with teaspoon-sized thin liquid bolus volumes. Clinicians should not recommend the chin down maneuver without first ruling out detrimental effects and seeing evidence of its benefit in videofluoroscopy. Fraser 2012

Head Turn

- Logemann 1989

- Videofluoroscopic studies of swallowing in the normal subjects revealed that head rotation to either side increased upper esophageal sphincter opening diameter by an average of 2mm without affecting the period of UES opening or the oropharyngeal transit time.

- We conclude that head rotation can improve swallowing in patients with unilateral oropharyngeal dysphagia. Two potentially beneficial effects were observed:
  - functional exclusion of the relatively flaccid, weakened pharyngeal wall, and
  - reduced UES tone
When compared with a neutral head position, rotating the head to the left or right:
- increased pharyngeal contraction pressure at the level of the valleculae and pyriform sinuses on the side of rotation
- decreased UES resting pressure on the side opposite
- increased UES anterior-posterior opening diameter

"Studies have laid a foundation for use of the head rotation as a compensatory mechanism for dysphagia characterized by unilateral weakness or possibly by increased tone and resistance to opening at the UES."

Use of supraglottic maneuver during swallowing resulted in minimal change in the timing or extent of tongue base movement. Therefore the patient continued to have significant pharyngeal/vallecular residue after the swallow and to aspirate Langmore 1998

Overall, results of the physiological study of the supraglottic swallow indicate that it does close the vocal folds earlier in the swallow while concurrently prolonging hyolaryngeal excursion. The original purpose of the technique to treat dysphagia accompanied by reduced or late vocal fold closure is supported by physiological findings.

Results show that these two swallowing maneuvers, which are known primarily as techniques to protect the airway, also function to strengthen the tongue pressure produced by the contact between the tongue and the hard palate during swallowing and this effect is more pronounced during the super supraglottic swallow.

**AREAS OF BREAKDOWN**
- Weakness
- Motor Planning/Skill
  - Behavior Changes
  - Neurological Dysfunction
- Multifactorial

**REHABILITATION**
NEUROPLASTICITY

Factors supporting the rehabilitation potential of many patients with dysphagia:

- Dysphagia research and clinical evidence indicate that positive neuroplastic changes are possible even in the presence of chronic conditions, multi-system atrophy and advanced age.

**NEUROPLASTIC PRINCIPLES**

- Use it or lose it
- Use it and improve it
- Repetition matters
- Intensity matters
- Plasticity is experience specific
- Salience
- Difficulty
- Transference
- Interference

Klein 2008
Robbins 2008
Plowman 2016

TRIALS

Klein et al 2002

Strength Exercise Fundamentals

A fundamental requirement of strength exercise is "overload". To increase the force-generating ability of a muscle, it must be progressively challenged at a sufficient intensity. (Wheeler-Hegland 2008)
Exercise Fundamentals

- These early alterations in neural activity can improve force production, coordination, and precision of movement.
- As training progresses, strength gains then appear to be more the result of morphologic changes within the muscle tissues because the relative contribution of neural factors decreases.
- Burkhead-Morgan et al 2007

Basic Exercise Principles

- Individual differences
- Overload
- Specificity
- Progression
- Adaptation
- Use/Disuse
- Reversibility

INDIRECT SWALLOWING INTERVENTIONS

THE EFFECT OF TONGUE STRENGTH ON MEAL CONSUMPTION IN LONG TERM CARE
Namasivayam 2015

- Tongue pressure measurement has been shown to hold promise as an indicator of poor meal consumption for elderly residents in long term care.
- There was a clear difference in tongue strength between LTC residents who showed signs of swallowing difficulty at mealtimes and those who did not.
- Reduced tongue strength was also associated with:
  - longer meal times,
  - reduced food intake and the
  - presence of observable choking and coughing at the meal

In General

IOPI/Swallow Strong Outcomes

- Increased swallowing pressures
- Airway invasion was reduced for liquids
- Lingual muscle volume increased

