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Expiratory Muscle Training Versus Functional Electrical Stimulation on Pulmonaryand Swallowing Functions in Covid-19 Patients

Samia W. Diab*[1], Nagwa M. Badr[1], Eman K. Ibrahim[2], Asmaa M. Mohamed[1]

[1]Department of Physical Therapist, of Physical Therapy for Cardiovascular / Respiratory Disorders and Geriatrics, Faculty of Physical Therapy, Cairo University, Giza, Egypt

[2]Department of Chest Diseases, Faculty of Medicine, Cairo University, Giza, Egypt

***Corresponding author:** Samia W. Diab, **Mobile:** (+20)01094762028, **E-Mail:** soodiab1994@gmail.com

ABSTRACT

Background: Coronaviruses are viruses that cause reductions in pulmonary and swallowing functions. The need for this study has been developed to apply a comparison between expiratory muscle strength training and functional electrical stimulation for the abdomenandneck in acute COVID-19 patients with dysphagia, aiming to determine the most effective technique to improve cough peak flow, peak expiratory flow, swallowing, and arterial blood gases. **Objective:**To determine the impact of electrical stimulation and expiratory muscle strength training on the pulmonary and swallowing functions in individuals with COVID-19. **Methods:**This clinical trial study included sixty patients with COVID-19, of both sexes, aged from 20 to 45 years,from El-Menshawy General Hospital, Tanta, Gharbia Governorate, Egypt, who were randomly chosen and divided into two equal groups equal. Expiratory muscle strength training was given to group A as one session per day, 30 minutes for each session, five times a week for four weeks.Group B received neck and abdominal functional electrical stimulation. Traditional dysphagia therapies, as well as chest physiotherapy, are administered to both groups. **Results:** After treatment, there was a significant difference between the two groups in terms of pH and PCO2 ($p< 0.001$). Additionally, there was a significantly higher SaO2, PEF, and GUSS in group B following therapy compared to group A ($p< 0.001$). **Conclusion:**Functional electrical stimulation had a greater impact on pulmonary and swallowing functions in COVID-19 patients than expiratory muscle strength training.

Keywords: Covid19, EMST 150, Dysphagia,Electrical stimulation,Pulmonary function.

INTRODUCTION

More than 24 million people globally have been impacted by the coronavirus that causes severe acute respiratory syndrome (SARS-CoV-2). Infected individuals with the COVID-19 virus may develop severe acute respiratory syndrome and other multi-organ system disorders, necessitating extended periods of recuperation. Although many COVID-19 patients present in acute care hospitals with dysphagia, the importance of swallowing rehabilitation in these patients has not been reported[(1)].

Variable levels of swallowing impairment may occur in non-intubated patients, and these impairments are probably closely related to changes in pulmonary respiratory function and virus-direct neural damage. Patients' ability to recover from COVID-19 may be hampered, which could have an impact on their health outcomes[(2)].After a protracted stay in the intensive care unit (ICU), endotracheal intubated patients have complained about swallowing problems. However, it is still unknown if the intubation, the viral infection itself, or both are to blame for the dysphagia[(3)].

Dysphagia is one of the many signs and symptoms that COVID-19 may produce. However, swallowing impairment can occur in varying degrees in non-intubated patients as well. These impairments are most likely caused by alterations in pulmonary respiratory function and virus-directed neuronal lesioning activity. There is a significant possibility that patients receiving invasive ventilation will develop swallowing problems[(4)].Expiratory muscular training (EMT), which increases pharyngeal muscle contraction, enhances not only the coughing function but also the swallowing function. EMT can be expected to be used as a therapeutic strategy to lessen respiratory difficulties because it improves airway clearance and lowers the risk of aspiration[(5)].

Pharyngeal electrical stimulation (PES) is a rapid and reliable therapy for dysphagia. Neuromuscular stimulation is used to treat the sensory afferent pathways that are causing pharyngeal dysfunction to enhance swallowing function. PES has been shown to help people with dysphagia recover safe swallowing following severe COVID-19[(6)]. For pharyngeal electrical stimulation, an electrode catheter that resembles a nasogastric feeding tube is employed (PES) [(7)].

The study aimed to determine the impact of electrical stimulation and expiratory muscle strength training on the pulmonary and swallowing functions in individuals with COVID-19.

SUBJECTSANDMETHODS

Studydesignandpopulation:

This clinical trial study included sixty patients with COVID-19, of both sexes, aged from 20 to 45 years, from El-Menshawy General Hospital, Tanta, Gharbia Governorate, Egypt, who were randomly divided into two equal groups.

