THE RELATIONSHIP OF KNOWLEDGE OF THE PHYSIOLOGY OF NORMAL AND ABNORMAL SWALLOWING TO ACCURACY INTERPRETING INSTRUMENTAL OBSERVATION OF SWALLOWING

A Dissertation presented to

the faculty of

the College of Health and Human Services of Ohio University

In partial fulfillment

of the requirements for the degree

Doctor of Philosophy

Robert K. Manning

March 2002

This dissertation entitled

THE RELATIONSHIP OF KNOWLEDGE OF THE PHYSIOLOGY OF NORMAL AND ABNORMAL SWALLOWING TO ACCURACY INTERPRETING INSTRUMENTAL OBSERVATION OF SWALLOWING

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MANNING, ROBERT K. Ph.D. March 2002. Hearing, Speech, and Language Sciences

The Relationship of Knowledge of the Physiology of Normal and Abnormal Swallowing to Accuracy Interpreting Instrumental Observation of Swallowing (102pp.)

Director of Dissertation: Richard Dean

The purpose of this study is to investigate the relationship of knowledge of the physiology of normal and abnormal swallowing to accuracy interpreting instrumental observation of swallowing. Participants included a group of undergraduate speech-language pathology students at Ohio University who had completed an undergraduate level anatomy and physiology course, a group of graduate speech-language pathology students at Ohio University who had completed a graduate level didactic course in dysphagia, and a group of experienced speech-language pathologists (SLPs) who were members of the Dysphagia Listserve. Participants were considered experienced SLPs after completing 20 or more Videofluoroscopic Swallow Study (VFSS). Participants were given no additional training by the investigator.

The investigation used a quasi-experimental research design. Participants completed a test of knowledge of the physiology of normal and abnormal swallowing and interpreted five VFSS video clips via a survey on the Internet. Group and individual scores from the two tasks were compared using one-way analysis of variance, one-way analysis of covariance, and correlation.

Results suggest that although knowledge of the physiology of normal and abnormal swallowing is inadequate as a total explanation for accuracy interpreting VFSS, it is highly correlated to accuracy interpreting VFSS. These results parallel the

investigation of Wooi, Scott, and Perry (2001) who found a significant relationship between knowledge of anatomical landmarks found in the swallowing mechanism and accuracy interpreting VFSS. When controlling for knowledge of the physiology of normal and abnormal swallowing, criteria involved in determining group membership combined with knowledge of the physiology of normal and abnormal swallowing were found to be significant predictors of accuracy interpreting VFSS.

This investigation is preliminary research designed with the purpose of establishing benchmarks for the education and experience needed to assess persons with dysphagia. If results from this study can be generalized to undergraduate and graduate students from ASHA accredited speech-language pathology programs throughout the U.S., it may be warranted to establish curricular content standards for undergraduate level anatomy and physiology coursework and graduate level didactic coursework in dysphagia.

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Acknowledgments

I would like to express my sincere gratitude to Dr. Donald Fucci and Dr. Richard Hedges, who served on my dissertation committee. I also would like to express my sincere gratitude to Dr. Gordon Brooks, who helped me with my statistics in this dissertation. I appreciate the many hours they have taken to read my dissertation proposal, updates, and final project. I have appreciated the constructive criticism and guidance throughout this endeavor. It has been wonderful working with this fine group of people.

I especially wish to thank Dr. Richard Dean, who has served as my academic and dissertation advisor. I sincerely appreciate the input and advice he has given me, as well as the independence I have needed to work at my own pace. I cannot begin to express my gratitude for his patience, understanding, and thoughtfulness throughout my time at Ohio University.

My fellow doctoral students deserve the biggest "Thank you." You all have inspired and motivated me in my times of greatest need. I would like to express my gratitude to my predecessor, Dr. Patricia Lohman-Hawk. We will always share a special bond.

Finally, to my wife, Carolyn, you have sacrificed so much of yourself for me. I love you and can only hope that you realize the depth of my gratitude. To my sons, Parker, Ty, and Trey, you are my inspiration.

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Chapter 1

Introduction

Swallowing has two purposes. Swallowing clears excess saliva from the mouth and it moves food from the mouth to the stomach (Tuchman & Walter, 1998). Swallowing occurs without much thought (Logemann, 1998). Because swallowing is reflexive and seems automatic, it is normally taken for granted. Unfortunately, impaired swallowing or dysphagia cannot be taken for granted, because it can be life threatening. Dysphagia can result in choking, which interferes with air exchange or may cause pulmonary inflammation and infection (Massey & Shaker, 1997). Furthermore, dysphagia can cause discomfort, poor nutrition, and poor health. Dysphagia is generally thought to compromise a person's quality of life because it threatens their ability to care for themselves (Logemann). Given these consequences of dysphagia, accurate diagnosis is a critical factor in identifying and minimizing its impact on quality of life for persons diagnosed with dysphagia.

Difficulty moving food safely from the mouth to the stomach is the most frequently used definition of dysphagia (Logemann, 1998). The scope of dysphagia was recently expanded to include the integration of those behavioral, sensory, and preliminary motor acts performed just prior to swallowing (Leopold & Kagel, 1996). Cognitive awareness of eating, visual recognition of food, and all physiological responses to smell and the presence of food in the mouth (e.g., increased salivary flow) are also included in the expanded definition of the integrated swallowing process (Leopold & Kagel).

Research has shown that comprehensive knowledge of the physiology of swallowing is necessary to accurately assess dysphagia (Scholten & Russell, 2000; Wooi, Scott, & Perry, 2001). However, assessment of the entire swallowing process is limited by the inability to visualize structures and functions involved once the mouth is closed. Consequently, the need to visualize the dynamic swallowing process has led to the use of instrumental assessment to provide dynamic visual images particularly of food in the throat. Instrumental assessment that provides dynamic visual images of the entire swallowing process includes Videofluoroscopy Swallow Study (VFSS) and Fiberoptic Endoscopic Evaluation of Swallowing (FEES).

VFSS is the most comprehensive diagnostic procedure for assessment of dysphagia (Wright, Boyd, & Workman, 1998). VFSS is the most comprehensive because it is the only procedure providing visualization of the entire dynamic swallowing process (e.g., from food mastication [chewing] to esophageal emptying) (Newman & Petersen, 1999). In adults, VFSS allows for visualization of abnormal structures and function affecting swallowing and potential dysphagia management strategies during the assessment. In infants and children, VFSS allows for a simultaneous and systematic visual assessment of the entire swallowing mechanism including some underlying causes of dysphagia (Newman & Petersen). According to Perlmann, Lu, and Jones (1997), "this examination is performed in order to determine if patients can progress to or continue safe oral intake" (p. 154). The strength of the VFSS is that the underlying physiology of dysphagia can be generally determined.

FEES also provides dynamic visual imaging for the assessment of dysphagia (Groher, 1992; Langmore, Schatz, & Olsen, 1988; Logemann, 1998; Mills, 2000;

Murray, 1999). FEES uses a fiberoptic camera lens to provide visual imaging. Because it excludes all oral events and significant events in the swallow sequence, FEES is not as comprehensive as VFSS (Logemann, 1998). Interpretation of dynamic visual imaging is limited to only the structures and function directly in front of the fiberoptic camera lens (Murray). Prior to conducting FEES, swallowing clinicians are extensively trained to perform FEES and interpret the resulting dynamic visual images (Groher; Langmore et al.; Logemann; Mills; Murray).

With approximately 50% of speech-language pathologists (SLPs) in the United States (U. S.) evaluating and treating dysphagia, acquiring the knowledge and skills needed to accurately interpret instrumental observation of swallowing is extremely important (American Speech-Language-Hearing Association [ASHA], 1990; ASHA, 2000). Learning to interpret instrumental observation of swallowing during the assessment of dysphagia appears to follow a continuum. The first stage of the continuum of learning is acquiring a comprehensive knowledge of physiology of the dynamic swallowing process. Scholten (2001) stated, "students must develop an understanding of the normal integrated swallow and how it can be affected to appreciate the assessment or treatment of dysphagia" (p. 10). Knowledge of the physiology of normal swallowing is typically learned in undergraduate-level anatomy and physiology classes. Hereafter, the first stage of the continuum will be known as Undergraduate. The second stage of the continuum is a comprehensive knowledge of the physiology of both normal and abnormal swallowing combined with advanced training in dysphagia. Advanced training includes didactic graduate-level coursework in dysphagia and continuing education workshops. ASHA (1996) has taken the position that graduate programs should teach students to

interpret instrumental observation of swallowing during assessment of dysphagia. Hereafter, the second stage of the continuum will be known as Graduate. Finally, a third stage of the continuum is the combination of comprehensive knowledge of the physiology of swallowing, advanced training in dysphagia, and experience performing instrumental assessment of dysphagia with patients. Radiologists learn to interpret diagnostic radiologic assessment through experience performing individual diagnostic procedures while in graduate medical training. However, there is insufficient data regarding how SLPs learn to interpret instrumental observation of swallowing when evaluating dysphagia (Perry, 1999). Hereafter, the third stage of the continuum will be known as Experienced.

Statement of the Problem

If one is to assume that knowledge of the physiology of normal and abnormal swallowing, advanced training in dysphagia, and experience performing instrumental assessment of dysphagia all play a role in interpretation of instrumental observation of swallowing, the relationship of education and experience needs to be investigated. To date there is insufficient information regarding the manner in which SLPs learn to interpret instrumental observation of swallowing during assessment of dysphagia. Yet, SLPs are routinely required to interpret instrumental observation of swallowing during assessment of dysphagia. There is the possibility with existing standards that SLPs assess patients with dysphagia without adequate education and experience needed to accurately interpret instrumental observations of swallowing.

Purpose and Research Hypotheses

The purpose of this study was to investigate the relationship of knowledge of the

physiology of normal and abnormal swallowing to accuracy interpreting instrumental observation of swallowing during assessment of dysphagia at the three points along a continuum of accumulating knowledge of the physiology of normal and abnormal swallowing (e.g., Undergraduate, Graduate, and Experienced). In this investigation, instrumental observation of swallowing was limited to VFSS. It was hypothesized that a significant difference would be found in knowledge of the physiology of normal and abnormal swallowing at the three points along a continuum. It was hypothesized that participants in an Experienced group would demonstrate the highest level of knowledge of the physiology of normal and abnormal swallowing followed by participants in a Graduate group. It was also hypothesized that participants in an Undergraduate group would demonstrate the lowest level of knowledge of the physiology of normal and abnormal swallowing. It was further hypothesized that significant differences would be found among accuracy interpreting VFSS at the three points along the continuum, when controlling for the varying levels of knowledge of the physiology of normal and abnormal swallowing among participants of this investigation. It was hypothesized that participants in an Experienced group would demonstrate the highest accuracy interpreting VFSS when controlling for knowledge of the physiology of normal and abnormal swallowing followed by participants in a Graduate group. It was also hypothesized that participants in an Undergraduate group would demonstrate the lowest accuracy interpreting VFSS when controlling for knowledge of the physiology of normal and abnormal swallowing. Finally, it was hypothesized that a significant, positive relationship would be found between knowledge of the physiology of normal and

abnormal swallowing and accuracy interpreting VFSS among the participants of this investigation.

Research Questions

1. Are there significant differences in knowledge of the physiology of normal and abnormal swallowing among subjects in an Undergraduate, Graduate, and Experienced groups?

2. When controlling for knowledge of the physiology of normal and abnormal swallowing, are there significant differences in the ability to interpret VFSS when assessing dysphagia among subjects in the Undergraduate, Graduate, and Experienced groups?

3. Does a significant relationship exist between accuracy interpreting VFSS and knowledge of the physiology of normal and abnormal swallowing among subjects in this study?

Chapter 2

Review of Literature

Although research demonstrates that instrumental observation of swallowing provides the most accurate visualization for a patient's dysphagia, knowledge about how speech-language pathologists (SLPs) learn to interpret instrumental observation of swallowing during instrumental assessment of dysphagia is not well reported in the literature. Consequently, the following literature review is not limited to the normal procedures (e.g., searching online databases, reviewing textbooks, reviewing peer-reviewed journals, etc.). This literature review also includes personal interviews and written correspondence with experts in the field of radiographic and fluoroscopic imaging (i.e., radiologists), consultation with publishers of textbooks and training materials for dysphagia, and discussions with the administration of the American Speech-Language-Hearing Association's (ASHA) Special Interest Division for Dysphagia #13.

The following literature review is divided into three sections. The first section provides background information about the role and responsibilities of SLPs during instrumental assessment. The second section examines contemporary education and training materials used to teach SLPs to interpret instrumental observation of swallowing. Finally, the third section investigates how radiologists are educated and trained to interpret diagnostic radiological assessments.

SLP's Role During Instrumental Assessment

Before reviewing the literature on training SLPs to interpret instrumental observation of swallowing during assessment of dysphagia, ASHA's position on SLPs

role in performing and interpreting instrumental assessment for dysphagia will be summarized.

Scope of practice. ASHA has included instrumental assessment procedures for swallowing in the scope of practice for SLPs (ASHA, 1996). More specifically, instrumental techniques included in the amended scope of practice include Videofluoroscopic Swallow Study (VFSS) and Fiberoptic Endoscopic Evaluation of Swallowing (FEES) (ASHA, 1997).

