STUDY PROTOCOL

PHYSIOLOGICAL FLOW OF LIQUIDS IN HEALTHY SWALLOWING

(Experiments 2 and 4 of

***Physiological Flow of Liquids Used in Dysphagia Management*)**

NCT04114617

PI: Catriona M. Steele, Ph.D.

Swallowing Rehabilitation Research Laboratory

Toronto Rehabilitation Institute – University Health Network

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1. Introduction

This protocol covers two experiments (experiments 2 and 4) that form part of a larger project entitled Physiological Flow of Liquids Used in Dysphagia Management. The project has been submitted to the National Institutes of Health for R01 funding, and has scored at the 9th %ile. Confirmation of funding is expected by October, 2015.

The overall goal of the project is to collect measurements of liquid flow through the oropharynx (i.e., mouth and throat) during swallowing. The factors that are expected to influence liquid flow include the liquid consistency (i.e., thin, slightly-thick, mildly-thick, moderately-thick, extremely thick) and the forces applied during swallowing (i.e., tongue pressures and swallowing muscle contraction). The objective is to determine how these factors interact to influence the flow of a liquid through the oropharynx, both in healthy adults and in adults who have swallowing impairment.

Experiments 1 and 3 of the project involve basic science bench experiments, in which we will develop and test the liquid stimuli for use in the subsequent human subject experiments. Experiments 1 and 3 involve collaboration with co-investigators Dr. Ben Hanson (University Colllege London) and Dr. Lisa Duizer (University of Guelph) and consultant Dr. David James (University of Toronto, Mechanical Engineering).

Experiments 2 and 4 (which comprise the focus of this protocol) will use the liquids developed in experiments 1 and 3 and collect measures of liquid flow and swallowing behaviour in healthy adults, i.e., those with no known swallowing impairment. Experiments 2 and 4 will take place at the Swallowing Rehabilitation Research Lab of the Toronto Rehabilitation Institute. Videofluoroscopy x-rays for Experiment 2 will be conducted on a purchased service basis in the diagnostic imaging department at the Toronto General Hospital.

Experiment 5 (for which a separate protocol will be submitted at a later date) will collect the same measures of liquid flow and swallowing behaviour in adults with swallowing impairment due to 5 different etiologies, and will be a multi-site study involving co-investigators Dr. Mark Bayley (Toronto Rehabilitation Institute – Brain and Spinal Cord Program), Drs. Anthony Burns and Cathy Craven (Toronto Rehabilitation Institute – Lyndhurst Centre – Brain and Spinal Cord Program), Drs. Douglas Chepeha and Andrew Hope (Princess Margaret Hospital Head and Neck Cancer Centre) and Dr. Emily Plowman (University of Florida, Gainesville).

2. Steering Committee

In addition to the PI, co-investigators and consultants named above, Dr. Julie Cichero and Mr. Peter Lam, who are co-chairs of the *International Dysphagia Diet Standardisation Initiative* (www.iddsi.org) will serve as consultants to the project. Together, this team of 12 key personnel will form the steering committee for the project. An annual face to face meeting and quarterly teleconference calls are planned for study oversight and progress review.

3. Purpose and Specific Aims

Dysphagia (swallowing impairment) is a serious condition, involving two primary functional concerns[1]:

1) the ability to swallow safely, without material entering the airway (penetration-aspiration);
2) the ability to swallow efficiently, without leaving residue behind in the pockets of the pharynx.

Impaired swallowing safety is linked to pneumonia[2] while impaired efficiency contributes to risk of malnutrition[3-8]. Dysphagia is estimated to affect 6.7% of hospital admissions in the USA with an annual attributable cost of $547 million[9, 10]. Dysphagia is common in the elderly[5, 11] and in individuals with stroke[12], brain injury[13], head and neck cancer[14-16], cervical spine injury or surgery[17], and developmental or neurodegenerative conditions[18-20]. When an individual presents with dysphagia, the most common intervention is to alter the consistency of the foods and fluids they consume[21, 22]. Thicker liquids flow more slowly (making them easier to control and making penetration-aspiration less likely). Pureed/ minced/soft foods are thought to be easier to transport than unaltered solid foods. **Despite the simplicity of these ideas, we lack evidence to guide the modification of food and liquid textures for clinical benefit.**

The National Dysphagia Diet(6), a guideline that is currently in use in the USA, describes four levels of liquid consistency: *thin*, *nectar-*, *honey-* and *spoon-thick* liquids. Although viscosity ranges are proposed for these categories, these lack empirical evidence. **Viscosity measurement is complex and not practical for caregivers, clinicians or institutional kitchens to perform.** A recent systematic review published by the *International Dysphagia Diet Standardisation Initiative* (IDDSI) concluded, "**there is a need to classify food and fluid behavior in the context of the physiological processes involved in oral transport and flow initiation"**[23]**.** We propose to take up this challenge with a pivotal and comprehensive study **to determine physiological-rheological correlates (i.e. bolus flow and swallowing kinematics) across a continuum of liquid consistency in healthy and disordered swallowing.** To do this, we will prepare starch- and gum-thickened liquids in 5 consistencies (*Level 0 - thin*, *Level 1 - slightly-thick, Level 2 - mildly-thick, Level 3 - moderately-thick* and *Level 5 - extremely-thick*) according to the IDDSI framework. Operational definitions for these consistencies have been developed by

IDDSI based on gravity-flow tests (i.e. practical tests that can be used to verify consistency at the time of preparation). The IDDSI gravity-flow testing method is illustrated in Appendix A. Experiments 1 and 3 will be basic science experiments to confirm the flow properties of these liquids and to identify barium and non-barium liquids with matching flow properties. In experiments 2, 4 and 5 we will use these liquids and collect time-linked videofluoroscopic measures of bolus flow and physiological measures of swallowing behavior (i.e. tongue pressures and submental muscle contraction patterns) **to determine the dose-response pattern of progressive increments of liquid thickening in adults with and without dysphagia**.

We have three specific aims, the first two of which will be addressed in this protocol:

Aim 1: To determine the relationship between bolus flow and healthy swallowing physiology. In Experiment 2, we will collect concurrent videofluoroscopic and physiological measures of swallowing (tongue pressure, electromyography [sEMG], nasal airflow) in healthy adults using barium stimuli across the continuum of liquid consistency. Significance: This will show the impact of consistency on bolus flow through the oropharynx, controlling for the forces used to initiate flow and propel the bolus.

Aim 2: To compare healthy swallowing physiology for barium versus non-barium stimuli. In Experiment 4, we will collect physiological measures of swallowing using barium and non-barium stimuli matched for consistency. Significance: This will determine how swallowing behaviors (tongue pressures, sEMG, nasal airflow, tracheal sounds and accelerometry, where captured) differ between barium and non-barium stimuli with matched consistency, enabling us to develop models of flow accounting for these differences.

Aim 3: To explore the relationship between bolus flow and swallowing physiology in dysphagia. In a future planned experiment (Experiment 5), we will collect concurrent videofluoroscopy and physiological measures of swallowing in adults with dysphagia using barium stimuli across the continuum of liquid consistency. We will study 5 groups in whom dysphagia is common: stroke; acquired brain injury; oropharyngeal cancer; cervical spine surgery/injury; and neuro-degenerative disease. Significance: This will enable us to identify the boundaries of *ideal* thickening (i.e., *not too thin* and *not too thick*), based on swallowing pathophysiology (altered pressure and force generation capacity).

4. Methods

Participants:

Experiments 2 and 4 will involve the participation of a single sample of participants in the following sub-groups:

i) 40 healthy adults, aged under 60 years old, recruited from the Toronto population at large;

ii) 40 healthy adults, aged over 60 years old, recruited from the Toronto population at large;

Participants will be asked to complete both experiments. Recruitment for Experiment 4 was terminated on July 24 2018 due to technical issues encountered with the equipment that could not be repaired by the manufacturer. The target age ranges for the age sub-groups in Experiments 2 and 4 have been selected based on our previous research, which suggests that significant age-related differences in tongue pressures in swallowing are detectable over the age of 60[24-27]. We will recruit an equal number of male and female participants within each age-group. Participants of all ethnic and racial groups will be accepted, however adequate comprehension of the English language consent documents will be required.

