



EFFECTIVENESS OF NEUROMUSCULAR ELECTRICAL STIMULATION ON IMPROVING SWALLOWING FUNCTION IN POST STROKE SUBJECTS WITH OROPHARYNGEAL DYSPHAGIA

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ABSTRACT

Background and Objective: Oropharyngeal dysphagia is a common complication of a stroke which can impede participation in rehabilitation and has been associated with poor outcomes. Neuromuscular electrical stimulation is one of the adjunct treatments of choice with conventional swallowing rehabilitation in physiotherapy. The objective of this study was to investigate the effect of NMES on oropharyngeal dysphagia and improving swallowing function in post Stroke subjects. **Methods:** Quasi experimental study design. 108 subjects with mean age of 58 years having a clinical diagnosis of Stroke with oropharyngeal dysphagia were allocated into two groups by using the convenience sampling method. In Group-A (n=54) subjects were treated with neuromuscular electrical stimulation and conventional swallowing rehabilitation program, whereas in Group-B (n=54) subjects were treated with conventional swallowing rehabilitation. Participants were given interventions five times a week for 4 weeks. The outcomes of this intervention were measured by water swallowing test and Eating assessment tool. **Results:** Independent 't' test was used to compare the mean significance difference between continuous variables. Paired 't' test was used to assess the statistically significant difference pre and post test scores. Data analysis indicated significant improvement in both groups within, but the group using NMES alongside conventional swallowing rehab exhibited superior improvement compared to the standalone conventional program in between-group comparison. **Conclusion:** Neuromuscular electrical stimulation along with conventional swallowing rehabilitation is more effective when compared to the conventional swallowing rehabilitation program alone. Thus, this study concludes that neuromuscular electrical stimulation is a useful adjunct in improving swallowing function along with rehabilitation.

KEYWORDS: stroke, oropharyngeal dysphagia, neuromuscular electrical stimulation, conventional swallowing rehabilitation, water swallowing test, eating assessment tool.

INTRODUCTION

Oropharyngeal dysphagia (OD) has been reported as one of the most common complications after a stroke. It can lead to increase in hospital stay, delays functional recovery and reduces quality of life.^[1] More than 50% of stroke survivors struggle with dysphagia, and while most of these patients regain their swallowing ability within 7 days, 11-13% still experience dysphagia after 6 months. Studies have shown that 80% of patients with chronic dysphagia require different enteral feeding methods.^[2]

Dysphagia can result from stroke-related lesions in various neuroanatomical localizations, particularly in the Infratentorial and supratentorial areas, according to Philipp Balcerak et al. Brainstem lesions commonly

found in the Infratentorial area are more frequently associated with dysphagia compared to hemisphere strokes (supratentorial lesions). The highest risk of dysphagia comes from combination lesions, where multiple areas are affected by the stroke. While supratentorial strokes are frequently linked to sensory-afferent impairments affecting swallowing sensations, Infratentorial injuries primarily lead to dysphagia through motor deficits, impacting the actual motor function of swallowing.^[3]

Dysphagia is characterized by an irregular swallowing pattern or disturbances in bolus flow from the mouth to the esophagus and is a serious problem in various neurological conditions, with stroke being one of the

most common causes. Swallowing is a complex activity that involves the coordinated action of oral, pharyngeal, and laryngeal muscles.^[4]

Symptoms of dysphagia may include drooling or leaking from the oral cavity during food intake, as well as coughing before or after swallowing. Causing an increased risk of aspiration pneumonia, malnutrition, suffocation, decreased physical activity, dehydration, and weight loss. Moreover, the inability to eat or drink negatively impacts psychological well-being, results in isolation and social exclusion this disrupts daily routines.^[5,6]

