Normalization Patterns of the Surface Electromyographic Signal in the Phonation Evaluation

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Summary: Purpose. The aim of the study was to compare the different parameters, regarding the peak and mean, at different phonatory tasks for standardization of electromyography signal of electrical activity (EA) of the laryngeal extrinsic muscles on voice evaluation.

Methods. The electrical potentials of the suprahyoid (SH) and infrahyoid (IH) muscles of 35 voluntary nondysphonic subjects were evaluated using three evaluations of rest, two maneuvers to determine maximum voluntary sustained activity (MVSA), and usual and strong intensity of vowel /ɛ/ and 20–30 count emissions. The EA signal was converted using root mean square in microvolts and normalized by mean and peak of each task. The selected normalization task was that with minor coefficient of variation for all muscles.

Results. The tasks that provided minor coefficient of variation of EA in both muscle groups were the peak of vowel /ɛ/ (mean potentials equal to 43.31 ± 2.97 for right IH, 36.27 ± 2.76 for left IH, and 42.11 ± 2.57 for SH) and the 20–30 count emissions (mean potentials equal to 31.30 ± 308 for right IH, 30.56 ± 2.76 for left IH, and 30.43 ± 4.22 for SH), both in usual intensity and MVSA, as second option.

Conclusions. The peak of vowel /ɛ/ and 20–30 count emissions is usual intensity, and the MVSA as second option should be considered for signal normalization in SH and IH muscles, and may provide conditions for using the surface electromyography in voice clinic.

Key Words: Electromyography–Phonation–Laryngeal muscles.

INTRODUCTION

Understanding the extrinsic laryngeal muscle behavior has been subject of studies on surface electromyography (SEMG) to measure the electrical activity (EA) of these muscles during phonation.

However, the high variability in the electromyography records can hamper the electrical signal interpretation. This variability, proper of each condition of the individual being assessed, often limits comparisons due to the tissue and physiological differences that underlie the evaluation of electrical signal of muscles or muscle groups.

The criteria established by the institutions promoting and integrating scientific research in the area, such as the International Society of Electrophysiology and Kinesiology and the SEMG for the Non-Invasive Assessment of Muscles (Seniam), recommend standardizing the electrical signal through the use of a reference for reducing the variability within and between individuals. This pattern is defined from the absolute values of root means square of the amplitude of captured signal. This signal is expressed in microvolts or it can be relativized and expressed in percentage. In this case, it is regarded as the maximum reference (100%) of the subject production, also allowing the comparability between studies using the same pattern.

There are several possibilities of setting the parameter for signal normalization, which include maximum peak of EA, maximal voluntary contraction (MVC), submaximal contraction, or mean EA (MEA).[1–4]

In phonation studies, the MVC[5–16] is the reference most often used for normalization because it promotes the maximal optimal activation of the muscles of interest that may be related to phonation. Specifically, regarding the extrinsic laryngeal muscles, the principle of maximum voluntary sustained activity (MVSA) is the most current reference.[6]

Phonation is a dynamic phenomenon and its clinical evaluation involves sustained emissions, as in continuous vowels and nonsustained emissions, like the excerpts of connected or spontaneous speech, reading, or singing. Thus, even there being predilection in most studies for using the MVC, there is no consensus on the muscles to be evaluated and on the normalization method to be used.

Physiologically, the antagonistic functions of the suprahyoid (SH) and infrahyoid (IH) groups include stability and laryngeal traction, raising (SH) or lowering (IH) the hyoid bone when swallowing and speaking, but not being activated in isolation. However, regarding the EA, there are questions such as during the sustained emission of a vowel in which there should be sound stability, theoretically; do these muscles show EA variation by differing from the emission of passage of speech? Once noted the difference in muscular EA among elicited phonation tasks for normalization purposes, would it be the maximum contraction of these muscles or the maximum peak reached at the different tasks the best parameters for normalization purposes to be considered as 100% captured EA? Could it be the rest considered as baseline (0%) for signal normalization?

From the foregoing, this study aimed at comparing the different parameters of electromyography signals of EA from

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extrinsic laryngeal muscles regarding the peak and mean at different phonation tasks for standardization in the electromyography signal on the voice evaluation.

METHOD

Thirty-five volunteers were included. They were speakers of both sex, 30 were females (85.7%), mean age 38.3 ± 2.2 years, ranging between 18 and 45 years. Volunteers had no dysphonia, signaled by perceptual assessment of voice performed by three experts in voice, and absence of the following self-reported or evident conditions on physical examination: cervical myoskeletal system disorder, hearing impairment of any kind and degree that could compromise the phonation control for height and intensity of voice, neurologic disorders that impaired the examinations, and use of orthoses or metal prostheses.