Expiratory muscle strength training was given to group A as one session per day, 30 minutes for each session, five times a week for four weeks. Group B received neck and abdominal functional electrical stimulation. Traditional dysphagia therapies, as well as chest physiotherapy, are administered to both groups.

Ethical consent:

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The protocol for this study was authorized by Cairo University's Faculty of Physical Therapy's scientific research ethics committee. Each patient received a thorough explanation of the study process before the initial evaluation. They were informed of the study's goal, scope, and risks, and written informed consent was acquired.The study was conducted according to the Declaration of Helsinki.

Measure:

The basic vital signs were monitored (Bp, temperature, heart rate, and respiration) before and after.Arterial blood gaseswere measured before and after the study using (Abbott Laboratories Pharmaceutical Company, Singapore, analyzer). before and after the study. The range of measurements made on COVID-19 patients before the use of functional electrical stimulation and expiratory muscle training, including arterial blood pressure (PH) readings between 7.38 and 7.48, partial pressure of carbon dioxide (Paco2) readings between 38 and 65 mm Hg, and oxygen saturation (Sao2) readings between 65 and 98%. The test was conducted while the individuals were seated, holding the peak flow meter horizontally without blocking the markers' (arrows') motion or covering the slot. The individual was instructed to inhale deeply and then forcefully exhale while maintaining an airtight seal between their lips and the instrument's customized mouthpiece. The highest reading from three retakes of the test was used as the result.Gugging Swallowing Screen (GUSS)to evaluate the degree of swallowing function.

DataCollection:

1)Patient's medical history was carefully taken including their general condition.2)Using a standard weight and height scale to measure the weight and height of each patient to calculate body mass index(BMI)(kg/m^2).3)Conduct laboratory research to identify measurable characteristics(C-reactive protein by latex on the slide, lymphocyte count byCBCERMA-210N, platelet count).4) The use of a chest CT scan was discoveredas a promising screening technique in people without symptoms.Additionally, it became obvious that chest CT scans can be used with great sensitivity indiagnosing patients by enhancing the definitive diagnostictechniques and comparing the resultsof the scans in patients who were unquestionably infected[8].5) Arterial blood gas analyzer(Abbott Laboratories Pharmaceutical Company, Singapore) used to measure arterial blood gases before and after the study.6) Peak flow meter was conducted while seating to measure how fast air comes out of your lungs when you exhale forcefully.7)Gugging Swallowing Screen (GUSS)to evaluate the degree of swallowing function.

Statisticalanalysis

SPSS version 25 for Windows was used for all statistical analyses (IBM SPSS, Chicago, IL, USA). An unpaired t-test was used to compare subject characteristics between groups. To compare how gender was distributed among groups, the Chi-squared test was employed. The data's normal distribution was checked using the Shapiro-Wilk test. Levene's test for homogeneity of variances was used to verify the homogeneity of variances between groups. To examine effects on pH, PCO2, SaO2, PEF, and GUSS within and across groups, a mixed design MANOVA was used.Post-hoc testing using the Bonferroni correction was done for further multiple comparisons. The significance level for each statistical test was set at p 0.05.

RESULTS

This study looked at the impact of electricalstimulation and training of the expiratory muscles on pulmonary and swallowing functioning in COVID-19 patients.

Sixty COVID-19 patients participated in this trial. The twogroups, A and B, each had 30 subjects, and these wereseparated. Both groups received electrical stimulation(Taiwan's Ev-906, 4CH Digital TENS/EMS) and exhalatorymuscular strength training (EMST 150). Statistics were usedto analyze and compare data on pH, oxygen saturation, partialpressure of carbon dioxide (PCO2), percent of normal peakflow (PEF), and the Gugging Swallowing Screen (GUSS)from both groups (pre- and post-treatment).

There was no statistically significant difference between the groups when comparing the subjects' overall characteristics (mean age, weight, height, and BMI; $p > 0.05$).

