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| RESEARCH ARTICLE

The Effectiveness of Neuromuscular Electrical Stimulation on Swallowing Function in Stroke Patients with Dysphagia: A Systematic Review

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| ABSTRACT
Dysphagia is a complication that often occurs and triggers the occurrence of aspiration pneumonia and death from stroke. Neuromuscular electrical stimulation (NMES) is a muscle strengthening therapy and sensorimotor recovery with electrical stimulation that can improve swallowing function. This study aims to find evidence of the effectiveness of NMES therapy on swallowing function in stroke patients with dysphagia. The method used in this research is a systematic review through online databases, namely: PubMed, ProQuest, Sciencedirect, and Wiley Online Library, on articles with full text criteria, using Indonesian or English, publications in the last 5 years, and a quasi-experimental research design and randomized controlled trials. Search articles using keywords "stroke", "cerebrovascular accident", "dysphagia", "neuromuscular electrical stimulation", "swallowing function", and "deglutitions function" combined using the boolean operator AND or OR. The search results found 10 articles that match the inclusion criteria. From 10 articles, there was 1 quasi-experimental article and 9 randomized controlled trial articles. The results showed that NMES could be an optional intervention to improve swallowing function after a stroke. Based on the reviews, NMES is effective in improving swallowing function in stroke patients with dysphagia; more high-quality evidence is needed to determine the proper procedure and other treatments that can be combined with NMES therapy.

| KEYWORDS

Stroke; Neuromuscular Electrical Stimulation; Dysphagia; Swallowing Function.

| ARTICLE INFORMATION

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1. Introduction

Stroke is classically characterized as a neurological deficit associated with acute focal injury to the central nervous system (CNS) caused by vascular disturbances (Sacco et al., 2013). Stroke is the second leading cause of death globally. This disease affects around 13.7 million people and kills around 5.5 million annually (Kuriakose & Xiao, 2020). Swallowing problems related to stroke are known as post-stroke dysphagia and are one of the most feared physical effects of stroke because they occur in 39-81% of stroke patients (Kariasa, 2022; Martino et al., 2012).

Post-stroke dysphagia (DPS), defined as difficulty swallowing after stroke, is a common complication that affects many patients in the first hours and days after an ictus. DPS is associated with increased mortality and morbidity (Cohen et al., 2016). Dysphagia is an important factor in aspiration pneumonia and death in stroke patients (Feng et al., 2019). The study conducted by Arnold et al. (2016) stated that patients with dysphagia have an 8.5-fold higher risk of death and a much higher risk of pneumonia compared to patients with normal swallowing.

Several interventions have been carried out in an effort to treat dysphagia. The methods used include modifying food and fluids, changing postures and changing swallowing strategies with several rehabilitative techniques (Cohen et al., 2016). However, the

effect achieved after this traditional therapy intervention is not ideal. Therefore, it is necessary to apply more effective intervention therapy for PSD patients. Noninvasive nerve stimulation therapy has attracted particular attention in the treatment of PSD.

Neuromuscular electrical stimulation (NMES) is widely used for the treatment of pain management, muscle strengthening and sensorimotor recovery (Doucet et al., 2012). In recent years, neuromuscular electrical stimulation (NMES) as a professional technical means of treating swallowing dysfunction after stroke has been used clinically to improve swallowing function by activating the central motor cortex and corticobulbar pathways related to swallowing (Wang et al., 2017). NMES facilitate muscle contraction and are used in innervated muscles to recruit motor units and increase muscle strength (Carnaby-Mann & Crary, 2007).

2. Methodology

2.1 Literature Search and Study Selection

This academic journal search was conducted through 4 online databases, namely: ScienceDirect, PubMed, ProQuest, and Wiley Online Library, using the keywords (stroke or cerebrovascular accident) AND dysphagia AND neuromuscular electrical stimulation AND (swallowing function or deglutitions function). Article results are imported to Mendeley Desktop to facilitate deduplication. Next, select and examine articles that meet the requirements according to the inclusion criteria.

