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EVALUATION OF THE VARIATION OF THE MUCOSAL WAVE ACCORDING TO THE PHONATION TONE THROUGH BIOMECHANICAL VOICE ANALYSIS

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Abstract: Rationale and objectives: When an individual changes the pitch of his or her voice, his or her vocal folds undergo structural and dynamic variations that produce not only a different sound, but also a vocal pattern and differences in the characteristics of the mucosal wave; which in turn must be detected by tools that allow this phenomenon to be objectified. Thus, the objective of this work is to evaluate the changes observed in the correlate of the mucosal wave, in the open and closed phase, when modifying the phonation mode. Methods: The study analyzed voice recordings of 160 subjects without voice pathology obtained from the database of the Saarbrucker Stimmdatenbank Institut für Phonetik. Biomechanical analysis of the evaluated voice samples was performed using the Voice Clinical Systems® biomechanical analysis tool. Selected voice samples were sent to the Voice Clinical Systems® virtual laboratory using the "Analysis for Research" option. Results: The results show that there is a significant difference ($p < 0.001$) in the mucosal wave values observed in the open and closed phase in relation to the tone used by the subject. It can be observed how phonation in high pitches modifies the biomechanical properties of the free edge and reduces the mucosal wave amplitude. Likewise, phonation in low tones produces, regardless of the sex of the subject, an increase in the mucosal wave effect ($p < 0.001$). Finally, the amplitude of the mucosal wave in opening also shows higher values in the male group than in the female group for all frequencies. Conclusions: It is important to find evaluation methods and tools that allow us to evaluate the mucosal wave objectively and reliably. Biomechanical analysis of the voice has proven to be effective in identifying the changes observed in the effect of the mucosal wave and derived from the modification of the phonatory pattern. A broader understanding of the characteristics of the mucosal wave complements the diagnosis and will help to more accurately characterize the voice pathology and guide towards more effective treatment.

Keywords: Biomechanical analysis; Aphonia; voice pathology; Mucous wave.

INTRODUCTION AND GOALS

The biomechanical study of the voice analyzes the mechanical and structural factors that participate in the development of the movement of the free edge of the vocal folds, using a model based on the underlying histological structure; It allows us to non-invasively and from a voice sample obtain a description of the dynamics of the free edge reflected by a set of biomechanical parameters. This development offers parameters that directly correlate with the mucosal wave effect observed during a given phonation, and also allows the characterization of pathology through parameters that quantify and evaluate changes in the mucosal wave[1].

The validity of biomechanical analysis is established as a tool to evaluate the dynamics of the vocal cycle[2]; identifies the variation of vocal behavior patterns in relation to the type of phonation and the presence of pathology through its parameters; it even provides a more complete and accurate description of free edge dynamics than the electroglottogram; It constitutes a valid tool for screening voice pathology, even to discriminate functional pathology[3]. (figure 1-2)

When an individual changes the pitch of his or her voice, his or her vocal cords undergo structural and dynamic variations that produce not only a different sound but also a different vocal pattern and mucosal wave that must be detected accordingly by objective tools or methods[4, 5] Therefore, the objective of this work is to evaluate the changes observed in the correlate of the mucosal wave, in the open and closed phase, by modifying the

phonation mode.