Outcomes of tongue-pressure strength and accuracy training for dysphagia following acquired brain injury
Steele 2013

- Findings suggest that tongue–palate pressure generation plays a pivotal role in establishing the overall strength of a swallow.
- Tongue-pressure plays a primary role in controlling the flow of liquids through the mouth and pharynx.
- The tongue is responsible for initiating the driving forces that propel liquids and foods through the oropharynx into the esophagus.
- When tongue-pressure generation is impaired, liquids may spill into the pharynx before the airway is protected, or bolus clearance may be impaired, leaving residue in the pharynx.
Outcomes Of Tongue-Pressure Strength And Accuracy Training For Dysphagia Following Acquired Brain Injury Steele 2013

- All six participants in this study achieved increases in either anterior or posterior tongue strength.
- Even the participants with dysphagia of longer than 18 months chronicity demonstrated convincing improvements in both anterior and posterior tongue strength.
- Tongue-pressure resistance exercises, practiced 2-3 times weekly are an effective method for increasing tongue strength in individuals with neurogenic dysphagia.
- Five of the six patients displaying aspiration on thin liquids showed resolution of this impairment.
- Did not observe any positive trends with respect to improved bolus clearance and reduced residues in the valleculae and pyriform sinuses.

SHAKER Antunes 2012

Systematic Review

- Nine studies were included in the review.
- Reported Effects:
  - Increase in the anterior excursion of the larynx.
  - Increase in diameter of the upper esophageal sphincter opening.
  - Elimination of dysphagic symptoms.

ELECTRICAL STIMULATION

The Effects Of Vitalstim On Clinical And Research Thinking In Dysphagia Logemann 2007

"The reaction to Vitalstim was from clinicians eager to offer a uniform treatment procedure to their oropharyngeal dysphagic patients without the need for careful assessment of the patient’s swallow physiology to define the specific swallow problems from which the patient was suffering. Vitalstim gave some clinicians an “easy out” from understanding each patient’s underlying swallow physiology; if they so desired. Unfortunately, this led to a large market for Vitalstim among clinicians and desperate patients willing to ‘try anything’ whether or not it had a firm scientific base and known efficacy.”

Neuromuscular Electrical Stimulation Versus Traditional Therapy In Patients With Parkinson’s Disease And Oropharyngeal Dysphagia Heijnen 2011

- Eighty-eight patients were randomized over three treatment groups:
  - Traditional therapy
  - Treatment combined with NMES at sensory level
  - Treatment combined with NMES at motor level
- All groups showed significant therapy effects. However, only slight non significant differences between groups were found.

Electrical Stimulation Meta-analysis Carnaby 2007

- Two researchers independently performed data extraction.
- 81 studies reviewed but only 7 met criteria.
  - Methodology
  - Quantitative Analysis
  - Publication Bias
In conclusion, this preliminary meta-analysis examining the effectiveness of NMES has shown a small statistically significant improvement in clinical swallowing performance for adult dysphagic patients receiving this form of treatment.

A systematic review reveals that surface NMES to the neck has been most extensively studied with promising findings, yet high-quality controlled trials are needed to provide evidence of efficacy.

We need to improve our understanding of the effects of e-stim in specific types of disorders and specific levels of severity before we can widely apply the treatment to the general dysphagic population.

