Clinical Outcomes Summary
Biofeedback in Strength and Skill App (BiSSkApp)

The BiSSkApp product has been recently developed to integrate traditional rehabilitation approaches for dysphagia with more contemporary approaches, and to maximise availability of intensive rehabilitation through a monitored telehealth approach. As this is a newly emerging product, to date there are no existing published data on BiSSkApp itself. However, the critical components that make up the product have research support in the published data. These components include: (1) the use of sEMG as an adjunctive modality in dysphagia rehabilitation, focusing heavily on strength based swallowing training; (2) the emergence of increased understanding of behavioural neuromodulation of swallowing, (3) the implementation of swallowing skill training, and (4) implementation of telehealth modalities in swallowing rehabilitation.

Strength and Skill-based Swallowing Training

BiSSkApp currently provides options for two primary rehabilitation approaches: the more traditional strength training approach and a more contemporary skill training approach. This represents a significant expansion in our understanding of cortical control of swallowing and the impact on rehabilitation planning and potential. Although strength and skill are inextricably linked, specific strength training focuses largely on generating increase force generation during execution of a swallowing responses. Skill training shifts the focus away from peripheral muscle recruitment to focus on 'skilled movement' in swallowing, or precision and integration of timing and force. A number of publications have documented this conceptual shift in rehabilitation. Clinicians are directed to the following peer reviewed publications:

1. Huckabee ML and Macrae, P. (2014) Rethinking Rehab: Skill Based Training for Swallowing Impairment. SIG 13 Perspectives on Swallowing and Swallowing Disorders (Dysphagia) 23: 46-53. (Invited article)
2. Huckabee ML & Burnip E (2018). Still rethinking rehab: Motor learning treatment approaches for dysphagia. SIG 13, Swallowing and Swallowing Disorders (Dysphagia), 13(3): 146-156. (invited article).
3. Huckabee ML, and Lamvik-Gozdzikowska K (2018). Reconsidering rehabilitation for neurogenic dysphagia: Strengthening skill in swallowing. Curr Phys Med Rehabil Rep (2018) 6: 186. . (invited article).
4. Zimmerman, E., et al., *Motor learning, neuroplasticity, and strength and skill training: moving from compensation to retraining in behavioral management of dysphagia.* American Journal of Speech-Language Pathology, 2020. **29**(2S): p. 1065-1077.
5. Zimmerman, E., Carnaby, G., Lazarus, C. L., & Malandraki, G. A. (2020). Motor Learning, Neuroplasticity, and Strength and Skill Training: Moving From Compensation to Retraining in Behavioral Management of Dysphagia. *American journal of speech-language pathology*, *29*(2S), 1065–1077.

6. Huckabee, M. L., Flynn, R., & Mills, M. (2023). Expanding Rehabilitation Options for Dysphagia: Skill-Based Swallowing Training. Dysphagia, 38(3), 756–767. (invited article)

7. Huckabee, M. L., Mills, M., Flynn, R., & Doeltgen, S. (2023). The Evolution of Swallowing Rehabilitation and Emergence of Biofeedback Modalities. Current Otorhinolaryngol Reports, 11(2), 144-153.

Strength Training

Since our very first directed attempts at rehabilitation of dysphagia, the mainstay of approaches have targeted muscle strengthening – exercises with a focused intent to increase force generation to drive the bolus through the oropharynx. Included within the muscle strengthening domain are exercises such as effortful swallowing, Mendelsohn manoeuvre, head lift, chin tuck against resistance, lingual pressure exercises, and expiratory muscle strength training. A small collection of published research is outlined below. Despite more than four decades of integration into clinical practice and a long series of clinical studies and small clinical trial publication, systematic reviews - much less metanalyses – are not frequently available. Several reasons for this paucity of published quality research exist. A key limitation in behavioural research is the complexity of clinical trials in patients where dysphagic presentation may be highly variable within a given aetiology and indeed where our overall understanding of pathophysiology vs biomechanics may hinder development of appropriate exercise approaches. For the interested reader, the final article by Borders outlines key limitations in our research base. Of note, for exercise approaches that have been supported through commercialisation of technologies, greater data are ultimately available (EMST, IOPI, CTAR), suggesting that the use of technology may either facilitate treatment outputs or at the very least allow for greater control of treatment execution and outcome measurement. Despite these limitations, muscle strengthening approaches have prevailed for decades in swallowing rehabilitation.

