

Pitts, T., Bolser, D., Rosenbek, J., Troche, M., & Sapienza, C. (2008). Voluntary cough production and swallow dysfunction in Parkinson's disease. *Dysphagia*, 23, 3, 297-301. *Epub ahead of print.*

Cough is important for airway clearance, particularly if penetration/aspiration of foreign material occurs during swallow. Measures of voluntary cough production from ten male participants with stage II-III Parkinson's disease (PD) who showed no videofluorographic evidence of penetration/aspiration (Group 1) were examined and compared with those of ten male participants with stage II-III PD who showed videofluorographic evidence of penetration/aspiration (Group 2). The degree of penetration/aspiration was expertly judged from the videofluorographic examinations of the participants' sequential swallow of a thin, 30-cc bolus. Measured cough parameters included inspiratory phase duration, inspiratory peak flow, compression phase duration, expiratory peak flow, expiratory rise time, and cough volume acceleration. Results indicated significant group differences for the majority of cough measures, except for inspiratory phase duration and inspiratory peak flow. A modest relationship existed between voluntary cough parameters and penetration/aspiration scores. Decreased ability to adequately clear material from the airway with voluntary cough may exacerbate symptoms resulting from penetration/aspiration, particularly for those with neurodegenerative disease. Measurement of voluntary cough may be useful for the evaluation of airway clearance ability.

Ludlow, C.L., Adler, C.H., Berke, G.S., Bielaowicz, S.A., Blitzer, A., Bressman, S., Hallet, M., Jinnah, H.A., Juergens, U., Perlmutter, J.S., Sapienza, C., Singleton, A., Tanner, C., & Woodson, G.E. (2008). Research profiles in spasmodic dysphonia: Report of the NIH Research planning workshop. *American Academy of Otolaryngology – Head and Neck Surgery*.

Troche, M., & Sapienza, C. (2008). Effects of levodopa on speech timing in patients with idiopathic Parkinson's disease. [www.speechpathology.com](http://www.speechpathology.com) (peer-reviewed).

Safety and timing of swallow are essential for health and quality of life. The study of swallow in Parkinson's disease (PD) is especially important, in that aspiration pneumonia is the leading cause of death in this population. One of the therapeutic strategies employed in the treatment of swallowing problems is diet modification. The primary aim of this study was to investigate the effects of bolus consistency on P-A score and timing of the oral-pharyngeal swallow of persons with PD. The secondary goal was to explore the relationship between various quantifiable components of hyoid movement and measures of swallow timing and penetration/aspiration. The videoradiographic images of ten participants with PD swallowing six thin, and six pudding thick boluses were measured. The results demonstrated various significant differences and relationships among the dependent variables (i.e., oral transit time, pharyngeal transit time, number of tongue pumps, P-A score, and SWAL-QOL measures). The implications for further research and clinical practice are discussed.

Wheeler, K., Rosenbek, J., & Sapienza, C.M. (2008). Submental EMG hyoid movement during Mendelsohn maneuver, Effortful swallow and expiratory muscle strength training. *Journal of Speech Language and Hearing Research*.22, Epub ahead of print.

**Purpose:** This study investigated the concurrent biomechanical and electromyographic properties of 2 swallow-specific tasks (effortful swallow and Mendelsohn maneuver) and 1 swallow-nonspecific (expiratory muscle strength training [EMST]) swallow therapy task in order to examine the differential effects of each on hyoid motion and associated submental activation in healthy adults, with the overall goal of characterizing task-specific and overload properties of each task. **Method:** Twenty-five healthy male and female adults (M = 25 years of age) participated in this prospective, experimental study with 1 participant group. Each participant completed all study tasks (including normal swallow, Mendelsohn maneuver swallow, effortful swallow, and EMST task) in random order during concurrent videofluoroscopy and surface electromyography recording. **Results:** Results revealed significant differences in the trajectory of hyoid motion as measured by overall displacement and angle of elevation of the hyoid bone. As well, timing of hyoid movement and amplitude differences existed between tasks with regard to the activation of the submental musculature. **Conclusions:** Study results demonstrated differential effects of the 3 experimental tasks on the principles of task specificity and overload. These principles are important in the development of effective rehabilitative programs. Subsequent direction for future research is suggested.