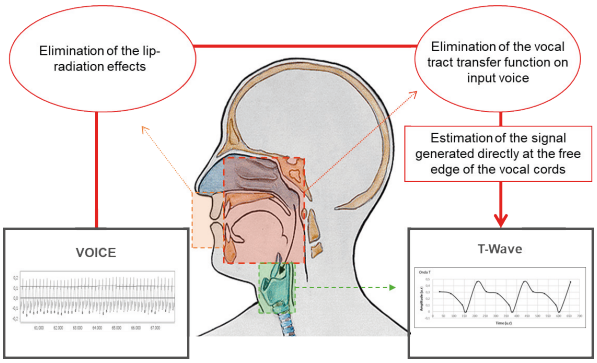


Figure 1: vocal tract model

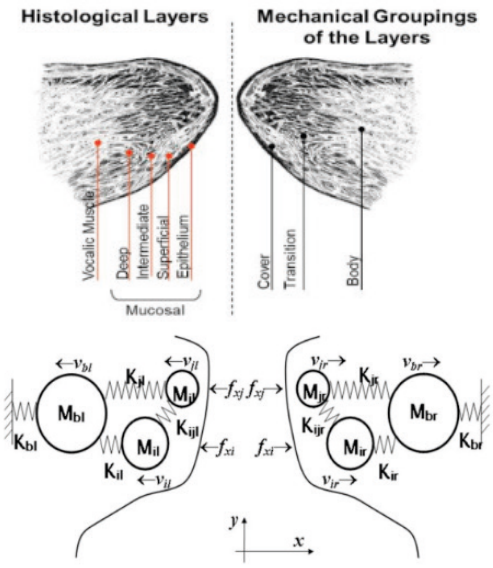


Figure 2: model and histological correlate

MATERIALS AND METHODS

This is a descriptive study, the study analyzed the voice recordings of 171 subjects without voice pathology obtained from the database of the Saarbrucker Stimmdatenbank Institut für Phonetik.

Biomechanical analysis of the evaluated voice samples was performed using the Voice Clinical Systems® biomechanical analysis tool. Selected voice samples were sent to the Voice Clinical Systems® virtual laboratory using the "R3 Full Analysis" option.

The variables studied: age, sex; and parameters of the biomechanical analysis of the voice: fundamental frequency (P01); and characteristics of the mucosal wave such as the degree of amplitude in the closed phase (P17) and open phase (P18); degree of enhancement of the defect in the closing and opening phase, respectively (P19-P20) (figure 3).

• SET H			(Mucosal wave and edema correlates)		
P1 7	MW Ind. Closing (r.u)	0,0	190 - 330	130 - 370	0,0
P1 8	MW Ind. Opening (r.u)	0,0	20 - 65	10 - 100	0,0
P1 9	Adequacy ratio MW closing (r.u)	0,0	(-10) - 60	(-40) - 90	0,0
P2 0	Adequacy ratio MW opening (r.u)	0,0	0 - 100	200	0,0

Figure 3: Biomechanical parameters in relation to mucosal wave characteristics

RESULTS AND DISCUSSION

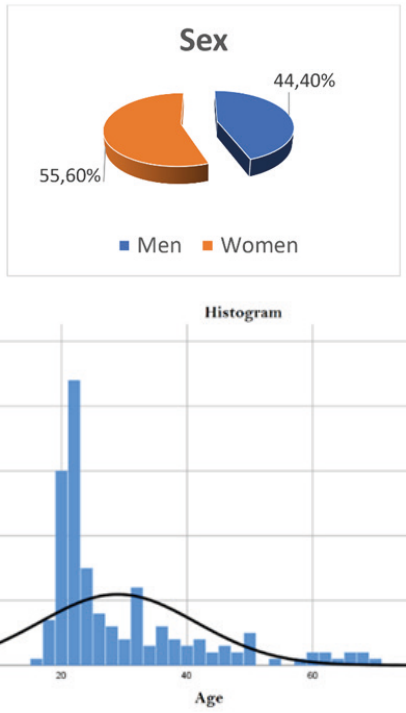
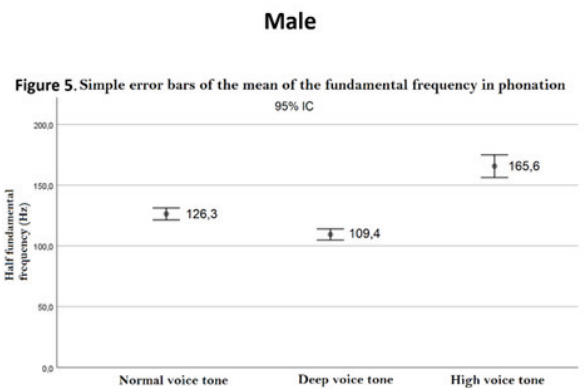


Figure 4: Distribution of variables by sex and age

The study consisted of 171 subjects; 76 men (44.4%); 95 Women (55.6%); average age 28.9 years; standard deviation 12.4 years (Figure 4).

