

Acoustic and auditory-perceptual analyses of voice before and after speech-language therapy in patients with mutational falsetto

Análises perceptivo-auditiva e acústica da voz nos momentos pré e pós fonoterapia de pacientes com falsete mutacional

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ABSTRACT

The most common mutational voice disorder is the mutational falsetto. The voices of four young male patients with mutational falsetto were acoustically and auditory-perceptively analyzed in pre- and post-therapy situations to verify the result of speech-language intervention. For data collection, the patients were asked to say the days of the week. Four speech-language pathologists performed auditory assessment of these emissions using auditory-perceptual parameters: overall grade of dysphonia, roughness, breathiness, strain, instability, and pitch. The emissions of each patient corresponding to pre- and post-therapy were randomly presented to the evaluators, who did not have prior knowledge of the condition being analyzed. The assessment was performed by comparison, and the evaluators should inform whether the second emission was better, worse or unchanged when compared to the first. When change was observed, they should select three auditory-perceptual parameters regarding the expressive modification. The evaluators were informed only about subjects' age and gender. Mean, maximum and minimum fundamental frequencies were extracted from each emission of the patients using the Praat Program (version 5132). Semitone values were also extracted and analyzed. Data was statistically analyzed. In the post-therapy condition, the evaluators found an improvement in the vocal quality of all patients, as well as a decrease in the mean, minimum and maximum fundamental frequencies and in the semitones, resulting in a deeper and more stable vocal pattern.

Keywords: Speech acoustics; Dysphonia; Speech therapy; Voice; Voice disorders

INTRODUCTION

Voice production is an innate neurophysiologic function of sophisticated muscle processing with psychological manifestations. Due to its flexibility, voice works as sensible indicator

of the speaker's emotions, attitudes, physical conditions, and socio-cultural role⁽¹⁾.

Voice development follows the individual's physical and emotional development. Vocal changes during puberty are one of the most important milestones in passing from childhood to adulthood, especially to men, being recognized as physiological voice mutation or vocal mutation⁽²⁾.

During voice mutation the larynx goes through deep modifications. In men, at around 13 years old, vocal folds suffer a pronounced growth, doubling in size. As a result, voice decreases one octave, and the adult voice is established. In women, this growth is less significant, and voice decreases only two to three notes around 12 to 14 years old^(2,3). These changes, along with all the other secondary sexual characteristics, allow the differentiation of gender through voice, something that do not occur during childhood⁽³⁾.

When these characteristic puberty changes occur, a functional adjustment to the new anatomic conditions is necessary, which is translated in the mean decrease of fundamental frequency, an adjustment that takes from a few months to a year to occur. The boy's voice may become mildly rough, weak

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and unstable, with some variations and bitonality, but tending to low sounds⁽³⁾.

However, when vocal mutation is not correctly processed or when it is not adequately complete, a mutational dysphonia or puberphonia occurs. The cause is rarely organic, and it is usually part of the psycho-emotional sphere^(2,3).

Mutational dysphonia may be didactically classified into: prolonged, incomplete, excessive, premature, retarded, and mutational falsetto⁽²⁾. Among them, the mutational falsetto is considered the most frequent, representing 2% of the functional dysphonias⁽³⁾.

The voice observed in mutational falsetto dysphonia is high pitched up to two octaves higher than the expected fundamental frequency, with veiled vocal quality and poor harmonics. Bitonality and/or breathiness can also occur, with reduced vocal intensity and quickly achieved vocal fatigue^(2,3).

An excessively high pitched voice may constitute a true social and professional problem, mainly observed in male individuals⁽⁴⁾. Voice control is an essential component of a person's ability to adjust to social situations. When the voice is altered, feelings of insecurity and inadequacy may emerge⁽⁵⁾.

Speech-language therapy is the elected approach to treat mutational dysphonia, except for the cases with organic etiology, that will undergo approaches that are specific to the situation, or when speech-language therapy is not successful in this type of dysphonia⁽⁴⁾.

