FINGER KAZOO: SPECTROGRAPHIC ACOUSTIC MODIFICATIONS AND VOCAL SELF-ASSESSMENT

Finger kazoo: *modificações vocais acústicas espectrográficas e autoavaliação vocal*

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ABSTRACT

Purpose: to correlate the spectrographic vocal modifications and self-evaluation after finger kazoo. **Methods:** visual spectrographic analysis of the vowel /a:/ of 46 adult women, without vocal complaints or laryngeal alterations and self-evaluation before (Moment 1 – M1), after *finger kazoo* (M2) and after five minutes of silence (M3). Kappa, Chi-square and Spearman tests. The parameter for improving the voice was the statistical significance of the results after the finger kazoo. **Results:** improvement of darkening tracing of the formant (F) and high frequencies, of tracing regularity and definition of the harmonics. Best voice self-reported as increasing of intensity of the tracing darkening of F3, improvement of tracing definition and number of harmonic and replacement of harmonics with noise in medium frequencies. **Conclusions:** after the *finger kazoo*, there was an increase of darkening, regularity and definition of the spectrographic tracing and best voice self-reported.

KEYWORDS: Voice; Phonation; Rehabilitation; Speech Acoustics

INTRODUCTION

The nonlinear theory of voice production suggests that the vocal tract, in addition to exercising filter function of the sound produced in the glottal source, also acts as a modifier of the patterns of vocal fold vibration by modifying the acoustic impedance. Thus there is a biofeedback between filter and source, promoting the influence of the filter on the source [1-4]

Voice therapy is indicated for patients with voice disorders at both the source and at filter level (resonance), as for those who wish to improve voice[4-8]. The semi-occluded vocal tract exercises (SOVTE), category in which is included the finger kazoo (FK) technique, have been widely used as features in speech therapy and voice Improvement[2,3,9,10].

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In these cases, the Speech therapist is the professional that possesses the capacity to act in the vocal rehabilitation and improvement. Because of this, it is a must to have the anatomic and physiologic knowledge of the phonation system, besides its acoustic, aerodynamics and correlation among emotive estates and neurological conditions with the voice, as well as having mastered the techniques which comprise all the phonation process[11-13].

Due to technological advances in laryngology and the availability of modern tools for voice assessment and the verification of the effects of various vocal techniques, studies regarding voice have shown a progress in an attempt to deepen their understanding and thus increase the effectiveness of speech-language intervention[2,8,13-15]. However, some vocal techniques have not yet presented sufficient evidence of its effects, making it critical to perform studies like this that seeks to describe the vocal changes after FK.

The spectrograms analysis is one way to check the effect of vocal techniques [6,13-15]. This analysis provides data that are related to the vibratory pattern of the vocal folds, the shape of the vocal tract and their changes in time, and their interpretation varies with age, sex, type of phonation and vocal training [5,16,17]. It becomes also important, the studies of self-assessment of the voice of the subjects after performing the voice techniques [2,14], which have considered the point of view of the patient about his voice, contributing more generally to the understanding of the effects of vocal techniques.

Thus, the present study's aim was to correlate the spectrography acoustic vocal modifications and the vocal self-evaluation occurred immediately after the execution of the FK phonotherapeutic technique and after five minutes of absolute silence in female adults without vocal complaints and without laryngeal disorders.

METHODS

The research was characterized for being an analytical cross-sectional observational study of a quantitative nature, approved by the Ethics Committee of Research of the home institution (016945/2010-76). Participants received the necessary clarifications about the study and signed the Statement of Informed Consent (IC), as recommended by the standard 196/96 of The National Commission of Ethics in Research.

Inclusion and exclusion criteria

The target population was composed of individuals who sought the voice sector of a clinical school of speech-language pathologist for performing vocal improvement during the period June 2010 to June 2011. Inclusion criteria: IC signature, females, since the literature shows a greater number of studies with this population [2,13,15,18-21]; ages between 18 and 40 years, because it comprises an age range free from hormonal and structural changes during the period of vocal change or aging[8,13,15,20-22]; complete glottic closure or presence of a triangular slit after the otorhinolaryngological exam, for representing the female laryngeal standard with no negative impact on the voice[5,23].