Some compensatory swallowing strategies and rehabilitative strategies are used to maintain safety. Compensatory strategies involve modifications in the volume and texture of food, as well as employing maneuvers such as Mendelsohn maneuver, chin tuck combined with head turn. Rehabilitative strategies involve treatment techniques include tongue strengthening exercises, thermal-tactile stimulation, tongue hold exercises, supraglottic and super-supraglottic Swallow, effortful swallow, oral motor exercises and the Shaker exercise, ice massage.^[7,8,9]

Recent advances in treatment primarily concentrate on two main areas: peripheral stimulation strategies and central, and non-invasive stimulation strategies. Transcutaneous and intra pharyngeal the stimulation of electricity, pharmacological stimulation using transient receptor potential channels of the vanilloid subtype agonists, and non-invasive brain stimulation techniques like repetitive transcranial magnetic stimulation and transcranial direct current stimulation are among the emerging treatments for swallow dysfunction among poststroke patients.^[10]

The latest studies have provided evidence of the therapeutic effects of Neuromuscular Electrical Stimulation (NMES). These effects are attributed to the treatment's ability to enhance swallowing function by strengthening relevant muscles, rehabilitating the swallowing reflex and regulating cortical excitability. However, additional research indicates that NMES can augment sensory input in the oropharyngeal region and improve the sensitivity of muscle contraction.^[11]

NMES is commonly used for pain management, muscle strength, and sensory motor recovery. It stimulates muscle contractions and activates sensory pathways through motor and sensory stimulation, depolarizing peripheral motor nerves, typically at neuromuscular junctions or motor end plates. NMES is applied to innervated muscles to increase muscle strength and reinforce damaged oropharyngeal musculature using surface electrodes triggering muscle contraction through nerve fibre depolarization in the neck muscles.^[12,13]

Numerous studies have highlighted the difficulties in effectively dealing with the restoration of swallowing function using current therapeutic approaches. Exploring different strategies has consequently become more crucial. Combining and implementing into practice a wide range of exercises specifically made to work on the rehabilitation of swallowing function is one potential route. Clinicians and patients can collaborate to improve training results and eventually, recovery outcomes by including a variety of activities that are tailored to individual needs. This multidimensional strategy must be used in future rehabilitation as it has the potential to significantly enhance the quality of life of individuals who struggle with dysphagia. However, the evidence regarding its effectiveness remains limited and inconclusive. While some studies have suggested positive outcomes significant impact on dysphagia and some studies concluded that additional Research needed to better understand the impact.^[14]

The aim of the study is to assess the effectiveness of neuromuscular electrical stimulation combined with conventional swallowing rehabilitation for improving swallowing function in post stroke subjects with oropharyngeal dysphagia in comparison with conventional swallowing rehabilitation alone.

MATERIALS AND METHODS

Study design: Quasi experimental study

Ethical clearance and informed consent: The study protocol was approved by the Ethical Committee of GSL Medical College & General Hospital, the investigator explained the purpose of the study and given the subject information sheet. The participants were requested to provide their consent for participation in the study. All the participants signed the informed consent and the rights of the included participants have been secured.

Study population: post stroke subjects with oropharyngeal dysphagia

Study setting: The study was conducted at the Department of Physiotherapy, GSL Medical College and General Hospital, Rajamahendravaram, Andhra Pradesh, India.