Speech-language therapy in these cases has the purpose to deactivate the infantile functional adjustment and to obtain muscular balance that provides a stable emission, with notes passing without breaks or irregularities, as well as to establish a fundamental frequency within the expected normality range according to the individual's gender and age. Speech-language therapy must focus the establishment of an effective communication, especially regarding vocal behavior and the psychodynamics of the communication process^(2,5).

Considering the low prevalence of mutational falsetto dysphonia⁽³⁾, case reports are important to obtain a higher number of researches analyzing the results of speech-language intervention in these individuals, helping the elaboration of treatment protocols for this type of dysphonia.

The purpose of the present study is to present the auditory-perceptual and acoustic results of the voices of youngsters with mutational falsetto, in pre and post speech-language therapy.

CLINICAL CASE PRESENTATION

Participants were four young male subjects, identified as P1 (18 years old), P2 (19 years old), P3 (20 years old), and P4 (22 years old). All patients were treated by the same speech-language pathologist (SLP) in a private practice, during the period from January 2007 and December 2008. The inclusion criteria were: to have speech-language pathology diagnosis of functional dysphonia caused by mutational falsetto, and normal results on the larynx assessment performed by an otorhinolaryngologist. All participants signed the Free and Informed Consent Term, agreeing with their participation in this research and with the publication of its results, according

to the Resolution 196/96. The study was approved by the Research Ethics Committee of the Universidade Federal de Minas Gerais (UFMG), under protocol number ETIC 203/09.

The pre- and post-intervention vocal emissions of the participants were analyzed. The speech-language therapy involved: a) voice psychodynamics – with the purpose to develop awareness regarding the communication patterns; b) pitch adjustment – using the digital laryngeal manipulation technique, the method of facilitating sounds in descending scales, and the “b” prolonged technique; c) improvement of overall voice pattern – using the nasal sounds and the over articulation techniques. The number of speech-language pathology sessions carried out with each participant was one (P1), five (P2), four (P3), and 10 (P5).

The first recording was conducted at the first consultation, and the second, on the discharge session. Subjects were required to say the days of the week using habitual vocal frequency and intensity. It was used a stereo omnidirectional condenser microphone, sensitivity of -20 dB, from Equitek® E-100, connected to a electricity source (Phanton Power) of a mixer table Mackie 1202 VLZ-12 channels. Participants were standing in their feet, with the microphone placed 10 cm from their mouths and with a directional uptake angle of 90°, away from the body and from the recording unity to avoid the caption of machine noise.

Recordings were conducted in a silent room, with noise lower than 50 dB NPS, controlled by a Radio Shack® (cat. N. 33-2055) sound pressure level meter.

Connected speech recording used an IBM PC Aptiva E30PTM, AMD – K6 – 2/500 MHz processor, 128 mega bits RAM memory, rigid disk of 8.4 gigabytes, Crystal Sound Fusion sound card™; the PRAAT software was used.

For each participant (P1 to P4), the acoustic measures were extracted from each emission (day of the week), therefore, it was obtained 14 values of each measure, seven pre-intervention and seven after speech-language therapy discharge. A total of 28 pre-treatment and 28 post-treatment emissions were analyzed from all four patients.

It was extracted the mean fundamental frequency (f0) in Hz, the minimum f0, the maximum f0, and the number of semitones. The mean f0 was automatically obtained, and the minimum and maximum f0 were manually extracted by visual inspection of the higher and lower frequency curve, as observed in Figure 1. To obtain the semitone values, it was used the minimum and maximum fundamental frequency values in the software found in the electronic address <http://users.utu.fi/jyrtuoma/speech/semitone.html>, which calculate the distance between frequencies in semitone values.

Auditory-perceptual analysis was conducted using the following parameters: overall grade of dysphonia (G), roughness (R), breathiness (B), strain (S), instability (I), and pitch.

Auditory-perceptual analysis was carried out independently by four speech-language therapists with voice expertise, who received auditory training with the purpose to standardize the auditory-perceptual concepts considered in the analysis. This training comprised the concept identification and the exemplification of each parameter to be analyzed, using another voice data basis.