Exclusion criteria: vocal complaints, since this may signal some kind of organic or functional voice disorder[5,7,8,13,15,21,23]; medical diagnosis of laryngeal disorders[5,7,8,13,15,18,23]; history of neurological, endocrinological, psychiatric, gastric or respiratory diseases that could influence the vocal performance or understanding of the orders for the performed procedures[4,5,7,8,13,15,23]; reports of hormonal changes, such as those typical of pregnancy, menstrual or premenstrual period; being with a flu and/or with respiratory allergies, because they can cause vocal fold oedema[13,15], or any another disease that could limit the performance of the FK technique implementation during the day of evaluations; alcoholism and smoking habits, which are aggressive to the larynx, and can generate laryngeal disorders[2,5,8,13,15,18,21,23]; have done speech-language and/or otorhinolaryngological therapy to rule out the possibility that the individual had any laryngeal disorder (even already treated) or vocal habituation due to treatment or training, knowledge of the studied vocal technique; hearing loss by interfering in the voice self-monitoring[5,8,13,15,20,23,24] changes in the stomatognathic system that could interfere in the implementation of the technique or in vocal assessment[5,7,8,13,15,20]; inability to perform the FK technique; being a singer or singing in choirs regularly (at least once a week) in order to avoid the individual already had notions of vocal techniques or had his voice trained[13,15].

An interview was carried out covering some inclusion and exclusion criteria. After that, the individuals performed a visual inspection of the larynx with an otorhinolaryngologist for the application of an exclusion criterion based on the presence of laryngeal disorders[5,7,8,13,18,23]. It was also carried out an evaluation of the stomatognathic system and its functions, to exclude individuals with any disorder that could jeopardize the implementation of the FK technique[5,7,8,13,20], as well as a hearing screening test, through the scanning of the 500, 1000, 2000, 4000 25 dB frequencies by air in an acoustically treated booth (*Fonix* audiometer, FA 12 Digital) [5,8,13,20,23,24].

Subjects studied

Of the 58 volunteers, in the interview, one was excluded for being in the menstrual period on the day of evaluations, one for being a singer, and two for being male. During the othorrinolaringological evaluation, one was excluded for the presence of an oedema in the vocal folds, one for the presence of microweb, one for the presence of a vocal fold sulcus, and one for vocal nodules. During the hearing screening, one was excluded for reduction of hearing; and three were excluded because they did not perform all stages of selection. Thus, the sample was formed by 46 adult women, aged between 18 and 39 years (average 23,2 years), blinded in respect to the research objectives.

Procedures for data collection

During data collection, it was requested to each individual, in the orthostatic position to issue the vowel /a:/ [5,6,8,10,12,13,15-17,21,22,25,26]. Emissions were captured with a microphone (stereo condenser, unidirectional, 96KHz, 16 bit, 50% of the input recording level), coupled to a professional digital recorder (Zoom, H4n), which was set on a pedestal and positioned at 90º and positioned at a distance of four centimetres between the microphone and the mouth[12,13,15,21,22,26]. Data was collected in an acoustically treated room, with ambient noise below 50dB sound pressure level, as measured by sound pressure meter Instrutherm, Dec-480[5,6,22,26,27].

The emission of the vowel /a:/ and the technical repetitions of FK were performed in Maximum Phonation Time (MPT), as the MPT represents the capacity of individual resistance of the individual due to the interaction of breathing, phonation and resonance levels which vary from individual to individual[3,15,21].

Thereafter, the individuals produced three series of 15 replications of the FK technique, so that each technique emission was done in MPT and was considered a repetition[11,13-15,21].

For the production of FK, it must produce a breath sound, with the lips rounded and protruded, as in the emission of /u:/, with no variation in pitch and loudness, without inflating the cheeks, with the tongue relaxed and lowered, while the index finger should remain vertically positioned on the lips, with the same gesture used to ask for silence, touching them lightly, but without pressing them. During this production, it should be heard a secondary sound, as a friction, corresponding to the flow of air in contact with the index finger [2,28].

The technique was performed with each individual seated comfortably, without cervical dislocation, with an angle of 90° between the chin and the neck and with no increase in muscle contraction of the shoulder girdle and suprahyoid region, with feet flat on the floor, back straight, keeping a constant rhythm between one exercise and another without making use of the expiratory reserve. Although, they should make use of the costodiaphragmatic-abdominal breathing and avoid the fluctuation or variability of pitch and loudness. A speech therapyst visually monitored those aspects[5,7,12,13].

The technique was explained, demonstrated and monitored by a speech therapyst (the same with all participants), that verified if each individual presented conditions for the implementation according to the model, by making the necessary corrections so that all individuals perform the technique correctly and in a similar way[2,12,14,21].