Table(1): Comparison of age, weight, height, and BMI betweenboth groups

	Group A	**Group B**	**MD**	**t- value**	**p-value**	**Sig**
	$\overline{X}$ **±SD**	$\overline{X}$ **±SD**				
Age (years)	32.63± 7.36	31.63± 7.14	1	0.53	0.59	**NS**
Weight (kg)	77.66± 7.54	78.46± 7.99	-0.8	-0.39	0.69	**NS**
Height (cm)	167.9± 8.03	168.16± 8.57	-0.26	-0.12	0.9	**NS**
BMI (kg/m²)	27.54± 1.75	27.72± 1.51	-0.18	-0.41	0.68	**NS**

According to group A's sex distribution, there were 2 (7%) females and 28 (93%) males. According to group B's sex distribution, there were 2 (7%) females and 28 (93%) men. Between groups A and B, there was no discernible variation in the distribution of sexes (p = 1). To examine how the therapy affected pH, PCO2, SaO2, PEF, and GUSS, a mixed MANOVA was used. Treatment and time had a significant interaction impact (p = 0.001). (p = 0.001). The main impact of time was significant. The primary effect of the therapy was significant (p = 0.001). The mean SD pH before treatment for group A was 7.420.04 and 7.390.03 after treatment. The percent change was 0.4%, and the mean

difference was 0.03. The pH of group A post-treatment was significantly lower than it was pre-treatment (p = 0.001).

The mean SD pH before treatment for group B was 7.430.03 and 7.360.02 after treatment. The percent change was 0.94%, while the average difference was 0.07. The pH of group B post-treatment was significantly lower than it was pre-treatment (p = 0.001).

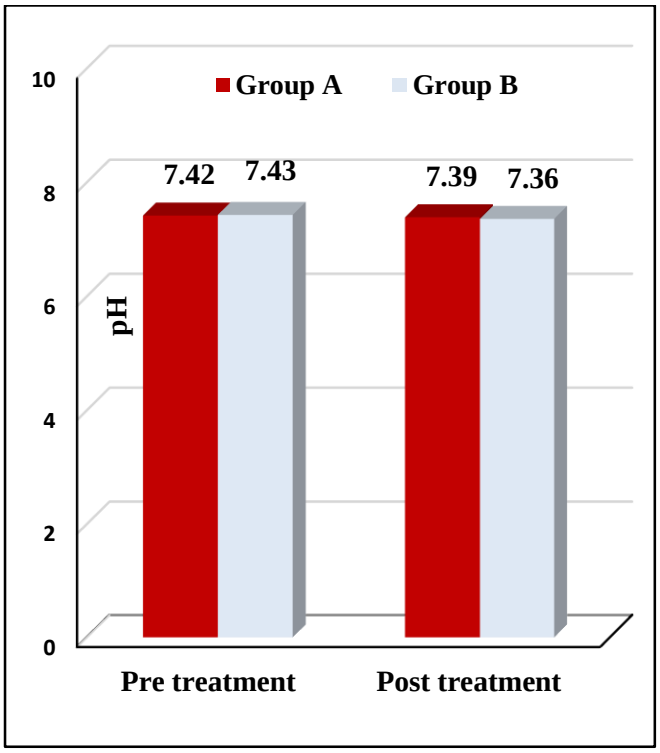

Fig. (1): Mean PH pre-and post-treatment of both groups.

The mean and standard deviation (SD) PCO2 pre-treatment values for group A were 52.234.95 mmHg and 45.92.02 mmHg, respectively. The percent change was 12.12%, and the average difference was 6.33 mmHg.

When compared to pre-treatment, group A's PCO2 significantly decreased (p0.001) after treatment. The mean SD PCO2 pre-treatment and post-treatment values for group B were 51.73 6.37 mmHg and 36.87 2.98 mmHg, respectively. The percent change was 28.73%, and the mean difference was 14.86 mmHg. When compared to pre-treatment, group B's PCO2 significantly decreased (p=0.001) after treatment.

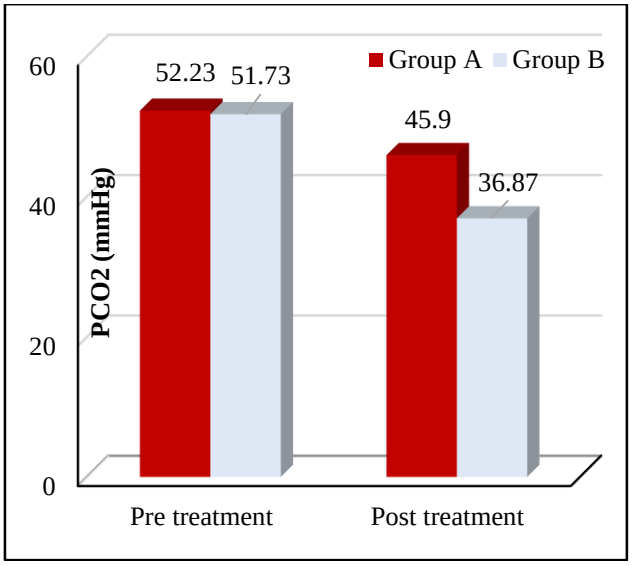

Fig. (2): Mean PCO2 pre-and post-treatment of both groups.