Exclusion Criteria:

- The healthy adult participants for Experiments 2 and 4 will be accepted into the study, provided that they have no prior history of swallowing, motor speech, gastro-esophageal or neurological difficulties, chronic sinusitis or taste disturbance.
- Individuals with a history of surgery to the speech or swallowing apparatus (other than routine tonsillectomy or adenoidectomy) will be excluded.
- Similarly, due to the requirement to swallow stimuli containing starch based thickeners, which carry a significant carbohydrate load, individuals with Type 1 Diabetes will be excluded.
- Due to the fact that neurological impairments comprise an exclusion criterion, individuals with cognitive communication difficulties that may hinder comprehension of the study documents will be excluded from this study.
- Individuals with known allergies to latex or medical adhesive will be excluded, due to the probability that these items will come into contact with the oral mucosa, neck, and chin areas during data collection.
- As a further precaution due to the use of radiation in experiment 2, we will exclude women who report current pregnancy and individuals who report that they have had an x-ray to the neck in the past 6 months.
- Finally, individuals who report that they are occupationally exposed to radiation will be advised that they should not participate if they believe their occupational radiation exposure may exceed half the allowed Ontario annual limit of 20 mSv.
- These exclusion criteria will be confirmed using a self-report questionnaire form at the time of intake into the study (see Appendix B). Any questions will be clarified through

discussion with the research assistant responsible for participant intake, and, where necessary with the principal investigator.

Children will not be involved in this protocol due to the use of radiation. Although the research questions are of interest for all ages, including children, we feel that it is most appropriate to answer the current research questions in adults before considering whether similar studies should be repeated in children. In particular, the variety of physiological variation we detect in both healthy adults and those with dysphagia will help to determine whether a future study involving healthy children requires videofluoroscopy to establish a healthy reference perspective.

Recruitment:

Recruitment of participants for Experiments 2 and 4 will be conducted in two ways:

1) We will request permission to contact individuals who have registered with the Toronto Rehabilitation Institute research volunteer database, who have agreed to be contacted for future studies and who meet the broad inclusion criteria of the study.
2) We will conduct a broad public advertising campaign through local newspapers, magazines, a web-site, mailings and posters at community centres, seniors' residences, places of worship, and around the University of Toronto and the Toronto Rehabilitation Institute. In particular, we anticipate advertising in a seniors' magazine (*50Plus*) and its associated website, which has been useful in previous studies. Participants will be required to attend a 1-hour intake appointment to confirm their eligibility to participate, introduce them to the research protocol, complete the intake questionnaire, and obtain informed consent (see attached consent documents in Appendices C and D).

Stimuli:

Prior to launching Experiments 2 and 4, we will develop an array of barium (Experiment 1) and non-barium (Experiment 3) stimuli in thin, slightly-thick, mildly-thick, moderately-thick and extremely-thick consistencies, defined using the International Dysphagia Diet Standardisation Initiative (IDDSI) gravity-flow measures. The barium stimuli will be prepared using E-Z-Paque® barium in 20% w/v barium concentration[84] with starch and gum-based thickening agents (Nestlé Resource® ThickenUp® and ThickenUp Clear®). The non-barium stimuli will be prepared using Nestlé® Pure Life® Splash, a mildly lemon-flavored water [87-89]. Starch and gum-based thickening agents will be added to match the flow characteristics of the barium stimuli developed in Experiment 1. Experiments 1 and 3 will produce two arrays (barium; non-barium) of starch- and gum-thickened liquids representative of each IDDSI flow level, for a total array of 1 thin and 8 thickened stimuli (4 gum; 4 starch).

All stimuli will be prepared in the Swallowing Rehabilitation Research Laboratory not longer than 6 hours prior to scheduled use, according to a strict standard operating procedure (see

Appendix D). Barium stimuli will be transported to the radiology suite at Toronto General Hospital in a cooler, as per routine clinical procedures.

Data to be collected from each participant:

The following types of data will be collected from participants in Experiments 2, and 4:

a) An intake questionnaire noting age, sex, ethnicity and race data and confirming eligibility based on the absence of reported exclusion criteria.

b) During the intake process, we will ask to review a list of conditions that could alter the results of the research study and identify whether any of these conditions apply. This disclosing the use of any medications that they are currently taking, in order to allow us to control for the possible influence of medication on oral sensory and motor function. Medications do not qualify as the basis for exclusion. However, it is important for us to collect information regarding the use of benzodiazepines and neuroleptic medications that are known to have possible effects on swallowing, particularly with respect to causing xerostomia (dry mouth).

Signals to be collected from each participant:

c) Tongue-pressure waveform data, using the hand-held Iowa Oral Performance Instrument (IOPI) will be collected at the anterior position during 3 anterior maximum presses and 3 saliva swallows.

d) Nasal airflow collected using nasal cannula and registered on the KayPENTAX Swallowing Signals Lab during swallows.

e) A videofluoroscopy recording of swallowing involving a pulse rate of 30 pulses per second and video capture at 30 frames per second.

Data Collection Procedures:

Experiment 2: Prior to data collection, a nasal cannula will be placed around the participant's head with flexible prongs resting in their nostrils to measure airflow.

A single use disposable tongue bulb for the hand-held Iowa Oral Performance Instrument (IOPI) will be placed inside the participant's mouth. Tongue pressure signal will be collected at the anterior position during 3 anterior maximum presses and 3 saliva swallows.

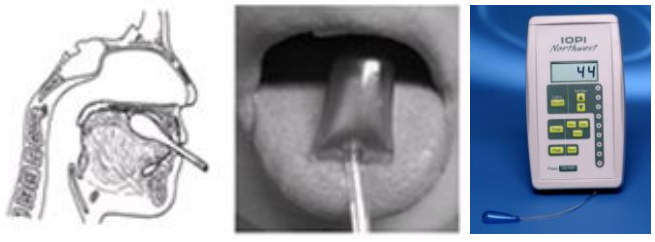

Image 1. Tongue pressure sensors.

Following sensor attachment, the participants will be seated on a chair inside the fluoroscopy unit. The video output line from the fluoroscopy unit and the nasal cannula will then be connected to the KayPENTAX Digital Swallow Workstation Swallowing Signals Lab equipment,

which is located on a properly insulated cart with an uninterrupted power supply and isolation transformer.

Participants will be asked to swallow the barium stimuli developed in Experiment 1 (9 in total) in videofluoroscopy, with concurrent measurement of nasal airflow. Videofluoroscopy will be performed at maximum temporal resolution (30 pulses/second) and captured at 30 frames/second. Each stimulus will be presented twice, in a randomized block design. Participants will be allowed to take natural sized sips of each stimulus from cups containing 40 ml. Cup weights before and after each sip will be taken on a digital balance so that sip volume and mass can be calculated.

Experiment 4: Experiment 4 was terminated on July 24 2018 due to technical issues encountered with the equipment that could not be repaired by the manufacturer.