When phonation occurs with low or serious tones, the fundamental frequency (P01) decreases; and in high tones it increases regardless of gender (Fig 5); The analysis of variance found statistically significant differences.



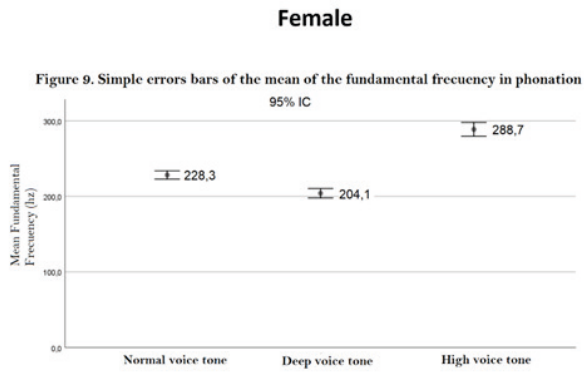


Figure 5: the results of P01 (Fundamental Frequency) are shown in relation to sex in natural pitch phonation and high and low pitch phonation

The analysis of variance (95% CI) found statistically significant differences ($p < 0.001$); There are changes in the properties of the mucosal wave during phonation in the male study population; with high tones its amplitude decreases in the closed phase (Pr17), in the adequacy indices in closed and opening there is a minimal increase (Pr19, Pr20). In low tones its amplitude increases in the closed phase (Pr17) and the adequacy indices in closed and opening also increase (Pr19, Pr20). The amplitude in the opening phase (Pr18) also changes, but without statistically significant differences. This is illustrated in figure 6.

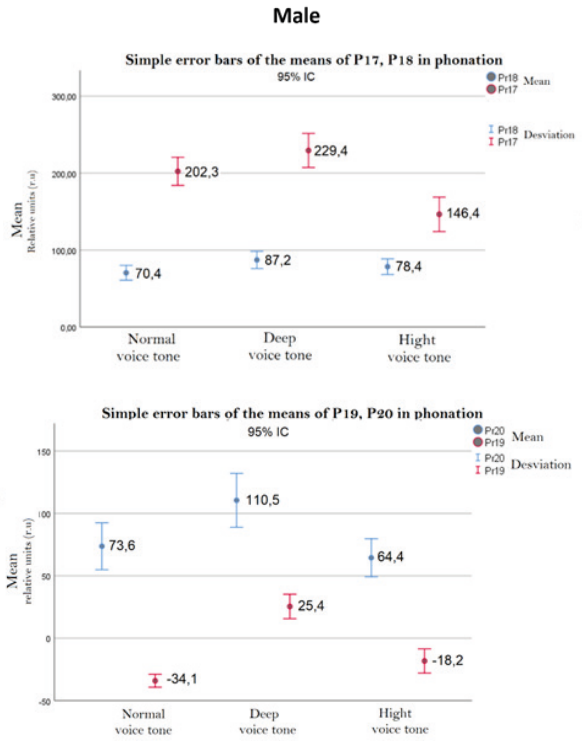


Figure 6: simple error bars for P017, P018, P019 and P020 in natural phonation, low and high tones in males.

Similarly, in the female population of the study, statistically significant differences ($p < 0.001$) were shown in the properties of the free edge and the mucosal wave; with high tones its amplitude (Pr17) and the adequacy index in closed phase (Pr19) decrease; In the opening phase the amplitude (Pr18) and the opening adequacy index (Pr20) are high. In low tones the amplitude (Pr17-Pr18) increases in all its phases; the adequacy index in opening increases (Pr20); and decreases in the closing phase (Pr19). (Figure 7).