Proficiencies and responsibilities. Clinical certification by ASHA, required of all practicing clinicians, means that SLPs have met the education, knowledge, and experience requirements for providing basic clinical services in the field of speech-language pathology (SLP) (ASHA, 1992). However, ASHA's Ad Hoc Committee on Advances in Clinical Practices (1992) stated that clinical certification alone does not provide sufficient education, knowledge, or experience to perform instrumental assessment in dysphagia. ASHA's Ad Hoc Committee on Advances in Clinical Practice (1992) issued a position statement to ensure that patients with dysphagia receive the best quality of care, welfare, safety, and comfort from clinically certified SLPs. ASHA's Ad Hoc Committee on Advances in Clinical Practice reported "there is no intention to imply that the practitioner holding ASHA certification is prepared to conduct the procedure(s); nor is it incumbent on any certified professional to provide the procedure(s) merely because the practitioner holds certification" (p. III-27). Therefore, ASHA's Position Statement (1992), *Instrumental Diagnostic Procedures for Swallowing*, is intended to serve as a guideline for acquiring the knowledge, proficiencies, and skills needed for clinical competence needed when conducting VFSS and FEES.

ASHA's position statement and guidelines have learning objectives for acquiring the knowledge and skills needed to perform and interpret VFSS and FEES. Each learning objective has proficiencies and specific knowledge and skills to be learned before SLPs can perform VFSS and FEES. Table 1 lists the objectives, proficiencies, and knowledge and skills needed to perform VFSS. Table 2 lists the objectives, proficiencies, and knowledge and skills needed to perform FEES (ASHA, 1992).

ASHA has subsequently issued a separate position statement outlining the role of SLPs during performance and interpretation of FEES (ASHA, 2000). According to ASHA, the scope of practice for SLPs does not include rendering a medical diagnosis from the performance and interpretation of VFSS or FEES. Physicians are the only professionals licensed to make a medical diagnosis related to the pathophysiology of swallowing dysfunction. However, ASHA's position statement indicates that SLPs are able to use FEES for assessing and treating dysphagia in the absence of a medical diagnosis that has been rendered by a physician (ASHA).

Summary of SLP's Role During Instrumental Assessment

In summary, the role of the SLP during instrumental assessment is competently performing instrumental assessment:

1. Instrumental assessment is included in the scope of practice for SLPs.
2. Clinical certification by ASHA is not inclusive of education, knowledge, or experience needed to manage dysphagia.
3. ASHA issued a position statement to serve as a guideline for acquiring education and experience to perform and interpret instrumental assessment.

Table 1

ASHA's Guidelines for Knowledge and Skills in Videofluoroscopic Swallow Study (VFSS)

Objectives	Proficiencies	Knowledge/Skills needed
To conduct VFSS of oral preparatory, oral, pharyngeal, and cervical esophageal stages of swallowing.	Performing VFSS; Providing pertinent information to radiologist and referring physician regarding results of VFSS;	Knowledge of the results of clinical assessment including history, cognitive, nutritional, hydration, respiratory status, and physical findings.
	Preparing and delivering bolus;	Knowledge of effects on swallowing physiology from changes in bolus size and consistency.
	Postural Changes during VFSS	Knowledge of effects on swallowing physiology from postural changes.
To interpret results of VFSS	Evaluating anatomy & physiology of swallowing mechanism	Knowledge of anatomy & physiology for adults and children. Knowledge of normal variability of normal swallowing. Knowledge of the effects on swallowing physiology from bolus consistency and postural changes.

Note. From " Instrumental Diagnostic Procedures for Swallowing," American Speech-Language-Hearing Association, 1992, Asha, 32, (Supplement 7), p. III-30 . Copyright American Speech-Language-Hearing Association. Adapted with permission of author.

Table 2

ASHA's Guidelines for Knowledge and Skills in Fiberoptic Endoscopic Evaluation of Swallowing (FEES)

Objectives	Proficiencies	Knowledge/Skills needed
To perform FEES in consultation with physician for pharyngeal swallowing phase	Positioning of Patient; Apply topical anesthesia; Transnasally insert fiberoptic camera; Prepare bolus material; Assessing need to modify bolus; Assessing pharyngeal and laryngeal flow and residue; Positioning patient for swallowing maneuvers to determine appropriate strategies.	Knowledge of appearance of anatomy at rest. Knowledge of signs of aspiration. Knowledge of instrumental FEES procedure. Knowledge of sterilization of FEES equipment. Knowledge of correct patient positioning. Identifying and using medical emergency personnel. Knowledge of contraindications of topical anesthesia.
To interpret the results of FEES	Determining presence of premature spillage; Evaluating normalcy of function of pharyngeal and laryngeal structures; Determining whether or not other diagnostic should be instituted.	Knowledge of pharyngeal anatomy. Knowledge of physiology of swallowing Knowledge of advantages of other assessment procedures. Knowledge of signs of premature spillage, residue, penetration, and aspiration. Knowledge of effects of bolus manipulation. Knowledge of effects of postural adjustments. Knowledge of effects of abnormal physiology.

Note. From " Instrumental Diagnostic Procedures for Swallowing," American Speech-Language-Hearing Association, 1992, Asha, 32, (Supplement 7), p. III-34. Adapted with permission of author.

4. SLPs cannot make a medical diagnosis from VFSS and FEES.

5. SLPs can assess and treat dysphagia using VFSS and FEES.

Professional Education and Training for SLPs

Since insufficient information exists regarding how SLPs learn to interpret instrumental observation of swallowing, it is important to examine the current methods and training materials used to learn interpretation skills.

Physiology of normal and abnormal swallowing coursework. It has been reported that SLPs must acquire a thorough knowledge of the physiology of normal and abnormal swallowing to accurately interpret instrumental observation of swallowing (Scholten & Russell, 2000; Wooi et al., 2001). Wooi et al. found a significant relationship between knowledge of anatomical landmarks found in the swallowing mechanism and accuracy interpreting instrumental observation of swallowing. During the Wooi et al. investigation, students from an undergraduate level anatomy and physiology class were taught anatomic landmarks on the swallowing mechanism from static radiographic images. Upon completion of the teaching sessions, participants demonstrated a strong relationship between their ability to identify anatomic landmarks from static images and ability to accurately interpret VFSS (Wooi et al.).

Advanced training in dysphagia. ASHA has taken the position that graduate programs should provide the knowledge and skills students need to interpret instrumental observation of swallowing (ASHA, 1996). However, ASHA (1995) reported that only 18 of the 112 such programs applying for Educational Standards Board (ESB) accreditation offered academic coursework in dysphagia. Of these 18 programs offering dysphagia coursework, most included dysphagia as a section or part of lectures in motor speech

disorders or neurological disorders. ASHA reported that many of these 18 programs offered no observation or practicum opportunities for dysphagia services. Over a series of phone conversations, facsimile transmissions, and electronic mail correspondences with the investigator, Janet Brown (personal communication, May 18, 2001), Director of Healthcare Services for ASHA, reported that ASHA's position is that the number of graduate education and training programs offering courses in dysphagia has increased. However, no current data exist regarding the number of dysphagia courses offered by graduate education and training programs applying for ESB accreditation. Moreover, ASHA has no required standards regarding the knowledge and skills that must be learned to be certified clinically competent when interpreting instrumental observation of swallowing (J. Brown, personal communication, May 18, 2001).

ASHA's Special Interest Division of Dysphagia #13 (1997) developed a suggested graduate curriculum for educating and training SLPs to evaluate and manage dysphagia. The suggested graduate curriculum was designed to serve as a guide for graduate education and training programs. The suggested graduate curriculum included basic skills and knowledge deemed necessary for SLPs performing instrumental assessment of dysphagia providing instrumental observation of swallowing (See Table 3). ASHA's Special Interest Division for Dysphagia #13 (1997) suggested graduate curriculum include a basic graduate level didactic course, practical lab and observations, suggestions for clinical practicum, and an advanced level research course. According to the Special Interest Division for Dysphagia #13 (1997), an introductory graduate level course should include four hours of lecture per week. Instrumental and noninstrumental assessments are included in the suggested graduate curriculum. More specifically, the

Special Interest Division for Dysphagia #13 (1997) suggested specific lecture content to teach the basic skills and knowledge for assessment of instrumental observation of swallowing (See Table 4).

Table 3

ASHA's Basic Skills for Instrumental Assessment in Dysphagia

Basic Skills
1. Understand the normal anatomic, physiologic, and developmental influences across the life span on swallowing and respiration.
2. Understand the various etiologies and components of abnormal swallowing and respiration.
3. Understand differences between dysphagic symptoms in adults and infants.
4. Understand principles of a clinical oropharyngeal sensory motor examination.
5. Understand the various instrumental procedures used in evaluating swallowing and their specific advantages and disadvantages.
6. Understand principles of dysphagia diagnosis and treatment across age spans and conditions.
7. Evaluate the signs and symptoms of dysphagia as revealed by videofluoroscopy, clinical, and other instrumental examinations.
8. Write a dysphagia evaluation based on objective findings of instrumental and noninstrumental assessment.
9. Develop a remediation plan and functional goals based on videofluoroscopy (or other objective measures) and clinical examinations.

Note. From "Graduate Curriculum on Swallowing and Swallowing Disorders," by ASHA Special Interest Division 13: Swallowing and Swallowing Disorders, 1997, ASHA Desk Reference, 3, pp. 248a-248n.

Table 4

Lecture Content Specified for Imaging Assessment in Dysphagia

Instrumentation	Specific Content
Videofluoroscopy	Definition and Rationale Procedure/Protocol Findings and Interpretation Radiation Safety Procedures
Flexible Endoscopy	Definition and Rationale Procedure/Protocol Findings and Interpretations Advantages and Disadvantages

Note. From "Graduate Curriculum on Swallowing and Swallowing Disorders," by ASHA Special Interest Division 13: Swallowing and Swallowing Disorders, 1997, ASHA Desk Reference, 3, pp. 248a-248n. Copyright American Speech-Language-Hearing Association. Adapted with permission of author.

Additional observation lab work and clinical practicum are suggested each week. Content for the lab and clinical practicum includes (a) interpretation of videotape imaging studies, (b) observation of a variety of levels of severity and various disorders, (c) hands-on training and demonstrations in diagnostic and treatment techniques with adults and children, (d) report writing, and (e) community-based clinical partnerships (ASHA, 1997).

ASHA's Special Interest Division for Dysphagia #13 (1997) has no data regarding the number of graduate education and training programs using the suggested

curriculum. Consequently, no data are available regarding the effectiveness of the education and training suggested in the curriculum (J. Brown, personal communication, May 21, 2001).

Continuing education training workshops. Many SLPs learn to assess and treat dysphagia by attending continuing education workshops. Continuing education workshops are designed to allow licensed SLPs to supplement knowledge and skills regarding current trends and technology in the field. In 2000, the subject area of dysphagia had the second highest number of continuing education workshops offered (e.g., 645 seminars) and the second highest enrollment (e.g., 13,958) of any seminars on the ASHA Registry for Continuing Education (J. Brown, personal communication, May 24, 2001). However, weaknesses are inherent in continuing education programs on dysphagia topics. ASHA has limited control regarding the content taught during continuing education workshops. Brown (personal communication, May 24, 2001) stated, "we have standards that each course must meet to be on the Registry, but we don't monitor the methods or effectiveness of the individual seminars."

Textbooks. Undergraduate anatomy and physiology textbooks mainly focus on the parameters of normal speech, language, and hearing. Although content is left to the instructor's discretion, the anatomy and physiology of the swallowing mechanism is generally included but may be limited to a paragraph or small number of pages or a section in textbooks (Martini, 1989; Perkins & Kent, 1986; Seikel, King, & Drumright, 2000; Zemlin, 1988).

Several advanced training textbooks in dysphagia have been written to educate and train SLPs in evaluation and treatment of adult dysphagia (Groher, 1992;

Logemann, 1998; Murray, 1999; Perlman & Schulze-Delrieu, 1997; Sonies, 1997; Swigert, 2000) and pediatric dysphagia (Arvedson & Brodsky, 1993; Rosenthal, Shepherd, & Lotze, 1994; Swigert, 1998; Tuchman & Walter, 1998). These textbooks are generally designed to include an understanding of anatomy and physiology of normal and abnormal swallowing. Chapters and sections designed to prepare SLPs to conduct assessment using instrumental observation of swallowing are generally included in these textbooks. These chapters and sections generally give a historical perspective of imaging technology, procedures involved in imaging assessment, equipment used, types of pathology visualized, and treatment strategies utilized during imaging assessment. Static radiographic images are used to provide visualization of anatomy, physiology, and pathology seen during dynamic instrumental assessment. Consequently, textbooks are limited in their ability to provide the skills and knowledge needed to visualize the image of the dynamic swallow during instrumental assessment (Scholten, 2001).

Clinical manuals. Clinical manuals provide a systematic support for clinical training (Hall, 2001; Logemann, 1993; Murray, 1999). These manuals are generally designed to provide procedural guidelines for dysphagia evaluation using visualization technology. These manuals also use static radiographic images to assist in learning to interpret dynamic images. Consequently, these manuals are also limited in their ability address the skills and knowledge needed to visualize or interpret the image of the dynamic swallow during instrumental assessment (Scholten, 2001).

Teaching aids. Teaching aids have been developed to improve visualization of the dynamic swallow process. Such teaching aids include educational videos and interactive multimedia programs (i.e., CD-ROM's). According to Scholten (2001), most teaching

materials are static in nature and cannot accurately represent the dynamic character of the swallow. Scholten called the static nature of teaching materials a contributing factor to poor understanding of the dynamic nature of swallowing. Scholten reported that the only teaching materials with elements of motion are VFSS and FEES films originally acquired during actual swallowing assessments. Diagnostic VFSS films rarely have sufficient definition for teaching and FEES film interpretation requires very specialized training (Scholten).