Study duration: The study was conducted during the period of one year

Sampling method: Convenience sampling

Intervention duration: 20 sessions, 5days a week for 4 weeks

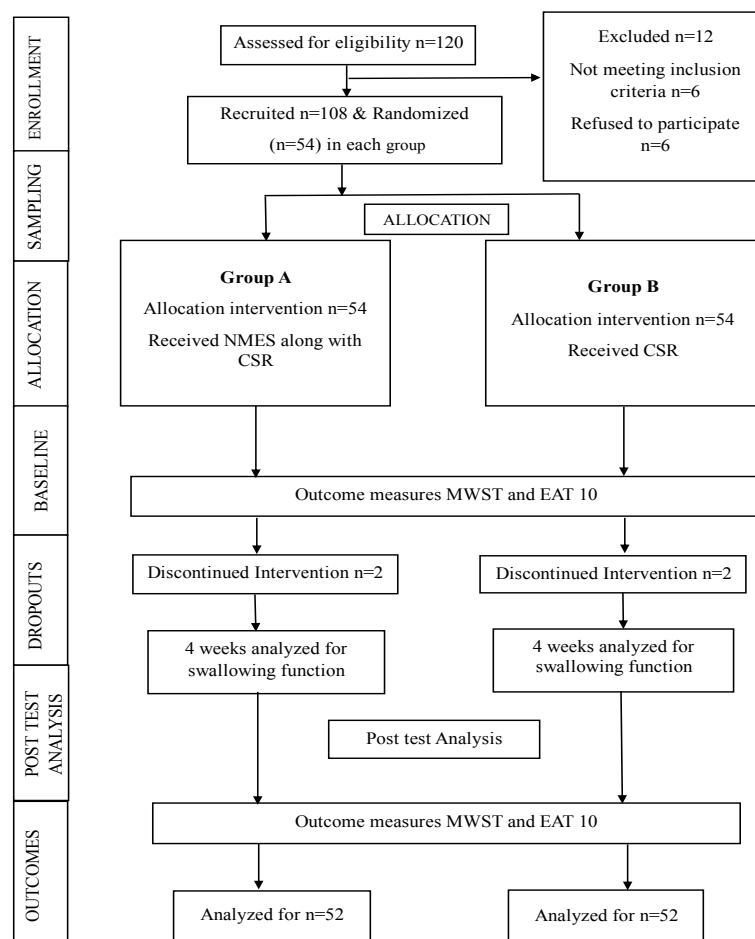
Sample size: A total of 120 subjects were screened, in that 108 subjects were recruited in the study after meeting the inclusion criteria. Recruited participants explained the purpose and relevance of the study. The participants were included in the study after obtaining informed consent. By using the convenience sampling method all eligible participants were allocated in group A and Group B. Inclusion Criteria: Subjects diagnosed with post stroke oropharyngeal dysphagia by neuro physician,

Subjects with good cognitive abilities mini mental state examination score more than 24 points, Subjects able to generate a swallow either to the command or reflexively, Post stroke dysphagia more than 7 days. Exclusion Criteria: Subjects who had pacemaker or other serious cardiac disease, Subjects who had lesion or infection on treatment site, Severe communication difficulty, Allergic reaction when electrodes placed, Malignancy, Subjects with sensory impairment.

Outcome measures: Modified water swallowing test^[15]: The modified water swallow test is a Clinical examination designed to assess subjects' capacity for safe and efficient swallowing. It involves observing the subjects as they take a 3ML of water. The subject is given 3ml of cold water in the oral vestibule and then instructed to swallow the water. If possible, give more water and ask to swallow 2 more times and the worst swallowing activity is to be assessed. By examining elements like coughing, choking, or changes in breathing

before or after Swallowing, the test assists in identifying potential swallowing issues, aspiration concerns. It only takes a few minutes and offers useful information on a patient's swallowing function. Eating assessment tool-10 (EAT-10)^[16]: The Eating Assessment Tool-10 (EAT-10) is a self-administered questionnaire designed to know their own swallowing abilities. It consists of ten items, each with a scale from 0 (no problem) to 4 (severe problem). These items cover various aspects of swallowing, including eating, drinking liquids, eating in public, physical pain, stress or anxiety, coughing, voice quality, trouble swallowing saliva, trouble swallowing food, and choking on food. The EAT-10 provides valuable insights into how individuals subjectively experience their swallowing function. Higher scores indicate a greater self-perceived difficulty with swallowing. This questionnaire is easy to administer and quickly offers information on a patient's perception of their swallowing function, which can be a useful component in the overall assessment of dysphagia.

