Fundamental Frequency Histograms Measured by Electroglottography During Speech: A Pilot Study for Standardization

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Summary: This study was designed to develop a database for the electroglottographic measurement of fundamental frequency (Fo) in normal subjects in running speech, for reference in the diagnosis and follow-up of dysphonic patients. A prospective pilot study included 20 healthy male volunteers without laryngeal disorder. Electroglottographic recordings of speaking Fo during connected speech (French) were obtained from two texts with different prosodic content. Fo histograms were sensitive to the variation of speaking Fo between both texts. Graphic representation of the range and distribution of the Fo of the speaker were designed as normalized Fo histograms with plot lines at 5th and 95th percentiles. Less than 5% variability of Fo histograms was recorded when recording more than 15 subjects. This pilot study designed a graphic display of standardized electroglottographic Fo measurements during the physiological condition of connected speech. As the degree of Fo variability depends on the phonetic contents of the text and on the language spoken, a separate histogram for normal subjects needs to be developed in each country or at least for each voice laboratory, with a standard, previously chosen text.

Key Words: Fundamental frequency—Electroglottography—Standardization—Diagnosis—Speech.

INTRODUCTION

The fundamental frequency (Fo), which is defined as the number of vocal fold contacts during 1 second, reflects several laryngeal and extralaryngeal characteristics of a speaker, such as laryngeal size, subglottic pressure, and voicing mode. Fo varies during connected speech in that it is also affected by the phonetic and the prosodic contents of speech.

Electroglottography (EGG) is an interesting modality for measuring Fo.[1,2] EGG is a noninvasive method, which is based on Ohm's law that measures

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the variation in electrical resistance between two electrodes placed on each side of the thyroid cartilage.[3,4] The electroglottographic wave reflects variations of the vocal fold contact area.[4–13] EGG provides a physiological measure of Fo at the level of the laryngeal source.[14,15] The EGG signal is much easier to process in comparison with the acoustic signal.[14]

An advantage of EGG is that it can measure Fo during connected speech because no measurement sensors are introduced into the mouth. Whereas sustained vowels are often the basis for objective evaluation, Fourcin pointed out the interest of assessing connected "real-life" speech.[16] Fourcin[3] first described histograms of Fo during connected speech as a representation of the range and distribution of the vocal fold frequencies.[6]

The issue remains that no standard Fo histograms are usable as a normalized database. The absence of such normative values limits its practical application.[14] As long as normal values have not been validated, the clinical application of EGG will be limited.

The aim of this study was to determine the speech pattern of normal electroglottographic values for Fo histograms in French.

SUBJECTS AND METHODS

Subjects

Twenty healthy male volunteers were prospectively studied. All subjects gave informed consent to participate in this study and underwent medical history and laryngeal examination. Inclusion criteria were male subjects, native French speakers, aged between 25 and 45 years, with no history of laryngeal or neurologic disease, no complaint of voice or speech deterioration, and a laryngeal examination with normal findings. Ages ranged from 26 to 39 years (mean, 32.5 years). To generalize the measurement for routine practical application, we included patients having had past light tobacco intake or very mild current consumption. Thirteen subjects were nonsmokers, and 7 had tobacco intake of less than one pack of cigarettes per day. None were professional singers. All subjects were evaluated and recorded by the same author (R.E.K).

Instrumentation

The EGG Laryngograph (Laryngograph Ltd, London, U.K.) measured the EGG signals that were displayed and analyzed by a computer data-processor SESANE (SQLab, Aix-en-Provence, France). The EGG device recorded the electric impedance across the neck between two electrodes placed on either side of the thyroid cartilage and held in contact with the skin by an elastic collar. The output of the EGG device was processed by an electronic preamplifier (DIANA; SQLab, Aix-en-Provence, France) and then by a 16-bit analog-to-digital (A/D) converter that was included in a 366-MHz Pentium personal computer (Gateway 2000; Gateway, Irvine, CA). The *SESANE* (SQLab, Aix-en-Provence, France) software was simultaneously applied for acoustic signal acquisition and analysis. An AKG (Vienna, Austria) model C410 condensor microphone mounted on a headset was connected to the personal computer via the A/D converter DIANA for acoustic recordings. Both electroglottographic and acoustic measures were displayed by SESANE software.

Procedure

The following procedure was implemented for each recording. The microphone was placed on the side of the mouth at 8 cm from the labial commissure. The sound intensity was calibrated with a buzzer placed 22 cm in front of the microphone before each recording. The subjects were seated upright. Electrodes of the Laryngograph were placed approximately 1.5 cm laterally to the anterior angle of the thyroid cartilage with no conducting gel between the electrode and the skin. The subject was instructed to speak normally at a comfortable pitch and intensity level. The connected speech task consisted in the reading of two texts at a comfortable pitch and intensity. Text 1 was a story, and text 2 included 20 sentences (see the Appendix) from a database statistically representative of the distribution of phonemes in the French language (CNET, technical note 1980, NT/LAA/TSS/26). One single trial of each text was obtained. The reading of each text lasted more than 1 minute.

Data analysis

The simultaneously recorded EGG and acoustic signals were directly digitized. EGG signals were