After each set of FK technique, there was a passive rest for 30 seconds, during which the individuals sat in complete silence[5,11,13-15,21]. During the technique, performance it was allowed to ingest 250 ml of water [29], without this being considered as an intervening variable in the results, since the literature indicates the intake of water from two to three hours before a vocal performance, because the hydration occurs in a systemic way, and the ingested water takes hours to reach the larynx [5].

Immediately upon completion of the technical series, prior to any another emission, the individuals had the vowel /a:/ taken on the same pre-technical conditions. Shortly they answered to an enclosed questionnaire of self-evaluation on the global effect of FK technique, in which they should mark on one of three options: “better voice”, “equal voice” or “worse voice”. It was considered the first emission, prior to the technique, as a base for self-judgement [4,30,31]. After five minutes after the execution of the FK technique, during which the individual remained seated and in complete silence the individuals had the vowel /a:/ taken on the same pre-technical conditions /a:/ and the same questionnaire was completed[2,32].

Procedures for the analysis of collected data

For the acoustic analysis of voice, it was eliminated the vocal attack from the vowel /a:/ and the end of utterance for those excerpts not to alter the signal analysis, since the end of extended emissions typically show amplitude and frequency decreases. From this edition, it was standardized the interval of four seconds for the analysis window (corresponding to the shortest edited time of all vowel supports done by the group) [2,5,13,15-17,25].

For the spectographies, it was used the Real Time Spectrogram program from Kay Pentax®, installed in a computer that was adequated to all manufacturer’s specifications in a bandwidth filter of 100 points (646,00Hz) and in a narrowband filter of 1024 points (63,09Hz), with a sampling rate of 11KHz e 16bits in the resolution of 5KHz, and the results were compared with the literature[6,13,14,33,34].

In the bandwidth spectrography (SBW), the formants (F) were visually classified according to the following aspects: the tracing darkening of the F (F1, F2, F3 and F4); tracing darkening of the high-frequency tracing; tracing darkening all over the voice spectrogram; presence of noise all over the voice spectrogram, as well as in high, medium and low frequencies, F bandwidth; tracing definition of F; tracing regularity[6,8,13-15,26,33,35].

In the narrowband spectrography SNB, there were considered the following aspects visually classified: stroke color in high frequencies, the stroke color all over the voice spectrogram, the presence of noise between the harmonics all over the voice spectrogram, as well as in high, medium and low frequencies, replacement of harmonics with noise all over the voice spectrogram as well as in high, medium and low frequencies, tracing definition of harmonics, tracing regularity, presence of sub-harmonics, and number of harmonics[6,8,13-15,26,33,35].

In the evaluation of stroke color of (of F, in high frequencies and all over the spectrogram) it was considered the level of stroke color, which can vary from black (strong stroke color) to pale grey (weak stroke color)[6] and could be classified into more intense (improvement), less intense (worsening) or no change. The noise is presented in the spectrogram as a shaded or dotted image, according to the degree of darkening of the shading / dithering, it could be classified as decreased (improvement), increased (worsened) or no changes[6,35]. The F bandwidth could be classified into wider (improvement), less wide (worsening) or no change. The F and the tracing definition of harmonics was evaluated according to their visibility, demarcation and symmetry, defined as more (improvement), less definite (worsening) or no change. The tracing regularity is related to its continuity and stability and could be classified into more regular (improvement), less regular (worsening) or no changes[6].

The spectrographic analysis was performed individually by three speech therapysts with experience and a master degree in the voice area, they were not the study's authors, they were blinded with respect to research objectives, to the technique used, to the identification of individuals at the time of evaluation, to the replication of emissions, as well as to the evaluation of the other judges, being only informed that the voices belonged to adult women[6,13,21,22,30].

The SBW and SNB of the three moments of the vowel /a:/ emission prior to the technique performing (Moment 1 – M1), immediately after the technique (Moment 2 – M2), five minutes after the technique (Moment – M3) of each individual were paired for the comparative assessment of the judges, which would analyze the latter relative to the first. So, three pairs were formed for each individual (pair M1-M2, pair M1-M3 and pair M2-M3), but were coded and randomized for the judges to be unaware of the different moments of emissions [6,31].

There were replicated 20% of the spectographies pairs, without the knowledge of the judges, for further statistical analysis of ratings reliability [30,35]. Thus, there were evaluated 138 pairs and more than 30 replicates, totalling 168 pairs evaluated by each of the judges.

