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Time-Domain Electromyographic Biomarkers for the Assessment of Post-Stroke Dysphagia Rehabilitation

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Extended Abstract

Dysphagia, a significant and frequently underdiagnosed swallowing disorder, poses a serious risk to patient health and quality of life [1]. The lack of a standardized quantitative assessment method has driven the exploration of surface electromyography (sEMG) as a tool to identify neuromuscular biomarkers for dysphagia [2]. As demonstrated in our previous study, patients suffering from post-stroke dysphagia exhibited delayed swallowing reaction times (M1) in comparison to healthy subjects and higher neuromuscular variability, as indicated by the coefficient of variation of the submental muscle complex (CV-M1), in contrast to both healthy subjects and post-stroke patients without dysphagia [3].

Building upon these initial findings, the present study evaluates the impact of dysphagia rehabilitation on muscular swallowing parameters in post-stroke dysphagic patients. The primary objective is to determine whether rehabilitation can ameliorate dysphagia-specific neuromuscular abnormalities.

In this study, a total of 85 participants were recruited: 32 post-stroke patients with dysphagia (assessed both before and after two months of rehabilitation), 32 post-stroke patients without dysphagia, and 21 healthy subjects. Within the post-stroke dysphagic group, pre- and post-rehabilitation comparisons were performed using the Wilcoxon paired test, while the Wilcoxon unpaired test was used to compare with the other groups. The analysis focused on M1 and CV-M1 from sEMG measurements of both the suprahyoid and infrahyoid muscles while subjects performed a swallowing protocol previously described [3].

Consistent with our previous research [3], the pre-rehabilitation analysis confirmed that the patient group exhibited significantly delayed swallowing reaction times of supra-hyoid muscles compared to healthy individuals (median M1: 694 ms and 479 ms, respectively; $p=0.002$). This prolonged period of inactivity before muscle engagement persisted post-rehabilitation (median M1 749 ms). These results suggest that the neural processing delays characteristic of stroke pathology remain unaltered despite dysphagia rehabilitation. CV-M1 levels were significantly higher in dysphagic patients (90%) compared to non-dysphagic stroke controls (67%, $p=0.024$) and healthy subjects (55%, $p<0.001$). Following rehabilitation, CV-M1 decreased substantially (78%), with no significant difference compared to non-dysphagic stroke patients ($p=0.26$). Similarly, in infrahyoid muscles, CV-M1 levels were significantly elevated in dysphagic patients compared to healthy subjects before rehabilitation, but after rehabilitation, levels normalized, showing no significant difference with healthy subjects.

These findings suggest that although dysphagia rehabilitation appears to be effective in partially normalizing neuromuscular variability—as reflected by improvements in CV-M1—it does not address the broader stroke-related deficits responsible for delayed swallowing reaction times [4]. The dissociation between improvements in dysphagia-specific neuromuscular coordination and the persistence of delayed neural activation underscores the necessity for targeted therapeutic strategies that can concurrently manage both dimensions of the pathology.

Future research should focus on validating these preliminary results with larger sample sizes and exploring the long-term functional outcomes of targeted rehabilitation strategies, thereby contributing to more effective and comprehensive dysphagia management protocols.

References

1. Dziewas R, Allescher H-D, Aroyo I, Bartolome G, Beilenhoff U, Bohlender J, Breitbach-Snowdon H, Fheodoroff K, Glahn J, Heppner H-J, Hörmann K, Ledl C, Lücking C, Pokieser P, Schefold JC, Schröter-Morasch H, Schweikert K, Sparing R, Trapl-Grundschober M, Wallesch C, Warnecke T, Werner CJ, Weßling J, Wirth R, Pflug C (2021) Diagnosis and treatment of neurogenic dysphagia – S1 guideline of the German Society of Neurology. Neurol Res Pract 3:. https://doi.org/10.1186/s42466-021-00122-3
2. Crary MA, Baldwin BO Surface Electromyographic Characteristics of Swallowing in Dysphagia Secondary to Brainstem Stroke
3. Imaz-Higuera J, Prats-Boluda G, Ye-Lin Y, Martinez-de-Juan JL, Gutierrez-Delgado M, Prieto-House J, Más-Sesé G, Belda-Calabuig A, Garcia-Casado J (2025) Post-Stroke Dysphagia: Evaluating myoelectric alterations in swallowing muscles. Measurement (Lond) 249:. https://doi.org/10.1016/j.measurement.2025.117010
4. Verin E, Leroi AM (2009) Poststroke dysphagia rehabilitation by repetitive transcranial magnetic stimulation: A noncontrolled pilot study. Dysphagia 24:204–210. https://doi.org/10.1007/s00455-008-9195-7