• 60 participants with PD completed EMST 4 weeks, 5 times per week using a calibrated or sham device
• The EMST group demonstrated improved swallow safety as evidenced by improved Penetration-Aspiration Scores.
• The EMST group demonstrated improved hyolaryngeal function.
• The EMST group displayed improve airway closure

• 71 year old male with spinal onset ALS was provided with expiratory muscle strength training
• Maximum expiratory pressure declined 9% over an 8-week sham training period
• Expiratory pressure improved 102% following 8 weeks of actual training
• Improvements in maximum expiratory pressures were maintained for 6 months following training

68 participants with PD completed EMST 4 weeks, 5 times per week using a calibrated or sham device
The EMST group demonstrated improved swallow safety as evidenced by improved Penetration-Aspiration Scores.
The EMST group demonstrated improved hyolaryngeal function.
The EMST group displayed improve airway closure

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Impact Of Expiratory Strength Training In ALS Plowman 2015

- 25 ALS patients participated
- Patients completed a 5 week EMST protocol
- There were significant improvements in maximum expiratory pressures
- Maximum hyoid displacement during swallowing occurred
- No significant differences were observed for PEs or cough spirometer measures

DIRECT SWALLOW INTERVENTIONS

Comparison Of Effortful And Noneffortful Swallows In Healthy Middle-aged And Older Adults Hind 2001

- Sixty-four healthy men and women between 45 and 93 years of age from the community participated
- Participants swallowed 3-mL, thin liquid boluses both normally and using the effortful swallow strategy
- The biomechanics and bolus flow patterns of swallows were analyzed from videofluoroscopic and simultaneous oral pressure data
- Subjects at all ages generated significantly increased oral pressure using the effortful swallow

EFFORTFUL SWALLOW

Comparison Of Effortful And Noneffortful Swallows In Healthy Middle-aged And Older Adults Hind 2001

- Several durational measures were significantly longer with the effortful swallow including:
  - Hyoid maximum anterior excursion
  - Laryngeal vestibule closure
  - Duration of the upper esophageal sphincter opening
- The hyoid bone moved further in the superior direction with the effortful swallow
- There was a trend of decreased oral residue with the effortful swallow

Timing Of Pharyngeal And Upper Esophageal Sphincter Pressures As A Function Of Normal And Effortful Swallowing In Young Healthy Adults Hiss 2005

- Eighteen adults, nine males and nine females
- Timing of pharyngeal pressure and onset and duration of UES relaxation were measured across ten trials of normal and ten trials of effortful swallows
- The effortful swallow elicited longer pharyngeal pressure and UES relaxation durations
Fourteen normal subjects swallowed multiple, 5-ml water boluses using three techniques: normal swallow, effortful swallow, and the Mendelsohn maneuver.

Effortful swallow increased maximum velopharyngeal pressure.

Effortful swallow increased minimum UES pressure.

The effect of an effortful swallow on the healthy adult esophagus was investigated using concurrent oral and esophageal manometry on ten normal adults while swallowing 5-ml boluses of water.

Effortful swallowing resulted in significantly increased peristaltic amplitudes within the distal smooth muscle region of the esophagus, without affecting the more proximal regions containing striated muscle fibers.

The results of this study hold tremendous clinical potential for esophageal disorders that result in abnormally low peristaltic pressures in the distal esophageal body, such as achalasia, scleroderma, and ineffective esophageal motility.

The effects of swallow condition (effortful vs. non-effortful) were examined for 18 adults via combined solid-state manometry and intraluminal impedance.

The effortful swallow condition yielded significantly higher esophageal amplitudes across all sensor locations.

Further, the effortful swallowing decreased the risk of incomplete bolus clearance when compared with non-effortful swallowing.

The effortful swallow offers a behavioral manipulation of the esophageal phase of swallowing, and future studies will determine its clinical potential for treating esophageal dysmotility in patient populations.

The impact of effortful swallows:

- Increased tongue to palate contact
- Improved hyolaryngeal elevation
- Hyolaryngeal anterior excursion
- Increase tongue contact with pharyngeal wall
- Increased/prolonged pharyngeal pressure
- Increased duration of UES opening
- Increase Velopharyngeal pressure
- Increased duration of LVC
- Increased esophageal peristalsis

The Mendelsohn maneuver was intended to volitionally augment UES opening by prolonging elevation of the larynx for an extended period of time during the swallow.