Subsequently, it was performed the Kappa coefficient calculation to verify the intra-rater[12,22] showing values of 0,57; 0,49; and 0,53 respectively for each of the three judges. The inter-eater reliability among three judges was of 0,2, considering: 0,6 and 0,79, good; 0,4 and 0,59, moderated; 0,2 and 0,39, regular; between zero and 0,19, poor; between zero and –1, no reliability[22,35]. For the survey results, there were considered the predominant answers in the assessors' judgements[12,22].

After tabulating the data, it was applied the Chi-square test to assess the significance of the results of vocal self-evaluation and of SBW and SNB between the pair M1-M2, M1-M3 and M2-M3. It was applied the correlation test of Spearman to check the correlation between vocal self- evaluation and the parameters evaluated in the SBW and in the SNB. For all tests, it was considered the significance level of 5% (p <0.05).

RESULTS

Table 1 shows the result of vocal self-assessment performed by the subjects.

2, 3, 4, 5, 6, and 7 are indicated changes observed through the analysis of SBW and SNB comparing the three stages involved in making the FK.

Tables 8 and 9 show the correlations between vocal self-assessment and SBW and SNB.

Table 1 – Vocal self-evaluation on the global effect of FK technique

M1XM2 n (%)				M1XM3 n (%)			
Better voice	Worse Voice	Equal voice	p- value	Better voice	Worse Voice	Equal voice	p- value
40(86,96)	2 (4,35)	4 (8,70)	0,0001*	37(80,43)	2 (4,35)	7(15,22)	0,0001*

Chi Squared Test
* Statistically significant values (p<0,05)
M1- moment 1
M2- moment 2
M3- moment 3

Table 2 – Acoustic vocal modifications in bandwidth spectrography between M1xM2

		M1XM2			
		Worsening n (%)	No change n (%)	Improvement n (%)	p-value
Stroke color of F	F1	9 (19,57)	15 (32,61)	22 (47,83)	0,063
	F2	7 (15,22)	18 (39,13)	21 (45,65)	0,028*
	F3	8 (17,39)	14 (30,43)	24 (52,17)	0,014*
	F4	7 (15,22)	15 (32,61)	24 (52,17)	0,008*
	Stroke color of high frequencies	10 (21,74)	9 (19,57)	27 (58,70)	0,001*
	Stroke color all over the voice spectrogram	10 (21,74)	11 (23,91)	25 (54,35)	0,010*
Presence of noise	All over the voice spectrogram	17 (36,96)	18 (39,13)	11 (23,91)	0,392
	In high frequencies	16 (34,78)	23 (50,00)	7(15,22)	0,015*
	In medium frequencies	9 (19,57)	24 (52,17)	13 (28,26)	0,019*
	In low frequencies	4 (8,70)	39 (84,78)	3 (6,52)	0,000*
Tracing definition of F	F1	5 (10,87)	28 (60,87)	13 (28,26)	0,000*
	F2	10 (21,74)	11 (23,91)	25 (54,35)	0,010*
	F3	10 (21,74)	14 (30,43)	22 (47,82)	0,000*
	F4	10 (21,74)	16 (34,78)	20 (43,48)	0,191
Tracing regularity		11 (23,91)	10 (21,74)	25 (54,35)	0,010*

Chi Squared Test
* Statistically significant values ($p<0,05$)
M1- moment 1
M2- moment 2

Table 3 – Acoustic vocal modifications in bandwidth spectrography between M1 e M3

		M1XM3			
		Worsening n (%)	**No change n (%)**	**Improvement n (%)**	**p-value**
Stroke color of F	F1	7 (15,22)	15 (32,61)	24 (52,17)	0,008*
	F2	18 (39,13)	6 (13,04)	22 (47,83)	0,010*
	F3	10 (21,74)	11 (23,91)	25 (54,35)	0,010*
	F4	5 (10,87)	17 (36,96)	24 (52,17)	0,002*
	Stroke color of high frequencies	7 (15,22)	12 (26,09)	27 (58,70)	0,000*
	Stroke color all over the voice spectrogram	11 (23,91)	15 (32,61)	20 (43,48)	0,265
Presence of noise	All over the voice spectrogram	17 (36,96)	19 (41,30)	10 (21,74)	0,233
	In high frequencies	20 (43,48)	19 (41,30)	7 (15,22)	0,032*
	In medium frequencies	19 (41,30)	22 (47,83)	5 (10,87)	0,004*
	In low frequencies	9 (19,57)	34 (73,91)	3 (6,52)	0,000*
Tracing definition of F	F1	4 (8,70)	23 (50,00)	19 (41,30)	0,001*
	F2	17 (36,96)	9 (19,57)	20 (43,48)	0,121
	F3	14 (30,43)	7 (15,22)	25 (54,35)	0,004*
	F4	7 (15,22)	17 (36,96)	22 (47,83)	0,022*
Tracing regularity		20 (43,48)	6 (13,04)	20 (43,48)	0,140