2.2 Inclusion and Exclusion Criteria

The inclusion and exclusion criteria from eligible studies were:

a. Participants: the study population consisted of adults who had a stroke with dysphagia. We excluded studies with subjects who had a diagnosis other than stroke
b. Intervention: neuromuscular electrical stimulation
c. Study design: a quasi-experimental and randomized controlled trial.
d. Year of Publication: Last 5 years (2017-2022)
e. Type of literature: articles published in English or Indonesian.

2.3 Quality Assessment

The Researcher assessed the methodological quality of the studies using the JBI Critical Appraisal Checklist for Quasi-Experimental Studies for 1 article and the JBI Critical Appraisal Checklist for Randomized Controlled Trials for 9 other articles.

3. Results and Discussion

There are 2683 articles identified based on the keywords that have been determined. Furthermore, the articles were filtered based on inclusion criteria, year of publication and language, title and abstract, method and research results so that 10 articles were obtained that were relevant and available in full text form. The methodology in this systematic review is based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines by following the PRISMA flow diagram.

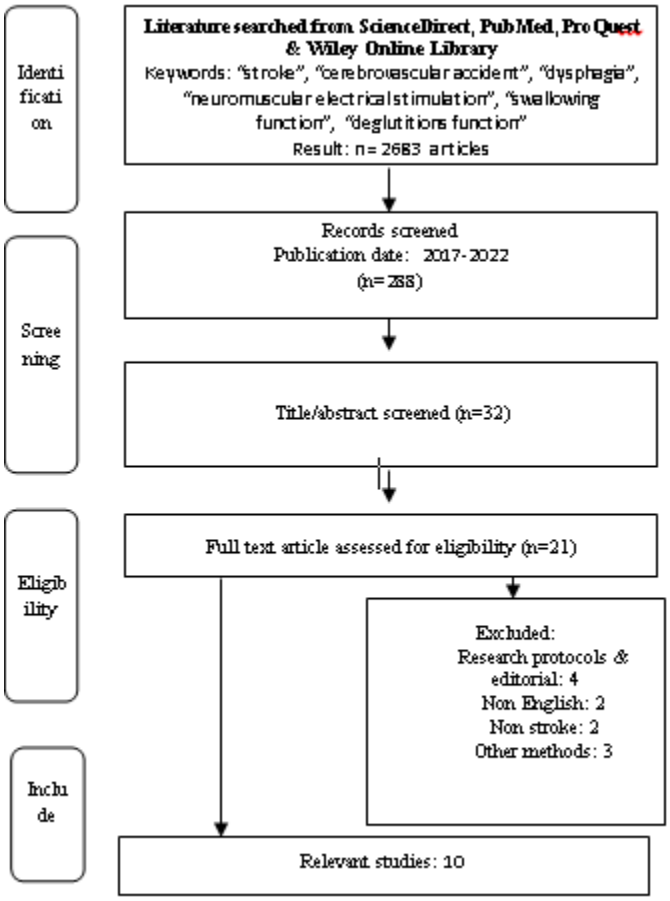

Chart 1. PRISMA 2020 flow diagram

3.1 Search Results

The following are selected journals based on the results of PRISMA, which carried out data tabulation and narrative analysis.

Tabel 1. Data Extraction

No.	Author (year)	Article title	Purpose	Design	Sampel	Data Collection	Result
1	Meng et al. (2017)	The effect of surface neuromuscular electrical stimulation on patients with post-stroke dysphagia	To assess whether the clinical efficacy of a therapeutic protocol using surface neuromuscular electrical stimulation (sNMES) on patients with post-stroke dysphagia (PSD) is superior to that without sNMES and whether swallowing functional	Randomized clinical trial (RCT)	Thirty patients with PSD were randomly allocated into treatment group A (TGA), treatment group B (TGB) and control group according to a random number table.	This study was conducted between August 2013 and May 2014; patients admitted to the Rehabilitation Department of the Affiliated Hospital of Qingdao University were all assessed using a water swallow test (WST). The three groups of patients all received traditional dysphagia therapy (TDT) and other general rehabilitation therapy, such as physical therapy and occupational therapy, as a basic treatment project. Besides this, sNMES treatment was applied on	Swallowing function in the patients with PSD was significantly improved using TDT combined with NMES. Stimulating electrodes placed at the suprahyoid region or on both suprahyoid and infrahyoid regions resulted in no difference in effect. However, NMES on suprahyoid region could further improve the moving distance of the