Data Processing:
Signals collected from the participants (which may include tongue-pressure, sEMG, nasal airflow, tracheal sounds and accelerometry waveform data) will be segmented using an automatic segmentation algorithm developed previously in the PI's lab. Similarly, the videofluoroscopy recordings will be spliced into single bolus clips and the audio channel will be muted to remove cues that might bias rating. Blinded videofluoroscopy rating will then be performed in duplicate by trained raters in the Steele Lab following established procedures[85] (see Appendix E). Discrepancies between raters will be flagged and resolved at consensus meetings, as required. These procedures will yield a large number of parameters for each swallow, as listed below:

a) Peak tongue-pressure amplitude (in mm Hg);
b) Rise-time to peak tongue-pressure (in ms);
c) Decay-time for tongue-pressure (in ms);
d) Tongue-pressure area-under-the-curve;
e) Peak sEMG amplitude (in μV);
f) Rise-time to peak sEMG amplitude (in ms);
g) Decay-time for sEMG (in ms);
h) sEMG area-under-the-curve;
i) Duration of apnea (ms);
j) Breathing pattern pre- and post- swallow;
k) Bolus transit time from ramus of mandible to vallecular pit (in ms);
l) Bolus dwell time in pharynx from ramus of mandible to laryngeal vestibule closure (in ms);

m) Pharyngeal bolus transit time from ramus of mandible to upper esophageal sphincter opening (in ms);
n) Bolus transit time from ramus of mandible to tail exiting the upper esophageal sphincter (in ms);
o) Amount of residual left behind in the valleculae and pyriform sinuses after the initial swallow (measured using the Normalized Residue Ratio Scale[28];
p) Number of swallows for the bolus.

Data Analysis:
We will model the impact of bolus consistency on videofluoroscopic measures of pharyngeal bolus flow (i.e., the interval from the bolus passing the mandibular ramus until laryngeal vestibule closure; pharyngeal transit time) and post-swallow residue (Normalized Residue Ratio Scale(45)). The analyses for Experiments 2 and 4 will involve linear mixed model ANOVAs with repeated measures. A path analysis approach(86) will be used to first identify differences in tongue-pressure and submental sEMG measures (amplitude, rise time, decay time) across stimuli. The influence of variations in bolus volume will also be explored using univariate tests, and, if confirmed to be significant, will be used as a covariate in the subsequent statistical models. Similarly, differences in the dependent variables as a function of sex or age (continuous or divided into groups) will be explored first in a univariate fashion, and, if significant, these between-participant factors will be included in the model.

For Experiment 2, **our main hypothesis is that liquids with similar gravity-flow properties will show similar pharyngeal bolus flow.** Our goal will be to detect differences in bolus flow measures ≥200 ms as a function of consistency, with a medium effect size (Cohen's $d \geq 0.5$)(96). We hypothesize that the healthy participants in these experiments will use higher amplitudes of tongue pressure and/or submental muscle contraction (sEMG) during oral propulsion of starch-thickened stimuli, thereby achieving a similar outcome for both starch- and gum-thickened liquids in terms of pharyngeal bolus flow. Model fit for different covariance structures will be explored using restricted log likelihood estimation. Age-group (< vs. > 60 years) will be used as a between-groups factor while bolus consistency will be used as the within-participants factor. Sample size calculations have been performed using the data from the PI's previous grant, in which ultrasound measures of the duration of hyoid movement differed by 200-400 ms between age-groups and tongue-pressure amplitudes varied by 10-35 mm Hg depending on the liquid studied. A power calculation shows that 36 participants per group will be needed to detect this difference with 80% power (α=0.05). Allowing a margin for attrition, we have therefore planned to enroll n=40 per participant group: total N=80 for Experiments 2 and 4. This sample size will also be adequately powered for Experiment 4 to detect differences ≥10 mm Hg in tongue-pressure amplitudes.

For Experiment 4, **our main hypothesis is that liquids with similar flow properties based on the IDDSI gravity-flow tests will elicit different tongue pressure and sEMG measures based on their actual viscosities.** This hypothesis is predicated on the idea that healthy adults modulate oral phase propulsive forces used for boluses of differing consistency with the goal of establishing uniform pharyngeal flow (as hypothesized for Experiment 2). Significant contrasts are expected between the two extremes of the liquid continuum: [*thin* and *slightly-thick*] vs. [*moderately-* and *extremely-thick*]. We expect that measures for the *mildly-thick* liquids will fall in between, but that differences may not be large enough to achieve statistical significance versus the extremes in pairwise comparisons. We predict that barium stimuli will elicit higher amplitudes of tongue-pressure than non-barium stimuli based on their increased density.

5. Risks and Benefits

Risks

The following risks will be disclosed to all participants in Experiments 2 and 4 prior to obtaining their consent to participate:

a) It is possible that participants may dislike the taste or texture of some of the thickened liquid stimuli in the study. Participants will be reminded that they are free to discontinue participation at any time.

b) It is possible that participants may experience some fatigue during the data collection sessions. Participants will be reminded that they should disclose any fatigue or discomfort to the research team, and that they are free to discontinue any particular session or to withdraw from the study at any time.

c) Participants will receive exposure to radiation during the videofluoroscopy. Based on a previous videofluoroscopic study that we have conducted in healthy adults, Experiment 2 is expected to involve 118+/-18 seconds of radiation exposure[29], with an associated dose estimate of <0.35 milliSieverts. Moro and Cazzani[30] showed that this dose (0.35mSv) corresponds to a risk of 1 in 39,000 of developing a radiation-induced stochastic effect from a videofluoroscopy. We will use a 3-minute warning bell to alert the data collection team to exposure time, and will terminate the protocol at the first opportunity following the bell.

d) Aspiration (entry of material into the airway) is a possible risk during the videofluoroscopic swallowing study that will be performed. This risk is always present for videofluorscopic swallowing studies, which are intended to document the presence and severity of swallowing abnormalities, including (but not limited to aspiration). When aspiration is observed, standard procedures will be followed to encourage coughing and throat clearing to expel the aspirated material. The protocol will be terminated immediately. Any participant who experiences aspiration will be counseled regarding aspiration prevention strategies and aspiration-risk following the videofluoroscopy.

e) Choking is an extremely unlikely event. However, in the event of choking, routine emergency procedures will be followed. All study personnel carry current CPR certification.
f) In the unlikely event that an incidental finding is noted on the videofluoroscopy (such as a diverticulum or a mass) the attending SRRL licensed speech-language pathologist will consult the on-call radiologist and generate a clinical report documenting the observation. These findings will be communicated with the participant as per usual clinical practice.

Benefits
There are no benefits anticipated for participants in this study.

6. Privacy and Confidentiality

Routine practices for ensuring the confidentiality and privacy of all participants will be followed in this study. All research personnel at the Toronto Rehabilitation Institute are required to sign a confidentiality agreement at the time of hire. Participants will be assigned a non-identifying alphanumeric study code, and the master key for this code will be retained separately by the Principal Investigator in a password-protected file on a secure, password-protected, encrypted research server. Daily back-up of this research server is performed centrally at the Toronto Rehabilitation Institute to protect against data loss. Hard copies of the participant consent forms will be maintained in a binder, kept in a locked filing cabinet in the Swallowing Rehabilitation Research Lab.

All waveform and videofluoroscopic data will be stored electronically on the secure, password protected, encrypted research server. Any hard copy data will be transcribed into an electronic file (stored on the server), and the hard copy records will be stored in a locked filing cabinet in the Swallowing Rehabilitation Research Lab. Only the participant's alphanumeric study code number will appear on the data collection sheets and in the data collection files.

Access to participant information and experimental raw data will be restricted to the study personnel named in this application. All records will be destroyed after 10 years under the supervision of Dr. Steele.

7. Compensation

Data collection for each participant will involve 2 separate appointments: a) intake; b) Experiment 2 (ivideofluoroscopy). Each appointment is expected to last 1 hour. An honorarium of $50 will be provided per participant to cover expenses associated with participation in the study. This will be paid at the end of your final study visit.

8. Conflicts of interest

Dr. Steele, the principal investigator, holds current and prior research contracts with Bracco Canada and Nestle Health Science, who are manufacturers of the barium products and thickening agents that will be used in this study. She has also served in an advisory capacity on expert panels for Nestle Health Science. These relationships will be disclosed to participants in the study information sheet. All products for use in the study will be purchased. Neither Bracco Canada nor Nestle Health Science will have any role as sponsors of this study. Dr. Steele will not receive any financial payment, either personally or to the lab, related to the use of Nestle or Bracco products in this study.

9. Informed Consent Process

All participants who show an interest in participating will be provided with detailed information about this study via the Participant Information Sheet and Consent Form . Only after confirming they have understood all the information that is provided and after verifying they have no more questions, can they sign the consent form. A copy of the consent form will be provided to them.