1. Stathopoulos, E., & Felson Duchan, J. (2006). History and principles of exercise-based therapy: how they inform our current treatment. *Seminars in speech and language*, *27*(4), 227–235. https://doi.org/10.1055/s-2006-955113
2. Burkhead, L. M., Sapienza, C. M., & Rosenbek, J. C. (2007). Strength-training exercise in dysphagia rehabilitation: principles, procedures, and directions for future research. *Dysphagia*, *22*(3), 251–265. https://doi.org/10.1007/s00455-006-9074-z
3. Ploumis, A., Papadopoulou, S. L., Theodorou, S. J., Exarchakos, G., Givissis, P., & Beris, A. (2018). Cervical isometric exercises improve dysphagia and cervical spine malalignment following stroke with hemiparesis: a randomized controlled trial. *European journal of physical and rehabilitation medicine*, *54*(6), 845–852. https://doi.org/10.23736/S1973-9087.17.04952-8
4. Mancopes, R., Smaoui, S., & Steele, C. M. (2020). Effects of Expiratory Muscle Strength Training on Videofluoroscopic Measures of Swallowing: A Systematic Review. *American journal of speech-language pathology*, *29*(1), 335–356. https://doi.org/10.1044/2019_AJSLP-19-00107
5. Smaoui, S., Langridge, A., & Steele, C. M. (2020). The Effect of Lingual Resistance Training Interventions on Adult Swallow Function: A Systematic Review. *Dysphagia*, *35*(5), 745–761. https://doi.org/10.1007/s00455-019-10066-1
6. Doeltgen, S. H., Kaur, H., Daniels, S. K., Mohammadi, L., & Murray, J. (2022). Behavioral Interventions Targeting Insufficient Upper Esophageal Sphincter Opening During Swallowing: A Scoping Review. *Dysphagia*, *37*(4), 699–714. https://doi.org/10.1007/s00455-021-10349-6

7. Liu, J., Wang, Q., Tian, J., Zhou, W., Gao, Y., Chen, X., Zhang, W., Gao, Y., & Zhou, L. (2023). Effects of chin tuck against resistance exercise on post-stroke dysphagia rehabilitation: A systematic review and meta-analysis. *Frontiers in neurology*, *13*, 1109140.
8. Borders, J. C., Grande, A. A., & Troche, M. S. (2022). Statistical Power and Swallowing Rehabilitation Research: Current Landscape and Next Steps. *Dysphagia*, *37*(6), 1673–1688. https://doi.org/10.1007/s00455-022-10428-2

Biofeedback in Dysphagia Rehabilitation

Very early in our history of muscle strengthening for swallowing, the use of surface electromyography (sEMG) appeared in our literature as an adjunct to facilitate execution of muscle strengthening approaches. The use of biofeedback modality was proposed as a means to allow patients greater insight into the relative degree of force generation during strengthening exercises, particularly effortful swallowing and Mendelsohn manoeuvre. A large number of publications have documented various aspects of swallowing using sEMG data (bolus size, viscosity, manoeuvre type, etc …); a smaller number have reported on use of sEMG in rehabilitation programmes. A small sampling of these are included below (1-5). Of interest if the systematic review and metanalysis by Benfield et al (6). This publication sought to evaluate the influence of sEMG biofeedback on swallowing outcomes; however, much of this literature does not address this question specifically. In order to do this, strengthening exercises with the use of sEMG would have to be compared to outcomes of the same exercises without sEMG. An intriguing question arises: historically sEMG has focused on execution of muscle strengthening as the assumed 'active treatment', with sEMG as merely as adjunct to facilitate execution. But is this what the active treatment actually was? Or does the use of a biofeedback modality shift the focus away from peripheral strengthening to modulating cortical engagement that drives swallowing behaviour? The publication below by Ng et al (7), is a first step at identifying underlying pathophysiology behind biomechanical movement that may, in future, help us clarify rehabilitation approaches.