Kim J., Davenport, P., Sapienza, C.M. (2008). Effect of expiratory muscle strength training on elderly cough function. *Archives of Gerontology and Geriatrics*, 1856, 1-6

Age-related loss of muscle strength, known as sarcopenia, in the expiratory muscles, along with reductions in lung elastic recoil and chest wall compliance decreases the intrathoracic airway pressure as well as expiratory flow rates and velocity, greatly impacting an elderly person's ability to generate the forces essential for cough. This study examined the effects of a 4-week expiratory muscle strength training (EMST) program on maximum expiratory pressure (MEP) and cough function in 18 healthy but sedentary elderly adults. MEP significantly increased after the EMST program from 77.14+/-20.20 to 110.83+/-26.11cmH<sub>2</sub>O. Parameters measured during reflexive coughs produced by capsaicin challenge, indicated that compression phase duration significantly decreased (from 0.35+/-0.19 to 0.16+/-0.17s), peak expiratory flow rate decreased (from 4.98+/-2.18 to 8.00+/-3.05l/s) and post-peak plateau integral amplitude significantly increased (from 3.49+/-2.46 to 6.83+/-4.16l/ss) with the EMST program. EMST seems to be an effective program to increase the expiratory muscle strength in the sedentary elderly, which contribute to an enhanced cough function.

Sapienza, C.M. (2008, invited). Respiratory muscle strength training. *Current Opinion in Otolaryngology and Head and Neck Surgery*, 16, 3, 216-220.

**Purpose:** To provide an overview of respiratory muscle strength training applications for voice and speech disorders. **Recent Findings:** Little examination of respiratory muscle training for the rehabilitation of voice and speech has occurred. Less than a handful of

studies discuss use of strengthening techniques for the voice-disordered population and of those, inspiratory muscle strength training shows promise for use with upper airway disorders including abductor vocal fold paralysis and paradoxical vocal cord dysfunction. Case study results of Lance Adams syndrome indicated a positive outcome for maximum phonation time and improved intelligibility ratings and communication effectiveness. Work with the multiple sclerosis population showed no change in qualitative ratings of patient voice handicap and no significant improvement in speech production variables. Current trials with Parkinson's disease are ongoing with no published data currently available with regard to voice and speech production.

Summary: Respiratory muscle strengthening programs are either inspiratory or expiratory and are typically accomplished using handheld devices. Training durations typically examined have been 4-8 weeks. Training trials usually take 20-30 min per day. Training frequency varies across studies. Detraining outcomes are important to examine as part of clinical trials. Defining detraining outcomes has major implications for the development of a complete rehabilitation program.

Wheeler, K.M., Huber, J.E., Pitts, T., & Sapienza, C.M. (2008).

Lung volume during swallowing: Single bolus swallows in healthy young adults. *Journal of Speech, Language and Hearing Research, 22*, Epub ahead of print

Purpose: This study examined the relationship between swallowing and lung volume initiation in healthy adults during single swallows of boluses differing in volume and consistency. Differences in lung volume according to respiratory phase surrounding the swallow were also assessed. Method: Nine men and 11 women between the ages of 19 and 28 years served as study participants. Lung volume and respiratory phase data were recorded as each participant completed 5 trials each of 10-mL and 20-mL water boluses by cup, and thin and thick paste boluses by spoon, presented in randomized order. Results: Significant differences in lung volume at swallow initiation were found based on bolus consistency but not on bolus volume. No differences were found for lung volume initiation based on the respiratory phase surrounding the swallow or for the respiratory pattern based on bolus volume or consistency. Conclusion: Findings of this study extend the existing knowledge base regarding the interaction of the swallow and respiratory systems by identifying targeted lung volumes at swallow initiation. In addition to other swallow-related biomechanical events and respiratory phase relationships surrounding a swallow, the lung volume at swallow initiation may be an important consideration when investigating swallow physiology and physiopathy.

Gonzalez, L.J., Musson, N., Rosenbek, J.C., & Sapienza, C.M. (2008). Neuroplasticity and rehabilitation research for speech, language, and swallowing disorders. *Journal of Speech Language and Hearing Research, 51*, 1, 222-4. Review.

Purpose: This article introduces a collection of consensus statements regarding the application of neuroplasticity principles to rehabilitation of dysphagia, dysarthria, apraxia, and aphasia.

Ludlow, C.L., Hoit, J., Kent, R., Ramig, L., Shrivastav, R., Smith, A., Strand, E., Yorkston, K., & Sapienza, C. (2008). Translating principles of neural plasticity into research on speech motor control recovery and rehabilitation. *Journal of Speech, Language and Hearing Research, 51*, S240-258.

**Purpose:** To review the principles of neural plasticity and make recommendations for research on the neural bases for rehabilitation of neurogenic speech disorders. **Method:** A working group in speech motor control and disorders developed this report, which examines the potential relevance of basic research on the brain mechanisms involved in neural plasticity and discusses possible similarities and differences for application to speech motor control disorders. The possible involvement of neural plasticity in changes in speech production in normalcy, development, aging, and neurological diseases and disorders was considered. This report focuses on the appropriate use of functional and structural neuroimaging and the design of feasibility studies aimed at understanding how brain mechanisms are altered by environmental manipulations such as training and stimulation and how these changes might enhance the future development of rehabilitative methods for persons with speech motor control disorders. **Conclusions:** Increased collaboration with neuroscientists working in clinical research centers addressing human communication disorders might foster research in this area. It is hoped that this article will encourage future research on speech motor control disorders to address the principles of neural plasticity and their application for rehabilitation.