FLOW CHART



PROCEDURE: This study consisted of 4 weeks of intervention which includes neuromuscular electrical Stimulation (NMES) along with conventional swallowing rehabilitation (group A) and Conventional

swallowing rehabilitation (group B). At the baseline and at the end of the Intervention outcome measures are measured by using modified water swallow test and eat 10.

GROUP A**NEUROMUSCULAR**

ELECTRICAL STIMULATION (NMES): Subjects were placed in a seated or semi-reclined posture, the specific positioning varying based on the patient's comfort and the clinician's preference. A common approach involved an upright seated position, with the subject comfortably seated in a chair, ensuring proper back support to maintain good posture during the intervention. The subject's head was positioned in a neutral alignment, neither too far forward nor too far back, to ensure the proper placement of electrodes under the chin, targeting the suprahyoid muscles associated with laryngeal elevation. Electrodes were strategically placed under the chin to target the suprahyoid muscles, particularly associated with laryngeal elevation.

The NMES parameters included a frequency of 30 Hz, pulse duration of 300 μ s, and an initial amplitude intensity of 1.5 mA. This amplitude was progressively increased by 2.5 mA, adjusted based on individual tolerance. Additionally, a resting period of 5 to 20 seconds was incorporated between stimulations to optimize the therapy. Each subject received a total of 20 sessions, scheduled five days a week for four weeks, with each session lasting 30 minutes.^[17]

GROUP B**CONVENTIONAL**

SWALLOWING REHABILITATION: Each subject has attended 20 sessions over 4 weeks 5 sessions per week. The conventional Swallowing rehabilitation includes head and neck positioning^[18], effortful swallowing^[19],

Swallowing maneuvers Mendelsohn maneuver^[20], shaker's exercises^[21], supraglottic safety swallow^[22] and Oro motor exercises.^[23]

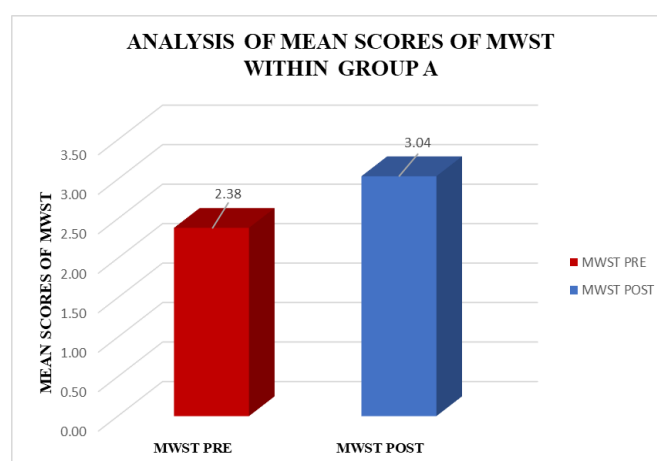
STATISTICAL ANALYSIS: All Statistical analysis was done by using SPSS version 21.0 and Microsoft Excel 2007. Descriptive statistical data was presented in the form of mean $\pm$ standard. Deviation and mean differences and percentages were calculated and presented. Within the Groups: Paired student "t" test was performed to assess the statistical Difference within the groups for group A and group B Between the Groups: Independent student "t" test was performed to assess the Statistically Significant difference in mean value between the groups. For all statistical analysis, $P < 0.05$ was considered as statistically significant.

RESULTS

The aim of the study is to assess the effectiveness of neuromuscular electrical stimulation combined with conventional swallowing rehabilitation for improving swallowing function in post stroke subjects with oropharyngeal dysphagia in comparison with conventional swallowing rehabilitation alone. A total of 120 subjects were screened for eligibility, amongst 108 subjects were included in the study trail. All the 108 subjects who met inclusion criteria have undergone baseline assessment and included subjects were allotted in group A and Group B by using convenience sampling method consisting of 54 subjects in each group. In this study 54 participants completed training 54 in group A and 54 in group B. In respective groups results showed that there is a statistical difference between two groups.

