Multidimensional Voice Data on Participants With Perceptually Normal Voices From Ages 60 to 80: A Preliminary Acoustic Reference for the Elderly Population

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Summary: Objective. The purpose of this study was to provide a preliminary acoustic reference for an elderly population (aged 60–80) with *perceptually normal* voices to determine the degree of noise in the vocal signal of this population; a younger population (aged 20–30) with perceptually normal voices participated for comparison. The participants were tested on the *Multidimensional Voice Program* (model 5105, KayPENTAX, Lincoln Park, NJ), and the following acoustic parameters were evaluated: relative average perturbation (cycle-to-cycle frequency perturbations), shimmer (cycle-to-cycle amplitude perturbations), and noise-to-harmonic ratio (degree of noise in the vocal signal).

Method. Fifty participants between the ages of 60 and 80 (mean age, 69.5) and 50 participants between the ages of 20 and 30 (mean age, 23.23) were tested by sustaining the vowel /a/ on the *Multidimensional Voice Program*. Voice and/or speech samples were also recorded for each participant to reveal perceptually normal voices.

Results. The older group had significantly higher levels of relative average perturbation, shimmer, and noise-to-harmonic ratio than the younger group, and males had significantly higher levels of shimmer than females.

Conclusion and Implications. The acoustic values obtained for the older group with *perceptually normal voices* resembled data in the literature, particularly when the ages of the participants in the studies were similar. The present findings may possibly be used as a preliminary reference against which to compare clinical acoustic data to older clients with dysphonic voices.

Key Words: Elderly population–Younger population–Perceptually normal voices–Relative average perturbations (RAP)—related to jitter–Noise-to-harmonic ratio (NHR).

INTRODUCTION

Review of the literature

Since 1985, there has been an increase in the number of elderly clients with vocal difficulties seen in speech and hearing clinics.[1–3] A study conducted by Pontes et al[4] examined the glottic characteristics and voice complaints of the elderly population. The complaints were consistent with findings such as vocal fold atrophy, a reduction in the volume and elasticity of the vocal folds, polypoid degeneration, and a change in fundamental frequency (F_0). In a questionnaire administered to 107 geriatric residents, 20% of the participants claimed to have difficulty using their voices.[1] Physicians and therapists treating these older clients should differentiate the natural effects on the aging voice (ie, presbyphonia or presbylaryngis) from other dysphonias.[5,6] The effects of presbylaryngis can be reversed with therapeutic exercises.[3]

Anatomical and physiological changes in the vocal folds secondary to aging. Anatomical and physiological changes of the vocal folds occur as individuals age and affect the acoustic output of voice.[2,7] There are, however, limited normative acoustic data reflecting these changes with regard to the elderly population.

Phonation occurs as a result of the collaborative functioning of the respiratory, laryngeal, and resonation systems. As individual ages, muscles weaken and body parts change. The respiratory system, which generates subglottic pressure beneath the adducted vocal folds (to eventually abduct the vocal folds), experiences a loss of elasticity of the lung tissue, weakness of respiratory muscles, and decreased lung pressure. These changes affect volume in the lungs, which eventually affects the adduction and abduction of vocal folds.[8,9] According to Awan,[10] measurements of laryngeal and respiratory functions are necessary to fully assess the speech and/or voice function in elderly people. The findings by Awan also showed that elderly women demonstrated lower maximum phonation time and diminished vital capacity, consistent with decreased respiratory capacity, but not glottal inefficiency, as phonation quotient (ie, rate of airflow through the glottis) was similar to younger women.

In a normative study related to the *KayPENTAX Phonatory Aerodynamic System* Model 6600 (KayPENTAX, Lincoln Park, NJ), aging was found to affect the parameters for mean expiratory level, sound pressure level, and F_0. These results were attributed to anatomical changes within the respiratory and laryngeal systems, as well as differences in speech breathing in the aging population.[11]

Xue and Deliyski[7] conducted an investigation to identify vocal histologic changes correlated with aging as compared with younger adults. Their results indicated a correlation between aging and decreased thickness in the lamina propria of

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the vocal folds and a reduction in the mucosal thickness. More recently, Pontes et al[4] found that the superficial layer of the lamina propria becomes thicker and more edematous, whereas in men, the intermediary layer of the lamina propria becomes thinner and the deeper layer becomes thicker. According to Sato et al,[12] there is a reduction in the number of cells in the vocal folds and changes in the viscoelasticity of the vocal fold mucosa with an increase in age.

Some elderly speakers present with incomplete closure or bowing of the vocal folds, secondary to atrophy or flabbiness,[7,13] modifications in cricoarytenoid articulation, modifications in the vocal fold ligament,[14–16] or to reduced activity of the thyroarytenoid muscles revealed (in studies using electromyographic ranges).[17] Videostroboscopy conducted by Biever and Bless[18] demonstrated that greater aperiodicity, mucosal wave alterations, incomplete glottal closure, and reduced amplitude of vocal fold vibration occurred in the voices of geriatric women when compared with the young group.