Chi Squared Test
* Statistically significant values (p<0,05)
M1- moment 1
M3- moment 3

Table 4 – Acoustic vocal modifications in bandwidth spectrography between M2 e M3

		M2XM3			
		Worsening n (%)	**No change n (%)**	**Improvement n (%)**	**p-value**
Stroke color of F	F1	12 (26,09)	22 (47,83)	12 (26,09)	0,113
	F2	20 (43,48)	12 (26,09)	14 (30,43)	0,322
	F3	21 (45,65)	10 (21,74)	15 (32,61)	0,138
	F4	15 (32,61)	17 (36,96)	14 (30,43)	0,858
	Stroke color of high frequencies	17 (36,96)	16 (34,78)	13 (28,26)	0,753
	Stroke color all over the voice spectrogram	20 (43,48)	12 (26,09)	14 (30,43)	0,322
Presence of noise	All over the voice spectrogram	15 (32,61)	22 (47,83)	9 (19,57)	0,063
	In high frequencies	12 (26,09)	26 (56,52)	8 (17,39)	0,002*
	In medium frequencies	12 (26,09)	25 (54,35)	9 (19,57)	0,008*
	In low frequencies	5 (10,87)	38 (82,61)	3 (6,52)	0,000*
Tracing definition of F	F1	13 (28,26)	27 (58,70)	6 (13,04)	0,000*
	F2	22 (47,83)	12 (26,09)	12 (26,09)	0,113
	F3	21 (45,65)	13 (28,26)	12 (26,09)	0,204
	F4	21 (45,65)	13 (28,26)	12 (26,09)	0,204
Tracing regularity		23 (50,00)	10 (21,74)	13 (28.26)	0,048*

Chi Squared Test
* Statistically significant values (p<0,05)
M2- moment 2
M3- moment 3

Table 5 – Acoustic vocal modifications in narrowband spectrography between the pair M1 e M2

		M1XM2			
		Worsening n (%)	No change n (%)	Improvement n (%)	p-value
Stroke color of high frequencies		9 (19,57)	13 (28,26)	24 (52,17)	0,019*
Stroke color all over the voice spectrogram		8 (17,39)	17 (36,96)	21 (45,65)	0,055
Presence of noise	Between the harmonics	15 (32,61)	24 (52,17)	7 (15,22)	0,008*
	In high frequencies	15 (32,61)	25 (54,35)	6 (13,04)	0,002*
	In medium frequencies	15 (32,61)	22 (47,83)	9 (19,57)	0,063
	In low frequencies	8 (17,39)	32 (69,57)	6 (13,04)	0,000*
Replacement of harmonics with noise	All over the voice spectrogram	7 (15,22)	22 (47,83)	17 (36,96)	0,022
	In all frequencies	4 (8,70)	25 (54,35)	17 (36,96)	0,000*
	In medium frequencies	11 (23,91)	20 (43,48)	15 (32,61)	0,265
	In low frequencies	2 (4,35)	41 (89,13)	3 (6,52)	0,000*
Tracing definition of harmonics		12 (26,09)	9 (19,57)	25 (54,35)	0,008*
Tracing regularity		9 (19,57)	14 (30,43)	23 (50)	0,037*
Number of harmonics		15 (32,61)	9 (19,57)	22 (47,83)	0,063
Presence of sub-harmonics		2 (4,35)	40 (86,96)	4 (8,70)	0,000*

Chi Squared Test
* Statistically significant values (p<0,05)
M1- moment 1
M2- moment 2

Table 6 – Acoustic vocal modifications in narrowband spectrography between the pair M1 e M3