ANALYSIS OF MEAN SCORES OF MWST WITHIN GROUP A**TABLE-1**

GROUP A		MEAN	SD	P VALUE	INFERENCE
MWST	PRE-TEST	2.38	0.49	0.0001	Highly
	POSTTEST	3.03	0.59		significant

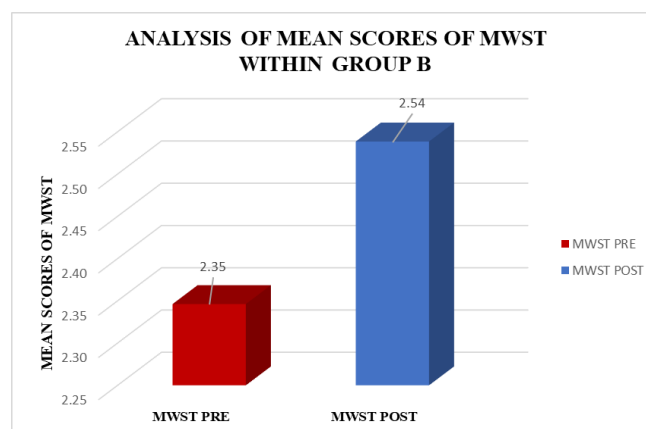
**GRAPH -1**

Results: The above Table and Graph shows that mean score of MWST changes from pretest to posttest values within Group-A were found to be statistically significant.

ANALYSIS OF MEAN SCORES OF MWST FROM WITHIN GROUP B

TABLE- 2

GROUP B		MEAN	SD	P VALUE	INFERENCE
MWST	PRE-TEST	2.34	0.48	0.0001	
	POST TEST	2.53	0.54		Highly significant



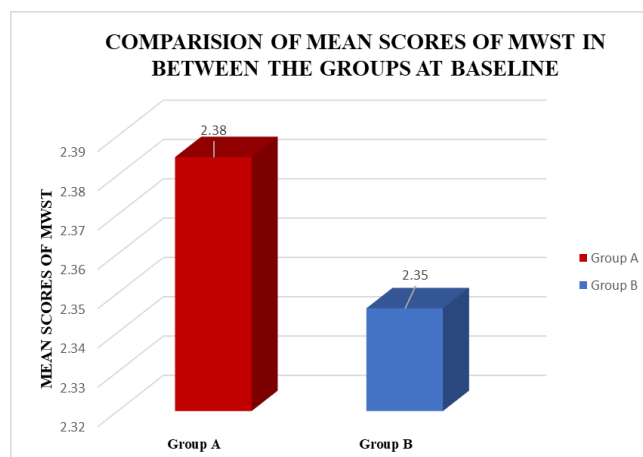
GRAPH- 2

Results: The above Table and Graph shows mean score of MWST changes from pretest to posttest values within Group-B were found to be significant.

COMPARISON OF MEAN SCORES OF MWST IN BETWEEN THE GROUPS PRETEST

TABLE-3

GROUPS	MEAN	SD	P VALUE	INFERENCE
Group A	2.38	0.49	0.6873	
Group B	2.34	0.48		Insignificant



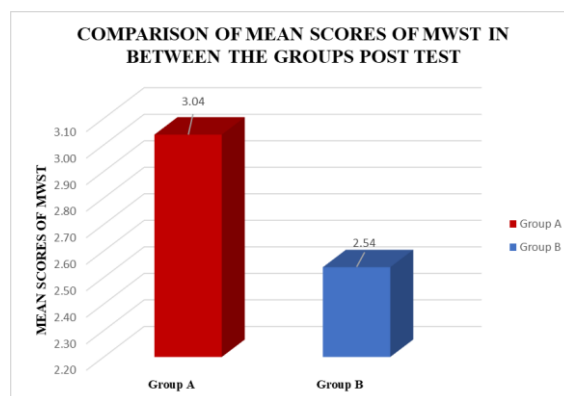
GRAPH-3

Results: The above Table and Graph shows the baseline measurement of MWST in Group-A and Group-B were found to be statistically Insignificant.