1. Bryant M. [Huckabee ML] (1991). Biofeedback in the treatment of a selected dysphagic patient. *Dysphagia*, *6*(3), 140–144. https://doi.org/10.1007/BF02493516
2. Crary M. A. (1995). A direct intervention program for chronic neurogenic dysphagia secondary to brainstem stroke. *Dysphagia*, *10*(1), 6–18.
3. Huckabee ML, Cannito MP. Outcomes of swallowing rehabilitation in chronic brainstem dysphagia: A retrospective evaluation. Dysphagia. 1999;14(2):93-109. doi: 10.1007/PL00009593.
4. Crary, M. A., Carnaby Mann, G. D., Groher, M. E., & Helseth, E. (2004). Functional benefits of dysphagia therapy using adjunctive sEMG biofeedback. *Dysphagia*, *19*(3), 160–164 https://doi.org/10.1007/s00455-004-0003-8y
5. McCullough GH, Kamarunas E, Mann GC, Schmidley JW, Robbins JA, Crary MA. Effects of Mendelsohn maneuver on measures of swallowing duration post stroke. Top Stroke Rehabil. 2012;19(3):234-43. doi: 10.1310/tsr1903-234.
6. McCullough GH, Kim Y. Effects of the Mendelsohn maneuver on extent of hyoid movement and UES opening post-stroke. Dysphagia. 2013;28(4):511-9. doi: 10.1007/s00455-013-9461-1.

7. Ng, K. B., Jones, R. D., Hernandez, E. G., Macrae, P., & Huckabee, M. L. (2021). Classification of Stroke Patients with Dysphagia into Subgroups Based on Patterns of Submental Muscle Strength and Skill Impairment. *Archives of physical medicine and rehabilitation*, *102*(5), 895–904.
8. Nordio, S., Arcara, G., Berta, G., Dellai, A., Brisotto, C., Koch, I., Cazzador, D., Aspidistria, M., Ventura, L., Turolla, A., D'Imperio, D., & Battel, I. (2022). Biofeedback as an Adjunctive Treatment for Post-stroke Dysphagia: A Pilot-Randomized Controlled Trial. *Dysphagia*, *37*(5), 1207–1216.
9. Archer, S. K., Smith, C. H., & Newham, D. J. (2021). Surface Electromyographic Biofeedback and the Effortful Swallow Exercise for Stroke-Related Dysphagia and in Healthy Ageing. *Dysphagia*, *36*(2), 281-292.
10. Benfield, J. K., Everton, L. F., Bath, P. M., & England, T. J. (2019). Does Therapy with Biofeedback Improve Swallowing in Adults with Dysphagia? A Systematic Review and Meta-Analysis. *Archives of Physical Medicine and Rehabilitation*, *100*(3), 551–561.
11. Albuquerque, L. C. A., Pernambuco, L., da Silva, C. M.,Chateaubriand, M. M., & da Silva, H. J. (2019). Effects of electromyographic biofeedback as an adjunctive therapy in the treatment of swallowing disorders: A systematic review of the literature. European Archives of Otorhinolaryngology, 276(4), 927–938.