In group A, the mean SD SaO2 pre-treatment was 87.67%, while the post-treatment value was 96.43%. The percent of change was 10%, while the mean difference was -8.76%. The SaO2 of group A increased significantly after therapy compared to before treatment (p = 0.001).The mean SD SaO2 pre-treatment for group B was 88.434.68% and 98.20.88% after treatment. The percent of change was 11.05%, while the mean difference was -9.77%. When compared to before therapy, group B's SaO2 increased significantly (p =0.001).

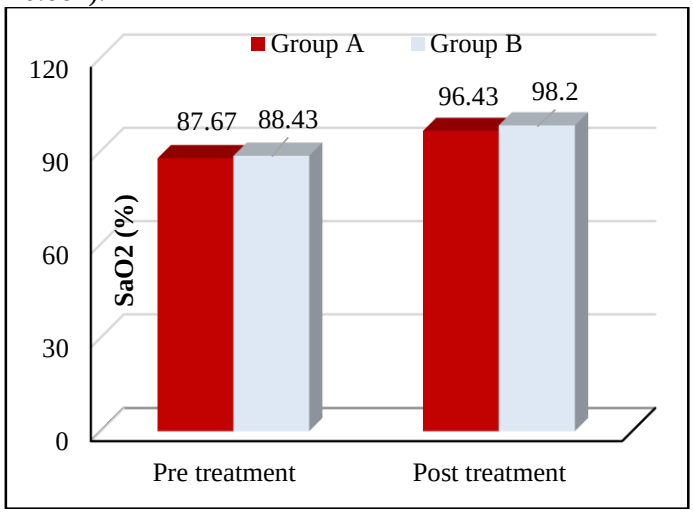

Fig. (3): Mean Sao2pre-and post-treatment of both groups.

The mean SD PEF in group A before therapy was 65.67%, and it was 77.63% (3.72% after treatment.The percent of change was 18.21%, while the mean difference was -11.96%. PEF in group A increased significantly post-treatment compared to pre-treatment (p = 0.001). Pre-treatment mean SD PEF for group B was 68.477.35%, and the post-treatment mean SD PEF was 89.434.77%. The percent of change was 30.61%, while the mean difference was -20.96%. PEF in group B increased significantly post-treatment compared to pre-treatment (p = 0.001).

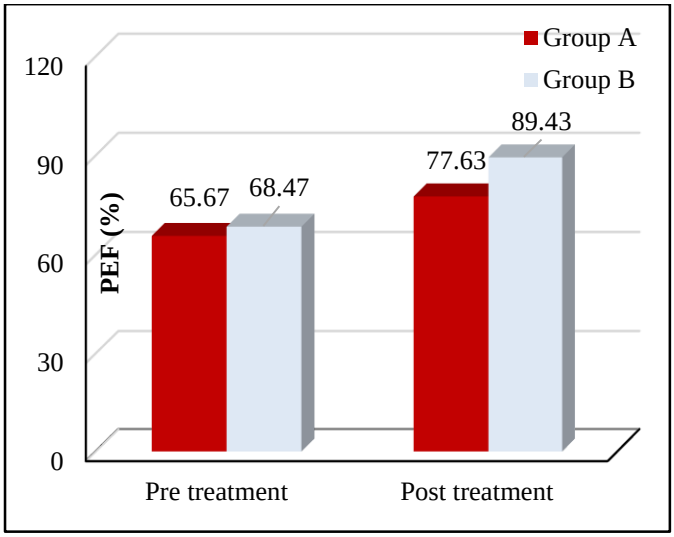

Fig. (4): Mean PEF pre-and post-treatment of both groups.

The mean SD GUSS score for group A before treatment was 11.07 2.41, and it was 17.4 1.19 after therapy. The percent change was 57.18%, and the average difference was -6.33. When compared to pre-treatment, group A's GUSS score increased significantly (p0.001) after therapy. The mean SD GUSS score for group B before treatment was 11.772.21, and it was 19.570.89 after therapy.

The percent change was 66.27%, and the mean difference was -7.8. The GUSS score for group B post-treatment increased significantly compared to that of group B pre-treatment (p = 0.001).