Mendelsohn 1989
The purpose of this study was to determine whether any lasting physiologic changes in swallowing function can occur from utilizing the Mendelsohn maneuver as an exercise. 18 participants with dysphagia post-stroke evaluated with videofluoroscopy after treatment using the Mendelsohn maneuver versus no treatment. Participants performed Mendelsohn maneuvers between 30 and 40 times in therapy sessions but did not use it when swallowing during VFSS examinations or when eating at home. Physiologic changes in the extent of hyoid movement during the swallow and concurrent opening of the UES occurred.

Mendelsohn Maneuver

Research suggests that because of the sustained muscle contractions, the Mendelsohn Maneuver may result in greater cortical stimulation. Benefits of the Mendelsohn Maneuver

- Increased hyolaryngeal excursion
- Increased hyolaryngeal elevation
- Increased duration of UES opening
- Increased timing and coordination

High-resolution Manometry Of Pharyngeal Swallow Pressure Events Associated With Effortful Swallow And The Mendelsohn Maneuver

Fourteen normal subjects swallowed multiple, 5-ml water boluses using three techniques: normal swallow, effortful swallow, and the Mendelsohn maneuver. Duration of velopharyngeal pressure above baseline increased significantly. Decreased UES pressure duration was prolonged by the Mendelsohn maneuver. An increase in tongue-base pressure duration occurred with the Mendelsohn maneuver, but this increase was not statistically significant.

Skill Based Therapy/Can the Swallow “Learn”?

Surface Electrical Stimulation Perturbation Context Determines The Presence Of Error Reduction In Swallowing Hyolaryngeal Kinematics

Peak hyolaryngeal elevation was perturbed during swallowing in 16 healthy adults with surface electrical stimulation in 2 different ways during videofluoroscopy: intermittent was applied only during swallowing, and continuous was applied during swallowing and during inter-swallow intervals. Although peak hyoid elevation was significantly lower at the start of the perturbation phase, LVC timing was maintained in these healthy adults. Estimates of fluid efforts showed that peak elevation gradually increased in the continuous group for both the hyoid and the larynx.

Historical Perspective

Historical approaches to swallowing rehabilitation have lacked specificity. Approaches have persisted with a strong bias toward a presumption of weakness and consequent strengthening tasks. Speech pathologists...should know from other areas within our domain, that this is unlikely to be the case.
Skill Based Training
Huckabee 2015

Skill-based training can be defined at a basic level as the acquisition of skill through functional repetition and refinement of movement patterns.

Skill Based Training
Huckabee 2015

Three key ingredients for successful skill acquisition include:
- specificity of practice
- task challenge
- feedback

Skill Training For Swallowing Rehabilitation In Patients With Parkinson’s Disease
Athukorala 2014

• Results: Immediately after post treatment, the swallowing rate for liquids, eEMG durational parameters of premotor time, and pre-swallow time improved. A functional carryover effect was seen from dry to water swallows.
• Swallowing related quality of life improved.
• Reassessment at 2 weeks after treatment termination revealed short-term retention of treatment effects.
• Conclusions: A skill-based training approach produced functional, biomechanical, and swallowing-related quality of life improvements in this cohort indicating compelling evidence for the effectiveness of this novel approach for dysphagia rehabilitation in PD.

TREATMENT CONSIDERATIONS

THE BOLUS AS A THERAPEUTIC TOOL

Pharyngeal Swallow Adaptations To Bolus Volume Measured With High-Resolution Manometry
Hoffman 2010

• Velopharyngeal duration, maximum tongue base pressure, tongue base pressure rise rate, UES opening duration, and total swallow duration varied significantly across bolus volumes.
• Maximum velopharyngeal pressures and minimum UES pressures had a direct relationship with increase in bolus volume.
• Velopharyngeal pressure duration, UES opening duration, and total swallow duration increased as bolus volume increased.
Effects Of Age, Gender, Bolus Condition, Viscosity, And Volume On Pharyngeal And Upper Esophageal Sphincter Pressure And Temporal Measurements During Swallowing

Butler 2009

"A volume effect was also found for upper pharyngeal pressure duration. One may expect that larger volumes would elicit longer pharyngeal pressure duration but actually, the opposite phenomenon was observed. It is plausible that a larger bolus can capitalize on its weight, velocity, and gravity better than a 5-mL bolus. A 5-mL bolus is more dependent on driving pressure durations from above to maintain an efficient bolus transit through the pharynx."