Videofluoroscopic Swallowing Studies: Evaluation and Therapy Planning is an educational video designed to improve interpretation of dynamic visual images during VFSS (Logemann, 1988). The purpose of the video was to provide visualization of the dynamic swallow process. This video also provided visualization of commonly used therapeutic interventions used during VFSS. VFSS movies originally produced for diagnostic purposes were used to demonstrate the dynamic swallow process. The 25-video sequences on this video vary in quality of imaging. Some images lack contrast and sharpness and are difficult to watch. This video is limited in its ability to teach the knowledge and skills needed to interpret dynamic visual images viewed during instrumental assessment. The biggest limitation of the video is that it lacks text or spoken dialogue.

To overcome the limitations of currently available teaching resources (e.g., still radiographic images and non-interactive media) in dysphagia, Scholten (2001) developed an interactive multimedia CD-ROM, *The Dynamic Swallow*. This (Scholten) program teaches various aspects of swallowing by integrating presentation of text, graphics, voice-overs, video, and animation of normal and abnormal swallow physiology. The

interactive aspects of *The Dynamic Swallow* (Scholten) program allow students to manipulate various aspects of the swallowing process. For example, by clicking on separate computer program icons, students can view aspects of normal swallowing process and disordered swallowing processes in both dynamic animation and videofluoroscopy. According to Scholten, "students can selectively manipulate parts of this process to understand the normal swallow and to simulate different aspects of dysfunction and the consequent effect on swallow safety and efficiency" (p.10). Scholten reported that this program was created as a result of her concern that students have difficulty in developing a useful understanding of the dynamic nature of swallowing from static images.

Martin-Harris, McConnel, and McMahon (1999) produced *Radiographic Interpretation of Swallowing Disorders*. This program is an interactive CD-ROM with 36 different patient cases. It is designed to teach five learning outcomes: (a) identify pertinent anatomic structures of the upper aerodigestive tract depicted radiographically; (b) define the physiologic components of normal swallowing during VFSS; (c) distinguish swallowing disorders on VFSS that involve oral, pharyngeal, and cervical esophageal structures and functions; (d) recognize swallowing radiographic problem profiles that may occur with varied medical and surgical conditions; and (e) select appropriate swallowing treatment strategies based on component analysis of swallowing function. A competency assessment of knowledge and skills follows completion of the learning outcomes.

A Virtual Patient Training Module is currently being developed at Ohio University (Dean, Manning, & Thompson, 2001). The training module is an interactive

CD-ROM that will provide students with realistic assessment experiences (e.g., medical chart review and videofluoroscopy). It will provide students with a comprehensive experience for assessing and managing a virtual patient with dysphagia. The training module will facilitate clinical decision-making by requiring a student to administer a clinical assessment and instrumental assessment (VFSS). During VFSS, students will be required to determine appropriate trial dysphagia management strategies. Students will be required to document results of clinical decision-making throughout the training module. The training module will allow the student's clinical decision-making to be monitored and assessed by an instructor (Dean et al., 2001).

Experience Performing VFSS

Variations exist in the techniques used to administer instrumental assessment of dysphagia such as diagnostic materials administered to patients, the methodology used for recording and reviewing results of instrumental assessment of dysphagia, the involvement and expertise of physicians and SLPs, and the criteria used for interpretation of instrumental observation of swallowing (Ott, 1998). It has been reported that accuracy interpreting VFSS is correlated to experience performing VFSS (Kuhlemeier, Yates, & Palmer, 1998; McCullough et al., 2001; Murray & Jacobsen, 2001). McCullough et al. determined that with additional training, experienced SLPs could reliably interpret VFSS over time. According to Murray and Jacobsen (2001), accuracy interpreting VFSS is correlated to the number of VFSSs performed each week.

Differences in Pediatric and Adult Dysphagia

Pediatric dysphagia differs from adult dysphagia in many ways such as coordination of swallowing with respiration, anatomy and physiology, and suggested

therapeutic interventions. Consequently, graduate level coursework in dysphagia and continuing education seminars for adult dysphagia and pediatric dysphagia are routinely taught separately. Furthermore, advanced training textbooks in dysphagia, clinical manuals in dysphagia, and training aids should be designed specifically to provide information about either dysphagia in the pediatric population or dysphagia in the adult population.

Summary of Professional Education and Training for SLPs

In summary, graduate level education and training programs, textbooks, and training materials appear to focus on teaching students to use their knowledge of the anatomy and physiology to interpret dynamic visual imaging:

1. ASHA's position is that graduate education and training programs should provide the knowledge and skills needed to interpret instrumental observation of swallowing during the assessment of dysphagia.

2. ASHA's basic skills and knowledge for instrumental assessment in dysphagia focus on an understanding of normal anatomic, physiologic, and developmental influences on swallowing and respiration.

3. ASHA established no specific requirements for education and training for knowledge and skills needed to interpret instrumental observation of swallowing.

4. Continuing education seminars are designed to update knowledge and skills regarding current trends and technology in the field.

5. ASHA has limited control over methods of teaching and effectiveness of continuing education seminars.

6. Advanced training textbooks are written to include an understanding of the anatomy and physiology of normal and abnormal swallowing.

7. Clinical manuals provide procedural support for the instrumental evaluation of dysphagia. No information was found regarding interpretation of instrumental observation of swallowing during assessment of dysphagia.

8. Some current training aids do not provide a "hands-on" training experience (CD-ROM's). Educational videos are non-interactive and do allow students to simulate or interact with the assessment process.

9. Interactive multimedia programs are allowing simulation of the assessment process.

10. Accuracy interpreting VFSS is correlated to experience performing VFSS.

11. Knowledge of the physiology of normal and abnormal swallowing differs for the pediatric population and dysphagia in the adult population and should be independent areas of study.

Professional Education and Training in Radiology

The absence of sufficient information documenting how SLPs are trained has been demonstrated. Therefore, it should be instructive to determine how radiologists receive their formal training in interpreting dynamic visual imaging.

Physicians. Radiology had become the keystone to modern diagnosis (Morgan, 1971). However, some physicians, while attending medical school, have not received specialized training in static and dynamic image interpretation (J. Bensler, personal communication, July 20, 2001). Many academic radiology department chairs have taken a position that teaching radiology is burdensome and have failed to place the appropriate

emphasis on radiology in the standard medical school curriculum (Lalli, 1973; Squire & Novelline, 1985). According to Squire (1989), many medical schools make only a token effort to instruct medical students in radiologic anatomy in the first year. During the first 4 years of medical school, students generally observe radiological procedures during brief rotations (generally 2 week period of time) (J. Bensler, personal communication, July 20, 2001).

Radiologists. Researchers in the field of radiology reported that academic coursework alone (i.e. lectures on anatomy and physiology) resulted in "poor learning" regarding interpretation of dynamic visual images (Squire, 1989). Gonnella, Goran, Williamson, and Cotsonas (1970) found that recall of lecture material does not translate into action when students are faced with real situations involving the care of patients. According to Rubin (1989), radiology is a complex skill involving the ability to combine information from visual pattern recognition, knowledge of anatomy, knowledge of physiology, and knowledge of pathological processes with patient-specific information. However, little is known about how radiologists acquire this complex ability or skill (Rubin). Other studies have described radiology as a "clinical problem solving" skill in which accurate radiological interpretation goes beyond simple visual perception of radiologic images (Laws, 1981; Miller & Andrews, 1977; Rubin).

Past research indicated that 20% to 40% of the statements made in radiology reports are erroneous and many of these erroneous statements were life-threatening (Rhea, Potsaid, & DeLuca, 1979; Swensson, Hessel, & Herman, 1977). The error rate was higher with less experienced radiologists (Christensen et al., 1981; Doubilet & Herman, 1981; Rhea et al.). Consequently, medical schools utilize experience-based

learning along with lecture when teaching radiologists to interpret radiographic test results (American Council of Graduate Medical Education [ACGME], 2001). Didactic training is accompanied by intense instructor-to-student clinical training to ensure the information learned during in-class lectures is implemented during hands-on radiological training (J. Bensler, personal communication, July 20, 2001).

Physicians receive their specialty training in radiology during graduate level residency programs. ACGME (2001) has set standards for professional education and training for radiologists. Resident education and training in diagnostic radiology focuses on clinically oriented graduate medical education. Residency programs can include as many as 4 years of diagnostic radiology and 1 year of education and training in a subspecialty of diagnostic radiology.

ACGME requires progressive clinical supervision throughout the residency program. To ensure diagnostic radiology residents gain sufficient experience in radiological procedures and interpretation, ACGME has set minimum standards. Diagnostic radiology residents must train in hospitals and diagnostic facilities completing no less than 75,000 diagnostic radiology procedures per year. Individual diagnostic radiology residents are required to complete no less than 7,000 diagnostic radiology procedures each year.

The final year of diagnostic radiology residency involves education and training in a subspecialty area such as pediatric radiology, neuroradiology, or vascular interventional radiology. Videofluoroscopy is included in vascular interventional radiology. Residents are intensely educated and trained in the subspecialty by medical school faculty members. Upon completion, residents are expected to have a thorough

knowledge of the clinical indications, interpretation, and limitations of each diagnostic procedure. Residents are expected to have an understanding of the significance of symptoms, the pathophysiology and natural history of disorders, and contraindications for each diagnostic procedure. Residents are expected to complete a minimum of 500 diagnostic procedures in the subspecialty area.

Professional education and training standards required in radiology differ greatly when compared to the professional education and training standards to use instrumental assessment in speech-language pathology. Radiologists are required to complete specialty training over a period of up to 5 years. During this specialty training, ACGME has set standards regarding the minimum number of radiologic diagnostic procedures that must be completed. Although clinical certification is required for practicing clinicians, the ASHA does not require minimum standards for SLPs assessing and treating persons with dysphagia, nor does clinical certification provide sufficient education, knowledge, or experience to perform instrumental assessment in dysphagia.

Image interpretation aids. Radiology image interpretation aids, which include radiologic interpretation textbooks and pocket-sized charts listing procedural guidelines, tend to focus on improving positioning of a patient for imaging, accuracy of radiation beam projection, and image definition (Houston & Davis, 2001; Scheffer & Tobin, 1997). Very little information is provided on the knowledge and skills needed to accurately interpret static and dynamic images. Image interpretation aids generally consist of static radiographic images, which by nature fail to accurately provide visualization of the dynamic nature of swallowing (Scholten, 2001). Houston and Davis provide a list of important observations when completing fluoroscopic swallowing assessment (See Table

5). When asked by electronic mail about sources for training materials that train radiologists to interpret fluoroscopic images, Houston (personal communication, October 3, 2001) replied:

> Now that you mention it, I realize how little material there is available on the actual interpretation of swallowing studies. Our *Fundamentals of Fluoroscopy* book only really covers the techniques for obtaining the images, not the interpretation of the resulting images.

Computer-assisted instruction. According to McGhee, Bennett, Morris, and Witanowski (1989), computer-assisted instruction (CAI) has become an important tool in radiological instruction. McGhee and colleagues (1989) reported that with the continual invention of diagnostic equipment, the volume of radiologic information taught to medical students continues to grow. Consequently, many academic radiologists are finding teaching much more difficult due to time constraints. CAI systems have provided an interactive method of teaching new technology to medical students, residents, and practicing physicians by augmenting other learning methods such as textbooks and lectures (McGhee et al.).

SLP's are beginning to utilize CAI. *A Virtual Patient Training Module*, which currently being developed at Ohio University, uses similar technology to introduce an interactive method of providing VFSS interpretation experiences to students currently in graduate training programs and practicing SLPs by supplementing other educational resources such as textbooks, clinical treatment manuals, and continuing education workshops (Dean et al., 2001). The training module will allow clinical decision-making and visual pattern recognition from VFSS film to be recorded and monitored by an instructor (Dean et al.).

Table 5

Important Observations of Swallowing during VFSS

Observations of Swallowing
1. Quality of Oral Transfer
2. Nasopharyngeal Reflux
3. Pooling in Valleculae and Pyriform Recesses
4. Laryngeal Penetration
5. Frank Tracheal Aspiration (below true vocal folds)
6. Cricopharyngeal Achalasia (failure to relax)
7. Cricopharyngeal Hypertrophy
8. Anterior Osteophytosis of the Cervical Spine.
9. Posterior Pharyngeal wall Thickening (edema, hematoma, abscess)

Note. From Fundamentals of Fluoroscopy (p. 20), by J. D. Houston, & M. Davis, 2001, Philadelphia: W. B. Saunders. Adapted with permission.

Summary of Professional Education and Training in Radiology

In summary, professional education and training in radiology appears to focus on experience-based learning:

1. Some medical students receive professional education and training in radiology from lecture material accompanied by intense instructor-to-student clinical training.

2. Researchers in the field of radiology report that academic coursework alone results in "poor learning" with little carryover of information to the bedside.

3. Radiology is a complex skill requiring the ability to combine information from visual pattern recognition, knowledge of anatomy, knowledge of physiology, and knowledge of pathological processes with pertinent patient-specific information.

4. Physicians receive specialty training in radiology at the graduate medical level (i.e. residency).

5. The radiology residency program can include as many as four years of education and training in diagnostic radiology and a final year of education and training in a subspecialty area that may include fluoroscopy.

