Supplementary materials

Supplementary Table. Papers' overview

Study (Year)	Population	Intervention	Sample Size	Key Outcomes	Muscle-Specific Outcomes
Winnicka et al. (2024)	Children with primary dysphagia (~33 mo)	NMES 30 min, 2×/day, 5 days; 80 Hz; 100–700 μs; 7 placements; repeated 1–2 mo	n=34 (no control)	FOIS ↑ (median 1→2.5); 70% oral feeding; 12/34 exclusive oral	↑ facial/tongue tone; better swallow–breath coordination
Marcus et al. (2019)	Infants/children with neurological dysphagia (~9 mo)	NMES 20–45 min; 2×/wk; 2–4 mo; 3–12 mA	n=7 (pilot)	VFSS improved; 5/5 full/partial oral feeding at follow-up	≈20% ↑ mandibular EMG amplitude
Andreoli et al. (2019)	Medically complex children	NMES during feeding therapy; ~20–26 weeks	n=15 (case series)	FOIS 3.07→4.47 ($p<0.0001$); aspiration improved	Enhanced suprahyoid activation (clinical)
Propp et al. (2022)	Children ≤18 y (systematic review, 10 studies)	NMES vs standard therapy (varied)	n=393 total	SMD 0.18–1.49; many improved oral intake; heterogeneity	Improved pharyngeal coordination (subsets)
Langmore et al. (2015)	Head & neck cancer; post-treatment dysphagia	Active NMES+ex vs sham+ex; 12 wk; double-blind RCT	n=170	No NMES benefit; PAS worse in active NMES; diet/QoL ↑ both	Not reported; study focused on clinical/functional swallowing outcomes.
Terré & Mearin (2015)	ABI (stroke/TBI) with oropharyngeal dysphagia	NMES+conv vs sham+conv; ~20 sessions; blinded RCT	n≈20	Faster FOIS improvement during treatment; convergence later	↑ pharyngeal contraction (manometry)
Seo et al. (2021)	Adults with dysphagia	4-channel sequential NMES vs 2-channel; 2–3 wk; double-blind RCT	n=23 completed	Greater VDS gains; PAS/FOIS improved in 4-channel	Sequenced supra/thyro/infrahyoid activation
Lee et al. (2021)	Adults with dysphagia	Sequential 4-channel NMES during swallowing	n≈20–30	Improved kinematics and clinical scores	Targets supra-/thyrohyoid/infrahyoid
Ludlow et al. (2007)	Chronic pharyngeal dysphagia	Surface ES at rest & during swallows (submandibular/laryngeal)	n≈25	Rest stimulation depressed hyoid/larynx; low-sensory levels reduced aspiration	Hyolaryngeal depression at high-motor intensities
Baijens et	Parkinson's	Single-session ES	n=10	Mixed/limited	Position-dependent

al. (2012)	disease with dysphagia	during VFSS; varied positions	PD + 10 controls	immediate effects	biomechanics
Park et al. (2019)	Post-stroke dysphagia	NMES + effortful swallow with EMG-biofeedback; 4 wk	n=10 (pilot)	VDS and PAS improved pre-post	Suprahyoid activation via EMG feedback
Blumenfeld et al. (2006)	Mixed adult dysphagia (resp. failure, stroke, sepsis)	NMES (VitalStim) 30 min ×10 sessions	n=80	Severity improved (d=0.88; p=0.003)	↑ suprahyoid activation (clinical)
Fraser et al. (2002)	Adults post-stroke	Pharyngeal ES 5 Hz, 10 min	n=16	Pharyngeal transit time & aspiration score improved (p<0.01)	↑ corticobulbar excitability
Carnaby-Mann & Crary (2007)	Adults post-stroke (meta-analysis)	NMES + conventional therapy	n=255	UES opening ↑ ~15%	↑ thyrohyoid strength (inferred)
Lim et al. (2009)	Adults post-stroke	NMES vs thermal-tactile; randomized	n≈28	NMES superior on swallowing outcomes	Not reported; study focused on clinical/functional swallowing outcomes.
Lin et al. (2011)	Adults post-stroke	NMES + thermal-tactile vs control	n≈36	NMES group superior	Not reported; study focused on clinical/functional swallowing outcomes.
Park et al. (2016)	Adults post-stroke	Effortful swallowing + NMES	n≈40	Hyoid excursion & function improved	Not reported; study focused on clinical/functional swallowing outcomes.
Oh et al. (2014)	Adults with dysphagia	Suprahyoid-targeted NMES	n≈28	Hyoid elevation & timing improved	Suprahyoid region targeted; study focused on clinical outcomes, muscle-level metrics not reported.
Oh et al. (2020)	Adults with dysphagia (mixed)	Suprahyoid vs infrahyoid NMES; comparative	n≈60	Both improved FOIS; suprahyoid ↓ penetration-aspiration more	Targets both supra- and infrahyoid regions; study did not report muscle-level metrics.
Ryu et al. (2009)	Head & neck cancer after treatment	NMES therapy (clinical)	n≈30	Functional gains reported	Not reported; study focused on clinical/functional swallowing outcomes.
Archer et al. (2013)	Head & neck cancer survivors	NMES + exercise vs exercise	n≈32	No added benefit from NMES	Not reported; study focused on clinical/functional swallowing outcomes.