Table(2): Mean GUSS score pre-and post-treatment of both groups

GUSS score	Pre-treatment $\overline{X}$ ±SD	Post-treatment $\overline{X}$ ±SD	MD	% of change	P-value	Sig
Group A	11.07± 2.41	17.4 ± 1.19	-6.33	57.18	0.001	S
Group B	11.77 ± 2.21	19.57 ± 0.89	-7.8	66.27	0.001	S
MD	-0.7	-2.17				
P-value	0.24	0.001				
Sig	NS	S				

Table(3): Percentage of improvement of each parameter in both groups

Parameter	Group A	Group B
PH	0.4%	0.94%
PCO2	12.12%	28.73%
Sao2	10%	11.05%
PEF	18.21%	30.61%
GUSS	57.18%	66.27%

DISCUSSION

In this clinical trial study, 60 COVID-19 patients took part. All patients from El-Menshawy Hospital in Tanta City who were referred both as in-patients and outpatients were included. Thirty subjects from each of the two groups, A and B, were divided up. Their BMI ranged from 18.5 to 29.9 kg/m2, and their ages ranged from 35 to 45. The practical part of the study was conducted from March to April 2022.

Expiratory muscle strength training (EMST 150) was given to Group A. Traditional therapy for dysphagia includes posture correction and swallowing exercises that include (Effortful Swallow, Masako Maneuver, Mendelsohn Maneuver, Yawn, Supraglottic Maneuver, and Tongue Range of Motion). Turning, coughing, deep breathing, postural drainage, and percussion are all part of chest physiotherapy.For four weeks, group B got electrical stimulation (Ev-906, 4CH Digital TENS/EMS, Taiwan)on the anterior neck(avoiding the carotid artery area) and abdominal area, one session every day, lasting 30 minutes.

Additionally, the same previous conventional dysphagia treatments continue to include chest physiotherapy, posture correction, and swallowing exercises. Data on pH, the partial pressure of carbon dioxide (PCO2), oxygen saturation (SaO2), the percent of normal peak flow (PEF), and the Gugging Swallowing Screen (GUSS) from both groups (before and post-therapy) were statistically examined and compared.

In this study, it was found that there was no significant difference between groups pre-treatment (p > 0.05). The sex distribution in Group A revealed that there were 2 (7%) females and 28 (93%) males. The sex distribution in Group B revealed that there were 2 (7%) females and 28 (93%) males. There was no significant difference in sex distribution between both groups (p = 1).There was a significant decrease in pH and PCO2 in group B compared with that of group A post-treatment (p <0.001). Also, there was a significant increase in SaO2, PEF, and GUSS in group B compared with that of group A post-treatment (p< 0.001).

The results of this study are consistent with a recently published pilot study by **Koestenberger*et al.*[9]**, which discovered that oral intubated ICU patients who received PES treatment recovered from swallowing much more quickly than those who received stimulation after extubation. This demonstrates how administering PES early may speed up the recovery from dysphagia.

Even though they were preliminary, **McCaughey *et al.*[10]**results provided the most trustworthy proof that earlier weaning is possible.

The transversus abdominis and the internal and external oblique muscles were automatically synchronized with the participant's breathing pattern and stimulated during the exhale by placing NMES across the posterior-lateral abdominal wall. Up until the patient was moved out of the intensive care unit, stimulation was administered twice daily for 30 minutes. The study contrasted group A, which received stimulation that caused a noticeable, powerful muscular contraction, with group A, which only received sensory-level stimulation with enough amplitude to be felt on

the skin (10 Hz frequency and 350 s pulse width) (30 Hz frequency and a pulse-width of 350 s).Both the median ICU stay (6.5 vs. 34 days, p = 0.039) and median ventilation duration (11 vs. not estimable days, p = 0.011) were shorter in the intervention group than in group B.

Additionally, **Linder *et al.*[11]**showed the advantages of functional electrical stimulation (FES) for muscles that were either partially or completely paralyzed as a result of an upper motor neuron injury. Mechanistically, FES generates contraction in the abdominal muscles.It in turn can cause coughing by sufficiently constricting the air in the lungs. Patients with COVID-19 can use the same approach, which can stimulate their respiratory systems.

Additionally, it was shown that a device that irradiated smooth muscle tissue might enlarge the respiratory airway, improve gaseous exchange, and lessen pulmonary mucus secretion [12].