			outcome is different with regards to different electrode placement on patients' skin of the neck.			different sites of patients' neck skin in groups A and B separately. The protocol of sNMES 118 was 30 minutes per treatment, 5 times per week, and 119 patients underwent 10 sessions. The outcome of the VFSS was measured using dysphagia outcome and severity scale (DOSS).	hyoid bone anteriorly.
2	Donghwan et al. (2022)	The effect of neuromuscular electrical stimulation with different electrode positions on swallowing in stroke patients with oropharyngeal dysphagia: A randomized trial	To examine the effects of neuromuscular electrical stimulation (NMES) on oropharyngeal swallowing function according to 2 types of placement, acting as assistance and as resistance, in stroke patients with dysphagia.	Randomi zedtrial	38 stroke patients with dysphasia were randomly assigned to the suprahyoid group (SMG) or infrahyoid muscle group (IMG); 26 patients completed the intervention.	This study was conducted from September 2015 to February 2016 at the rehabilitation center of two local hospitals in the Republic of Korea. All participants received EST for 30 min/d, 5 d/wk, for 4 weeks (total, 20 158 sessions). The Penetration-Aspiration Scale (PAS) is a standard evaluation that reflects airway penetration and aspiration. The Functional Oral Intake Scale (FOIS) evaluates the oral intake of food and liquids in stroke patients.	Both groups showed significant improvements in oropharyngeal function and level of functional oral intake, but there was no significant difference between the two groups. However, the SMG showed a more reduced penetration-aspiration compared with the IMG.
3.	Zhang & Wu (2021)	Effects of Synchronized Neuromuscular Electrical Stimulation (NMES) on the Submental Muscles During Ingestion of a Specified Volume of Soft Food in Patients with Mild-to-Moderate Dysphagia Following Stroke	To evaluate the effects of synchronized NMES on the submental mus-cles during ingestion of a specified volume of soft food in patients with mild-to-moderate dysphagia following stroke	RCT	Eighty-three patients with mild-to-moderate dysphagia following stroke were enrolled and randomly divided into 3 groups: conventional training (CT) (n=28), eating training (ET) (n=28), and intensive swallowing training (IST) (n=27).	This study was conducted at the Affiliated Hospital of Guizhou Medical University between June 1, 2018 and May 31, 2020. Patients who met the inclusion criteria were divided into 3 groups using the random number table meth- od: conventional training (CT), eating training (ET), and intensive swallowing training (IST). The same experienced physician generated the random allocation sequence, enrolled the participants, and assigned them to the interventions.	Feeding a specified volume of soft food plus synchronized NMES of the submental muscles can improve the swallowing function of patients with mild-to-moderate dysphagia following stroke, and it reduces their risk of food aspiration.
4.	Kumaresa n etal. (2018)	Effects of Neuro Muscular Electrical Stimulation on Swallowing Function and Quality of Life	To determine the effects of Neuromuscular electrical stimulation on swallowing function and quality of life in	Quasi Experime ntal study design	Total of 30 post stroke dysphagia subjects were selected.	Patients were screened for the Functional oral Intake Scale and Quality of Life Questionnaire as a pre test measurement. Electrode Placement- Inactive electrode placed under the Neck region, Active	Neuro muscular electrical stimulation in Post stroke dysphagic patients improved swallowing function and quality of life.