The vocal screening was performed by visual analogical scale (VAS) that is widely used.[17] The numerical correspondence—numerical scale of VAS—allows the categorization of vocal quality variability in four degrees. In this study, the criteria for classifying the absence of dysphonia included a 20–30 count evaluated as VAS equal to one without vocal complaints, or a 20–30 count and also the emission of /ε/ vowel in usual intensity evaluated as VAS equal to one in the presence of vocal complaints.

The phonatory descriptors were mean usual intensity equal to 68.74 ± 1.23 dB and mean strong intensity of 83.38 ± 0.94 dB for emission of /ε/ vowel, and 53.32 ± 1.40 dB for 20–30 count in usual intensity and 66.24 ± 1.15 dB in strong intensity.

The sample size was calculated according to the Altman nomogram, considering the adequacy of the significance level, proof power, and the effect to be identified by the study.[18] The convenience sampling was randomized with the table of random numbers by assuming the exhaustion of sample identified by the absence of discrepant variations in SEMG evaluations.[18]

The software Miotool 200 system (Miotec™, Brazil) with windowing 32 and gain equal to 2000 for each channel capturing the electrical potential of the SH and IH muscles and measuring them in microvolts (μV). This gain allows adjusting the signal to the muscles reaching values up to 574.93 μV, according to manufacturer's instructions. From the four channels provided in the system, three of them were used. Each one was connected to a sensor SDS500 by claws to infant disposable surface electrodes of Medi-Trace brand (Kendall™, Canada). The signal analysis was performed using the software Miograph 2.0.

The SEMG's equipment was connected to the notebook LG (São Paulo, Brazil), 160 GB HD, Intel Inside Dual-Core 1.7 GHz running the Windows Vista Premium operational system.

For data collection, the researcher explained the objectives, as well as the rights and obligations of the researcher and participants on the research, inviting them to participate by signing the informed consent. To minimize the selection bias, all subjects underwent a structured interview for identifying the complaints and evident signs indicative of vocal and hearing disorders, as well as alterations in the cervical region.

Complied with the inclusion criteria, the participant was referred for speech therapy reserved room for the onsite assessment and electromyography recording. The participant was seated in a chair, with the upright torso, eyes open, feet flat on the floor, arms resting on the legs, and back to the equipment to avoid any monitoring attempt or visual feedback. There was no need for shaving the participants. After cleaning the area with a gauze soaked in 70% ethyl alcohol, the electrodes were placed: 01 channel with 02 electrodes in the longitudinal submandibular region to obtain the signals mainly from digastric and mylohyoid muscles considered floor of the mouth in direction to the fiber of the anterior belly of digastric muscle; and 02 channels arranged bilaterally to the larynx at 1 cm from the thyroid incision.[6] The interelectrode distance was 1 cm from center to center.

Data collection started by capturing the electrical signal of MVSA. The participant was asked to carry out the incomplete muscular maneuvers of incomplete swallowing with effort and tongue retracted with mouth open as advocated in Balata et al.[6] After 1 minute rest, the participant performed all tasks neatly as shown in Figure 1. Each procedure was performed, interspersed with rest of 10 seconds, always preceded by the explanation

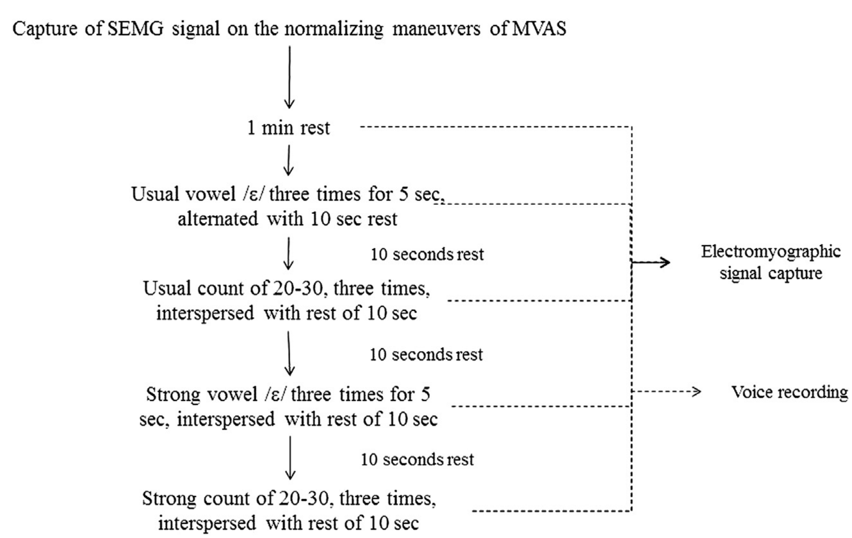

FIGURE 1. Flowchart of research data collection.