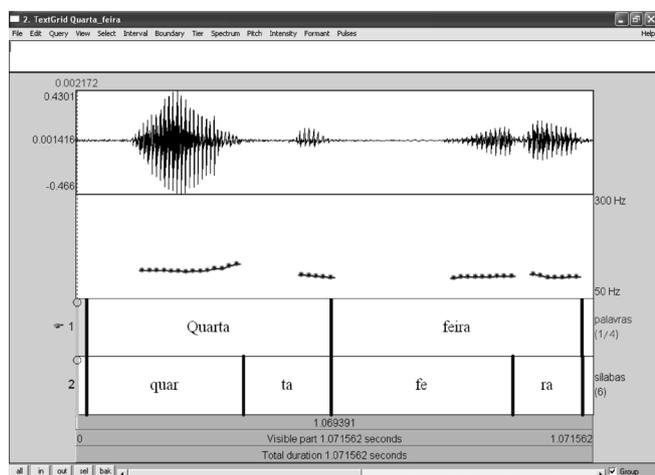


Figure 1. PRAAT software screen

For the auditory-perceptual voice assessment, the emissions of each patient were presented in pairs, in random order of register (pre- and post-speech therapy). The assessment was performed by comparison, and the evaluators should state whether the second emission was better, worse or without any change regarding the first emission. When alterations were evident, the evaluators should mark three parameters in which the improvement was expressive. The age and gender of the patients were previously informed to all evaluators.

Twenty percent of the voice emissions were repeated to test the intra-evaluator agreement, and it was verified 100% of agreement for each of the four speech-language therapists.

Statistical analysis used the statistical software SPSS (Statistical Package for the Social Sciences), version 17.0. First, a descriptive analysis of the data was conducted, using measures of central tendency and dispersion. After that, the non-parametric test for paired samples (Wilcoxon) was used to verify the existence of differences between pre- and post-intervention mean, minimum and maximum fundamental frequencies, and semitones, considering the significance level of 5%.

In the auditory-perceptual analysis the evaluators considered that there was improvement in the parameter G of all the participants (100%) in the post-intervention condition.

Table 1 shows that the overall grade of dysphonia (G) (100%), the pitch (100%), and the vocal instability (I) (56.25%) were the vocal parameters that most improved after speech-language therapy, demonstrating that there was an overall improvement in voice quality, the pitch was lower, and the

Table 1. Occurrence of auditory-perceptual parameters indicated as better after speech-language therapy

Evaluators	Parâmetros perceptivo-auditivos					
	G	R	B	S	Pitch	I
1	4	0	1	1	4	2
2	4	2	2	1	4	3
3	4	0	0	0	4	4
4	4	2	1	2	4	0
Total (%)	100	25	25	25	100	56.25

Note: G = overall grade; R = roughness; B = breathiness; S = strain; I = instability

voice was more stable. The other parameters – roughness (R), breathiness (B), and strain (S) – presented mild improvement (25%) in the evaluators’ opinion.

Table 2 presents the values of mean, minimum, and maximum fundamental frequencies (Hz) in the pre- and post-therapy conditions, and its variation in semitones (st). All the analyzed voices had their fundamental frequency and semitone values significantly decreased after speech-language therapy, with lower-pitched emissions and lower variability.

DISCUSSION

Voice assessment involves several procedures with the purpose to get to know the vocal behavior of an individual, identifying the possible causes that triggered and maintain the dysphonia⁽³⁾.

In this research, the intra-evaluator agreement regarding the auditory-perceptual parameters was 100%, indicating high intra-evaluator agreement to most of the auditory-perceptual characteristics. It is possible that the auditory-perceptual analysis, in this research, was an easy task, because it used specific auditory-perceptive parameters proposed by the researchers, since the literature points out better performance of evaluator in perceptual analysis specific parameters are used⁽⁶⁾. Moreover, the comparison task, when analyzing treatment results, helps the auditory analysis of the vocal modifications that occurred after speech-language intervention⁽⁶⁾.