		in Subjects with Post Stroke Dysphagia	post stroke dysphagia.			electrode over the pharyngeal area of either side of the Hyoid Bone. Electrical stimulation was given with the frequency of 30 Hz duration of 100ms; intensity was increased till minimal palpable observable contraction interrupted direct current is used. This treatment technique was followed 2 weeks duration for a single session per day for 6 days/ week.	
5.	Zhang et al. (2022)	Neuromuscular electrical stimulation improves swallowing initiation in patients with post-stroke dysphagia	To investigate the immediate effect of neuromuscular electrical stimulation (NMES) on swallowing initiation in post- stroke patients using videofluoroscopic swallowing study (VFSS) data. Materials	A randomiz ed, self-controlled crossove design was	35 patients with post-stroke dysphagia.	This study was conducted at the Third Affiliated Hospital of Sun Yat-sen University. The primary evaluation indicators included the Modified Barium Swallow Impairment Profile-6 (MBSImp-6) and Penetration-Aspiration Scale (PAS). Secondary indicators included oral transit time (OTT), pharyngeal transit time (PTT), and laryngeal closure duration (LCD).	Neuromuscular electrical stimulation may represent a supplementary approach for promoting early feeding training in patients with post-stroke dysphagia.
6.	Zhang et al. (2019)	Repetitive transcranial magnetic stimulation in combination with neuromuscular electrical stimulation for treatment of post-stroke dysphagia Journal	To determine whether repetitive transcranial magnetic stimulation (rTMS) combined with neuromuscular electrical stimulation (NMES) effectively amel- iorates dysphagia and how rTMS protocols (bilateral vs. unilateral) combined with NMES can be optimized.	Random	Sixty-four patients were randomly divided into four groups using a random distribution table.	Patients with their first-ever stroke complicated with dysphagia were consecutively recruited from June 2016 to December 2017 from the neurologic rehabilitation outpatient clinic at the Affiliated Changzhou No. 2 People's Hospital of Nanjing Medical University and the 102nd Hospital of PLA. rTMS was delivered by a magnetic stimulator with a 70-mm figure-of-eight coil. NMES was performed using a modified hand-held battery-powered electrical stimulator for 30 minutes once daily. Dysphagia was assessed using the Dysphagia Outcome and Severity Scale.	The combination of rTMS with NMES was superior to NMES alone in improving the recovery of post-stroke dysphagia, and the combination of bilateral rTMS with NMES was more effective than unilateral rTMS combined with NMES.
7	Jeon et al. (2020)	Effects of Neuromuscular Electrical	To investigate the therapeutic effects of NMES	randomized controlle	Thirty-four stroke patients were recruited	The study population consisted of stroke patients admitted to a rehabilitation	NMES plus upper cervical spine mobilization can be

		Stimulation (NMES) Plus Upper Cervical Spine Mobilization on Forward Head Posture and Swallowing Function in Stroke Patients with Dysphagia	in conjunction with upper cervical mobilization in stroke patients with dysphagia.	d clinical trial	and divided into an experimental group (n = 17; NMES plus upper cervical spine mobilization) and a control group (n = 17;	hospital located at Gyeonggi-do. Swallowing function was measured by variations in video fluoroscopic dysphagia scale (VDS) and penetration–aspiration scale (PAS) scores using the video fluoroscopic swallowing study (VFSS). The study period was 4 weeks. All interventions were performed in a sitting position, and both groups received NMES for 30 min.	regarded as a promising method to improve swallowing function, and forward head posture changes in stroke patients with dysphagia.
8	Byeon, H. (2020)	Combined Effects of NMES and Mendelsohn Maneuver on the Swallowing Function and Swallowing–Quality of Life of Patients with Stroke-Induced Sub-Acute Swallowing Disorders	This study aimed to prove the effects of a compound swallowing intervention (Mendelsohn maneuver + neuromuscular electrical stimulation (NMES)) on the swallowing function and the quality of life by applying the compound swallowing intervention to patients with sub-acute swallowing disorders due to cerebral infarction for eight weeks.	Nonequivalent control group pretest–posttest design	43 subjects who were diagnosed with swallowing disorders due to cerebral infarction. The experiment consisted of the Mendelsohn maneuver treatment group (n = 15), the NMES treatment group (n = 13), the compound intervention group (Mendelsohn maneuver + NMES; n = 15).	This study was conducted at the rehabilitation departments of four general hospitals located in Seoul and Incheon between July 2018 and January 2019. This study measured Functional Dysphagia Scale (FDS) and Swallowing–the quality of life (SWAL–QOL) before treatment application (baseline) and after the intervention (after 8 weeks) over the total 8 weeks of the experiment period.	NMES can be more effective when it is combined with a traditional swallowing rehabilitation therapy rather than a single intervention method.
9.	Seo et al., 2021	Clinical effectiveness of the sequential 4-channel NMES compared with that of the conventional 2-channel NMES for the treatment of dysphagia in a prospective, double-blind,	To evaluate and compare the rehabilitative effectiveness of the sequential 4-channel NMES with that of conventional 2-channel NMES.	prospective randomized case–control study	26 subjects with dysphagia were enrolled. Twelve subjects in the 4-channel NMES group and eleven subjects in the 2-channel NMES group completed the intervention.	This study was conducted from October 1, 2018, to August 4, 2019, at the rehabilitation unit of five teaching hospi- tals. All participants received 2- or 4-channel NMES for 2–3 weeks (minimal session: 7 times, treatment duration: 300–800 min). Initial and follow-up evaluations were performed using the videofluoroscopic dysphagia scale (VDS), the penetration aspiration scale	The sequential 4-channel NMES, through its activation of the suprahyoid and thyrohyoid muscles and other infrahyoid muscles mimicking physiological activation, may be a new effective treatment for dysphagia.