Rofes et al. (2013)	Elderly with oropharyngeal dysphagia	NMES + compensatory strategies	n≈40	Swallowing safety & efficiency improved	Not reported; study focused on clinical/functional swallowing outcomes.
Suiter et al. (2006)	Outpatient dysphagia cohort	NMES clinical program	n≈45	Functional swallowing improvements	Not reported; study focused on clinical/functional swallowing outcomes.
Doeltgen et al. (2011)	Healthy volunteers	Submental ES at rest vs task (mechanistic)	n=20	Parameter-dependent effects on hyolaryngeal kinematics	Kinematic/EMG-guided protocol; detailed muscle metrics not tabulated in the study.
Jayasekeran et al. (2010)	Adults with post-stroke dysphagia / virtual lesion	Pharyngeal Electrical Stimulation (PES); single-blind pilot RCT	n≈20–30	PES improved swallowing after stroke/virtual lesion vs sham	Not applicable to peripheral muscle metrics (PES is primarily afferent/pharyngeal stimulation); muscle-specific EMG not reported.
Bath et al. (2016)	Post-stroke dysphagia	PES multicenter randomized controlled trial	n≈160	Pilot RCTs summarized: improved swallowing measures vs sham in selected cases	Not applicable to peripheral muscle metrics (PES is primarily afferent/pharyngeal stimulation); muscle-specific EMG not reported.
Vasant et al. (2016)	Post-stroke dysphagia	PES phase II single-blind RCT	n≈60	Clinical effects consistent with improved swallowing; early-phase evidence	Not applicable to peripheral muscle metrics (PES is primarily afferent/pharyngeal stimulation); muscle-specific EMG not reported.
Suntrup et al. (2015)	Severe post-stroke dysphagia, tracheotomized	PES randomized trial (ICU)	n≈60	Higher decannulation rate; reduced aspiration compared with control	Not applicable to peripheral muscle metrics (PES is primarily afferent/pharyngeal stimulation); muscle-specific EMG not reported.
Beom et al. (2015)	Brain-injured adults with dysphagia	NMES suprahyoid vs infrahyoid stimulation (comparative)	n≈40	Suprahyoid targeting more effective for swallowing outcomes	Targets both supra- and infrahyoid regions; study did not report muscle-level metrics.
Beom et al. (2011)	Brain-injured adults with dysphagia	Repetitive NMES to suprahyoid + conventional therapy vs therapy alone	n=28	ASHA level improved in more patients with NMES;	Suprahyoid region targeted; study focused on clinical outcomes, muscle-

				mixed VDS	level metrics not reported.
Xia et al. (2011)	Post-stroke dysphagia	VitalStim + conventional swallowing training; 4 weeks	n≈60	Combined therapy superior to either alone; QoL improved	Surface NMES (VitalStim); muscle-specific outcomes not reported (clinical endpoints used).
Oh et al. (2020)	Adults with dysphagia (mixed etiologies)	NMES: suprahyoid vs infrahyoid placement; comparative	n≈60	Both placements improved FOIS; suprahyoid reduced PAS more	Targets both supra- and infrahyoid regions; study did not report muscle-level metrics.
Park et al. (2016)	Post-stroke dysphagia	Effortful swallow + NMES; 4 weeks	n≈40	Hyoid excursion and swallowing function improved vs control	Not reported; study focused on clinical/functional swallowing outcomes.
Park et al. (2018)	Post-stroke dysphagia	NMES + effortful swallow; 4 weeks	n≈50	FOIS and PAS improved vs baseline/control	Not reported; study focused on clinical/functional swallowing outcomes.
Lim et al. (2009)	Post-stroke dysphagia	NMES vs thermal-tactile stimulation; randomized	n≈28	NMES superior on clinical swallowing outcomes	Not reported; study focused on clinical/functional swallowing outcomes.
Lin et al. (2011)	Post-stroke dysphagia	NMES + thermal-tactile vs control	n≈36	NMES group showed superior gains	Not reported; study focused on clinical/functional swallowing outcomes.
Bogaardt et al. (2009)	Oropharyngeal dysphagia	NMES during therapy; cohort	n≈30	Swallowing outcomes improved	Not reported; study focused on clinical/functional swallowing outcomes.
Suiter et al. (2006)	Outpatient adult dysphagia	NMES clinical program; cohort	n≈45	Functional swallowing improvements reported	Not reported; study focused on clinical/functional swallowing outcomes.
Rofes et al. (2013)	Elderly with oropharyngeal dysphagia	NMES + compensatory strategies vs standard	n≈40	Swallowing safety & efficiency improved	Not reported; study focused on clinical/functional swallowing outcomes.
Archer et al. (2013)	HNC survivors with dysphagia	NMES + exercise vs exercise	n≈32	No additional benefit from NMES	Not reported; study focused on clinical/functional swallowing outcomes.
Diéguez-Pérez et al. (2020)	Post-stroke dysphagia (systematic review)	Surface NMES post-stroke; clinical outcomes synthesis	—	Evidence suggests benefit in some outcomes; heterogeneity & bias noted	Not reported; study focused on clinical/functional swallowing outcomes.
Alamer et al. (2020)	Adults with dysphagia	Adjunct NMES vs usual care across	—	Adjunct NMES associated with	Not reported; study focused on

	(meta-analysis)	RCTs		higher improvement rates vs control	clinical/functional swallowing outcomes.
Zhang et al. (2022)	Post-stroke dysphagia (clinical trial)	NMES adjunct to early feeding training	n≈60	Improved early feeding and swallowing recovery vs control	Not reported; study focused on clinical/functional swallowing outcomes.

Abbreviations: NMES – Neuromuscular Electrical Stimulation; UES – upper esophageal sphincter; EMG – electromyography.