		M1XM3			
		Worsening n (%)	**No change n (%)**	**Improvement n (%)**	**p-value**
Stroke color of high frequencies		6 (13,04)	19 (41,30)	21 (45,65)	0,013*
Stroke color all over the voice spectrogram		12 (26,09)	10 (21,74)	24 (52,17)	0,023*
Presence of noise	Between the harmonics	21 (45,65)	18 (39,13)	7 (15,22)	0,028*
	In high frequencies	18 (39,13)	25 (54,35)	3 (6,52)	0,000*
	In medium frequencies	21 (45,65)	15 (32,61)	10 (21,74)	0,138
	In low frequencies	16 (34,78)	25 (34,78)	5 (10,87)	0,001*
Replacement of harmonics with noise	All over the voice spectrogram	10 (21,74)	23 (50,00)	13 (28,26)	0,048*
	In all frequencies	6 (13,04)	29 (63,04)	11 (23,91)	0,000*
	In medium frequencies	11 (23,91)	24 (52,17)	11 (23,91)	0,025*
	In low frequencies	7 (15,22)	35 (76,09)	4 (8,70)	0,000*
Tracing definition of harmonics		18 (39,13)	8 (17,39)	20 (43,48)	0,067
Tracing regularity		15 (32,61)	8 (17,39)	23 (50,00)	0,025*
Number of harmonics		16 (34,78)	13 (28,26)	17 (36,96)	0,753
Presence of sub-harmonics		-	43 (93,48)	3 (6,52)	0,000*

Chi Squared Test
* Statistically significant values (p<0,05)
M1- moment 1
M3- moment 3

Table 7 – Acoustic vocal modifications in narrowband spectrography between the pair M2 e M3

		M2XM3			
		Worsening n (%)	No change n (%)	Improvement n (%)	p-value
Stroke color of high frequencies		19 (41,30)	15 (32,61)	12 (26,09)	0,447
Stroke color all over the voice spectrogram		17 (36,96)	14 (30,43)	15 (32,61)	0,858
Presence of noise	Between the harmonics	13 (28,26)	24 (52,17)	9 (19,57)	0,019*
	In high frequencies	8 (17,39)	31 (67,39)	7 (15,22)	0,000*
	In medium frequencies	15 (32,61)	22 (47,83)	9 (19,57)	0,063
	In low frequencies	12 (26,09)	28 (60,87)	6 (13,04)	0,000*
Replacement of harmonics with noise	All over the voice spectrogram	16 (34,78)	24 (52,17)	6 (13,04)	0,005*
	In all frequencies	14 (30,43)	25 (54,35)	7 (15,22)	0,004*
	In medium frequencies	13 (28,26)	27 (58,70)	6 (13,04)	0,000*
	In low frequencies	6 (13,04)	37 (80,43)	3 (6,52)	0,000*
Tracing definition of harmonics		21 (45,65)	9 (19,57)	16 (34,78)	0,093
Tracing regularity		18 (39,13)	17 (36,96)	11 (23,91)	0,392
Number of harmonics		19 (41,30)	13 (28,26)	14 (30,43)	0,509
Presence of sub-harmonics		-	43 (93,48)	3 (6,52)	0,000*

Chi Squared Test
* Statistically significant values (p<0,05)
M2- moment 2
M3- moment 3

Table 8 – Correlation between vocal self-evaluation and bandwidth spectrography variables

		Vocal self assessment			
		M1XM2		M1XM3	
		r	p-valor	r	p-valor
Stroke color of F	F1	-0,098	0,514	0,198	0,185
	F2	0,069	0,644	0,232	0,120
	F3	0,092	0,539	0,3193	0,030*
	F4	0,037	0,804	0,200	0,182
	Stroke color of high frequencies	0,109	0,467	0,051	0,732
	Stroke color all over the voice spectrogram	0,086	0,565	0,066	0,659
Presence of noise	All over the voice spectrogram	0,020	0,894	0,027	0,854
	In high frequencies	0,054	0,717	0,089	0,555
	In medium frequencies	0,040	0,787	0,100	0,506
	In low frequencies	-0,023	0,877	0,091	0,547
Tracing definition of F	F1	0,124	0,407	0,000	0,998
	F2	0,264	0,075	0,162	0,281
	F3	0,140	0,350	0,125	0,407
	F4	-0,039	0,796	0,137	0,367
Tracing regularity Regularidade do traçado		0,107	0,478	0,055	0,711

Spearman correlation test
*statistically significant values (p<0,05)
M1- moment 1
M2- moment 2
M3- moment 3

Table 9 – Correlation between vocal self-evaluation and the narrowband spectrography variables