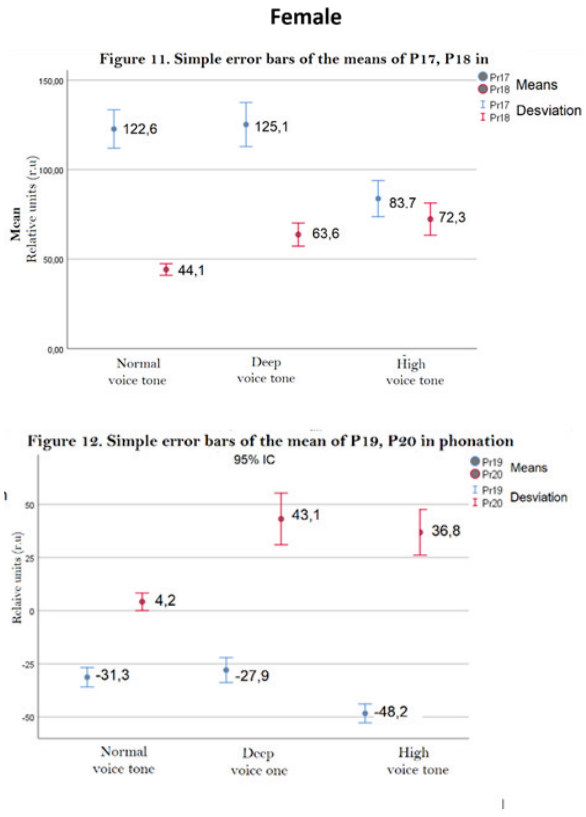


Figure 7: simple error bars for P017, P018, P019 and P020 in natural, low and high pitch phonation in the female study population

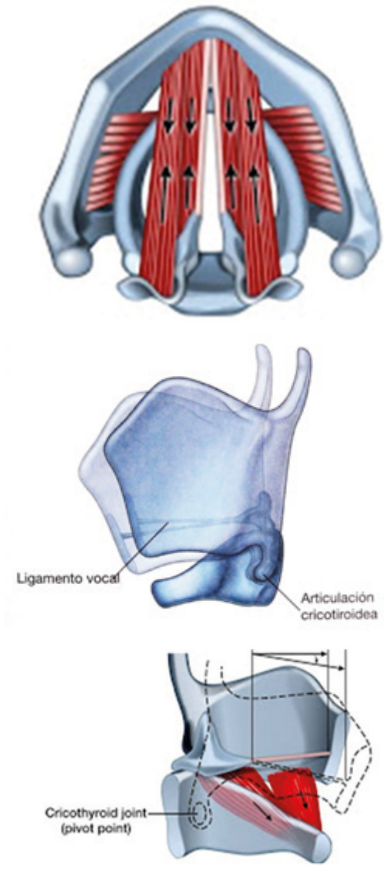


Figure 8: Muscles that modify the length of the vocal cords

High-pitched phonation modifies the biomechanical properties of the free edge and reduces the mucosal wave amplitude. In low tones it produces, regardless of sex, an increase in the mucosal wave effect. Finally, the amplitude of the mucosal wave in the opening phase also shows higher values in the male group than in the female group for all types of phonation. [4-6].

Due to the interaction of several elements; sex, age, airflow, laryngeal musculature and vocal fold composition; the phenomena that characterize the human voice will occur. The frequency is inversely proportional to the volume and length of the vocal cord, it is related to age, sex, and laryngeal muscles (Fig 8); It is directly proportional to its tension and rigidity. With the increase in the speed of vibration in the vocal cords; the amplitude of the mucosal wave decreases; and vice versa.[6]

CONCLUSIONS

It is important to find evaluation methods and tools that allow us to evaluate the mucosal wave objectively and reliably. Biomechanical analysis of the voice has demonstrated its effectiveness in identifying the changes observed in the mucosal wave effect and derived from the modification of the phonatory pattern. A broader understanding of the dynamics and behavior of the mucosal wave complements the diagnosis, and will help to more accurately characterize the voice pathology and guide towards more effective treatment.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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