		randomized controlled study				(PAS), the MD Anderson dysphagia inventory (MDADI), the functional oral intake scale (FOIS), and the Likert scale.	
10.	imonelli et al (2019)	A stimulus for eating. The use of neuromuscular transcutaneous electrical stimulation in patients affected by severe dysphagia after subacute stroke: A pilot randomized controlled trial	The aim of the study was to investigate the effect of laryngopharyngeal neuromuscular electrical stimulation on dysphagia caused by stroke.	Single blind randomized controlled trial	Thirty-three patients were divided into plus traditional dysphagia training (n = 17) and traditional dysphagia training alone in a time matched condition (n = 16).	This study was conducted from January 2013 to December 2015. All patients were treated 5 days/week for 8 weeks. Primary outcomes were considered the status of swallowing function according to the Functional Oral Intake Scale (FOIS), the instrumental Fiberoptic Endoscopic Examination of Swallowing examination, the Penetration Aspiration Scale and the Pooling score and the presence of oropharyngeal secretion.	Laryngopharyngeal neuromuscular electrical stimulation may be considered an additional and effective treatment option for dysphagia after stroke.

3.2 Discussion

a. Dysphagia screening in stroke patients

Dysphagia is a condition characterized by difficulty swallowing. Dysphagia affects up to half of acute stroke patients and carries a threefold to sevenfold increased risk of aspiration pneumonia. With subsequent mortality associated with pneumonia, dysphagia has been recognized as an independent predictor of mortality after stroke (Singh & Hamdy, 2006).

Early identification of dysphagia and aspiration risk is critical to avoid adverse health consequences for stroke patients. (Donovan et al., 2013). Dysphagia screening can detect swallowing problems early in acute stroke patients and prevent aspiration or other complications such as dehydration or nutritional problems (Mulyatsih & Pandin, 2020). There are many types of dysphagia screening. According to Poorjavad & Jalaie (2014), there are four reported highly qualified screening tests, including Oral Pharyngeal and Clinical Swallowing Examination, Bedside Aspiration Test, The Gugging Swallowing Screen, and The Toronto Bedside Swallowing Screening Test (TOR-BSST), which simple, valid, reliable, sensitive, and specific tests for screening swallowing disorders in almost all acute alert stroke patients.

b. Intervention in improving swallowing function

The primary aim of dysphagia management has been to reduce aspiration and to manage swallowing difficulties rather than rehabilitate the swallow. This is partly due to the heterogeneity of swallowing difficulties and developing knowledge of normal and disordered swallowing. Traditional management includes modifying food and fluid, altering posture and changing swallowing strategies with some rehabilitative techniques. These may be used independently but are mostly used together. Management depends on whether the focus is on the risk of aspiration or level of swallow breakdown and can be individualized (Cohen et al., 2016).

c. The effectiveness of NMES in improving dysphagia in stroke patients

Neuromuscular electrical stimulation (NMES) was originally used for the treatment of pain management, muscle strengthening and sensorimotor recovery. However, recently this therapy is often used as a therapy for swallowing dysfunction after a stroke (Doucet et al., 2012; Wang et al., 2017).

Research conducted by Zhang et al. (2022) stated that the use of NMES can significantly shorten oral transit time and improve the initiation of pharyngeal swallowing while reducing the risk of penetration and aspiration. These results suggest that NMES exerts a direct positive effect on swallow initiation in patients with dysphagia after stroke. NMES has also been shown to have a significant

positive effect on muscle training by increasing pharyngeal muscle contractile protein content and capillary density (Wakabayashi et al., 2018). In addition, neuromuscular electrical stimulation of the laryngopharynx in post-stroke patients with dysphonia improves training outcomes (Simonelli et al., 2019).