6. Physicians in radiology training programs must perform no less than 7,000 diagnostic procedures each year of residency.

7. Radiology textbooks focus on improving the image quality and definition by providing information about positioning and direction of radiation beam. Information about image interpretation is insufficiently addressed in current radiology textbooks.

8. Computer-Assisted Instruction has become an important tool in radiological instruction because the amount of information needed for competency in radiology continually grows.

Summary of Findings Presented in Literature Review

The following is a summary of the findings presented in this literature review. This summary will be presented in the following order: (a) role and responsibilities of SLPs during instrumental assessment of dysphagia, (b) professional education and training of SLPs in dysphagia, and (c) professional education and training in radiology.

In summary of the role and responsibilities of SLPs during instrumental assessment of dysphagia, ASHA has included instrumental assessment in the SLPs scope of practice. Clinical certification by ASHA does not necessarily indicate that SLPs have acquired the education, knowledge, and experience to perform and interpret visual imaging.

In summary of the professional education and training of SLPs in dysphagia, ASHA's position is that graduate education and training programs need to provide the knowledge and skills needed to accurately interpret instrumental observation of swallowing during the assessment of dysphagia. Although no specific requirements have been established, ASHA's recommended basic knowledge and skills for instrumental assessment in dysphagia focus on an understanding of normal anatomic, physiologic, and developmental influences. Many SLPs are attending Continuing Education (CEU) seminars to acquire or update knowledge and skills needed for instrumental assessment of dysphagia. However, ASHA has limited control over the information presented at CEU seminars. Current training aids do not provide a "hands-on" training experience. The basic knowledge and skills needed to accurately assess adult and pediatric dysphagia should be taught separately.

Finally, in summary of professional education and training in radiology, radiology is a complex skill requiring the ability to combine information from visual pattern recognition, knowledge of anatomy, knowledge of physiology, and knowledge of pathological processes with pertinent patient-specific information. Researchers in the field of radiology report academic coursework alone results in "poor learning" and that little carryover observed in the diagnostic radiologic procedures. Physicians receive specialty training at the graduate medical level (i.e., residency). Physicians in radiology residency programs must perform a minimum of 7,000 diagnostic procedures over the course of their specialty training. Radiology textbooks focus on improving x-ray image quality and definition by providing information about positioning and direction of radiation beam. Information about diagnostic radiographic image interpretation is

insufficiently addressed. Computer-Assisted Instruction (CAI) has become an important tool in radiological instruction. Because of the continual development of diagnostic technology in the field of radiology, radiology instructors cannot expose physicians in radiology training programs to all the needed information. Consequently, medical schools are relying on CAI to provide additional instruction in radiology.

Minimum standards required for professional education and training in radiology are the major difference in radiology when compared to professional education and training in speech-language pathology. Physicians in graduate medical programs must complete intensive didactic instruction combined with comprehensive student-to-instructor clinical supervision. ACGME has set minimum standards for the number of radiologic diagnostic procedures that must completed by radiology residents. In speech-language pathology, clinical certification is required, but clinical certification alone does not provide sufficient education, knowledge, or experience to perform instrumental assessment in dysphagia. ASHA has issued position statements regarding basic skills needed to perform instrumental assessment of dysphagia, but no standards have been issued.

Chapter 3

Method

The purpose of this study was to investigate the relationship between knowledge of the physiology of normal and abnormal swallowing and accuracy interpreting instrumental observation of swallowing when assessing dysphagia. As previously mentioned, learning to accurately interpret instrumental observation of swallowing when assessing dysphagia appeared to follow a continuum. The first point along the continuum was establishing knowledge of the physiology of normal swallowing. All speech-language pathologists (SLPs) in training typically complete a class in anatomy and physiology at the undergraduate level. The second point along the continuum occurs when knowledge of the physiology of normal swallowing is supplemented by a graduate-level didactic class or a continuing education workshop in dysphagia. The third point along the continuum occurs with knowledge provided from experience performing instrumental assessment of dysphagia. Consequently, three groups representing the three points along the continuum were used in this study. Using three groups, the study sought to determine whether significant differences existed in knowledge of the physiology of normal and abnormal swallowing at these three points along the continuum of professional training to manage swallowing disorders. This study further sought to determine whether significant differences existed between accuracy interpreting instrumental observation of swallowing among the three groups when controlling for the varying levels of knowledge of the physiology of normal and abnormal swallowing among participants of this study. Finally, this study sought to determine whether a

significant relationship existed between knowledge of the physiology of normal and abnormal swallowing and accuracy interpreting instrumental observation of swallowing among the participants of this study.

Research Design

A quasi-experimental design was used for this investigation (Hegde, 1999). One-way analysis of variance, one-way analysis of covariance, and correlation analysis were conducted.

Participants

Three groups representing the three points along the learning continuum were used in this investigation. Borenstein, Rothstein, Cohen, Schoenfeld, and Berlin (2000), who are the developers of *SamplePower 2.0* for Statistical Package for Social Sciences (SPSS), suggest using a ratio of 35 subjects per group for one-way analysis of covariance (ANCOVA) to yield a (high) statistical power of .80 with a medium effect size of .25. The within cell standard deviation was set at 1.0 and the standard deviation for variance was set for 1.0. The three groups included in this study were named Undergraduate, Graduate, and Experienced. The Undergraduate group consisted of 35 participants who had completed a didactic anatomy and physiology class at Ohio University 6 to 12 months prior to this study. Participants with additional formal study or practical experience with dysphagia were excluded from the Undergraduate group. The Graduate group consisted of 35 participants who in addition to a didactic anatomy and physiology class and also had completed a graduate-level didactic class in dysphagia at Ohio University within the past 12 months. Participants with no didactic class in dysphagia or participants with experience in managing patients with dysphagia were excluded from the

Graduate group. The Experienced group consisted of 35 participants who in addition to a didactic anatomy and physiology class and advanced training in dysphagia (i.e., graduate level coursework or ASHA-sponsored Continuing Education Workshops) were experienced at performing instrumental observation of swallowing when assessing dysphagia. During experimental procedures of the study, instrumental observation of swallowing was limited to VFSS. Participants were considered experienced performing VFSS if they had performed 20 VFSSs or more (J. Beamon, personal communication, August 22, 2001; T. Schoendorf, personal communication, August 22, 2001). The three groups were compared to determine whether significant differences existed in their knowledge of the physiology of normal and abnormal swallowing. When controlling for the knowledge of the physiology of normal and abnormal swallowing, groups were also compared to determine whether significant differences existed in accuracy interpreting VFSS among the three groups. Finally, the relationship between knowledge of the physiology of normal and abnormal swallowing and accuracy of interpreting VFSS was examined among all participants studied.

Procedure

Data were collected on knowledge of the physiology of normal and abnormal swallowing and accuracy interpreting VFSS when assessing dysphagia via a special survey presented over the Internet (See Appendix A). Invitations for participation were e-mailed to participants in Undergraduate group and Graduate group, all Ohio University students. Written invitation for participation in the Experienced group was posted on a listserve serving more than 900 subscribers, many known to be dysphagia practitioners (Manning, 2001). According to Brown (personal communication, August 28, 2001),

Director of Healthcare Services for ASHA, members of ASHA's Special Interest Division #13 utilize this dysphagia listserve. For grouping purposes, participants identified their current level of experience with dysphagia via the on-line survey. Participants were assigned to groups after answering questions about completed coursework and questions about number of VFSSs completed while managing actual patients. Participants were randomly selected from the returned surveys meeting participant selection criteria. Each participant's identity remained anonymous.

On-line survey. The on-line survey consisted of two parts: (a) a test of the physiology of normal and abnormal swallowing and (b) a test requiring the interpretation of individual swallows from VFSS results (See Appendix B). The first part was a test designed to examine each participant's knowledge of the normal and abnormal parameters included in the swallowing process. Parameters selected for testing were from the author's perception of appropriate difficulty for each point along the continuum described. In other words, test questions range from basic anatomy and physiology (i.e., designed for the Undergraduate group) to therapeutic intervention (i.e., designed for the Experienced group). The test consisted of multiple choice and fill-in-the-blank questions. The second part required participants to interpret five video clips of swallows taken from actual VFSS sessions. This task consisted of a single example of the physiology of normal swallowing and one each of the four most commonly observed swallowing disorders (e.g., premature spillage, delayed initiation of the swallowing reflex, stasis [food residue] in the throat, and aspiration [food below true vocal folds]).

Participants of this study received no additional training from the investigator because the purpose of this investigation was to determine existing abilities to interpret

VFSS. Completed on-line surveys were submitted to a central location where participant e-mail addresses were removed for subject anonymity before being forwarded to the investigator's e-mail account.

The *Claris Homepage 3.0* (1997) computer software program was used to author the on-line survey. VFSS images were taken from anonymous VFSS diagnostic videotapes obtained from Drake Hospital in Cincinnati, Ohio. A JVC SVHS Hi-Fi HR-S4600U videocassette recorder/player played the VFSS tape. VFSS images were converted into MPEG format using the *Avid Videoshop 3.0.2* (1990) computer software program. MPEG formatted VFSS images used in the online survey were originally recorded during VFSS development of the *Virtual Patient Training Module* (Dean et al., 2001). The *Media Cleaner Pro 4.0.2* (1995) computer software program further compressed the VFSS images for transmission over the Internet. A video control bar was included on each VFSS image to allow participants to replay the VFSS tasks as often as needed.

Content validity. Multiple choice and fill-in-the-blank questions for part one were adapted from anatomy and physiology textbooks (Martini, 1989; Perkins & Kent, 1986; Seikel et al., 2000; Zemlin, 1988), graduate level dysphagia textbooks (Groher, 1992; Logemann, 1998; Massey & Shaker, 1997; Mills, 2000; Perlman & Schulze-Delrieu, 1997; Sonies, 1997; Tuchman & Walter, 1998), and dysphagia treatment textbooks (Arvedson & Brodsky, 1993; Hall, 2000; Logemann, 1993; Murray, 1999; Newman & Petersen, 1999; Rosenthal et al., 1994; Swigert, 1998; Swigert, 2000; Tuchman, 1998). States of swallowing viewed on VFSS images were simplistic by nature to be sensitive to skills of participants in all three groups.

Reliability and validity analyses. The test of knowledge of the physiology of normal and abnormal swallowing on part one of the survey was divided into three sections. The questions were arranged with increasing difficulty. The first section included questions pertaining to knowledge of the physiology of normal and abnormal swallowing from anatomy and physiology textbooks. The second section included questions pertaining to advanced knowledge of the physiology of abnormal swallowing from graduate-level dysphagia textbooks. The third section included questions from dysphagia textbooks that discuss specific treatments for managing a patient's dysphagia. In other words, participants in Undergraduate group, Graduate group, and Experienced group were expected to answer a high percentage of the questions in the first section of the test. Participants in the Graduate group and the Experienced group were expected to answer a high percentage of the questions in the second section of the test. Only participants in the Experienced group were expected to answer a high percentage of the questions in the third section of the test. Table 6 illustrates the reliability scale for the 25-question knowledge of the physiology of normal and abnormal swallowing test. According to Aron and Aron (1997), a measure is considered reliable when its reliability scale alpha value is between .7 to .9. The reliability alpha value reported in Table 6 is .8099.

Table 6

Reliability Analysis for the Knowledge of Physiology of Normal and Abnormal Swallowing Test

	RELIABILITY ANALYSIS- SCALE (ALPHA)	
	Question	M
	Q1	.9714
	Q2	.4667
	Q3	.9143
	Q4	.8571
	Q5	.7143
	Q6	.5810
	Q7	.9238
	Q8	.9143
Questions in Section 1	Q9	.9238
	Q10	.7524
	Q11	.7810
	Q12	.7619
	Q13	.7524
	Q14	.5524
	Q15	.3333
	Q16	.4190
Questions in Section 2	Q17	.8095
	Q18	.7524
	Q19	.7429
	Q20	.2857
	Q21	.3905
	Q22	.6762
	Q23	.3524
	Q24	.5143
Questions in Section 3	Q25	.3810

Statistics for SCALE M = 16.5238

Reliability Coefficients
N of Cases = 105.0
N of Items = 25
Alpha = .8099

Note. Q = Question Number from Part 1 of Test of Physiology of Normal and Abnormal Swallowing in Appendix B.

Construct validity was measured using factor analysis. The knowledge of the physiology of normal and abnormal swallowing test contained eight factors or subtests such as coordination of respiration and mastication, coordination of respiration and deglutition, and timing of the pharyngeal phase for normal swallowing. According to Stevens (1996), construct validity is determined by the absolute value correlation statistic for the factors contained in a measure. Items are considered highly correlated if the absolute value correlation statistic is .4 or above (Stevens, 1996). Table 7 illustrates the correlation statistics for the eight factors in the knowledge of the physiology of normal and abnormal swallowing test.

Interrater reliability. VFSS images consisted of a single example of normal swallowing physiology and one each of the four most commonly observed swallowing disorders (e.g., premature spillage, delayed initiation of the swallowing reflex, stasis [food residue] in the throat, and aspiration [food below the true vocal folds]). Although variations in interrater reliability existed, McCullough et al. (2001) reported that experienced judges could be expected to reliably rate instrumental observations of swallowing in assessing dysphagia. Kuhlemeier et al. (1998) reported that interrater reliability below 90% is unacceptable. In the current study, interrater reliability was determined for each VFSS image by comparing the ratings of three experienced SLPs. Interrater reliability was 100% for all VFSS images used in this study.