The speech-language therapy of the four patients presented in this study varied in duration from one to ten weekly sessions. This variation in the number of sessions might be due to the patients showing different levels of vocal plasticity, which may have interfered on the time needed to reach the functional balance of voice. All the participants were followed by the same

Tabela 2. Valores da frequência fundamental média, mínima e máxima (Hz) pré e pós tratamento e sua variação em semitons (st)

	Mean F ₀		Minimum F ₀		Maximum F ₀		Semitones	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
n	28	28	28	28	28	28	28	28
Mean	222.4	120.9	202.1	114.9	253.5	131.2	3.9	2.6
SD	61.5	9.6	58.7	10.9	69.0	13.4	3.3	2.5
p-value	0.000*		0.000*		0.000		0.019*	

* Significant values (p<0.05) – Wilcoxon test

Note: F₀ = fundamental frequency; SD = standard deviation

professional, which assured higher standard in the therapeutic approach. Subject P1 was followed for only one session, because he lived in another city and, therefore, could not attend more sessions. It is worth mentioning that his analyzed voice corresponded to the beginning and the end of the same session. The therapist made telephone contact with the patient 15 days after discharge and he kept a stable emission.

According to the results found, all patients obtained a better voice standard after therapy. These findings agree with literature that indicates speech-language therapy as the elected approach to treat mutational dysphonia, showing good results in the improvement of patients' voices^(3,7-10).

With regards to auditory-perceptual analysis, the overall grade of dysphonia (G) improved in all the participants after intervention, corroborating other studies⁽⁷⁻⁹⁾.

The pitch parameter was different in pre- and post-therapy conditions, in all analyzed voices, and it was a distinguishing factor. Literature data corroborates this finding, describing decrease in pitch after speech-language therapy in these cases^(7,8). Researchers have assessed the voice of a male teenager with diagnosis of mutational falsetto, and found improvement in vocal quality with decrease in pitch on the auditory-perceptual analysis⁽⁸⁾.

In the present study, we found improvement on the vocal instability parameter (I) in 56.25% of the analyzed voices (Table 1). Literature indicates vocal instability as one of the more important factors in the period of voice mutation^(2,3), resulting, in part, from the lack of control of the longitudinal tension of vocal folds, regulated by the cricothyroid muscle due to the growth of larynx, vocal folds and breathing organs during puberty^(2,3,8).

Results suggest that subjects' vocal quality in the post-therapy condition is more stable, probably due to better placing of the larynx in the neck and consequent muscle synergy, also generating a lower pitch.

The parameters roughness (R), breathiness (B), and strain (S) also presented improvement after treatment, but with lower frequency.

Table 2 presents the pre- and post-intervention f0 values, as well as its variance in semitones (st). Results show that all patients had a decrease in the mean, maximum, and minimum fundamental frequency values, characterizing lower emissions. This result is correlated to the auditory-perceptual analysis in this study, with presence of lower pitch, which agrees with literature results⁽⁷⁻¹⁰⁾.

A study with ten teenagers with mutational falsetto in pre- and post-therapy conditions showed mean f0 values of 221 Hz and 119 Hz, respectively. These values are very close to those found in this research (222.4 Hz and 120.9 Hz)⁽⁹⁾.

Researchers⁽¹⁰⁾ acoustically analyzed the voices of 15 individuals with mutational dysphonia in pre- and post-therapy conditions, and verified vocal quality improvement and decrease of f0 after therapy. Another study⁽⁸⁾ was conducted with 45 subjects and, after six months of therapy, there was significant differences in f0 values, comparing pre- and post-intervention, with decrease of f0 in all patients.

Changes in fundamental frequency due to mutational falsetto dysphonia may lead to alterations in voice range. Voice

range is the number of notes used with pleasant vocal quality to the listener without generating fatigue to the speaker, corresponding to approximately one third of the maximum phonation range⁽³⁾. In phonetic studies, voice range is a measure extracted from the f0 that might be defined as "the speaker's melodic scale, the limits of higher and lower f0 during usual speech"⁽¹¹⁾. Voice range, as well as intonation, accent, rhythm, vocal quality, and temporal organization, are prosodic elements which acoustic correlates are fundamental frequency, intensity, and time. Therefore, prosody is the syntagmatic arrangement of these parameters⁽¹²⁾.