The consent form includes a specific section requesting consent to use of study-related images for future educational and teaching purposes.

10. Scholarly Review

This study has undergone scientific review by the MFSR Study Section of the National Institutes of Health (USA). Reviewer comments are attached in Appendix F.

11. Additional Ethics Reviews

There are no additional ethics reviews planned for Experiments 2 and 4, as covered by this protocol. Additional ethics submissions are planned for other experiments in the overall project as follows:

- Experiment 3c involves a sensory experiment, in which a panel of trained raters will be asked to describe the taste, texture and mouthfeel of the stimuli developed for the study. This experiment will be run independently by Dr. Lisa Duizer at the University of Guelph. A separate ethics application will be submitted at the University of Guelph regarding this experiment.
- Experiment 5 is a future planned experiment to measure bolus flow in individuals with swallowing impairment due to different etiologies. The experiment will involve multiple sites and co-investigators. A separate ethics protocol will be submitted for that experiment at a future date.

12. Contracts

There are no contracts required for experiments 2 and 4, which will be conducted exclusively at the Toronto Rehabilitation Institute. Subgrants have been requested, and contracts will be set up separately for the collaborations required for Experiments 1, 3 and 5 of the overall project.

13. Clinical Trials

Not applicable.

14. Budget

All costs for this study will be covered pending funding confirmation from the National Institutes of Health. The budget and budget justification for Experiments 2 and 4 are included in Appendices H and I.

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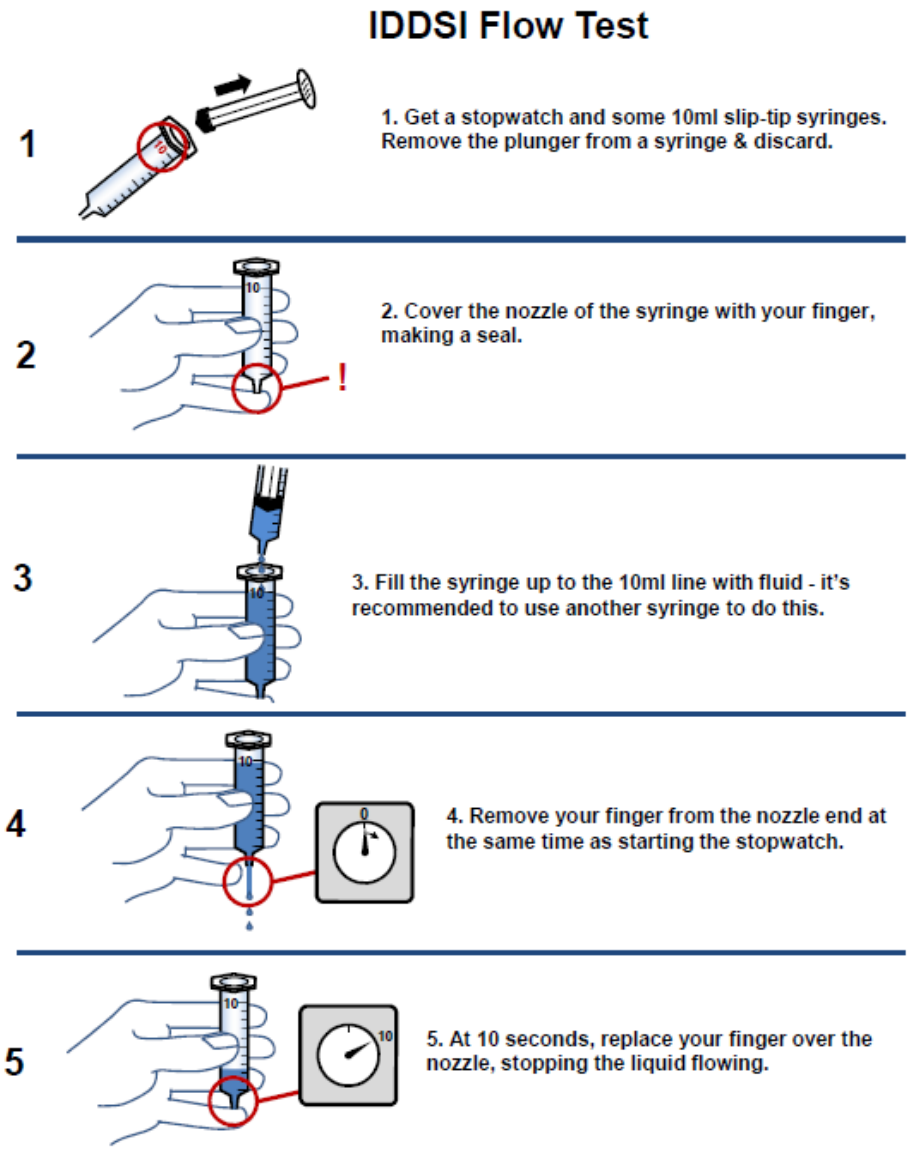
16. Appendices

Appendix A. IDDSI Gravity-Flow Testing Method



Appendix B. Exclusion Criteria Questionnaire

This is a list of conditions that could alter the results of this research study, or impact your eligibility to participate.

Please read the list and let us know if any of these apply to you, so that we can be certain that you meet the requirements to participate in the study.

a) Medical or Occupational Conditions:

- People with a prior medical history of stroke
- People with a prior medical history of acquired brain injury
- People with a diagnosis of Parkinson's Disease
- People with a diagnosis of Multiple Sclerosis (MS)
- People with a diagnosis of Amyotrophic Lateral Sclerosis (ALS)
- People with a diagnosis of Huntingdon's Disease
- People who have slurred speech or facial muscle problems
- People who have a swallowing disorder
- People who have Type I (insulin-dependent) Diabetes
- People who have had surgery in the head and neck area (other than tonsillectomy or adenoidectomy)
- People who have had radiation to the head and neck for cancer
- People who experience extreme mouth sensitivity (for example, when you go to the dentist)
- People who wear a full upper-plate denture, which covers the roof of the mouth
- Women who are pregnant
- People who have allergies to barium, potato starch, corn starch, xanthan gum, milk products, latex or adhesives
- People who have had an x-ray of their neck in the past 6 months
- People who work in a setting where they are exposed to radiation

b) Medication, Drug and Alcohol Use

- People who are taking sleeping pills or medication that makes them drowsy
- People who are taking "anti-Parkinson's" medications like Levodopa
- People who are experiencing dry mouth as a side effect of medication
- People who use drugs (Cocaine, Methamphetamine, Heroin, Ecstacy, etc.)
- People who are taking medicine that affects their sense of taste or smell

Appendix C. Race and Ethnicity Form

This study is funded by the National Institutes of Health in the United States.

As a condition of that funding, we are required to track the cultural heritage of participants in our study, to ensure representation of minority groups.