Table 7

Absolute Value Validity Correlation Statistics for the Knowledge of the Physiology of Normal and Abnormal Swallowing Test

Rotated Component Matrix

	Component							
Question	1	2	3	4	5	6	7	8
Q1					.850			
Q2								.832
Q3			.773					
Q4		.538						.438
Q5								.487
Q6	.404					.620		
Q7					.700			
Q8			.833					
Q9							.813	
Q10				.725				
Q11			.670					
Q12								
Q13				.564				
Q14			.486				-.411	
Q15				.561				
Q16					.773			
Q17		.510						
Q18		.678						
Q19		.693						
Q20	.821							
Q21	.688							
Q22		.669						
Q23	.779							
Q24	.710							
Q25	.844							

Note. Component 1 – Oral Dysphagia; Component 2- Respiration and Swallowing; Component 3- Aspiration; Component 4- Pharyngeal Phase; Component 5- Pressure Pump; Component 6- Respiration Pediatric; Component 7- Mastication; Component 8- Normal Swallow.

Scoring. Part One, which consisted of multiple choice and fill-in-the-blank questions, was numerically scored. Correct responses received one point, while incorrect scores received zero points. A score of 25 points was possible for the entire knowledge of the physiology of normal and abnormal swallowing test. Part Two, which consisted of the five VFSS images and five written questions regarding accuracy interpreting VFSS images, was also numerically scored. Written questions were in two parts. The question in the first part required the participant to determine whether the swallow in the VFSS was normal or abnormal after viewing each VFSS image. One point was given for correct responses while zero points were given for incorrect responses. The question in the second part required the participants to identify the swallow physiology of each VFSS image by choosing from a list of possible states of swallowing (See Appendix B). One point was given for correct responses while zero points were given for incorrect responses. A total of two points was possible for each of the five VFSS tasks. A score of 10 points was possible for the VFSS image interpretation tasks.

Data Analysis

One-way analysis of variance (ANOVA) was used to compare the knowledge of the physiology of normal and abnormal swallowing among the three groups. One-way analysis of covariance (ANCOVA) was used to determine whether knowledge of the physiology of normal and abnormal swallowing was related to accuracy of interpreting VFSS when controlling for the variable levels of knowledge of the physiology of normal and abnormal swallowing among participants. Finally, a Pearson Product Moment Correlation was used to determine whether a significant relationship existed between

knowledge of the physiology of normal and abnormal swallowing and accuracy interpreting VFSS among participants of this investigation.

Chapter 4

Results

The results of the investigation are reported in the order of the research questions previously stated on pages five and six.

Research Question 1. Are there significant differences in knowledge of the physiology of normal and abnormal swallowing among subjects in the Undergraduate, Graduate, and Experienced groups?

To determine whether significant differences in knowledge of the physiology of normal and abnormal swallowing existed among the groups, a one-way analysis of variance (ANOVA) was calculated. Participants were grouped according to the grouping criteria selected on the on-line survey: (a) Undergraduate, (b) Graduate, and (c) Experienced. The dependent variable was total score on the knowledge of the physiology of normal and abnormal swallowing test. The independent variable was group. Table 8 indicates the within cell knowledge of the physiology of normal and abnormal swallowing means and standard deviations for the one-way ANOVA. The ANOVA indicated that there was a significant difference in knowledge of the physiology of normal and abnormal swallowing for the three groups, F (2, 104) = 123.889, $p < .01$. Table 9 illustrates the statistics for the one-way ANOVA for Research Question 1.

Table 8

Knowledge of the Physiology of Normal and Abnormal Swallowing Mean Scores Among Three Groups

Group	n	M	SD
Undergraduate	35	11.26	2.84
Graduate	35	16.29	2.39
Experienced	35	20.68	2.24

Table 9

ANOVA Summary Table for Research Question 1

Source	Type III Sum of Squares	df	Mean Squares	F	Sig.
Between Group	1558.019	2	779.010	123.889	.000
Within Group	641.371	102	6.288		
Total	2199.390	104			

Note. Dependent Variable: Knowledge of the Physiology of Normal and Abnormal Swallowing

To determine where the groups were different, post-hoc Tukey pairwise comparisons were calculated. Post-hoc Tukey pairwise comparisons revealed significant differences among all three groups ($p < .01$) indicating that the participants in the Graduate group had significantly higher knowledge of the physiology of normal and abnormal swallowing scores when compared to the Undergraduate group and the Experienced group had significantly higher knowledge of the physiology of normal and abnormal swallowing scores than the Undergraduate and the Graduate groups. In other words, participants who had anatomy and physiology coursework and advanced training in dysphagia scored significantly higher on the physiology of normal and abnormal swallowing test when compared to the scores of participants who had anatomy and physiology coursework only. The results further indicated that participants who had anatomy and physiology coursework, advanced training in dysphagia, and experience performing VFSS scored significantly higher on the knowledge of the physiology of normal and abnormal swallowing test when compared to participants who had anatomy and physiology coursework only and participants who had anatomy and physiology coursework and advanced training in dysphagia. Table 10 illustrates the statistics for the post-hoc Tukey pairwise comparisons for Research Question 1.

Table 10

Post-Hoc Tukey Pairwise Comparisons for Knowledge of the Physiology of Normal and Abnormal Swallowing

Group	Group	Mean Diff.	SE	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1	2	-5.0286*	.59943	.000	-6.4543	-3.6029
	3	-9.4286*	.59943	.000	-10.8543	-8.0029
2	1	5.0286*	.59943	.000	3.6029	6.4543
	3	-4.4000*	.59943	.000	5.8257	-2.9743
3	1	9.4286*	.59943	.000	8.0029	10.8543
	2	4.4000*	.59943	.000	2.9743	5.8257

* $p < .01$

Note. Dependent Variable: Knowledge of the Physiology of Normal and Abnormal Swallowing. Group 1 = Undergraduate. Group 2 = Graduate. Group 3 = Experienced

Research Question 2. When controlling for knowledge of the physiology of normal and abnormal swallowing, are there significant differences in the ability to interpreting VFSS when assessing dysphagia among subjects in the Undergraduate, Graduate, and Experienced groups?

To determine whether accuracy interpreting VFSS was significantly different among the three groups when controlling for knowledge of the physiology of normal and abnormal swallowing, a one-way analysis of covariance (ANCOVA) was calculated. The response variable was accuracy interpreting VFSS score. The quantitative predictor was knowledge of the physiology of normal and abnormal swallowing score. To control for the varying levels of knowledge of the physiology of normal and abnormal swallowing among participants, estimated marginal means were calculated for the

response variable (i.e., accuracy interpreting VFSS scores) using a covariate for the quantitative predictor variable. In other words, the risk of knowledge of the physiology of normal and abnormal swallowing being a confounding variable was removed by using a covariate, which treats all scores for knowledge of the physiology of normal and abnormal swallowing as the same value (M = 16.0762). The qualitative predictor was group. Participants were grouped according to the grouping criteria selected on the on-line survey: (a) Undergraduate, (b) Graduate, and (c) Experienced. Interaction was measured between group and knowledge of the physiology of normal and abnormal swallowing scores. Table 11 indicates the estimated marginal means for accuracy interpreting videofluoroscopy means and standard deviations for the one-way ANCOVA.

Table 11

Accuracy Interpreting VFSS Marginal Means for the ANCOVA

Group	n	M	SE	95% Confidence Interval	
				Lower Bound	Upper Bound
Undergraduate	35	3.825[a]	.344	3.142	4.508
Graduate	35	5.497[a]	.174	5.153	5.842
Experienced	35	7.549[a]	.399	6.757	8.342

Note. a = Evaluated at covariates appeared in model: PHYSCORE = 16.0762
Dependent Variable: Accuracy Interpreting VFSS Score

The assumption of homogeneity of variance was met using the Levine test (p = .077), indicating that the variances of the accuracy interpreting VFSS scores were not statistically different. Therefore, the one-way ANCOVA was calculated for the linear model with accuracy interpreting VFSS as the response variable, covariate for the knowledge of the physiology of normal and abnormal swallowing as the quantitative predictor variable, group as the qualitative predictor variable, and Interaction between the knowledge of the physiology of normal and abnormal swallowing and group.

To determine whether Interaction (i.e., GROUP * PHYSCORE) significantly affected accuracy interpreting VFSS scores for the three groups when controlling for the knowledge of the physiology of normal and abnormal swallowing, the linear model was tested using the Homogeneity of Slopes test. The homogeneity of slopes statistic was calculated for the one-way ANCOVA, F (2, 99) = 2.673, $p < .01$. The homogeneity of slopes statistic was not statistically significant, indicating that the three groups had the same regression between accuracy interpreting VFSS and the covariate for the knowledge of the physiology of normal and abnormal swallowing among the three groups. In other words, accuracy interpreting VFSS scores had the same relationship to knowledge of the physiology of normal and abnormal swallowing in each of the three groups when controlling for knowledge of the physiology of normal and abnormal swallowing. Consequently, interaction was treated as zero and dropped from the linear model. Table 12 illustrates the statistics for the homogeneity of slopes for the one-way ANCOVA.

Table 12

Homogeneity of Slopes Statistics for Accuracy Interpreting VFSS

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	440.393[a]	5	88.079	84.193	.000	.810
Intercept	30.171	1	30.171	28.840	.000	.226
GROUP	.162	2	8.086	.077	.926	.002
PHYSCORE	7.586	1	7.586	7.251	.008	.068
GROUP*PHYSCORE	5.592	2	2.796	2.673	.074	.051
Error	103.569	99	1.046			
Total	4300.000	105				
Corrected Total	543.962	104				

Note. a = R Squared = .810 (Adjusted R Squared = .800). Dependent Variable: Accuracy Interpreting VFSS

Because the relationship between accuracy interpreting VFSS and the covariate for the knowledge of the physiology of normal and abnormal swallowing was the same for the three groups for the regression, the one-way ANCOVA further tested whether accuracy interpreting VFSS scores significantly differed among the three groups when controlling for the knowledge of the physiology of normal and abnormal swallowing. Table 13 illustrates the estimated marginal means for accuracy interpreting VFSS using covariates for the quantitative predictor variable (i.e., knowledge of the physiology of normal and abnormal swallowing) after Interaction was dropped from the linear model.

Table 13

Accuracy Interpreting VFSS Using Covariates

Group	n	Est. Marg. Mean	SE	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Undergraduate	35	4.223[a]	.265	3.698	4.748
Graduate	35	5.495[a]	.176	5.146	5.844
Experienced	35	8.225[a]	.258	7.713	8.737

Note. a = Evaluated at covariates appeared in the model PHYSCORE = 16.0762
Dependent Variable: Accuracy Interpreting VFSS

Using the estimated marginal means for the accuracy interpreting VFSS scores, the one-way ANCOVA was calculated to determine whether accuracy interpreting VFSS was significantly different among the three groups. In the linear model used to calculate one-way ANCOVA, accuracy interpreting VFSS was the response variable, the covariate for knowledge of the physiology of normal and abnormal swallowing was the quantitative predictor variable, and group was the qualitative predictor variable. The assumption regarding the homogeneity of variance was met using the Levine test (p = .159), indicating the variances of the accuracy interpreting VFSS scores among the three groups were not statistically different.

The one-way ANCOVA indicated that there was a significant difference among the three groups for accuracy interpreting VFSS when controlling for knowledge of the physiology of normal and abnormal swallowing, F (2, 101) = 45.163, p < .01. Table 14 illustrates the statistics for the one-way ANCOVA that determined whether accuracy

interpreting VFSS scores were significantly different among groups when controlling for knowledge of the physiology of normal and abnormal swallowing.

Table 14

ANCOVA Summary Table for Differences in Accuracy Interpreting VFSS

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	434.802	3	144.934	134.009	.000	.799
Intercept	48.516	1	48.516	44.889	.000	.308
PHYSCORE	5.640	1	5.218	5.218	.024	.049
GROUP	97.625	2	48.812	45.163	.000	.472
Error	109.160	101	1.081			
Total	4300.000	105				
Corrected Total	543.962	104				

Note. R Squared = .799 (Adjusted R Squared = .793). Dependent Variable: Accuracy Interpreting VFSS

To determine where the groups were different, post-hoc Bonferroni multiple comparisons were calculated. Post-hoc Bonferroni multiple comparisons revealed significant differences among accuracy interpreting VFSS scores for all three groups when controlling for the knowledge of the physiology of swallowing ($p < .01$) indicating that participants in the Graduate group had significantly higher accuracy interpreting VFSS scores when compared to participants in the Undergraduate group and participants in the Experienced group had significantly higher accuracy interpreting VFSS scores when compared to participants in the Undergraduate and Graduate groups. In other words, when controlling for varying levels of knowledge of the physiology of normal and

abnormal swallowing, participants who had anatomy and physiology coursework and advanced training in dysphagia had significantly higher accuracy interpreting VFSS scores when compared to the accuracy interpreting VFSS scores of participants who had anatomy and physiology coursework only. The results further indicated that participants who had anatomy and physiology coursework, advanced training in dysphagia, and experience performing VFSS had significantly higher accuracy interpreting VFSS scores when compared to participants who had anatomy and physiology coursework only and participants who had anatomy and physiology coursework and advanced training in dysphagia. Table 15 illustrates the statistics for the post-hoc Bonferroni multiple comparisons for Research Question 2.