Troche, M., Rosenbek, J., & Sapienza, C. (2008). Effects of bolus consistency on timing and safety of swallow in patients with Parkinson's disease. *Dysphagia, 23*, 1, 26-32.

Aspiration pneumonia is the leading cause of death in Parkinson's disease (PD) patients. In clinical practice, the videofluoroscopic examination (VFE) is the most common method for evaluation of swallowing disorders. One of the variables manipulated during the VFE is consistency of the bolus. The results of this examination greatly influence the recommendations made by speech-language pathologists regarding swallow therapy and/or intervention. The primary aim of this study was to investigate the effects of bolus consistency on penetration-aspiration (P-A) score and timing of swallow of persons with PD. The videoradiographic images of ten participants with PD swallowing six thin and six pudding-thick boluses were analyzed. Swallow timing and P-A were measured. (i.e., oral transit time, pharyngeal transit time, number of tongue pumps, and P-A score). The results demonstrated various significant differences and relationships among the dependent variables. Implications for further research and clinical practice are discussed.

Sapienza, C., Wheeler-Hegland, K.M., Stewart, K., & Nocera, J. (2008). Exercise prescription for dysphagia: Intensity and duration manipulation (Invited). *Perspectives on Swallowing and Swallowing Disorders. ASHA, Division 13*, 50-58.

This paper briefly reviews information available on exercise stimulus intensity and its interaction with stimulus duration, as well as reviews the current information on different

dysphagia treatment modalities as they relate to treatment intensity and duration. The available literature in this area suggests that exercise modalities are distinct and different with regard to the metabolic pathways accessed as a function of both stimulus intensity and duration. Defining treatment prescriptions for dysphagia is difficult at this time, however, because only limited data on stimulus duration or intensity is available for existing indirect and direct treatments. Acknowledgment of exercise physiology paradigms and mechanisms of muscle response to treatment is critical to design of rehabilitation protocols.

Sapienza, C.M. & Wheeler, K.M. (2006). Respiratory muscle strength training: Functional outcomes versus plasticity. *Seminars in Speech and Language* for a special edition called *New Frontiers in Dysphagia Rehabilitation*, 27, 4, 236-244.

Respiratory muscle strength training is a paradigm that has been used for numerous years with a variety of populations including but not limited to spinal cord injury, chronic obstructive pulmonary disease, multiple sclerosis, Parkinson's disease, voice disordered, sedentary elderly, and healthy young. The respiratory muscle strength program discussed here is an expiratory muscle strength training and uses a pressure threshold device with a regimented treatment protocol. The primary purpose of the expiratory muscle strength training program is to promote strength in the expiratory muscles. The training protocol occurs five times per day, 5 days a week, and consists of ~15-20 minutes per day of training by the user at home. The device threshold is changed weekly by a clinician to maintain a threshold load of 75% of an individual's maximum expiratory pressure. The threshold setting of the device is always based on the individual's recorded maximum expiratory pressure generated into a digital pressure gauge. Results of 4 weeks of expiratory muscle strength training protocols indicate up to a 50% improvement for healthy subjects, those with multiple sclerosis, and those with spinal cord injury. The potential transfer of expiratory muscle strength to functional outcomes is discussed, as well as how strength-training paradigms may influence cortical plasticity.

Shrivastav, R. & Sapienza, C. (2006). Some difference limens for the perception of breathiness. *Journal of the Acoustical Society of America*, 120, 1, 416-23.

Perception of breathy voice quality appears to be cued by changes in the vowel spectrum. These changes are related to alterations in the intensity of aspiration noise and spectral slope of the harmonic energy [Shrivastav and Sapienza, *J. Acoust. Soc. Am.*, 114 (4), 2217-2224 (2003)]. Ten young-adult listeners with normal hearing were tested using an adaptive listening task to determine the smallest change in signal-to-noise ratio that resulted in a change in breathiness. Six vowel continua, three female and three male, were generated using a Klatt synthesizer and served as stimuli. Results showed that listeners needed as much as 20-dB increase in aspiration noise to perceive a change in breathiness against a relatively normal voice. In contrast, listeners needed approximately an 11-dB increase in aspiration noise to discriminate breathiness against a severely breathy voice. The difference limens for breathiness were observed to vary across the six talkers. Voices having aspiration noise that was predominantly in the high

frequencies had smaller difference limens. No significant differences for male and female voice were observed.

Jones, H.N., Donovan, N.J., Sapienza, C.M., Fernandez, H.H. & Rosenbek, J.C. (2006). Expiratory muscle strength training in the treatment of a severe mixed dysarthria in a patient with Lance-Adams syndrome. *Journal of Medical Speech Language Pathology*, 14, 3, 207-217.