Behavioural Neuroplasticity in Swallowing Rehabilitation

The shift from muscle to brain began early in this century with greater access to functional neuroimaging and the recognition that swallowing motor control could be, at the very least, modulated by cortical downflow. Few clinicians will be unfamiliar with the landmark publications by Kleim and Jones (2008) and Robbins and colleagues (2008), which proposed a significant shift in our thinking about rehabilitation of dysphagia. These should be required reading for all clinicians with interests in rehabilitation. Other specific neuroimaging and behavioural neuroscience research (a few listed below) has documented the effects of motor imagery on swallowing neural networks and consequent motor outputs. All make for fascinating reading and provide a foundation for swallowing skill-based training.

1. Kleim JA, Jones TA. Principles of experience-dependent neural plasticity: implications for rehabilitation after brain damage. Journal of Speech, Language, and Hearing Research. 2008;51(1): S225-39. doi: 10.1044/1092-4388(2008/018).
2. Robbins J, Butler SG, Daniels SK, Diez Gross R, Langmore S, Lazarus CL, et al. Swallowing and dysphagia rehabilitation: translating principles of neural plasticity into clinically oriented evidence. Journal of Speech, Language, and Hearing Research. 2008;51(1): S276-300. doi: 10.1044/1092-4388(2008/021).
3. Jing YH, Lin T, Li WQ, Wu C, Li X, Ding Q, et al. Comparison of Activation Patterns in Mirror Neurons and the Swallowing Network During Action Observation and Execution: A Task-Based fMRI Study. Front Neurosci. 2020; 14:867. doi: 10.3389/fnins.2020.00867.
4. Kober SE, Grossinger D, Wood G. Effects of Motor Imagery and Visual Neurofeedback on Activation in the Swallowing Network: A Real-Time fMRI Study. Dysphagia. 2019;34(6):879-95. doi: 10.1007/s00455-019-09985-w.
5. Szynkiewicz SH, Nobriga CV, O'Donoghue CR, Becerra BJ, LaForge G. Motor Imagery Practice and Increased Tongue Strength: A Case Series Feasibility Report. Journal of speech, language, and hearing research. 2019;62(6):1676-84. doi: 10.1044/2019_JSLHR-S-18-0128.

6. Yang, H., Ang, K. K., Wang, C., Phua, K. S., & Guan, C. (2016). Neural and cortical analysis of swallowing and detection of motor imagery of swallow for dysphagia rehabilitation-A review. *Progress in brain research*, *228*, 185–219.

Skill Training in Swallowing Rehabilitation: Implementing Behavioural Neuroplasticity

With greater evidence of cortical control of swallowing, a body of work was consequently generated that sought to evaluate the capacity for modulation of individual aspects of the pharyngeal response. A unique feature of this research is the use of a biofeedback modality, thus allowing research participants/patients access to two key components of motor skill learning: knowledge of performance and knowledge of results. By utilising instrumentation to facilitate refinement of motor behaviour, individuals demonstrated the capacity to modify components of swallowing that were perhaps previously considered under reflexive control, suggesting significant capacity for motor control of swallowing.

Swallowing Respiratory Coordination

1. Martin-Harris, B., McFarland, D., Hill, E. G., Strange, C. B., Focht, K. L., Wan, Z., Blair, J., & McGrattan, K. (2015). Respiratory-swallow training in patients with head and neck cancer. *Archives of physical medicine and rehabilitation*, *96*(5), 885–893. https://doi.org/10.1016/j.apmr.2014.11.022
2. Martin-Harris, B., Garand, K. L. F., & McFarland, D. (2017). Optimizing Respiratory-Swallowing Coordination in Patients with Oropharyngeal Head and Neck Cancer. *Perspectives of the ASHA special interest groups*, *2*(13), 103–110. https://doi.org/10.1044/persp2.SIG13.103
3. Martin-Harris, B., Kantarcigil, C., Reedy, E. L., & McFarland, D. H. (2023). Cross-System Integration of Respiration and Deglutition: Function, Treatment, and Future Directions. *Dysphagia*, *38*(4), 1049–1058.