Table 15

Post-Hoc Bonferroni Multiple Comparisons for Research Question 2

					95% Confidence Interval	
Group	Group	Mean Diff.	SE	Sig.[a]	Lower Bound	Upper Bound
1	2	-1.672*	.385	.000	-2.831	-.513
	3	-3.724*	.527	.000	-5.310	-2.139
2	1	1.672*	.385	.000	.513	2.831
	3	-2.052*	.435	.000	-3.362	-.742
3	1	3.724*	.527	.000	2.139	5.310
	2	2.052*	.435	.000	.742	3.362

Note. Dependent Variable: Accuracy Interpreting VFSS. Based on estimated marginal means. * The mean difference is significant at the .01 level. Adjustment for multiple comparisons: Bonferroni. Group 1 = Undergraduate. Group 2 = Graduate. Group 3 = Experienced.

The one-way ANCOVA indicated that the covariate for the knowledge of the physiology of normal and abnormal swallowing was not a significant predictor of accuracy interpreting VFSS when measured independently, F (1, 101) = 5.218, $p < .01$. However, results of the one-way ANCOVA revealed that group was significant predictor of accuracy interpreting VFSS. Because knowledge of the physiology of normal and abnormal swallowing was included as a criterion used to determine group membership, these results indicate that knowledge of the physiology of normal and abnormal swallowing contributed in significantly predicting accuracy interpreting VFSS. In other words, the combinations of knowledge of the physiology of normal and abnormal swallowing, graduate level didactic coursework, and experience performing VFSS used to determine group membership were significant predictors of accuracy interpreting VFSS in this linear model. Table 16 illustrates the statistics for the one-way ANCOVA that determined whether a significant relationship existed between accuracy interpreting VFSS scores and the covariate for the knowledge of the physiology of normal and abnormal swallowing (i.e., the quantitative predictor) and group (i.e., the qualitative predictor).

Table 16

ANCOVA Summary Table for Relationship Between Accuracy Interpreting VFSS and the Covariate for the Knowledge of the Physiology of Normal and Abnormal Swallowing and Group

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	434.802	3	144.934	134.009	.000	.799
Intercept	48.516	1	48.516	44.889	.000	.308
PHYSCORE	5.640	1	5.218	5.218	.024	.049
GROUP	97.625	2	48.812	45.163	.000	.472
Error	109.160	101	1.081			
Total	4300.000	105				
Corrected Total	543.962	104				

Note. R Squared = .799 (Adjusted R Squared = .793). Dependent Variable: Accuracy Interpreting VFSS

To determine how much of the variance in accuracy interpreting VFSS was explained by the corrected linear model, the R Squared statistic was calculated. The corrected model explained approximately 80 percent of the variance in accuracy interpreting VFSS ($r^2 = .799$). To determine how much of the variance in accuracy interpreting VFSS was explained by the covariate for knowledge of the physiology of normal and abnormal swallowing (i.e., quantitative variable), the Partial Eta Squared statistic was calculated. The Partial Eta Squared statistic calculates the variance of the last variable entered into a linear model. In other words, the amount variance explained by the covariate for the knowledge of the physiology of normal and abnormal swallowing was calculated after group was included in the linear model. In the corrected model, the covariate for the knowledge of the physiology of normal and abnormal swallowing explained approximately five percent of the variance after the group variable had been

entered. To determine how much of the variance in accuracy interpreting VFSS was explained by group (i.e., qualitative variable), the Partial Eta Squared statistic was calculated. In this model, group explained approximately 47% of the total variance after the covariate had been entered. These results indicate that other criteria involved in determining group membership played significant roles in accuracy interpreting VFSS when controlling for knowledge of the physiology of normal and abnormal swallowing, which means variance in accuracy interpreting VFSS was explained by more than just differences in knowledge of the physiology of normal and abnormal swallowing. Table 17 summarizes the r^2 and Partial Eta Square statistics.

Table 17

ANCOVA Summary for R-Squared and Partial Eta Squared Statistics

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	434.802	3	144.934	134.009	.000	.799
Intercept	48.516	1	48.516	44.889	.000	.308
PHYSCORE	5.640	1	5.218	5.218	.024	.049
GROUP	97.625	2	48.812	45.163	.000	.472
Error	109.160	101	1.081			
Total	4300.000	105				
Corrected Total	543.962	104				

Note. R Squared = .799 (Adjusted R Squared = .793). Dependent Variable: Accuracy Interpreting VFSS

Research Question 3. Does a significant relationship exist between accuracy interpreting VFSS and the knowledge of the physiology of normal and abnormal swallowing among subjects in the study?

To determine whether a significance relationship existed between accuracy interpreting VFSS and knowledge of the physiology of normal and abnormal swallowing among participants in the study, a Pearson Product Moment Correlation was calculated. Results revealed a significant positive correlation between the accuracy interpreting VFSS and knowledge of the physiology of normal and abnormal swallowing, r (1, 103) = .787, $p < .01$ (two-tailed). For every one increment of heightened knowledge of the physiology of normal and abnormal swallowing test, accuracy interpreting VFSS improved approximately .8 of an increment, r (1, 103) = .787, $p < .01$ (two-tailed). According to Keyton (2001), a correlation coefficient ranging between .70-.90 is considered a high correlation, indicating a marked relationship between knowledge of the physiology of normal and abnormal swallowing and accuracy interpreting VFSS. Table 18 summarizes the correlation statistics between knowledge of the physiology of normal and abnormal swallowing and accuracy interpreting VFSS.

Table 18

Pearson Product Moment Correlation Between Knowledge of the Physiology of Normal and Abnormal Swallowing and Accuracy Interpreting VFSS

Variable		Knowledge	Accuracy
Knowledge	Pearson Correlation	1	.787**
	Significance (2-tailed)		.000
	N	105	105
Accuracy	Pearson Correlation	.787**	1
	Significance (2-tailed)		.000
	N	105	105

** Correlation is significant at the .01 level (two-tailed)
Note. Knowledge of the Physiology of Normal and Abnormal Swallowing variable is labeled Knowledge and Accuracy Interpreting VFSS variable is labeled Accuracy.

Summary of Findings

The following is a summary of the findings of this investigation. The results are given in the order in which the three research questions were asked.

1. Significant differences were found in knowledge of the physiology of normal and abnormal swallowing among participants in the Undergraduate, Graduate, and Experienced groups.

2. When controlling for knowledge of the physiology of normal and abnormal swallowing, significant differences were found in accuracy interpreting VFSS among the three groups. The covariate for the knowledge of the physiology of normal and abnormal swallowing (i.e., quantitative predictor variable) was not a significant predictor of accuracy interpreting VFSS when measured independently. However, group (i.e.,

qualitative predictor variable) was found to be a significant predictor of accuracy interpreting VFSS. Because knowledge of the physiology of normal and abnormal swallowing was included as a criterion in determining group membership, it was determined that knowledge of the physiology of normal and abnormal swallowing contributed in significantly predicting accuracy interpreting VFSS. The corrected linear model explained approximately 80 percent of the variance of accuracy interpreting VFSS, $\underline{r}^2$ (3, 101) = .799, $\underline{p} < .01$ (two-tailed). The Partial Eta Squared statistic revealed that the covariate for the knowledge of the physiology of normal and abnormal swallowing explained approximately five percent of the variance of accuracy interpreting VFSS after group had been factored into the linear model. The Partial Eta Squared revealed that the criteria used to determine group membership explained approximately 50% of the variance of accuracy interpreting VFSS after the covariate for knowledge of the physiology of normal and abnormal swallowing had been factored into the linear model.

3. A significant positive relationship was found between knowledge of the physiology of normal and abnormal swallowing and accuracy interpreting visual imaging. The strength of the correlation coefficient was considered high, indicating a marked relationship between knowledge of the physiology of normal and abnormal swallowing and accuracy interpreting VFSS. Results indicated that individuals who possessed a heightened knowledge of the physiology of normal and abnormal swallowing also interpreted VFSS more accurately.

Chapter 5

Discussion

The results of this investigation reported in the previous chapter are interpreted and discussed in the following order: Research Question 1, Research Question 2, Research Question 3, Summary and Conclusions, Limitations of the Study, Implications for Education and Training, and Implications for Future Research.

Research Question 1. Are there significant differences in knowledge of the physiology of normal and abnormal swallowing among subjects in the Undergraduate, Graduate, and Experienced groups?

This study found that participants in each of the three groups (e.g., Undergraduate, Graduate, and Experienced) demonstrated significantly different levels of knowledge of the physiology of normal and abnormal swallowing. As initially predicted, those participants in the Experienced group demonstrated the highest level of knowledge of the physiology of normal and abnormal swallowing. The lowest level of knowledge of the physiology of normal and abnormal swallowing was observed in those participants in the Undergraduate group. Figure 1 reflects the differences in group mean scores for the 25-question knowledge of the physiology of normal and abnormal swallowing test completed during this study.

Researchers have previously determined that a comprehensive knowledge of the physiology of normal and abnormal swallowing must be acquired to accurately assess and treat of dysphagia (Scholten & Russell, 2000; Wooi et al., 2001). In these studies,

knowledge of the physiology of normal and abnormal swallowing was measured for students in anatomy and physiology classes. Anatomy and physiology classes are typically completed at the undergraduate level. Results from the current investigation supplemented this research base by determining that knowledge of the physiology of normal and abnormal swallowing continues to increase beyond the completion of an undergraduate level anatomy and physiology class.

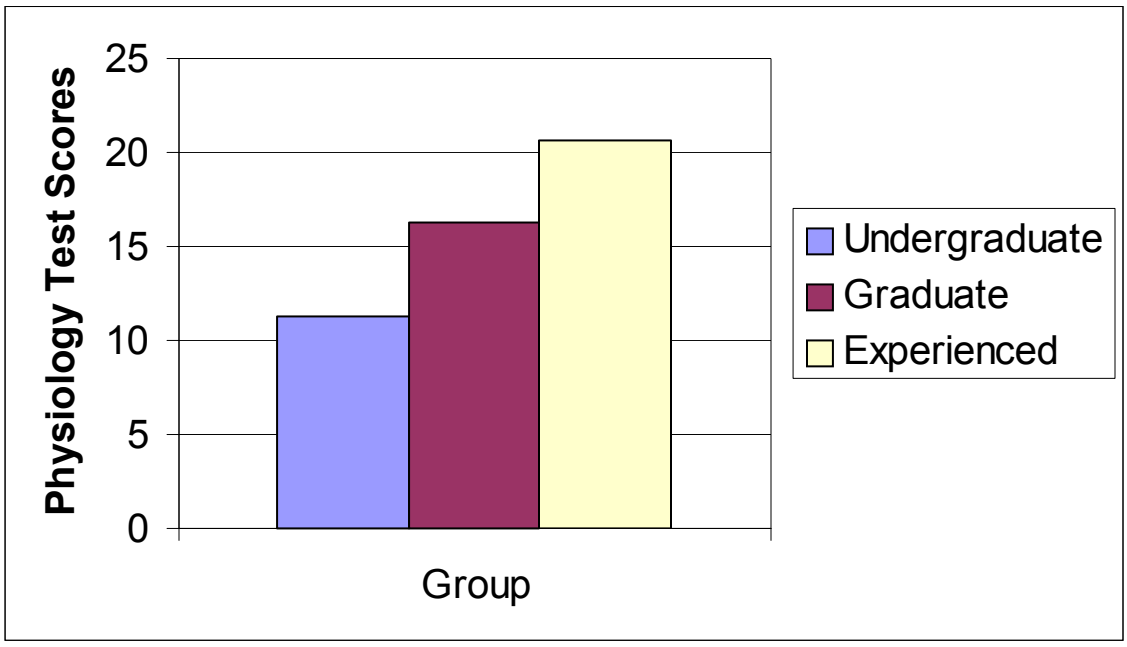

Figure 1. Knowledge of the physiology of normal and abnormal swallowing mean scores among three groups. * Significant differences found between all three groups, $p < .01$.

A limitation of the analysis of this question was the investigator's inability to predetermine anatomy and physiology course content for swallowing for members of the three groups. ASHA does not have a prescribed curriculum for undergraduate level anatomy and physiology coursework required for certification of SLPs. Therefore, the results reflect the varied exposure to the knowledge of the physiology of normal and abnormal swallowing by SLPs assessing and treating dysphagia.

Research Question 2. When controlling for knowledge of the physiology of normal and abnormal swallowing, are there significant differences in the ability to interpret VFSS when assessing dysphagia among subjects in the Undergraduate, Graduate, and Experienced groups?

When controlling for knowledge of the physiology of normal and abnormal swallowing, this study found significant differences in accuracy interpreting VFSS among the three groups. Group differences were due to the fact that participants were grouped to be representative of SLPs at the three points along the continuum of professional training. Consequently, groups were different in many characteristics of education and experience such as level of coursework completed (e.g., undergraduate & graduate), variety of coursework taken, motivation to learn about the physiology of normal and abnormal swallowing, clinical practicum hours completed, exposure to various syndromes and diseases, observational experience with dysphagia patients, variety of clinical work settings, and general professional maturation. Differences could be within group but certainly were between groups. An example of within group differences might be that some participants in the Undergraduate group have completed

different varieties of coursework, which might provide varying levels of exposure to abnormal physiology of swallowing. A between group difference might be motivation to learn about the physiology of normal and abnormal swallowing. For example, participants in the Graduate group might have greater motivation to learn about the physiology of normal and abnormal swallowing when compared to participants in the Undergraduate group, because a graduate-level dysphagia course is not included as a degree requirement at Ohio University.