If you are willing, please tell us which of the following racial groups you would identify yourself with most closely:

- ☐ Asian
- ☐ Black or African-American
- ☐ Hawaiian/Pacific Islander
- ☐ Native American Indian
- ☐ White
- ☐ Other: _____
- ☐ I prefer not to disclose my racial heritage

In addition, please tell us whether Spanish or Portuguese is your mother tongue:

- ☐ Yes
- ☐ No

Appendix D. Standard Operating Procedure for Mixing Barium Stimuli

(Attached as a separate document)

Appendix E. Standard Operating Procedures for Videofluoroscopy Rating

(Attached as a separate document)

Appendix F. Summary Statement from NIH Review

SUMMARY STATEMENT
(Privileged Communication) *Release Date:* 06/25/2015

PROGRAM CONTACT:
LANA SHEKIM
301 496-5061
shekiml@nidcd.nih.gov

Application Number: 2 R01 DC011020-04

Principal Investigator

STEELE, CATRIONA MARGARET PHD

Applicant Organization: UNIVERSITY HEALTH NETWORK

Review Group: MFSR
Motor Function, Speech and Rehabilitation Study Section

Meeting Date: 06/15/2015
Council: OCT 2015
Requested Start: 09/01/2015

RFA/PA: PA13-302
PCC: VS02

Dual IC(s): AG, HD, NR

Project Title: Physiological Flow of Liquids Used in Dysphagia Management (previously Tongue-Pressure Timing for Liquid Flow Detection and Control in Swallowing)
SRG Action: Impact Score: 23 Percentile: 9
Next Steps: Visit http://grants.nih.gov/grants/next_steps.htm
Human Subjects: 30-Human subjects involved - Certified, no SRG concerns
Animal Subjects: 10-No live vertebrate animals involved for competing appl.
Gender: 1A-Both genders, scientifically acceptable
Minority: 1A-Minorities and non-minorities, scientifically acceptable
Children: 3A-No children included, scientifically acceptable
Clinical Research - not NIH-defined Phase III Trial

Project Year	Direct Costs Requested	Estimated Total Cost
4	499,132	557,697
5	473,841	529,439
6	479,342	535,585
7	491,629	549,314
8	361,659	404,094
TOTAL	2,305,603	2,576,130

ADMINISTRATIVE BUDGET NOTE: The budget shown is the requested budget and has not been adjusted to reflect any recommendations made by reviewers. If an award is planned, the costs will be calculated by Institute grants management staff based on the recommendations outlined below in the COMMITTEE BUDGET RECOMMENDATIONS section.

2R01DC011020-04 Steele, Catriona

RESUME AND SUMMARY OF DISCUSSION: This application for a competing renewal proposes to determine the relationship between observable liquid flow properties and actual bolus flow through the oropharynx in subjects with and without dysphagia. The proposed work is highly significant in that it has the potential to have a powerful and sustained impact on research and clinical care for people with dysphagia, and research findings could translate directly into clinical care. The Principal Investigator is exceptionally well qualified to lead the project. She has also assembled an outstanding research team uniquely suited to perform the planned studies with their complementary expertise, experience, and skills. The simultaneous study of flow measures of various liquid consistencies and tongue pressures applied to that liquid when swallowing is an important, novel method. The application is very well written with a well-defined approach. The environment is outstanding. During the discussion, reviewers noted that progress in the previous project period was outstanding. However, there were also some concerns. The main issue of the discussion was about the lack of quotas between penetrators and aspirators or for the severity of dysphagia in Aim 3 as it may result in significant reduction in number of patients with higher penetration scores included in the study. Overall, the application is viewed as outstanding.

DESCRIPTION (provided by applicant): The practice of thickening liquids has become one of the most frequently used interventions for swallowing impairment (dysphagia). However, the terminology used to describe thickened liquids (such as nectar-thick and honey-thick) is subjective and we lack empirical evidence about how alterations in liquid consistency affect swallowing function and physiology. The International Dysphagia Diet Standardisation Initiative is a multidisciplinary task force (www.iddsi.org) that has recently developed a new taxonomy of terms to label different levels of liquid consistency used in dysphagia management; these are paired with operational definitions and practical gravity-flow measurement techniques that can be used by caregivers and clinicians to confirm the category of any liquid at the time of preparation or serving. The goal of the current proposal is to measure the in vitro physiological flow of liquids representative of the IDDSI levels of liquid consistency (thin, slightly-thick, mildly-thick, moderately-thick and extremely-thick). Physiological measures of liquid flow require an understanding both of the rheological properties of the liquid (gravity-flow; viscosity) and the forces that are applied to the liquid during swallowing (tongue pressure; swallowing muscle contraction). Additional sensory attributes of the bolus (such as slipperiness, graininess and cohesiveness) are also likely to be relevant. We will measure these properties and study bolus flow in healthy adults to establish a reference perspective of expected flow in the context of healthy tongue pressure generation. We will then collect comparative measures in individuals with dysphagia of different etiologies (stroke, acquired brain injury, oropharyngeal cancer, post cervical spine surgery, and neurodegenerative disease) to determine how alterations in swallowing motor function impact liquid flow. These measurements will provide information to guide clinicians in determining optimal levels of thickening to recommend for patients with dysphagia. This research is highly significant because it will establish a new foundation of understanding with respect to the influence of thickened liquids on swallowing. This is essential for advancing clinical practice and setting the stage for future treatment efficacy research.

PUBLIC HEALTH RELEVANCE: Thickened liquids have become the most common intervention for dysphagia (swallowing impairment), yet we lack a clear understanding of how this intervention works to achieve clinical benefit. In this project, we will advance our understanding of how thickening influences swallowing by measuring the physiological flow of 5 incremental degrees of liquid thickening. These measures of physiological flow will take into consideration both the physical flow properties of these liquids and the forces applied during swallowing by healthy adults and individuals with swallowing impairment due to stroke, brain injury, oropharyngeal cancer, post cervical spine surgery and neurodegenerative disease.

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CRITIQUE 1:

Significance: 1
Investigator(s): 1
Innovation: 1
Approach: 2
Environment: 1

Overall Impact: Thickened liquids are among the most commonly used treatments for dysphagia, yet the characteristics of what constitutes a liquid texture change are very poorly defined, have considerable variability within and between clinicians and institutions, and are absent knowledge of the physiological implications of thickening for safe and efficient swallowing. Because of these substantial and pervasive gaps in knowledge (that are very well addressed in this application), the proposed work presented here will have a powerful and sustained impact on research and clinical care for people with dysphagia. The research findings will translate directly into clinical care. This competitive renewal application furthers the substantial productivity of this investigative team in the last research period. The Principal Investigator and associated team have international reputations as experts in the field of dysphagia and, based on their prior work, are uniquely suited to perform the planned studies. This work is of extremely high impact and clinical relevance.

1. Significance:

Strengths

- The problem area of texture modification for dysphagia is highly significant.
- Texture modification may affect healthy people with normal swallows differently than people with dysphagia. This work is highly significant in its focus on this issue.
- Practical aspect of developing/quantifying gravity-flow methods of texture assessment that can be performed by caregivers, in contrast to viscosity that is not easily performed in a home or clinical setting.
- Study of physiological effects of texture modification is highly significant.

Weaknesses

- No weaknesses noted.

2. Investigator(s):

Strengths

- The Principal Investigator is an outstanding contributor to the field of dysphagia. She has assembled an equally outstanding group of collaborators in this work.
- The Principal Investigator and colleagues are part of the IDDS working group developing standards for liquid texture classification. She is thus part of the ongoing work in this clinical problem area and has command of the newest information and techniques to apply to developing solutions.
- Great care has been used in choosing collaborating institutions that add a great deal to the proposed work.

Weaknesses

- No weaknesses noted.

3. Innovation:

Strengths

- The research program developed by this Principal Investigator is highly innovative. She has identified a significant clinical gap in knowledge and has applied her work to finding solutions through rigorous research studies.

Weaknesses

- No major weaknesses noted.

4. Approach:

Strengths

- The application is very well written. Approach is well defined by an excellent overview of the aims in a very clear table with associated experiments and measures made within each experiment. The Approach then follows with the details of each experiment. All experiments are carefully constructed and feasible.
- Each aspect of the technical details of the experiments is well defined.
- Each experiment appears crucial and significant in leading to improved clinical implementation of texture modification in people with dysphagia.
- Comparisons of barium swallows to non-barium swallows is an important real-life contrast. That is, most videofluoroscopic assessments are obviously performed using barium compounds but food prepared by caregivers and ingested by people with dysphagia is non-barium. Therefore, the need to investigate the correspondence (or lack of correspondence) between these two conditions is very important and significant to interpretation of assessment findings and subsequent recommendations.

Weaknesses

- It is not clear how sEMG amplitude is quantified; that is, whether it is a normalized measure.

5. Environment:

Strengths

- Excellent environment and facilities to perform the proposed studies.

Weaknesses

- Multiple sites may add complexity to study management.