COMPARISON OF MEAN SCORES OF MWST IN BETWEEN THE GROUPS POSTTEST BETWEEN THE GROUPS

TABLE-4

GROUPS	MEAN	SD	P VALUE	INFERENCE
Group A	3.03	0.59	0.0001	Highly
Group B	2.53	0.54		Significant



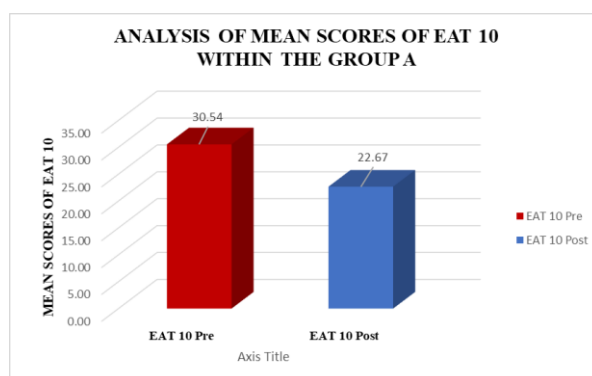
GRAPH-4

Results: The above Table and Graph shows the posttest measurement of mean score of MWST changes between the Group-A and Group-B were found to be statistically significant ($P < 0.05$)

ANALYSIS OF MEAN SCORES OF EAT 10 FROM WITHIN GROUP-A

TABLE-5

GROUP A		MEAN	SD	P VALUE	INFERENCE
EAT 10	PRE-TEST	30.53	2.01	0.0001	Highly
	POST TEST	22.67	3.37		Significant



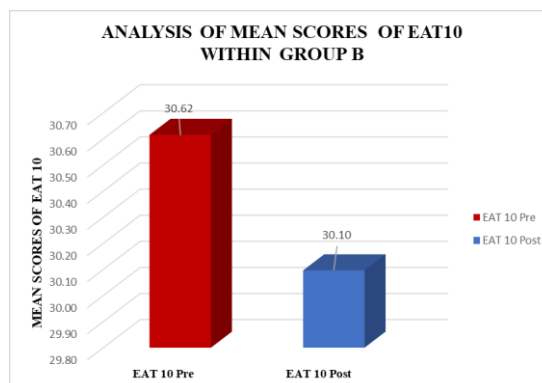
GRAPH-5

Results: The above Table and Graph shows EAT 10 values changes from pretest to posttest within Group- A were found to be statistically significant.

ANALYSIS OF MEAN SCORES OF EAT 10 FROM WITHIN GROUP B

TABLE-6

GROUP B		MEAN	SD	P VALUE	INFERENCE
EAT 10	PRE-TEST	30.61	2.43	0.0001	Highly
	POST TEST	30.09	2.19		Significant

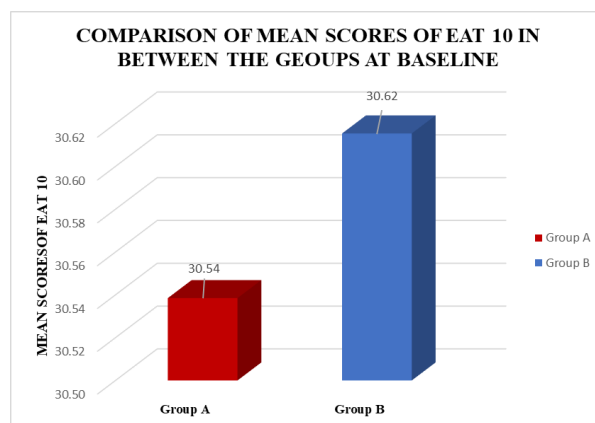


GRAPH-6

Results: The above Table and Graph shows the posttest measurement mean score of EAT 10 changes from pretest to posttest values within Group-B were found to be statistically significant ($P < 0.05$).