Participants in the Experienced group demonstrated the highest level of accuracy interpreting VFSS when controlling for knowledge of the physiology of normal and abnormal swallowing. Participants in the Undergraduate group demonstrated the least accuracy interpreting VFSS when controlling for knowledge of the physiology of normal and abnormal swallowing. Accuracy has been related to experience (Kuhlemeier et al., 1998; McCullough, et al, 2001; Murray & Jacobsen, 2001). When reviewing the literature for professional education and training for radiology, Rubin (1989) reported that radiology is a complex skill involving the ability to combine information from visual pattern recognition, knowledge of anatomy, knowledge of physiology, and knowledge of the pathological processes with patient-specific information. In the Murray and Jacobsen study, accuracy interpreting VFSS was attributed to improved visual processing related to experience performing VFSS.

Limitations of the current investigation included an institutional bias for the Undergraduate and Graduate groups and increased randomization in the Experienced group. Participants in the Undergraduate and Graduate groups were all students at Ohio University. Therefore, the potential for institutional bias related to teaching philosophy

was increased. All subscribers of the dysphagia listserve, who had performed more than 20 VFSSs, could have participated in this investigation. Consequently, the Experienced group had better randomization to control for institutional bias and quantity of learning experiences when compared to the Undergraduate and Graduate groups. A limitation to the current study was that criteria used to determine group membership in the Experienced group were self-reported. Finally, a limitation of the current study was that the VFSS interpretation tasks were simplistic by nature to be sensitive to skills of participants in all three groups. Figure 2 reflects the marginal mean scores on the 10-question survey for accuracy interpreting VFSS when controlling for knowledge of the physiology of normal and abnormal swallowing.

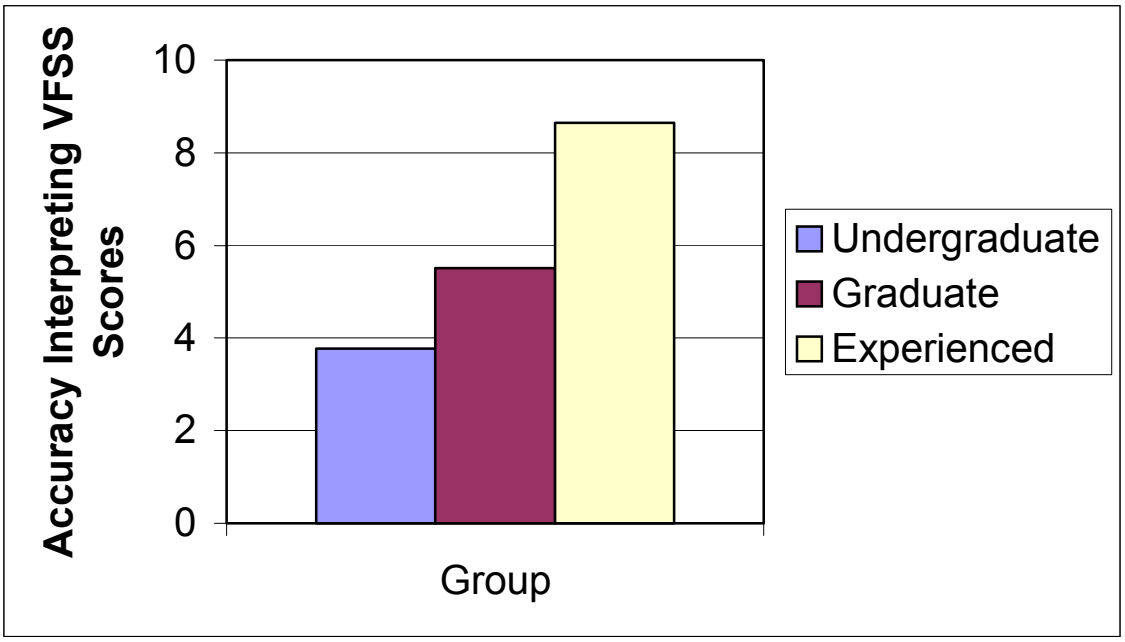

Figure 2. Accuracy Interpreting VFSS mean scores among three groups when controlling for knowledge of the physiology of normal and abnormal swallowing. * Significant differences were found between all three groups, $p < .01$.

Another major finding of the current study was that the criteria used to determine group membership were found to be significant predictors of accuracy interpreting VFSS. By using a covariate to reduce the risk that knowledge of the physiology of normal and abnormal swallowing would be a confounding variable, this finding indicated that knowledge of the physiology of normal and abnormal swallowing was inadequate as a total explanation for the variance in accuracy interpreting VFSS for the corrected linear model ($r^2 = .799$). Instead, other group differences also contributed to explaining the variance for the corrected linear model. As discussed previously, the three groups used in this investigation differed in many ways beyond knowledge of the physiology of normal and abnormal swallowing. Varying levels of coursework, variety of courses taken, motivation to learn about the physiology of normal and abnormal swallowing, clinical practicum hours completed, exposure to a various syndromes and diseases, observational experiences with dysphagia patients, variety of clinical work setting, and general professional maturation all may have contributed to explaining the variance for the corrected linear model. The Partial Eta Squared statistic indicated that approximately 47% of the total variance in accuracy interpreting VFSS was explained by these other criteria used to determine group membership.

Research Question 3. Does a significant relationship exist between accuracy interpreting VFSS and knowledge of the physiology of normal and abnormal swallowing among subjects in this study?

Consideration of a relationship between knowledge of the physiology of normal and abnormal swallowing and accuracy interpreting VFSS indicated that a significant

relationship existed. The (high) positive correlation indicated that as knowledge of the physiology of normal and abnormal swallowing heightened, accuracy interpreting VFSS improved due to a marked relationship between the two variables. Results are consistent with previous research (Scholten & Russell, 2000; Wooi et al., 2001).

Results from Research Question 2 indicated that knowledge of the physiology of normal and abnormal swallowing was inadequate as a total explanation of the variance in accuracy interpreting VFSS for the corrected linear model. However, Research Question 2 considered the relationship between knowledge of the physiology of normal and abnormal swallowing and accuracy interpreting VFSS for participants as members of groups. Criteria used to determine group membership were not included in Research Question 3. The high positive correlation in Research Question 3 indicated that knowledge of the physiology of normal and abnormal swallowing had a significant role in explaining the variance in accuracy interpreting VFSS for the corrected linear model. The correlation coefficient in Research Question 3 indicated that knowledge of the physiology of normal and abnormal swallowing explained approximately 62% of the variance in accuracy interpreting VFSS. Figure 3 illustrates the scatterplot of the positive high correlation between knowledge of the physiology of normal and abnormal swallowing and accuracy interpreting VFSS.

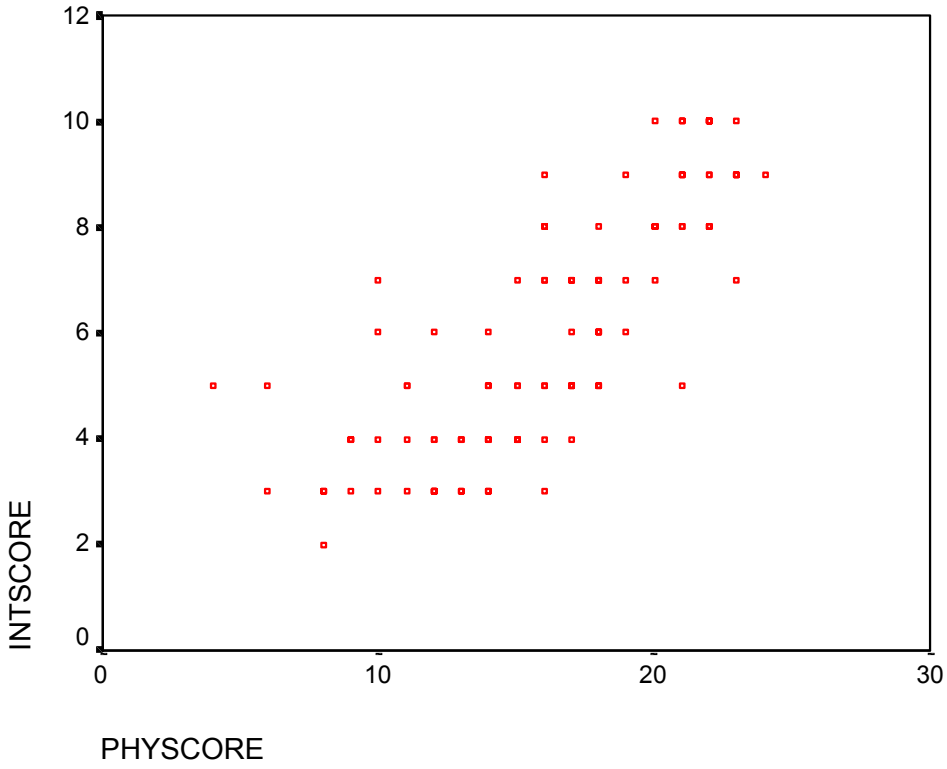

Figure 3. Scatterplot for the relationship between accuracy interpreting VFSS scores and knowledge of the physiology of normal and abnormal swallowing. * Significant correlation found between accuracy interpreting VFSS and knowledge of the physiology of normal and abnormal swallowing, $p < .01$ (two-tailed).

Summary and Conclusions

A summary of the findings of the current investigation is reported in the order of the research questions.

1. Knowledge of the physiology of normal and abnormal swallowing was significantly different for subjects trained in knowledge of the physiology of normal and abnormal swallowing only, those with knowledge of the physiology of normal and abnormal swallowing and specific didactic instruction in dysphagia, and those with

knowledge of the physiology of normal and abnormal swallowing, specific didactic instruction in dysphagia, and experience performing VFSS.

2. When controlling for knowledge of the physiology of normal and abnormal swallowing, accuracy interpreting VFSS was significantly different among the three groups. Group differences were intended in order for the groups to be representative of the three points along a continuum of professional training. Groups were different in characteristics of education and experience, indicating a progression of general professional maturity along the continuum of professional training. Another major finding of this study was that when controlling for knowledge of the physiology of swallowing, the criteria used to determine group membership were significant predictors of accuracy interpreting VFSS. This finding indicated that knowledge of the physiology of normal and abnormal swallowing was inadequate as a total explanation of variance in accuracy interpreting in the corrected linear model. Instead, other group differences also contributed to explaining the variance in accuracy interpreting VFSS for the corrected linear model. Results indicated that these other group differences explained approximately 47% of the total variance in accuracy interpreting VFSS in the corrected linear model.

3. A strong (high) positive relationship was found between knowledge of the physiology of normal and abnormal swallowing and accuracy interpreting VFSS. The high positive correlation coefficient indicated a marked relationship between knowledge of the physiology of swallowing and accuracy interpreting VFSS. Results from Research Question 2 indicated that knowledge of the physiology of normal and abnormal swallowing was inadequate as a total explanation for the variance in accuracy interpreting

VFSS. However, Research Question 2 considered the relationship of knowledge of the physiology of normal and abnormal swallowing and accuracy interpreting VFSS for participants as members of groups. Criteria used to determine group membership were not included in Research Question 3. Consequently, the high positive correlation indicated that knowledge of the physiology of normal and abnormal swallowing had a significant role in explaining the variance in accuracy interpreting VFSS. The correlation coefficient indicated that knowledge of the physiology of normal and abnormal swallowing explained approximately 62% of the variance in accuracy interpreting VFSS.

Based on the findings of the current investigation, it can be concluded that significant differences existed in knowledge of the physiology of normal and abnormal swallowing as participants progressed along the continuum of professional training, with knowledge of the physiology of normal and abnormal swallowing increasing at each successive stage along the continuum of learning. Based on the results of the current study, it can also be concluded that accuracy interpreting VFSS was significantly different at the three stages along a continuum of learning. Results of the current study indicated that accuracy interpreting VFSS improved as a result of the criteria used to determine group membership. However, a marked relationship existed between knowledge of the physiology of normal and abnormal swallowing and accuracy interpreting VFSS. Consequently, it can be concluded that the total variance in accuracy interpreting VFSS for the corrected linear model was explained by a combination of group differences and knowledge of the physiology of normal and abnormal swallowing. Further investigations regarding the best curriculum for anatomy and physiology instruction, specific didactic instruction in dysphagia, and the amount of experience

performing VFSS are warranted given the current findings that those participants with knowledge of the physiology of normal and abnormal swallowing, specific instruction in dysphagia, and experience performing VFSS had the highest level of accuracy interpreting VFSS.

Limitations of the Study

The following includes a summary of the limitations of the current investigation:

1. The investigator was unable to predetermine anatomy and physiology course content devoted to the physiology of normal and abnormal swallowing.

2. Institutional bias for participants in the Undergraduate and Graduate groups, while the Experienced group had more randomization.

3. In order to be representative of the three points along the continuum of professional training, the three groups in this study were different in ways other than just knowledge of the physiology of normal and abnormal swallowing VFSS movie clips were simplistic in nature to be sensitive to skills of participants in all three groups.

4. Grouping criteria were self-reported.

Implications for Future Education and Training

While further research is warranted to investigate the relationship of other grouping differences and accuracy interpreting VFSS, general educational and training implications can be offered from this study. This study found that as knowledge of the physiology of normal and abnormal swallowing increased with progression along the continuum of professional training, accuracy interpreting VFSS also increased. This finding may have important applications in investigating the effectiveness of specific didactic instruction in dysphagia at the graduate level and in continuing education

workshops. Investigations into the effectiveness of specific didactic instruction in dysphagia will be especially important given that ASHA has included dysphagia in its standards for certification of clinical competence effective in 2005.