		Vocal self assessment			
		M1XM2		M1XM3	
		r	p valor	r	p valor
Stroke color of high frequencies		0,020	0,891	0,185	0,216
Stroke color all over the voice spectrogram		0,061	0,685	0,102	0,498
Presence of noise	Between the harmonics	0,080	0,592	-0,085	0,573
	In high frequencies	0,060	0,687	-0,185	0,218
	In medium frequencies	0,096	0,525	-0,119	0,427
	In low frequencies	-0,045	0,766	0,067	0,657
Replacement of harmonics with noise	All over the voice spectrogram	-0,067	0,655	0,195	0,193
	In high frequencies	-0,006	0,966	0,016	0,915
	In medium frequencies	-0,123	0,415	0,392	0,006*
	In low frequencies	0,047	0,752	0,147	0,329
Tracing definition of harmonics		0,008	0,953	0,323	0,028*
Tracing regularity		-0,098	0,512	0,236	0,113
Number of harmonics		0,013	0,927	0,335	0,022*
Presence of sub-harmonics		-0,148	0,324	0,129	0,390

Spearman correlation test
*statistically significant values (p<0,05)
M1- moment 1
M2- moment 2
M3- moment 3

DISCUSSION

The visual record coming from the voice analysis, through the spectroscopy, presents the distribution of energy in the frequency and in time. Also seems to be an effective tool to check the effect of vocal techniques and to evaluate the evolution of the therapeutic process, although it is a complement analysis to auditory perceptual vocal assessment[6,13,35].

The transformation of the air proceeding from the lungs in the form of acoustic energy occurs in the glottal source due to the movements of the mucosa vocal folds and to the intrinsic laryngeal muscles (abductors and tensors). That process is capable of producing endless cycles of complex waves that are known as harmonics, so that the first harmonic is the fundamental frequency (f0). Certain groups of harmonics are changed and known as F, depending on the conformation of the vocal tract, resulting from the different mobilisations of the articulators, allowing to distinguish the various sounds of the tongue. The F are best evidenced in the SBW [25].

In the SBW of the present study, there was significant improvement in the intensity of F2, F3, F4 and high frequencies, a significant improvement of the definition of F2 and F3 and accuracy of stroke immediately after FK (M1XM2). We also found a significant increase in the intensity of the stroke color of all F and high frequencies as well as significant improvement in the definition of F3 and F4, after five minutes of absolute silence after the completion of FK (M1XM3) (Tables 2, 3 and 4).

In the SBW of the present study, there was an improvement of vocal resonance, reduction of noise, more formant and harmonic power and greater stability of the emission, suggesting a greater pneumo-phono-articulatory coordination with greater projection of the voice radiated from the lips [25], although there was worsening of the presence of noise in high frequencies in M1XM3 [1,2,4,9].

Similar findings were found in another study on SOVTE[14], being not found in literature works using a spectographic analysis with the FK technique.

In a study on sonorous tongue vibration technique, also in women without vocal complaints or laryngeal disorders, using three sets of 15 repetitions in TMF, there was a significant increase in the stroke color and in the tracing definition of F as well as in all vocal spectrogram, apart from the improvement in the tracing regularity[14].

Some authors suggest that the stroke color of the spectrographic tracing relates to the sound pressure that depends, in addition to respiratory strength, to the resistance of the glottis (the first point of discontinuity of impedance in vocal production) [6,26]. In vocal production, there are points that change the acoustic impedance, so that the two main ones are the glottis and the vocal tract. The first refers to the relationship between subglottic air pressure and air flow that passes between the vocal folds, while the second refers to the relationship between the acoustic pressure of the vocal tract and the resulting air flow[1,3].

In the present study, the stroke increased color intensity after FK may be explained due to the increased impedance of the vocal tract, which occurs in the FK by the semi occlusion of the lips, it acts as a protective mechanism for increasing the glottis air pressure in the supraglottic region, increasing the pressure also at glottic level. This tends to move away the vocal folds and reduce the impact when in contact medially, balancing the pressures at the level of the glottis and vocal tract (interaction source and filter or retroflex resonance) [1-3,9,36,37]. The literature shows that this process generates a more economical speech, enabling the same vocal production with less effort, greater vocal efficiency and greater absorption of the impact generated during phonation [1,2,4,9,31,36].

Thus, it is conceivable to think that the FK technique has initially generated an increased impedance in the vocal tract interfering in the sound produced by the glottis, which improves the stroke color of the spectrographic elements with more economic phonation after the technique application. This effect is described by some authors as one of the most pronounced SOVTE features[1,2,4].

The increase of the stroke color can also be related to the extensive mobilization of the mucosa and to the increased synchronization of the vibration of vocal folds that occurs during the technique with consequent improvement of the laryngeal signal. This generates an increase and a greater tracing definition of the harmonic energy and an improvement of vocal projection [5,25,32].