The installation of different electrodes also affects the results of this therapy. Oh et al. (2020) stated that electrodes placed in the area between the jaw and hyoid bone showed less penetration-aspiration compared to electrodes placed in the area under the hyoid to the infrahyoid muscle given for 30 minutes at an intensity of 9.0 mA to 14.0 mA (average 13.2 mA). NMES in the suprahyoid region can further increase the distance the hyoid bone moves anteriorly (Meng et al., 2017).

In addition, NMES therapy can also be combined with other non-pharmacological therapies. Research conducted by Zhang & Wu (2021) states that feeding a certain volume of soft food plus synchronized submental muscle NMES can improve the swallowing function of patients with mild to moderate dysphagia after stroke and reduce the risk of food aspiration. Apart from giving soft food, NMES therapy combined with various therapies, such as repetitive transcranial magnetic stimulation, upper cervical spine mobilization, Mendelsohn maneuvers, and others, is more effective when combined than a single intervention method.

4. Conclusion

This systematic review identified ten studies that validated the effectiveness of NMES in improving swallowing function in stroke patients with dysphagia compared to the standard care group. NMES therapy combined with traditional therapy shows more optimal results, as evidenced in the literature and is highly recommended for stroke patients with dysphagia. These findings have provided a number of directions for future research and clinical applications of this program. This study does not elaborate on other procedures and therapies that can be combined with NMES; therefore, further research is needed in this regard.

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References

[1] Arnold, M., Liesirova, K., Broeg-Morvay, A., Meisterernst, J., Schlager, M., Mono, M. L., El-Koussy, M., Kägi, G., Jung, S., & Sarikaya, H. (2016). Dysphagia in acute stroke: Incidence, burden and impact on clinical outcome. PLoS ONE, 11(2), 1–11. https://doi.org/10.1371/journal.pone.0148424

[2] Carnaby-Mann, G. D., & Crary, M. A. (2007). Examining the evidence on neuromuscular electrical stimulation for swallowing: A meta-analysis. Archives of Otolaryngology-*Head and Neck Surgery*, 133(6), 564–571. https://doi.org/10.1001/archotol.133.6.564

[3] Cohen, D. L., Roffe, C., Beavan, J., Blackett, B., Fairfield, C. A., Hamdy, S., Havard, D., McFarlane, M., McLauglin, C., Randall, M., Robson, K., Scutt, P., Smith, C., Smithard, D., Sprigg, N., Warusevitane, A., Watkins, C., Woodhouse, L., & Bath, P. M. (2016). Post-stroke dysphagia: A review and design considerations for future trials. *International Journal of Stroke, 11(4)*, 399–411. https://doi.org/10.1177/1747493016639057

[4] Donovan, N. J., Daniels, S. K., Edmiaston, J., Weinhardt, J., Summers, D., & Mitchell, P. H. (2013). Dysphagia screening: State of the art invitational conference proceeding from the state-of-the-art nursing symposium, international stroke conference 2012. Stroke, 44(4), 24–31. https://doi.org/10.1161/STR.0b013e3182877f57

[5] Doucet, B. M., Lam, A., & Griffin, L. (2012). Neuromuscular Electrical Stimulation for Skeletal Muscle Function. *Yale Journal of Biology and Medicine, 85(2)*, 201–215.

[6] Feng, M. C., Lin, Y. C., Chang, Y. H., Chen, C. H., Chiang, H. C., Huang, L. C., Yang, Y. H., & Hung, C. H. (2019). The Mortality and the Risk of Aspiration Pneumonia Related to Dysphagia in Stroke Patients. *Journal of Stroke and Cerebrovascular Diseases, 28(5),* 1381–1387. https://doi.org/10.1016/j.jstrokecerebrovasdis.2019.02.011

[7] Kuriakose, D., & Xiao, Z. (2020). Pathophysiology and treatment of stroke: Present status and future perspectives. International *Journal of Molecular Sciences, 21(20),* 1–24. https://doi.org/10.3390/ijms21207609