Researchers in speech-language pathology have previously determined that students must acquire a comprehensive knowledge of the physiology of normal and abnormal swallowing to accurately assess and effectively treat dysphagia (Scholten & Russell, 2000; Wooi et al., 2001). Findings from the current investigation contributed to this research base by determining that knowledge of the physiology of normal and abnormal swallowing was inadequate as a total explanation for group differences in accuracy interpreting VFSS. Other researchers have reported that accuracy interpreting VFSS was attributed to experience performing VFSS (Kuhlemeier et al. 1998; McCullough et al., 2001; Murray & Jacobsen, 2001). Results of the current finding contributed to this research base by determining that accuracy interpreting VFSS was highly correlated with a combination of knowledge of the physiology of normal and abnormal swallowing and others differences that determined group membership.

This investigation was preliminary research designed with the purpose of establishing benchmarks for the education and experience needed to accurately interpret VFSS. It should be noted that participants in two of three groups included in this study were students at Ohio University. Ohio University is an ASHA accredited speech-language pathology program and probably has similar instructional outcomes to other ASHA accredited speech-language pathology programs. However, this assumption should be viewed with caution. If results from this study can be generalized to undergraduate and graduate students from ASHA accredited speech-language pathology

programs throughout the U.S., it may be warranted to establish curricular content standards for undergraduate level anatomy and physiology coursework and graduate level didactic coursework in dysphagia. Such curricular content standards might provide some sort of standardization for the education of SLPs who assess and treat persons with dysphagia.

Implications for Future Research

Based on the results of the current investigation several avenues of future research are suggested:

1. Participants in the Graduate group were all students at Ohio University, which increased the potential for institutional bias. Since ASHA does not have set standards for curricular content in dysphagia, it cannot be assumed that graduate-level curricular content in dysphagia at Ohio University is similar to curricular content in dysphagia at other universities. Investigation comparing the relationship of knowledge of the physiology of normal and abnormal swallowing and accuracy interpreting VFSS is warranted for graduate-level students at different universities. Result of such an investigation may provide guidance for standards for curricular content in dysphagia.

2. The effectiveness of training materials using VFSS should be compared to the effectiveness of training material limited to static radiography images. It is suggested that static radiography images do not facilitate the skills and knowledge needed to visualize the image of the dynamic swallow during instrumental assessment (Scholten, 2001). Therefore, it is highly recommended that future investigations compare and contrast the effectiveness of VFSS and static radiography when educating and training SLP's.

3. In radiology, it has been reported that practitioners must develop a complex skill involving the ability to combine information from visual pattern recognition, knowledge of anatomy, knowledge of physiology, and knowledge of pathological processes with patient-specific information. It was also reported that radiology is a "clinical problem solving" skill in which accurate radiological interpretation goes beyond simple visual perception of radiological images. In the field of speech-language pathology, it was reported that training aids have been and are currently being developed to improve visualization of the dynamic swallow process. Therefore, it is highly recommended that future investigations test effectiveness of training aids that facilitate the integration of visual pattern recognition, knowledge of anatomy, knowledge of physiology, and knowledge of the pathological processes with patient-specific information in order to make appropriate clinical decisions when assessing and treating patients with dysphagia.

4. In the current investigation, instrumental observation of swallowing was limited to VFSS. A second line of investigations may be to test the interpretation skills of individuals performing Fiberoptic Endoscopic Evaluation of Swallowing (FEES). Accuracy interpreting FEES scores could be compared to scores from the knowledge of the physiology of normal and abnormal swallow test. It might be found that different relationship exists between knowledge of the physiology of normal and abnormal swallowing and accuracy interpreting FEES when compared to VFSS.

5. The current study examined the relationship of knowledge of the physiology of normal and abnormal swallowing and accuracy interpreting VFSS among three groups. Given that knowledge of the physiology of normal and abnormal swallowing was

insufficient as a total explanation for the variance in accuracy interpreting VFSS and that other group differences are therefore suggested, future parameters of this study should take different group foci. Within group differences were not measured in the current investigation, but examination of within group differences would be informative in future investigations of this type. Potentially, minimum standards used to determine expertise in performing and interpreting VFSS may be determined from such investigations.

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Appendix A

Written Invitation

My name is Kevin Manning. I am a doctoral student at Ohio University in Athens, Ohio. I am currently conducting a research project about how therapists learn to interpret dynamic images during videofluoroscopy (i.e. Modified Barium Swallow studies). I am inviting you to complete an online survey at the URL or web address posted below. **Please be aware that you are not required to complete this survey.** However, if you do complete this survey, you are giving your consent to use the information in my research project.

It is anticipated that knowledge about the best combination of knowledge, advanced training, and clinical experience needed to accurately interpret dynamic visual images during the assessment of swallowing disorders will result from this research project. Improving the ability of therapists to accurately interpret dynamic videofluoroscopy during the assessment of swallowing disorders will improve quality of life for patients with swallowing disorders. Quality improves because improved accuracy of assessment will improve treatment of swallowing disorders. I do not anticipate any risks to you for your participation in the research project.

It might take longer than usual to access the web page because there are five movie clips on the survey. I will appreciate your understanding and greatly appreciate your time completing this survey. The total time required to complete the survey is estimated to be between 5-10 minutes. I will post the results as soon as the research project is completed. If you have questions or problems accessing the survey, contact me through e-mail by replying to this invitation.

Thank you,

Kevin Manning

Survey Address

http://oak.cats.ohiou.edu/~rm399190

Appendix B

Test of Knowledge of the Physiology of Swallowing

Please indicate your answer by clicking on the radio button next to your selection or by typing your response in the textbox provided below the question. If you do not know the answer to a question, leave it blank. Please note that textboxes are limited to one-line responses (i.e. a total of 82 characters). Also, to play the movie clips, click on the arrow button found on the lower left corner of the screen. You can replay the click as many times as needed by clicking on that arrow button. Total time that is required to complete this survey is estimated to be 5-10 minutes. If you need to clear your answers and start over, a reset button can be found at the bottom of the page. However, if you click the reset button, all of your previous answers will be erased. When you have completed the survey, click the submit button. A text screen will appear to indicate the survey was successfully submitted. Thank you for taking the time to complete this survey. If you have questions about the survey or if you have problems completing the survey, contact Kevin Manning at the following e-mail address:

rm399190@ohiou.edu

What is your most current level of training in dysphagia (indicate only one)?

___ Undergraduate course in anatomy and physiology
___ Graduate-level course in dysphagia
___ Continuing Education Seminar (CEU) in dysphagia
___ Graduate-level course plus clinical experience in dysphagia
___ Graduate-level course plus CEU plus clinical experience in dysphagia

How many modified barium swallow studies (VFSS) have you performed?

___ 0
___ 1-10
___ 11-20
___ 21-30
___ More than 30

Appendix B, Continued

Part 1

Anatomy and Physiology Test

1. How many phases are there during the swallowing process?

___ 4
___ 5
___ 6
___ 7

2. During normal swallowing, how many airway barriers are there?

___ One
___ Two
___ Three
___ Four

3. What is the term used to describe food traveling below the true vocal folds?

___ Penetration
___ Vestibule
___ Aspiration
___ Peristalsis

4. Why does the epiglottis lower during swallowing?

_____

5. What is the purpose of saliva during swallowing?

_____

6. In what position is the velopharyngeal port during chewing?

___ Closed
___ Open

Appendix B, Continued

7. Which describes the action of the velum and larynx as the food enters the pharyngeal phase of swallowing?

___ Peristalsis
___ Elevation
___ Stasis
___ Aspiration

8. During a swallow, when can aspiration occur?

___ Before the pharyngeal phase
___ During the pharyngeal phase
___ After the pharyngeal phase
___ Before, during, and after the pharyngeal phase

9. Which of the following terms describes food retained in the valleculae?

___ Peristalsis
___ Aspiration
___ Penetration
___ Stasis/residue

10. What is/are the function(s) of the false vocal folds during swallowing?

_____

11. What is the approximate duration of the pharyngeal phase of swallowing?

___ One second
___ Two seconds
___ Three seconds
___ Four seconds

12. Contraction of the pharyngeal constrictors serves what purpose during swallowing?

_____

Appendix B, Continued

13. Which of the following describes the wave-like contraction of the pharyngeal constrictors?

___ Stasis
___ Vestibule
___ Retroflexion
___ Peristalsis

14. In adults, what type of jaw motion is observed while chewing?

___ Rotary
___ Lateral
___ Rotary-Lateral
___ Munching

15. In young children, what type of jaw motion is observed while chewing?

___ Rotary
___ Lateral
___ Rotary-Lateral
___ Munching

16. Which of the following best describes the coordination of respiration and swallowing in newborns?

___ Suck, hold breath, swallow
___ Breathe and swallow simultaneously
___ Hold breath, swallow, suck
___ Suck, swallow, hold breath

17. Which best describes the coordination of respiration and mastication in children and adults?

___ Hold breath and chew
___ Breathe and chew simultaneously

Appendix B, Continued

18. Which best describes the coordination of respiration and swallowing in children and adults?

___ Chew, hold breath, swallow
___ Breathe and swallow simultaneously
___ Hold breath, chew, swallow, breathe
___ Chew, swallow, hold breath

19. To open the cricopharyngeus, its muscles must do which of the following?

___ Relax
___ Contract

20. As the bolus approaches during swallowing, the relaxed cricopharyngeus muscle is pulled open by ____?

_____

21. What is the motor function of the anterior two-thirds of the tongue during the oral phase of swallowing?

_____

22. Thickening the consistency of food has what effect of pharyngeal transit timing?

_____

23. Why does the cricopharyngeus muscles remain closed after the completion of a swallow?

_____

24. Why would you turn a patient's head to the side of the weakness to affect dysphagia?

_____

Appendix B, Continued

25. How does an “effortful swallow” improve the physiology of swallowing?

_____

Part 2

Five movie clips are presented below. Interpret the following fluoroscopic films. To play, click on the arrow on the lower left side of the film.

Play VFSS Image

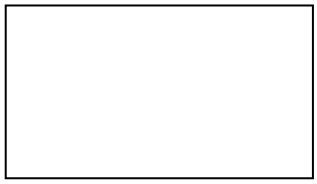
1. Is this swallow normal or abnormal?

___ Normal ___ Abnormal

If this swallow were abnormal, which of the following difficulties is noted?

___ Residual food in the valleculae (Stasis)
___ Aspiration (food in the Trachea)
___ Delayed initiation of the swallowing reflex
___ Premature spillage of food over the back of the tongue
___ None of the above apply. This swallow was normal

Appendix B, Continued



Play VFSS Image

2. Is this swallow normal or abnormal?

___ Normal ___ Abnormal

If the swallow were abnormal, which of the following difficulties would be noted?

___ Residual food in the valleculae (Stasis)
___ Aspiration (food in the Trachea)
___ Delayed initiation of the swallowing reflex
___ Premature spillage of food over the back of the tongue
___ None of the above apply. This swallow was normal

Play VFSS Image

3. Is this swallow normal or abnormal?

___ Normal ___ Abnormal

If this swallow was abnormal, which of the following difficulties was noted?

___ Residual food in the valleculae (Stasis)
___ Aspiration (food in the Trachea)
___ Delayed initiation of the swallowing reflex
___ Premature spillage of food over the back of the tongue
___ None of the above apply. This swallow was normal

Appendix B, Continued

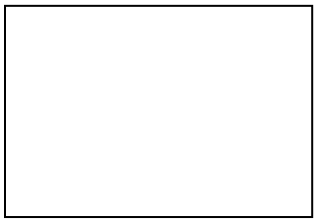
Play VFSS Image

4. Is this swallow normal or abnormal?

___ Normal ___ Abnormal

If this swallow were abnormal, which of the following difficulties was noted?

___ Residual food in the valleculae (Stasis)
___ Aspiration (food in the Trachea)
___ Delayed initiation of the swallowing reflex
___ Premature spillage of food over the back of the tongue
___ None of the above apply. This swallow was normal.



Play VFSS Image

5. Is this swallow normal or abnormal?

___ Normal ___ Abnormal

If this swallow was abnormal, which of the following difficulties was noted?

___ Residual food in the valleculae (Stasis)
___ Aspiration (food in the Trachea)
___ Delayed initiation of the swallowing reflex
___ Premature spillage of food over the back of the tongue
___ None of the above apply. This swallow was normal.

Appendix B, Continued

___ I do not want this information used in a research project.

If you have any questions about this survey or if you have any difficulties completing the survey, contact Kevin Manning at the following e-mail address:

rm399190@ohiou.edu

Reset Submit

Appendix C

Institutional Review Board Approval

OHIO UNIVERSITY O1E141

A determination has been made that the following research study is exempt from IRB review because it involves:

Category	2-	research involving the use of educational tests, survey procedures, interview procedures or observation of public behavior.
Project Title:		Determining How Speech-Language Pathologists Learn to Interpret Dynamic Visual Imaging During the Assessment of Dysphagia: A Preliminary Investigation.
Project Director:		Robert K. Manning
Department:		Speech & Language Sciences
Advisor:		Richard Dean

Rebecca Cale (Signature on file)
Rebecca Cale, Associate Director, Research Compliance
Institutional Review Board

10/25/01
Date