Protections for Human Subjects:

Acceptable Risks and/or Adequate Protections

- Acceptable

Data and Safety Monitoring Plan (Applicable for Clinical Trials Only):

Not Applicable (No Clinical Trials)

Inclusion of Women, Minorities and Children:

- Sex/Gender: Distribution justified scientifically

- Race/Ethnicity: Distribution justified scientifically
- Inclusion/Exclusion of Children under 21: Excluding ages < 21 justified scientifically
- A minority recruitment/enrollment plan may be helpful.

Vertebrate Animals:

Not Applicable (No Vertebrate Animals)

Biohazards:

Not Applicable (No Biohazards)

Renewal:

- This is a renewal application from an established and productive laboratory that extends important and clinically relevant work from the last funding period.

Applications from Foreign Organizations:

Justified

- The investigative team is uniquely qualified to carry out the proposed studies. Foreign members of the team are charter members of the IDDS, the working group tasked with standardizing methods for thickening liquids. The Principal Investigator is an internationally recognized authority on dysphagia. Thus, they have gained insights into this clinical problem, have identified gaps in knowledge that affect clinical practice, and have developed a unique research program to address those gaps in knowledge. This knowledge, expertise and resources are not readily available in the United States.

Budget and Period of Support:

Recommend as Requested

CRITIQUE 2:

Significance: 2
Investigator(s): 1
Innovation: 1
Approach: 2
Environment: 1

Overall Impact: The use of thickened liquids is an effective and commonly used technique to reduce aspiration and thereby improve swallow safety. However, there is a lack of knowledge about how differences in liquid consistency affect swallowing function and physiology. This proposal will study important issues about how characteristics of liquids and muscular forces influence the flow of the bolus through the oropharynx, and the effect these variables may have on people with different types of disorders at risk for dysphagia, an innovative approach. Results of this research will likely have a strong influence on improving the future practice of selecting liquid consistencies that are more appropriate for people with dysphagia to promote their safety. The Principal Investigator is exceptionally qualified to

carry out the proposed research plan and Co-Investigators have complementary skills and knowledge for the successful completion of the proposed research plan.

1. Significance:

Strengths

- Thickened liquids are one of the most important interventions for dysphagia because of their role in slowing bolus flow to improve swallowing safety and efficiency. However there is a gap in knowledge about how differences in liquid consistency affect swallowing function. The proposed strategy to measure various physical properties of the liquids and forces that occur during the swallow will likely provide important, specific, clinical insights to improve swallow safety.
- Because muscular forces that affect the flow of a bolus through the stages of swallowing may differ among people with different type of disorders, the study of these groups at risk for dysphagia will likely yield strong external validity significantly increasing the impact to the clinical population of interest.
- Considering that two boluses of the same viscosity flow differently under the application of different tongue pressures, the study of the interaction of the physical properties of consistencies and pressures is likely to provide greater internal validity leading to improved clinical treatment.

Weaknesses

- No major weaknesses noted.

2. Investigator(s):

Strengths

- The Principal Investigator is exceptionally well qualified to carry out the proposed research plan. Since 2012, the Principal Investigator published14 papers that focus on swallowing issues involved in the current proposal, seven of which she is the first author.
- The many Co-Investigators have the complementary skills and knowledge for the successful completion of the proposed research plan.

Weaknesses

- No weaknesses noted.

3. Innovation:

Strengths

- The simultaneous study of flow measures of various liquid consistencies and tongue pressures applied to that liquid when swallowing is an important, novel method that will provide a more complete and valid insight about how physical properties of the bolus interact with the forces occurring during swallowing to achieve improved clinical benefit.
- Current clinical terminology describing the thickness of liquids is derived from categorical terms without reference to their physical nature. This lack of specificity can lead to unwanted differences in their composition that could impact swallowing safety. The mapping of liquid consistencies to swallowing physiology is a novel approach toward improving safe swallowing.

Weaknesses

- No weaknesses noted.

4. Approach:

Strengths

- Because swallowing safety for people with dysphagia often depends upon food consistency, the proposed methods to better understand what influences this consistency for safe and efficient swallowing has a strong rationale.
- Studying the relationship between the flow of the bolus and swallowing, the association of this flow and swallowing physiology among people with different disorders, and comparison of the swallow characteristics of barium and non-barium materials combine to likely provide much understanding to utilize thickened liquids more effectively and prudently.

Weaknesses

- In the experiment studying sensory characteristics of swallowing stimuli in Aim 2, subjects will be trained to develop a common frame of reference for each perceptual attribute and will then be tested for their perceptions of the stimuli. There was insufficient information about these methods and data analysis to adequately understand or evaluate the validity of this experiment. This is a minor weakness that will likely have a minor effect on the goals of the project.

5. Environment:

Strengths

- The environment is outstanding because of the resources, facilities, and equipment available for the project at the various laboratories involved.

Weaknesses

- No weaknesses noted.

Protections for Human Subjects:

Acceptable Risks and/or Adequate Protections

- Risks to subjects are adequate. However, because there is a small amount of radiation exposure during videofluoroscopy, subjects should be informed about this exposure.

Data and Safety Monitoring Plan (Applicable for Clinical Trials Only):

Not Applicable (No Clinical Trials)

Inclusion of Women, Minorities and Children:

- Sex/Gender: Distribution justified scientifically
- Race/Ethnicity: Distribution justified scientifically
- Inclusion/Exclusion of Children under 21: Excluding ages < 21 justified scientifically
- The distribution of sex/gender and race/ethnicity is appropriate.

Vertebrate Animals:

Not Applicable (No Vertebrate Animals)

Biohazards:

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Not Applicable (No Biohazards)

Renewal:

- The current proposal is a renewal submission of an earlier, funded proposal. Based on the description from the earlier proposal, the current proposal successfully builds upon this earlier work. In fact, the current proposal explores potentially more important questions to better understand many of the potential important attributes of bolus consistency and sensory attributes, and the forces applied during the swallow that are relevant to a safer and more efficient swallow. This proposal is likely to successfully add to the foundation of knowledge gained during the research funded by the previous grant.

Applications from Foreign Organizations:

Justified

- Apparently, no other scientists in the United States are studying the research questions regarding the physiological flow of liquids of different consistencies in either healthy of disordered swallowing. Therefore, Dr. Steele and her laboratory are in a unique position to perform the proposed research in this research proposal.

Resource Sharing Plans:

Unacceptable

- No description of Resource Sharing Plans was provided in the application.

Budget and Period of Support:

Recommend as Requested

CRITIQUE 3:

Significance: 2
Investigator(s): 1
Innovation: 3
Approach: 4
Environment: 1

Overall Impact: This proposal will determine the relationship between observable liquid flow properties and actual bolus flow through the oropharynx in subjects with and without dysphagia. The determining the boundaries of ideal thickening based on swallowing pathophysiology will lead to more precise tailoring of liquid consistency prescriptions to swallowing ability of subjects with dysphagia. In addition, the results will provide simple and reliable methods for testing flow during liquid preparation and facilitate clear communication between professionals and caregivers, and promote patient safety. The proposal is not innovative technically, but brings Principal Investigator's, her collaborators' and other investigtors' substantial previous work in the field together to focus on "mapping of consistency to physiology across the entire continuum from thin to extremely-thick liquids" and it has great clinical significance for the assessment and treatment of dysphagia. The approach is outstanding for the study Aims 1 and 2 where "mapping of consistency to physiology across the entire continuum from thin to extremely-thick liquids" for healthy swallowing will be completed successfully due to very strong Principal Investigator, her excellent team and the environment. The enthusiasm for the proposal

however, dampened moderately due to concerns of attaining the same success in subjects with dysphagia in Aim 3. The lack of quotas between penetrators and aspirators or for the severity of dysphagia in Aim 3 for the patient groups is a concern in that, it may result in significant reduction in number of patients with higher penetration scores (3-5) and scores ≥ 6 (aspirators) included in the study and will reduce the impact of the study to the dysphagia field substantially. The potential overall impact of this proposal remains high because it will advance our understanding of how incremental degrees of liquid thickening influences swallowing physiology in subjects with and without dysphagia. The results will be useful in both future dysphagia assessment and treatment efficacy research.