COMPARISON OF MEAN SCORES OF EAT 10 IN BETWEEN THE GROUPS PRE-TEST
TABLE-7

GROUPS	MEAN	SD	P VALUE	INFERENCE
Group A	30.53	2.01	0.8610	
Group B	30.61	2.43		Insignificant

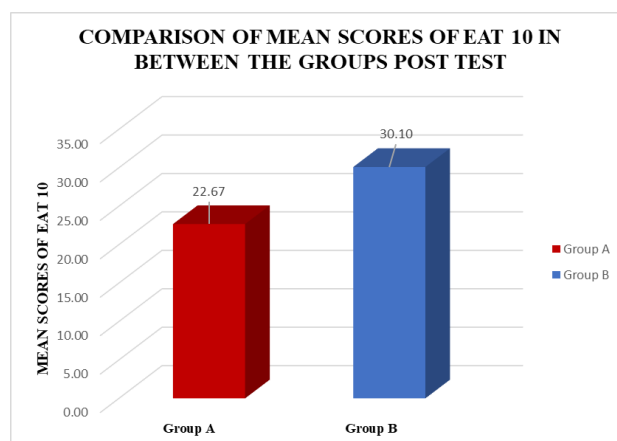


GRAPH-7

Results: The above Table and Graph shows the baseline measurement of EAT 10 in Group-A and Group-B were not found to be statistically insignificant.

COMPARISON OF MEAN SCORES OF EAT 10 IN BETWEEN THE GROUPS POST TEST
TABLE-8

GROUPS	MEAN	SD	P VALUE	INFERENCE
Group A	22.67	3.37	0.0001	Highly
Group B	30.09	2.19		Significant



GRAPH-8

Results: The above Table and Graph shows the mean score of posttest measurement of mean score of EAT 10 changes between the Group-A and Group-B were found to be statistically significant ($P < 0.05$).

DISCUSSION

The aim of this study was to evaluate the effectiveness of combining neuromuscular electrical Stimulation (NMES) with conventional swallowing rehabilitation in post-stroke subjects with Oropharyngeal dysphagia, comparing it with conventional rehabilitation alone.

The Widespread use of NMES in various dysphagia cases, including Parkinson's, head injuries, Muscular dystrophy, and multiple sclerosis, prompted the investigation. While previous Studies have reported mixed outcomes, this study aimed to contribute clarity to the Understanding of NMES efficacy in post-stroke dysphagia.^[24] The subjects in both group A and group B

underwent assessments for swallowing difficulty at Both the baseline and post-intervention stages. These assessments were conducted using the Modified water swallowing test and the eating assessment tool-10. Notably, there were two Dropouts in both groups in the study duration. Group A demonstrated a statistically significant improvement in both MWST and EAT 10, Supporting the effectiveness of the combined NMES and rehabilitation approach. Philipp Balcerak et al. proposed a mechanism wherein NMES stimulates muscle contraction and activates sensory pathways through motor and sensory stimulation. The application of surface Electrodes allows NMES to work peripherally on the neuromuscular system, particularly Targeting the suprahyoid muscles in the neck. This process triggers muscle contraction by Depolarizing nerve fibers, effectively reinforcing damaged oropharyngeal musculature.^[3] The rehabilitation of neurogenic dysphagia is thought to be primarily driven by Neuroplasticity, as highlighted by Ivy Cheng, Shaheen Hamdy et al. Stimulation, such as that provided by NMES, may induce neuroplastic changes by modulating synaptic strength. This Neuroplasticity, involving the brain's ability to reorganize and adapt, holds the potential for Improved neural connections and, consequently, enhanced swallowing function.^[25]

Ross Westemeyer's insights into motor learning principles align with the observed Improvements in Group A. Swallowing, being a sensorimotor skill, benefits from the Application of motor learning capacities. NMES, in conjunction with conventional Rehabilitation, likely enhances the motor learning process. This involves the acquisition and Refinement of swallowing skills, leading to improved coordination and efficiency of Swallowing movements over time.^[26]