Variation In Temporal Measures Of Swallowing: Sex And Volume Effects

Molfenter 2013

- Increased bolus volume
  - Increases UES opening duration
  - Increases laryngeal closure duration
  - Speeds up pharyngeal transit time interval
  - Caused shorter temporal intervals between the closing of the laryngeal vestibule and opening of the UES

Deglutitive Tongue Force Modulation By Volition, Volume, And Viscosity In Humans

Pouderoux 1995

- Bolus viscosity induced an increase of tongue-pulsive force and clearing pressure by the oral tongue.
- There was no force adaptation with increased bolus volume
- The anterior two thirds of the tongue showed both greater forces and greater modulation than did the tongue base

Effect Of Bolus Consistency On Swallowing – Does Altering Consistency Help?

Raut 2001

- Increased bolus viscosity led to increased amplitude of the bolus wave and clearing contraction within the pharynx.
- Bolus consistency influenced the coordination of the swallow response with delayed pharyngeal clearance.

Effect Of Swallowed Bolus Variables On Oral And Pharyngeal Phases Of Swallowing

Dantas 1990

The major effects of high bolus viscosity were:
- To delay oral and pharyngeal bolus transit,
- Increase the duration of pharyngeal peristaltic waves,
- Prolong and increase UES opening

The Effects Of Taste And Consistency On Swallow Physiology In Younger And Older Healthy Individuals

Ding 2003

- Tasting salty or sweet substances, heightenend facial nerve activation because branches of the facial nerve innervate the taste buds in the more anterior fields which are more sensitive to salty and sweet tastes
- The posterior part of tongue and the upper pharyngeal regions are innervated by the glossopharyngeal nerve, which is more sensitive to sour and bitter tastes
- Under sweet and sour taste conditions, the submental and infrahyoid muscle activation started significantly earlier than in the no-taste condition
The Effect Of Bolus Viscosity On Laryngeal Closure In Swallowing Inamoto 2013

- The thicker bolus showed significantly longer oral and pharyngeal transit times and extended duration of pharyngeal peristaltic waves.
- With thin liquid, the bolus reached the hypopharynx earlier and remained in the hypopharynx longer than with thick liquid.
- The duration of laryngeal closure was significantly longer for liquid than for paste.

Progression Of Exercise

- Think systematically
- Measure presentations
- Increasing bolus size challenges timing, triggering and coordination
- Increasing bolus viscosity/texture challenges strength
- Most patients with dysphagia demonstrate problems in both areas
- Sour/tart can speed up the swallow
- Carbonation may decrease penetration/aspiration
- Cold or hot can speed up the swallow

CONCLUSION

- What are my patient’s wishes?
- What physiological deficits that need to be rehabilitated?
- What are the research based interventions?
- Do I have a strong rationale?

Determining Clinical Appropriateness Of Intervention

- Where did you hear about it? Most responsible researchers will willingly offer their work for peer review and critique as a necessary step in working toward acceptance. Thus, research that eventually makes it to press has a much higher chance of presenting unbiased and well-substantiated information.
- Critically evaluate even what you read in journals with a keen eye on methodology, underlying theoretical support, and evaluative measures.
- Search the literature for replications of the research that supports the technique.
- Consider the professional and personal implications of utilization of the technique as being equally important as the possible implications for patient care.
- Recall your responsibility to the ASHA Code of Ethics under which we all practice.

Suggestions for Critical Evaluation of an Approach Huckabee 1997

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