The results of an expiratory muscle strength training (EMST) program is described in the rehabilitation of mixed dysarthria in a patient with Lance-Adams syndrome secondary to a motor vehicle accident (MVA) with associated traumatic brain injury (TBI). A pretest-posttest design was employed. Following EMST, maximum phonation duration, intelligibility scores of 14-word sentences, and Communicative Effectiveness Survey (CES) scores increased. Three months after the discontinuation of EMST, maximum phonation duration had decreased but remained increased in comparison to pretreatment performance, while intelligibility scores dropped below baseline level. CES scores continued to increase following the discontinuation of treatment. These data suggest that EMST was associated with a therapeutic effect for this patient, as evidenced by improved performance measured pre- and posttreatment.

Mendes, A.P., Brown, W.S., Sapienza, C.M. & Rothman, H. (2006). Effects of vocal training on respiratory kinematics during singing tasks. *Folia Phoniatrica*, 58, 363-377.

This longitudinal study determined the effects of vocal training (VT) on respiratory kinematics and muscle activity during singing tasks. Four voice students, 3 females and 1 male, were recorded during singing tasks once a semester for 3 consecutive semesters. Respiratory kinematic measures included lung volume, rib cage (RCE) and abdominal excursions (ABE). Surface electromyographic measures included burst duration (BD) and peak amplitude (PA) of the pectoralis major, rectus abdominis and external oblique muscles. Descriptive statistics revealed that RCE and ABE increased from the 1st to the 2nd semester, but decreased from the 2nd to the 3rd semester of VT. Overall, mean BD decreased from the 1st to the 2nd semester and increased from the 2nd to the 3rd semester. Mean PA increased from the 1st to the 2nd semester and decreased from the 2nd to the 3rd semester of VT. RCE and muscle force generation of the above muscles increased as the demand level and the length of the phonatory tasks increased. Interpretation of the results suggests that the respiratory system is highly responsive to VT, after only 3 semesters of training.

Silverman, E.P., Sapienza, C.M., Saleem, A., Carmichael, C., Davenport, P.W., Hoffman-Ruddy, B., & Okun, M.S. (2006). Tutorial on maximum inspiratory and expiratory mouth pressures in individuals with idiopathic Parkinson disease (IPD) and the preliminary results of an expiratory muscle strength training program. *NeuroRehabilitation*, 2, 1, 71-9.

Respiratory symptoms are recognized as sequelae of motor dysfunction in idiopathic Parkinson's disease (IPD) and these symptoms have the potential to cause problems with swallow, cough, voice and speech. Specifically, maneuvers that require rapid activation and coordination of upper airway and chest wall musculature become progressively impaired as motor dysfunction progresses during the natural course of the disease. This study reports on the maximum inspiratory and expiratory pressures produced by 28 participants (average age 64) diagnosed with moderate to severe IPD (average stage 2.5 with a range of 2.0-3.0). All measures were collected during the "medication on" state. Outcomes of a specific respiratory muscle strength training technique for improving maximum expiratory pressure are reported for three of the patients in this study. Techniques that focus on strengthening the respiratory muscles in patients with IPD (other than with low load breathing exercises), have not been previously reported. The results of this pilot study demonstrate that respiratory muscle weakness may be an important factor in the respiratory complications in IPD and that respiratory muscle strength training has the potential to improve expiratory muscle strength for this population. This improvement has the potential to positively impact high forced respiratory activities, such as forced breathing maneuvers, swallow, cough and speech functions that require greater magnitude and duration of expiration.

Wheeler, K.M., Collins, S., & Sapienza, C.M. (2006). The relationship between VHI scores and acoustic measures of disordered voice production. *Journal of Voice*, 20, 2, 308-317.

This study was designed to examine the relationship between the Voice Handicap Index (VHI) and acoustic measures of voice samples common in clinical practice. Fifty participants, 38 women and 12 men, ranging in age from 19 to 80 years, with a mean age of 49 years, served as participants. Of these 50 participants, 17 participants could be included in the acoustic analysis of voice based on measures of error calculated with the TF32 software. All participants completed the VHI and provided voice samples including three trials of the sustained vowel /A/ at a comfortable loudness level as well as a connected speech sample consisting of the Zoo Passage. Acoustic measures were made with TF32 and Cool Edit software and included fundamental frequency, jitter %, shimmer %, signal-to-noise ratio, mean root-mean-square intensity, fundamental frequency standard deviation, aphonic periods, and breath groups. Results indicate that these measures were not predictive of overall VHI score, and no cohesive or predictable pattern was identified when comparing individual measures with overall VHI or with each subscale item. Likely contributions to this lack of correlation and subsequent clinical implications are discussed, as well as the direction for further research.