1. Significance:

Strengths

- The study will determine the physiological and functional consequences of 5 incremental degrees of liquid thickening in both healthy and disordered populations.
- Concurrent measurement of tongue pressure, submental muscle contraction forces and bolus flow visualization under videofluoroscopy will help better understand the alteration in bolus flow either as a function of physical properties of the liquid, or as a function of the tongue pressures or muscular forces applied.
- Determining boundaries of ideal thickening based on swallowing pathophysiology will lead to more precise tailoring of liquid consistency prescriptions to swallowing ability of subjects with dysphagia.
- Principal Investigator's previous work findings.

Weaknesses

- No major weaknesses noted.

2. Investigator(s):

Strengths

- Dr. Steele published multiple papers in the area of dysphagia and has demonstrated exceptional productivity over the years. The study includes a team of experts who are essential for the success completion of this proposed study.

Weaknesses

- No weaknesses noted.

3. Innovation:

Strengths

- The proposal is not innovative technically, but brings Principal Investigator's, her collaborators' and other investigators' substantial previous work in the field together to focus on "mapping of consistency to physiology across the entire continuum from thin to extremely-thick liquids", and it has a great clinical significance for the assessment and treatment of dysphagia.

Weaknesses

- No major weaknesses noted.

4. Approach:

Strengths

- Proposal clearly states the research questions, their relevance to the dysphagia field and gives detailed descriptions of the approach to be used in answering each question.

- Aims are designed to address specific questions and they cover relevant aspects of the study to accomplish its goal of "mapping of consistency to physiology across the entire continuum from thin to extremely-thick liquids" in subjects with and without dysphagia.

Weaknesses

- Contribution of experiment 3(c) to the overall goals of the proposal is not clear. The utility of the information obtained from this experiment to the subjects with dysphagia who can present with varying sensory deficits in orapharynx is not addressed.
- This proposal will recruit adults with dysphagia who will require a videofluoroscopy for clinical purposes. it is not clear how this will effect the study and clinical protocol, e.g. when the study protocol will start and how this timing will effect the exploration of compensatory maneuvers and duration of the study.
- With the 18-task protocol for the proposed study, the entire protocol could receive up to 5.2 minutes of radiation exposure. It is left to the attending clinician's discretion to explore effects of compensatory maneuvers on minimizing/eliminating penetration-aspiration without the need of a thickener. Precautions need to be explained how to prevent subjects being put on thickened liquids too readily as management of their dysphagia when there are other alternatives.
- The protocol will be terminated immediately after the 3rd observation of penetration-aspiration. The lack of quotas between penetrators and aspirators in Aim 3 for patient groups is a concern in that it may result in significant reduction in number of patients with moderate to severe dysphagia included in the study, e.g. with PAS scores 4 and above it will reduce the impact of the study to the dysphagia field substantially.

5. Environment:

Strengths

- The Principal Investigator and Co-Investigators have established research laboratories with extensive and successful record of completing funded research.

Weaknesses

- No major weaknesses noted.

Protections for Human Subjects:

Acceptable Risks and/or Adequate Protections

- Confidentiality and privacy protection is in place and detailed.
- Potential risks of the study for each protocol are outlined and acceptable precautions and solutions are detailed in the proposal.

Data and Safety Monitoring Plan (Applicable for Clinical Trials Only):

Acceptable

Inclusion of Women, Minorities and Children:

- Sex/Gender: Distribution justified scientifically
- Race/Ethnicity: Distribution justified scientifically
- Inclusion/Exclusion of Children under 21: Excluding ages < 21 justified scientifically
- This study only will recruit adult males and females only. The exclusion of children is scientifically justified.

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Vertebrate Animals:

Not Applicable (No Vertebrate Animals)

Biohazards:

Not Applicable (No Biohazards)

Renewal:

- Dr. Steele has been very productive with her previous NIH grant and this application is a natural extension of the previous grant and can make a great impact in the field.

Applications from Foreign Organizations:

Justified

- Dr. Steele is a scientist with a great and significant productivity to the field. The Principal Investigator and her team have an established a great collaborative work which brings diverse background of scientists to further the dysphagia field. This application from a foreign organization is justified.

Resource Sharing Plans:

Acceptable

Budget and Period of Support:

Recommended budget modifications or possible overlap identified:

- Contribution of experiment 3(c) to overall goal of the proposal is not clear. Further, the proposal does not give clear justification why the experiment extends over 2 years.
- The study will approach/recruit adults with dysphagia who will require a videofluoroscopy for clinical purposes. It is not clear why videofluoroscopy cost needs to be paid if this is part of this test is their routine care. Is the cost for videofluoroscopy or a space?

THE FOLLOWING SECTIONS WERE PREPARED BY THE SCIENTIFIC REVIEW OFFICER TO SUMMARIZE THE OUTCOME OF DISCUSSIONS OF THE REVIEW COMMITTEE, OR REVIEWERS' WRITTEN CRITIQUES, ON THE FOLLOWING ISSUES:

PROTECTION OF HUMAN SUBJECTS (Resume): ACCEPTABLE
Risks to subjects are adequate. However, because there is a small amount of radiation exposure during videofluoroscopy, subjects should be informed about this exposure.

INCLUSION OF WOMEN PLAN (Resume): ACCEPTABLE

INCLUSION OF MINORITIES PLAN (Resume): ACCEPTABLE

INCLUSION OF CHILDREN PLAN (Resume): ACCEPTABLE

COMMITTEE BUDGET RECOMMENDATIONS: The budget was recommended as requested.

NIH has modified its policy regarding the receipt of resubmissions (amended applications). See Guide Notice NOT-OD-14-074 at http://grants.nih.gov/grants/guide/notice-files/NOT-OD-14-074.html. The impact/priority score is calculated after discussion of an application by averaging the overall scores (1-9) given by all voting reviewers on the committee and multiplying by 10. The criterion scores are submitted prior to the meeting by the individual reviewers assigned to an application, and are not discussed specifically at the review meeting or calculated into the overall impact score. Some applications also receive a percentile ranking. For details on the review process, see http://grants.nih.gov/grants/peer_review_process.htm#scoring.

Appendix G. Budget

The amounts below cover direct costs for Dr. Steele and her lab associated with the first two years of the overall project. Additional money is budgeted for the other experiments involving subgrants and collaborations.

YEAR 1 (2016)

Salary Costs

Person	Project Role	Requested Salary	Benefits	Funds Requested
Professor Catriona Steele	PI	$41,100.00	$10,275.00	$51,375.00
Melanie Peladeau-Pigeon	Clinical Research Coordinator	$25,874.00	$6,468.00	$32,342.00
Melanie Tapson	Clinical Research Coordinator	$19,405.00	$4,851.00	$24,256.00
Talia Wolkin	Clinical Research Coordinator	$12,937.00	$3,234.00	$16,171.00
Carly Barbon	Research Associate	$13,650.00	$3,413.00	$17,063.00
Ashley Waito	Graduate Student	$17,062.50	$4,265.50	$21,328.00
Teresa Valenzano	Graduate Student	$17,062.50	$4,265.50	$21,328.00

Equipment Costs

New KayPENTAX Digital Swallow Workstation	$114,393.00

Other Direct Costs

Materials and Supplies	$7,000.00
Consultant Services	$6,000.00
Computer Services	$4,200.00
Videofluoroscopies and Participant Honoraria	$17,000.00
Statistical Support	$4,050.00

TOTAL YEAR 1 BUDGET:	**$336,506.00**

YEAR 2 (2017)

Salary Costs

Person	Project Role	Requested Salary	Benefits	Funds Requested
Professor Catriona Steele	PI	$42,333.00	$10,583.00	$52,916.00
Melanie Peladeau-Pigeon	Clinical Research Coordinator	$26,650.00	$6,662.00	$33,312.00
Melanie Tapson	Clinical Research Coordinator	$39,975.00	$9,994.00	$49,969.00
Talia Wolkin	Clinical Research Coordinator	$26,650.00	$6,662.00	$33,312.00
Carly Barbon	Research Associate	$14,060.00	$3,515.00	$17,575.00
Ashley Waito	Graduate Student	$17,074.50	$3,690.50	$20,765.00
Teresa Valenzano	Graduate Student	$17,074.50	$3,690.50	$20,765.00

Other Direct Costs

Materials and Supplies	$6,500.00
Consultant Services	$6,000.00
Computer Services	$0.00
Videofluoroscopies and Participant Honoraria	$24,433.00
Statistical Support	$4,050.00

TOTAL YEAR 2 BUDGET: **$269,597.00**

Appendix H. Budget Justification

Personnel:

All salary and fringe benefits costs for study personnel assume a 3% annual inflation rate.