Isabel et al.'s systematic review highlighted the importance of optimizing muscular strength Through NMES. The recommended application parameters, including frequency, impulse Time, and intensity, are designed to induce targeted muscle contractions. When coupled with Voluntary contractions during the rehabilitation program, this approach contributes to an Overall increase in muscular strength. The simultaneous voluntary contractions requested from the patient serve to optimize the effects of NMES in reinforcing oropharyngeal musculature.^[27] The mechanisms underlying the observed improvements in Group A encompass a Comprehensive array of factors. These include peripheral neuromuscular stimulation, Neuroplasticity, motor learning principles, and the optimization of muscular strength through Carefully tailored NMES parameters. Together, these mechanisms contribute to the Statistically significant enhancements in both objective (MWST) and subjective (EAT-10) Measures of swallowing function.

On the other hand, Group B did not exhibit statistically significant improvement in either the MWST or EAT-10.

This aligns with Jacinda et al.'s discussion on compensation and Rehabilitation as current dysphagia management approaches. While compensatory procedures Enhance safety, returning to oral intake and regular diet necessitates rehabilitation activities That directly enhance swallowing function. Long-term functional outcomes. This reinforces the notion that rehabilitation activities focusing on direct enhancement of swallowing function Are crucial for sustained improvements.^[28]

Moreover, recent work by Alicia vose et al emphasized the potential benefits of incorporating Novel techniques, such as the maneuver and effortful swallowing, to directly target specific Aspects of swallowing function. These direct exercises, similar to those recommended by Jacinda et al., aim to optimize muscle strength and coordination, offering a more targeted Approach to dysphagia rehabilitation.^[29,30]

The findings in Group B align with existing literature, suggesting that compensatory measures Alone may not lead to substantial improvements in swallowing function. The addition of References from Alicia vose and Jacinda rcia et al, provides a broader context supporting the Argument for a comprehensive rehabilitation approach that includes targeted exercises to Enhance swallowing function.

The comparative analysis between Group A and Group B supports the study's conclusion that the combined intervention of NMES and conventional swallowing rehabilitation is more Effective than conventional rehabilitation alone. The positive outcomes in Group A suggest that NMES plays a crucial role in enhancing swallowing function when integrated with rehabilitation.

The study's implications extend to the potential integration of NMES into dysphagia rehabilitation protocols. Future research could explore individualized application parameters, long-term effects, and the integration of NMES with a broader spectrum of swallowing techniques to optimize therapeutic outcomes.

This study contributes valuable insights into the efficacy of NMES as an adjunct to conventional swallowing rehabilitation in post-stroke subjects with oropharyngeal dysphagia. The multifaceted discussion integrates various perspectives, emphasizing the positive impact of NMES on swallowing function and reinforcing the conclusion that NMES is a useful adjunct in improving swallowing function along with rehabilitation.

Limitations: In this study we utilized a convenience sampling method, which may introduce, Selection bias and limit the generalizability of the findings, there is no follow up in this study to evaluate the sustained effectiveness of the Intervention over time, no blinding of evaluators of outcomes was done. Recommendation of further research are the study may benefit from longer-

term follow-up assessments to evaluate the Sustained effectiveness of the intervention over time. This would provide valuable Information on the durability of the improvements in swallowing function, Efforts to minimize potential bias through blinding or objective outcome measures Could enhance the validity of the results, Future research could consider stratifying participants based on stroke severity to Better understand how it influences outcomes.

CONCLUSION

Neuromuscular electrical stimulation along with conventional swallowing rehabilitation Program is more effective when compared to the conventional swallowing rehabilitation Program alone. Thus, this study concludes that neuromuscular electrical stimulation is a useful Adjunct in improving swallowing function along with Rehabilitation.

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