Pharyngeal sequencing

1. Huckabee, M. L., Lamvik, K., & Jones, R. (2014). Pharyngeal mis-sequencing in dysphagia: characteristics, rehabilitative response, and etiological speculation. Journal of the neurological sciences, 343(1-2), 153–158. https://doi.org/10.1016/j.jns.2014.05.064
2. Lamvik, K., Jones, R., Sauer, S., Erfmann, K., & Huckabee, M. L. (2015). The capacity for volitional control of pharyngeal swallowing in healthy adults. *Physiology & behavior*, *152*(Pt A), 257–263.

Modulation of UES opening

1. Winiker, K., Gozdzikowska, K., Guiu Hernandez, E., Kwong, S. L., Macrae, P., & Huckabee, M. L. (2021). Potential for Volitional Control of Resting Pressure at the Upper Oesophageal Sphincter in Healthy Individuals. *Dysphagia*, *36*(3), 374–383.
2. Winiker, K., Gozdzikowska, K., Guiu Hernandez, E., Kwong, S. L., Macrae, P., & Huckabee, M. L. (2022). Potential for Behavioural Pressure Modulation at the Upper Oesophageal Sphincter in Healthy Swallowing. *Dysphagia*, *37*(4), 763–771. https://doi.org/10.1007/s00455-021-10324-1

3. Nativ-Zeltzer N, Belafsky PC, Bayoumi A, Kuhn MA. Volitional control of the upper esophageal sphincter with high-resolution manometry driven biofeedback. Laryngoscope investigative otolaryngology. 2019;4(2):264-8. doi: 10.1002/lio2.255.

Skill in lingual movement

1. Steele, C. M., Bayley, M. A., Péladeau-Pigeon, M., & Stokely, S. L. (2013). Tongue pressure profile training for dysphagia post stroke (TPPT): study protocol for an exploratory randomized controlled trial. *Trials*, *14*, 126. https://doi.org/10.1186/1745-6215-14-126
2. Steele, C. M., Bayley, M. T., Peladeau-Pigeon, M., Nagy, A., Namasivayam, A. M., Stokely, S. L., & Wolkin, T. (2016). A Randomized Trial Comparing Two Tongue-Pressure Resistance Training Protocols for Post-Stroke Dysphagia. *Dysphagia*, *31*(3), 452–461.

Skill training with surface electromyography (sEMG)

Much of the research above required implementation of oftentimes expensive methodology. A first attempt to implement skill based swallowing training with sEMG – an adaptation of the strength approach previously used – was generated from the University of Canterbury Rose Centre for Stroke Recovery and Research. This initial clinical implementation study in a small cohort of patients with Parkinson's Disease suggested considerable functional gain following two weeks of intensive daily rehabilitation using a treatment approach which focused not on maximal force generation during swallowing, rather than precision in timing and relative force (1). In this neurodegenerative patient population, statistically significant improvements were noted in measures of reduced premotor and pre-swallowing time, improved scores on the Timed Water Swallowing Test and improved quality of life (SwalQOL); these positive outcomes maintained across a two-week follow-up period of no direct treatment. The Biofeedback in Strength and Skill Training desktop software module was consequently redesigned as a commercially available product, based largely on the strength training and sEMG literature. BiSSkiT was released to the NZ, Australian and EU markets in 2016, prompting interest, and consequent early research, in the skill training approach. Several peer reviewed publications are included below which focus on skill training using the BiSSkiT protocol (abstract included) or similar protocols.

1. Athukorala RPM, Jones RDP, Sella OP, Huckabee M-LP. Skill Training for Swallowing Rehabilitation in Patients with Parkinson's Disease. Archives of physical medicine and rehabilitation. 2014;95(7):1374-82. doi: 10.1016/j.apmr.2014.03.001.
"Objective: To examine the effects of skill training on swallowing in individuals with dysphagia secondary to Parkinson's disease (PD) and to explore skill retention after treatment termination.
Design: Within-subject pilot study with follow-up after 2 weeks of treatment and after a 2-week nontreatment period.
Setting: Clinic in a research institute.
Participants: Patients (N=10; mean age, 67.4y) included 3 women (mean Hoehn and Yahr score, 2.6) and 7 men (mean Hoehn and Yahr score, 2.4).
Intervention: Patients underwent 10 daily sessions of skill training therapy focused on increasing precision in muscle contraction during swallowing using visual feedback.