Principal Investigator: Dr. Catriona M. Steele, Ph.D., CCC-SLP, BCS-S, ASHA Fellow will serve as Principal Investigator on this project. Dr. Steele is a Senior Scientist and Director of the Swallowing Rehabilitation Research Laboratory at the Toronto Rehabilitation Institute – University Health Network, as well as status-only Professor in the Department of Speech-Language Pathology at the University of Toronto. She has over 10 years of clinical research experience focusing on the measurement and rehabilitation of swallowing function. Dr. Steele's effort will be at 4.0 calendar months throughout the year. Her role will be to supervise key personnel, all data collection, and all data analyses. She will lead data interpretation and manuscript preparation. Salary support and fringe benefits are requested.

Research Engineer and Lab Manager: Ms. Melanie Peladeau-Pigeon, M.H.Sc., is a Clinical Engineer currently employed as Research Coordinator in Dr. Steele's laboratory. In this capacity, she oversees daily lab operations, including ordering supplies, managing institutional protocols and compliance with regulations and overseeing data entry, quality and retention. In addition to this, Melanie has particular expertise in signal processing as applied to the analysis of physiological swallowing signals (tongue pressure waveforms, submental EMG). She will oversee the development and use of automated signal processing methods to extract key parameters regarding tongue pressure and electromyography in Experiments 2, 4 and 5a-e. Melanie will contribute 4.0 calendar months to the project across the duration of the grant. Salary plus fringe benefits are requested.

Clinical Research Coordinator: Ms. Melanie Tapson, M.H.Sc., is currently Clinical Research Coordinator and Speech-Language Pathologist in Dr. Steele's laboratory. In this capacity, she will oversee the recruitment of participants (both healthy and patient participants) and all clinical aspects of data collection including videofluoroscopy. She will also train and supervise graduate research assistants in data collection. Melanie will contribute 3.0 calendar months to the project in year 1, 6.0 calendar months in years 2-4 and 3.0 calendar months in year 5 of the grant. Salary plus fringe benefits are requested.

Research Associate: Talia Wolkin (Goldhar), M. H.Sc., is currently a Research Associate and Speech-Language Pathologist in Dr. Steele's laboratory. In this capacity, she will oversee the blinded rating of all videofluoroscopies for the grant, including extraction of kinematic measures. She will also train and supervise graduate research assistants in videofluoroscopy rating. Talia will contribute 2.0 calendar months to the project in year 1 and 4.0 calendar months annually across the remainder of the grant. Salary plus fringe benefits are requested.

Graduate Research Assistants: To be named

- Two Graduate Research Assistants will be recruited at 50% effort beginning in year 1 of the project. These individuals will have a B.S. or M.S. in communication sciences and disorders, psychology, neuroscience, or a related field. These individuals will be responsible for assisting Dr. Steele with data collection for Experiments 2 and 4. These trainees will also receive training in videofluoroscopy rating and swallowing signal analysis, and will assist Dr. Steele with data analysis and manuscript preparation.

Consultants:

- Dr. David James is Professor of Mechanical Engineering, University of Toronto. Dr. James will serve as a consultant on this project. His contribution to the project will be to make facilities and equipment for rheological testing available in Toronto and to advise regarding rheological testing methods. An annual consulting fee of $2000 is requested, which will cover Dr. James' time advising regarding rheological testing as well as enable Dr. James' participation in annual project meetings.
- Dr. Julie Cichero, Ph.D. is a Speech-Language Pathologist and Honorary Senior Fellow in the School of Pharmacy, Faculty of Health and Behavioural Sciences at the University of Queensland, Australia. Together with Mr. Peter Lam (below), Dr. Cichero serves as Co-Chair of the International Dysphagia Diet Standardisation Initiative (www.iddsi.org). Dr. Cichero will serve as a consultant on this project. Her contribution will be to advise regarding the terminology, definitions and practical measurement of fluid consistency developed by IDDSI and the roll-out of IDDSI's recommendations to clinical audiences. An annual consulting fee of $2000 is requested, which enable Dr. Cichero's participation in annual project meetings.
- Mr. Peter Lam, R.D. is a Dietitian and Food Service Executive who serves as Co-Chair of the International Dysphagia Diet Standardisation Initiative (www.iddsi.org). Together with Dr. Cichero, Mr. Lam will serve as a consultant on this project. His contribution will be to advise regarding the terminology, definitions and practical measurement of fluid consistency developed by IDDSI and the roll-out of IDDSI's recommendations to clinical audiences. An annual consulting fee of $2000 is requested, which enable Mr. Lam's participation in annual project meetings.

Equipment:

- Funds are requested to purchase a new KayPENTAX Digital Swallow Workstation (DSW) with Swallowing Signals Lab (SSL) for Dr. Steele's laboratory. This equipment will supplement and eventually replace Dr. Steele's previous system, which is currently10 years old and beginning to show some wear and tear due to the need to move it repeatedly between Dr. Steele's laboratory and the videofluoroscopy suite at the Toronto General Hospital – University Health Network (a 20-minute journey in each direction through a connecting tunnel system and involving entry and exit through 3 elevators, which can cause jolts to the equipment cart). The DSW and SSL are required for registering all physiological signals during experiments 2 and 4 as well as for capturing concurrent videofluoroscopy in experiment 2. By purchasing a new system for

this project, we will be able to house one system in the videofluoroscopy suite and (for the remainder of its usable life), keep the original system in Dr. Steele's laboratory.
- Funds are requested for a one-time initial purchase of 300 tongue pressure sensors for the KayPENTAX Swallowing Signals Lab. This supply will be sufficient to cover the need for these sensors across the entire duration of the project.
- A 25% allowance for brokerage and customs fees is included for year 1 equipment costs.

Materials and Supplies:

Lab Supplies:

Funds are requested for general lab supplies including slip tip syringes, gloves, weigh boats, pipettes, thickening agents, barium, digital balances, cleaning supplies and EMG sensors.

Software Licenses:

The materials and supplies budget includes funds for additional software licenses (SPSS; MATLAB) for Dr. Steele's group and annual software maintenance fees (SPSS; MATLAB) across the duration of the project.

Computer Services:

A 4TB expansion unit for the dedicated server space used by Dr. Steele's lab is requested (at a cost of $4200) to enable secure storage of the videofluoroscopy recordings collected during the project.

Statistical Support:

Biostatistician Karen Grace Martin of The Analysis Factor (www.AnalysisFactor.com) will serve as the statistical advisor for the project with a budget of 30 hours each year (@ $135/hr).

Videofluoroscopy:

Funds are requested for radiographic imaging studies (videofluoroscopic swallow studies) to be conducted in a radiology suite for Experiment 2. For the Toronto based participants (Experiment 2), we will require a 15-minute booking in the Diagnostic Imaging department at the Toronto General Hospital – University Health Network, at a standard cost of $325 per procedure including radiologist and radiation technologist support.

Participant Honoraria:

Funds are requested to provide participants in Experiments 2 and 4 with an honorarium of $50 in recognition of their contribution and time.

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