In this research it was observed decrease in semitone values after therapy. We could not find a research with similar methodological design to compare. It is worth mentioning that these results represent the *corpus* of this research; future studies analyzing spontaneous speech of subjects with mutational falsetto dysphonia are important to understand the behavior of these measures in this kind of situation.

A study have used the counting from 20 to one to analyze the Speech Range Profile (SRP) of 86 subjects divided into three groups: 38 in the control group, 25 in the behavioral dysphonia group, and 23 in the neurologic dysphonia group⁽¹³⁾. The authors found semitone values of 8.49 st for the control group and 14.83 st for the dysphonic group, and explained these findings by the fact that dysphonia influences the standards of vocal stability and flexibility. The semitone values found in this research are lower to those presented in literature⁽¹³⁾, probably due to methodological aspects coming from the voice sample and the voice analysis software.

It is possible to suggest that some types of dysphonia, such as in patients with hypokinetic dysarthria, speech-language therapy promotes higher muscle flexibility and consequent increase in voice range; however, since mutational falsetto is characterized by unstable voice quality^(2,3), the vocal result after speech-language therapy is a lower range, since it might have favored a better muscle balance and adjusted the placement of larynx in the neck.

As psychic determinants are strongly present in adolescence, Speech-Language Pathology has an important role in this phase with regards to the vocal stability of the individual related to the integrality of his quality of life^(14,15).

With this case report, we expect to add more information regarding auditory-perceptual and acoustic aspects in individuals with mutational falsetto dysphonia and the possibilities of changes in these aspects with speech-language therapy.

Speech-language therapy was the elected approach to the cases described and provided, in a short period of time, a more stable emission, compatible with the physical and emotional characteristics of the studied participants.

Further studies analyzing self-perception of voice using assessment protocols are important to a multidimensional analysis, evaluating the impact of dysphonia on the quality of life of these individuals.

FINAL CONSIDERATIONS

Patients in this study presented improvement on the overall grade of dysphonia, lower pitch and higher vocal stability after

speech-language intervention, in addition to decrease in the fundamental frequency and semitone values. Research data

emphasize the effectiveness of speech-language therapy in a short period of time for cases of mutational falsetto dysphonia.

RESUMO

A disfonia da muda vocal mais comum é o falsete mutacional. Foram analisadas de forma perceptivo-auditiva e acústica as vozes de quatro jovens do gênero masculino com falsete mutacional nas situações pré e pós fonoterapia para apresentar o resultado da intervenção fonoaudiológica. Para coleta dos dados foi solicitado que os pacientes falassem os dias da semana. Quatro fonoaudiólogas avaliaram auditivamente tais emissões por meio dos parâmetros perceptivo-auditivos: grau geral da disfonia, rugosidade, sopro, tensão, instabilidade e *pitch*. As emissões de cada paciente correspondentes aos momentos pré e pós fonoterapia foram apresentadas aos avaliadores aleatoriamente, e os avaliadores não tinham conhecimento prévio da condição da voz analisada (pré ou pós tratamento). A avaliação foi realizada por comparação e os avaliadores deveriam informar se a segunda emissão era melhor, pior ou sem modificação em relação à primeira. Quando houve modificação, deveriam selecionar três parâmetros perceptivo-auditivos referentes à mudança expressiva. Foi informado aos avaliadores somente a idade e o gênero dos pacientes. A frequência fundamental média, assim como a máxima e a mínima foram extraídas de cada emissão dos pacientes utilizando-se o Programa Praat (versão 5132). Foram extraídos e analisados, ainda, os valores de semitom. Os dados foram analisados estatisticamente. Na condição pós fonoterapia os avaliadores consideraram que houve melhora na qualidade vocal de todos os pacientes e foi observada diminuição dos valores da frequência fundamental média, mínima e máxima e nos semitons resultando em um padrão vocal mais grave e estável.

Descritores: Acústica da fala; Disfonia; Fonoterapia; Voz; Distúrbios da voz

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