Main outcome measures: Data from the timed water swallow test, Test of Mastication and Swallowing Solids, surface electromyography (sEMG) of submental muscles, and swallowing-related quality of life questionnaire were collected at 2 baseline sessions (conducted 2wk apart) at the end of treatment and after 2 nontreatment weeks to assess skill retention.

Results: Immediately after posttreatment, the swallowing rate for liquids (P=.034), sEMG durational parameters of premotor time (P=.003), and preswallow time (P<.001) improved. A functional carryover effect was seen from dry to water swallows (P=.009). Additionally, swallowing-related quality of life improved (P=.018). Reassessment at 2 weeks after treatment termination revealed short-term retention of treatment effects.

Conclusions: A skill-based training approach produced functional, biomechanical, and swallowing-related quality of life improvements in this cohort indicating compelling evidence for the effectiveness of this novel approach for dysphagia rehabilitation in PD." [study abstract]

2. Perry SE, Sevitz JS, Curtis JA, Kuo S-H, Troche MS. Skill Training Resulted in Improved Swallowing in a Person with Multiple System Atrophy: An Endoscopy Study: Novel Dysphagia Therapy in Multiple System Atrophy. Movement disorders clinical practice (Hoboken, NJ). 2018;5(4):451-2. doi: 10.1002/mdc3.12628.
   Brief clinical reported; no abstract available.
3. Burchell, D., Hosking, S., Kambanaros, M., & Stiller, K. (2022). Skill-based swallowing therapy using a computer-based training program improves swallowing-related quality of life and swallowing function for adults with dysphagia: a pilot study. *Journal of Clinical Practice in Speech-Language Pathology*, *24*(3),130–137. https://doi.org/10.1080/22087168.2022.12370373
   "This study evaluated the effectiveness of a computer-based training program, called the Biofeedback in Strength and Skill Training (BiSSkiT). This program uses surface electromyography to target motor control and swallowing precision, by providing feedback regarding the timing and strength of muscle contractions in patients with dysphagia. A single-group pre–post study was undertaken, involving 10 participants with chronic dysphagia. Ten training sessions using the BiSSkiT program were undertaken over 3 to weeks. Questionnaires evaluating patient reported swallowing-related quality of life and swallowing function were completed twice at baseline, again at postintervention, and at 1 month follow-up. Improvements in outcome measures were seen, suggesting that the BiSSkiT computer-based training program may improve swallowing-related quality of life and swallowing function. Such computer-based interventions hold considerable promise for people with dysphagia; however, more research is required." [study abstract]
4. Benfield, J. K., Hedstrom, A., Everton, L. F., Bath, P. M., & England, T. J. (2023). Randomized controlled feasibility trial of swallow strength and skill training with surface electromyographic biofeedback in acute stroke patients with dysphagia. *Journal of oral rehabilitation*, *50*(6), 440–451. https://doi.org/10.1111/joor.13437
   "Background & Objectives: Swallow strength and skill training with surface electromyography(sEMG) biofeedback may improve dysphagia but little is known about the feasibility and efficacy of this intervention in acute stroke Methods: We conducted a randomized controlled feasibility study in acute stroke patients with dysphagia. Participants were randomized to either usual care or usual care plus swallow strength and skill training with sEMG biofeedback. Primary outcomes were feasibility and acceptability. Secondary measures included swallowing and clinical outcomes, safety and swallow physiology.