[8] Martino, R., Martin, R. E., & Black, S. (2012). Dysphagia after stroke and its management. CMAJ. *Canadian Medical Association Journal, 184*(10), 1127–1128. https://doi.org/10.1503/cmaj.101659

[9] Meng, P., Zhang, S., Wang, Q., Wang, P., Han, C., Gao, J., & Yue, S. (2017). The effect of surface neuromuscular electrical stimulation on patients with post-stroke dysphagia. *Journal of Back and Musculoskeletal Rehabilitation, 31(*2), 363–370. https://doi.org/10.3233/BMR-170788

[10] Mulyatsih, E., & Pandin, M. G. R. (2020). Dysphagia Screening Protocol For Acute Stroke Patient: A Literature Review. Angewandte Chemie International Edition, 6(11), 951–952., April. https://doi.org/10.20944/preprints202104.0197.v1

[11] Oh, D. H., Park, J. S., Kim, H. J., Chang, M. Y., & Hwang, N. K. (2020). The effect of neuromuscular electrical stimulation with different electrode positions on swallowing in stroke patients with oropharyngeal dysphagia: A randomized trial. *Journal of Back and Musculoskeletal Rehabilitation, 33(*4), 637–644. https://doi.org/10.3233/BMR-181133

[12] Poorjavad, M., & Jalaie, S. (2014). Systemic review on highly qualified screening tests for swallowing disorders following stroke: Validity and reliability issues. *Journal of Research in Medical Sciences, 19(8)*, 776-785.

[13] Sacco, R. L., Kasner, S. E., Broderick, J. P., Caplan, L. R., Connors, J. J., Culebras, A., Elkind, M. S. V., George, M. G., Hamdan, A. D., Higashida, R.

T., Hoh, B. L., Janis, L. S., Kase, C. S., Kleindorfer, D. O., Lee, J. M., Moseley, M. E., Peterson, E. D., Turan, T. N., Valderrama, A. L., & Vinters, H. V. (2013). An updated definition of stroke for the 21st century: A statement for healthcare professionals from the American heart association/American stroke association. Stroke, 44(7), 2064–2089. https://doi.org/10.1161/STR.0b013e318296aeca

[14] Simonelli, M., Ruoppolo, G., Iosa, M., Morone, G., Fusco, A., Grasso, M. G., Gallo, A., & Paolucci, S. (2019). A stimulus for eating. The use of neuromuscular transcutaneous electrical stimulation in patients affected by severe dysphagia after subacute stroke: A pilot randomized controlled trial. NeuroRehabilitation, 44(1), 103–110. https://doi.org/10.3233/NRE-182526

[15] Singh, S., & Hamdy, S. (2006). Dysphagia in stroke patients. P*ostgraduate Medical Journal,* 82(968), 383–391. https://doi.org/10.1136/pgmj.2005.043281

[16] Wakabayashi, H., Matsushima, M., Momosaki, R., Yoshida, S., Mutai, R., Yodoshi, T., Murayama, S., Hayashi, T., Horiguchi, R., & Ichikawa, H. (2018). The effects of resistance training of swallowing muscles on dysphagia in older people: A cluster, randomized, controlled trial. Nutrition, 48, 111–116. https://doi.org/10.1016/j.nut.2017.11.009

[17] Wang, Z., Song, W. Q., & Wang, L. (2017). Application of noninvasive brain stimulation for post-stroke dysphagia rehabilitation. Kaohsiung *Journal of Medical Sciences, 33(2*), 55–61. https://doi.org/10.1016/j.kjms.2016.11.007

[18] Zhang, Q., & Wu, S. (2021). Effects of synchronized neuromuscular electrical stimulation (NMES) on the submental muscles during ingestion of a specified volume of soft food in patients with mild-to-moderate dysphagia following stroke. Medical Science Monitor, 27, 1–10. https://doi.org/10.12659/MSM.928988

[19] Zhang, Y.W., Dou, Z.L., Zhao, F., Xie, C.Q., Shi, J., Yang, C., Wan, G.F., Wen, H.M., Chen, P.-R., & Tang, Z.-M. (2022). Neuromuscular electrical stimulation improves swallowing initiation in patients with post-stroke dysphagia. Frontiers in Neuroscience, 16(November), 1–10. https://doi.org/10.3389/fnins.2022.1011824