Kumagai*et al.*[13]also demonstrated that an electric stimulus had anti-viral effects against HIV-1. Additionally, **Vanderthommen*et al.*[14]**showed that at the same levels of effort (10% of the quadriceps maximum isometric voluntary torque), NMES increased blood flow and oxygen consumption in the muscle compared to voluntary muscular contractions. Furthermore, one NMES session is sufficient to promote the raised levels of mRNA for IGF-binding protein-4 (84%), MyoD (83%), myogenin (approximately 3-fold), cyclin D1 (50%), and p21-Waf1, which are indicative of the start of myogenic processes in skeletal muscle.

In the same study, a second NMES session (totaling 14 minutes spread over two days) was sufficient to raise the level of total skeletal muscle RNA, which is most likely an indication of a boost in the creation of muscle protein. These findings demonstrate that skeletal muscle molecules react to loading quite quickly. The researchers also discovered that NMES substantially increased muscular strength in comparison to the control (mean difference [MD] = 1.78, 95% CI: 0.44, 3.12 (p = 0.009)). NMES at this stage for a short length of time would be adequate to preserve muscle volume rather than improve it, according to the currently most popular regimens in the ICU.

In one of the greater studies**Dall' Acqua*et al.*[15],** the researchers observed that there was a considerable drop in the thickness of the control group's abdominal muscles but no significant improvement with NMES.

Research by **Nakamura *et al.*[16]**looked at the effects of a 20-min daily dosage of NMES (171 contractions per day) on femoral muscle volume and provides more evidence in favor of this theory. Both the control group and the intervention group's muscle volume decreased considerably, according to the study, although the NMES group's mean rate of decline was noticeably slower (NMES (SD) = 10.4% (SD 10.1%) compared to the control = 17.7% (SD 10.8%) (p = 0.04). To prevent muscle wasting in the ICU, NMES can be employed,according to the findings of these studies, and longer-term therapies, including those lasting up to 9 weeks. However, participants must continue using home-based NMES after being in the ICU to maintain their muscles' strength and health.

It's important to note that **Nakashini*et al.*[17]** indicate that choosing the motor point that would produce the largest contraction and increasing the number of contractions each session may help in more effectively maintaining muscular strength. While the control group got standard care, the NMES group had daily 30-minute sessions (180 contractions) for five days. ICUAW did not change, but there was a big difference in muscle size and power.

This suggests that additional research into the optimal dosage for ICU patients is necessary, and it supports a post-ICU NMES treatment phase for maintenance and strength recovery.Based on observations in Xenopuslaevis embryos.

Additionally, ES was anticipated to enhance COVID-19 patients' respiratory health, prevent SARS-CoV-2 growth, increase immunity, lessen pain, and can increase the antiviral drugs' penetration **[18]**.

The EMST resistance level in the trial, however, was 70%. When using 75% EMST resistance, **Yoon *et al.*[19]** found that meals resulted in the laryngeal lift, pharyngeal residue, and a significantly reduced pharyngeal transit time. These findings back up the decreased vallecular residue discovered in the current study. The pyriform sinuses residue in this investigation was the same for all groups. The posterior contraction of the longitudinal pharyngeal muscle and hyolaryngeal excursion, which pulls the hyoid bone forward, are assumed to be responsible for the opening of the upper esophageal sphincter, which is associated with the pyriform sinus residual. The upper esophageal sphincter's opening was not monitored in this experiment, though.

Patchett *et al.*[20] discovered evidence to support the idea that EMST induces favorable improvements in swallowing. However, these reviews either had a general focus on a variety of dysphagia treatments rather than focusing specifically on EMST**[21],** or they narratively summarised prior findings without a more in-depth examination and evaluation of objective measures of change in swallowing function. In mechanistic research on healthy people, **Wheeler *et al.*[22]**discovered that blowing through a pressure threshold device while doing the EMST task activates the suprahyoid muscle more than swallowing.

With a focus on objective videofluoroscopic measurements of swallowing function and/or physiology, **Sapienza *et al.*[24]** identified and critically reviewed the literature on alterations in swallowing

This result gave rise to the hypothesis that EMST might improve swallowing and airway protection in individuals with dysphagia**[23]**.

after EMST. In healthy young individuals, EMST using pressure threshold devices has been shown to theoretically improve expiratory pressure capacity.

A boost in PEMax was observed in the second research of healthy older people after 4 weeks of training, following a trend similar to that reported with the resistance training of the leg muscles **(25)**.

CONCLUSION

According to the study, functional electrical stimulation of the abdomen and neck using an EV-906, 4CH Digital TENS/EMS (Taiwan) device had a greater impact on breathing and swallowing in COVID-19 patients than exercising their expiratory muscles using an EMST 150 (Aspire Products LLC, USA) device.

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