   Results: Twenty-seven patients (13 biofeedback, 14 control) with average age of 73.3(SD 11.0) and National Institute of Health Stroke Scale (NIHSS) of 10.7 (5.1) were recruited 22.4 (9.5) days post stroke. About 84.6% of participants completed >80% of sessions; failed sessions were mainly due to participant availability, drowsiness or refusal. Sessions lasted for an average of 36.2 (7.4) min. Although 91.7% found the intervention comfortable with satisfactory administration time, frequency and time post stroke, 41.7% found it challenging. There were no treatment-related serious adverse events. The biofeedback group had a lower Dysphagia Severity Rating Scale (DSRS) score at 2 weeks compared to control (3.2 vs. 4.3), but the difference did not reach statistical significance.

Conclusions: Swallow strength and skill training with sEMG biofeedback appears feasible and acceptable to acute stroke patients with dysphagia. Preliminary data suggests it is safe and further research refining the intervention and investigating treatment dose and efficacy is warranted." [Abstract]

5. Battel, I., & Walshe, M. (2023). An intensive neurorehabilitation program with sEMG biofeedback to improve swallowing in idiopathic Parkinson's disease (IPD): A feasibility study. *International journal of language & communication disorders*, *58*(3), 813–825. https://doi.org/10.1111/1460-6984.12824

Based on clinical feedback from the BiSSkiT software, BiSSkApp was developed to encourage greater access to intensive rehabilitation that is not as constrained by resources. BiSSkApp is designed for (semi-) independent patient use with remote monitoring by a clinician.

Telerehabilitation in Dysphagia Management

The evaluation and utilisation of telehealth modalities in swallowing assessment and rehabilitation expanded greatly during and following the COVID pandemic. Nonetheless this body of literature is still early in development and expanding. Specific to swallowing telehealth, most clinical studies relate to implementation of telehealth for follow up management and rehabilitation relate to patients with head and neck cancer, as included in the subsequent references. Further research in neurogenic dysphagia is yet to be completed.

1. Ward, E. C., Raatz, M., Marshall, J., Wishart, L. R., & Burns, C. L. (2022). Telepractice and Dysphagia Management: The Era of COVID-19 and Beyond. *Dysphagia*, *37*(6), 1386–1399. https://doi.org/10.1007/s00455-022-10444-2
2. Wall, L. R., Ward, E. C., Cartmill, B., Hill, A. J., Isenring, E., Byrnes, J., & Porceddu, S. V. (2020). Prophylactic swallowing therapy for patients with head and neck cancer: A three-arm randomized parallel-group trial. *Head & neck*, *42*(5), 873–885. https://doi.org/10.1002/hed.26060
3. Wall, L. R., Kularatna, S., Ward, E. C., Cartmill, B., Hill, A. J., Isenring, E., Byrnes, J., & Porceddu, S. V. (2019). Economic Analysis of a Three-Arm RCT Exploring the Delivery of Intensive, Prophylactic Swallowing Therapy to Patients with Head and Neck Cancer During (Chemo)Radiotherapy. *Dysphagia*, *34*(5), 627–639. https://doi.org/10.1007/s00455-018-9960-1
4. Constantinescu, G., Rieger, J., Seikaly, H., & Eurich, D. (2021). Adherence to Home-Based Swallowing Therapy Using a Mobile System in Head and Neck Cancer Survivors. *American journal of speech-language pathology*, *30*(6), 2465–2475.

Final Summary

A comprehensive analysis of emerging research emphasizes the importance of targeted swallowing rehabilitation strategies, including skill-based training, respiratory training, and biofeedback. These interventions demonstrate significant potential for improving swallowing function across various conditions, including stroke, Parkinson's disease, and oropharyngeal dysphagia. The quality of evidence varies, with many studies being feasibility or pilot in nature, but the findings collectively underscore the benefits of innovative approaches in swallowing rehabilitation. Future research should aim to conduct larger, long-term trials to confirm these preliminary findings and establish robust clinical guidelines.