Changes related to gender. Men typically experience ossification and histologic changes earlier than women.[16] Characteristics found in aging men include vocal fold bowing and atrophy, in addition to the presence of sulci and fat degeneration. A glottic configuration known as "arrow pit" refers to bowing of the vocal folds plus the prominence of the vocal processes.[14,19] These vocal fold changes may potentially affect the adduction of vocal folds. Furthermore, changes in the laryngeal glands in the elderly male may lead to stiffness of the vocal folds resulting in an increase in the F_0. Pontes et al[4] discovered that geriatric males exhibited a higher F_0, whereas geriatric females had a lower F_0 compared with the younger population, the latter related to a reduction of estrogens and the presence of the hormone, androgen.[8] Additionally, edema has been found to be characteristic of older women.[20] Men's voices are also affected by changes in hormones in that elderly men with decreased estradiol (ie, type of estrogen) demonstrated more jitter and shimmer based on vocal parameter results from the *Multidimensional Voice Program* (*MDVP*; KayPENTAX).[21]

Acoustic studies related to aging. The effects of aging are reflected in studies that investigated acoustic vocal output. Xue and Deliyski[7] conducted a study that provided preliminary normative data of voice for elderly participants between the ages of 70 and 80. Results showed that the elderly participants exhibited "different (or poorer) measurements on all of the selected acoustic parameters of voice compared with young and middle-aged adults," indicating a need to adjust the threshold of pathology for the aging voice. Other researchers also found a direct relationship between the older individual and a deterioration of acoustic parameters of voice (eg, pitch, shimmer, jitter), with an increase in age (Linville and Fisher[22]; Hirano et al[23]; Ramig and Ringel[24]; and Ringel and Chodzko-Zajko[25]).

The *MDVP*[26] (model 5105, KayPENTAX, Lincoln Park, NJ) is often used to obtain acoustic parameters of voice (eg, F_0, jitter, relative average perturbation (RAP), shimmer, noise-to-harmonic ratio [NHR]). This instrument provides objective acoustic norms and thresholds of pathology for voice. According to the normative data provided by KayPENTAX, a threshold of aperiodicity greater than 0.680% for RAP and 3.810 for shimmer would potentially indicate a pathology.[27] Using the acoustic data obtained from the sustained phonation of /a/, the *MDVP* has been used to test a number of acoustic parameters (eg, as noted previously). This use of objective acoustic analysis has supported many research conclusions beside those related to older individuals (eg, the increased incidence of jitter and shimmer in deaf patients, the significant increase of jitter percentages in children with vocal fold nodules, and overall change in acoustic parameters in adults with vocal fold polyps).[28–30] Xue and Deliyski[7] stated that NHR is a general indicator of noise present in the vocal signal.

Some researchers, who have recently examined voice disorders in the elderly using the *MDVP*, noted the need for accurate parameters of normal vocal functioning in this increasing population.[31] Nishio et al[32] showed that the *MDVP* detected differences between the acoustic parameters of young and elderly voices. Other acoustic analysis software (eg, The *Sonneta* [Computer Program], version 1.op 46; MintLeaf Software Inc, Toronto, Canada) also revealed differences in vocal parameters between older and younger voices.[33]

There are limited investigations of *MDVP* parameters regarding norms for the elderly population and the effects of age as a confounding variable in defining normal acoustic parameters.[7] Just as the normative acoustical parameters for voice must be adjusted from child to adult related to the changing laryngeal structure, the natural aging process from middle to late adulthood has a significant effect on the speaker's acoustic vocal measurements and must therefore be evaluated. According to Gorham-Rowan and Laures-Gore,[13] there have also been conflicting results when using the *MDVP*-normed threshold values for jitter and shimmer to assess vocal quality in an older population. Some studies stated that there is an increase in jitter and shimmer values in an older population as compared with a young population,[34,35] and others have reported no significant difference between the two populations.[24,36] By neglecting to identify norms and adjust the pathology threshold for the elderly population, the validity of *MDVP* values is affected.

Need for the present study. Because of insufficient and contradictory acoustic research regarding phonation of elderly adults, there is a need to establish acoustic thresholds for this population. Changes in laryngeal and respiratory anatomy in the elderly population can lead to changes in phonation and dysphonia. Therefore, having data from older participants with *perceptually normal voices* can serve a reference that could assist speech-language pathologists in appropriately diagnosing and treating voice disorders in the elderly population. As stated by Andrianopoulos et al,[37] diagnosing a voice as abnormal requires a comparison to normative acoustic parameters of others of similar age, gender, and culture. There is a need for obtaining normative data for each gender and age group on acoustic parameters evaluated by the *MDVP*.[32] Comparing the acoustic data collected from the established *MDVP* acoustic norms of younger people would seemingly lead to a misguided diagnosis of many elderly speakers. To