There was also a worsening of the tracing regularity between the pair M2-M3, in contradiction with the significant improvement in this aspect immediately after FK, suggesting that this effect is more immediate and is not maintained for long periods (Table 4).

There were not changes concerning the presence of noise in high, medium and low frequencies. Also there was no change in the bandwidth of F and in the tracing definition of F1 during the three comparison moments (Table 2, 3 and 4), which can be understood by the fact that the group does not have vocal complaints, laryngeal disorders or stomatognatical problems that could promote the presence of noise, nasality or changes in the configuration of vocal tract during the emission of /a:/ used for evaluations. Results that meet those observed in study with individuals with adapted voices, in which there was not any change in these aspects[14].

It is possible that individuals with dysphonic voices tend to have most significant changes regarding noise after phonotherapy. This possibility converges with a work that found a significant noise reduction in spectroscopy of male and female voices, with different types of dysphonia after phonotherapy, although with no description of the techniques used in each case of dysphonia[6].

In SNB, there was significant increase in the stroke color of high frequencies, in the tracing definition of harmonics, in the tracing regularity and in the stroke color throughout all the vocal spectrogram, suggesting increased harmonic energy and reduction of the aperiodic energy of the vocal spectrogram[6], although there was significant worsening of the presence of noise between the harmonics, between the pair M1-M3 (Table 5, 6 and 7).

Extensive mobilization of the mucosa, that occurs due to the increased air flow during the technique, makes that the vocal folds vibrate in a more synchronized way, promoting an improvement of the laryngeal source signal, by the renewal of the mucus layer and the homogenization of the mucosa. This favours an increase in the number of amplified harmonics and its tracing definition of highest, which in turn are better propagated and modified by the vocal tract, with improved resonance [5,25,32].

Even, in this work, there were some aspects in which there were no significant changes, such as the presence of sub-harmonics, the presence of noise between the harmonics in high and low frequencies, and the replacement of harmonics with noise all over the vocal spectrogram and in the high, medium and low frequencies (Tables 5, 6 e 7) reinforce the already mentioned fact that the group studied did not have vocal complaints, laryngeal disorders, and presented adapted voices.

The FK, as on of SOVTE, tends to produce changes in patient's vocal self-reports, since it alters the proprioception, by increasing the intraoral pressure related to the air outlet resistance (increase in acoustic impedance of the vocal tract), facilitating the control and the execution of the technique and helping the self-monitoring of voice[1,4]. In this study, through voice self-assessment, it was found that most of the subjects reported significant better voice at both moments after FK (Table 1).

These facts suggest that the FK, one of the SOVTE, generates greater comfort during phonation, possibly due to the change in vocal fold vibration pattern that reduced the degree of adductor tension and to the balance of subglottic and supra-glottic pressure [1,2]. Such results can also be related to the improvement of resonance, displayed on the spectrographic analysis (Tables 2, 3, 4, 5, 6 and 7).

The SOVTE generate vibrations in the orofacial structures and sometimes on the chest, and the counterpressure in the larynx [1,2], being an important factor to be considered in speech therapy, since they help increasing the motivation of the patient that can understand what positive changes are occurring in his voice. For this reason, the vocal self-assessment of the subject has been highly valued and described in several studies [2,4,8,14,15,31,36].

The improve in the self perception of voice after the FK meets the literature on SOVTE [4,8]. In a study that examined the effects of the immediate execution of a minute of the phonation technique into tubes with individuals with and without laryngeal affec-tions, the vocal self-assessment showed significant predominance of positive feelings (easier and better voice) in both evaluated study groups [4].

In the self-evaluation performed by the subjects in a study that evaluated the effect of fricative sound /ž/ sound technique,a significant group majority has noticed its voice better. Among the positive sensa-tions mentioned were "cleaner and clearer voice with greater production facility, less blurry, more regular, forcing less the emission and managing to keep the voice longer" [8].

However, in research with the performance of a minute blow with sound with seniors, most did not notice any significant effect after the execution of the technique. This was possibly due to the fact that the execution time of one minute have been insuf-ficient to cause the perception of vocal changes by the subjects [31].

In the current study, there was significant corre-lation between improvement in M1XM3 of vocal self-assessment and the increasing intensity of F3 stroke color in SBW [5,34,37], and between the improvement of vocal self-assessment and greater definition and number of harmonics in the SNB (Table 8), showing the reciprocity between the subjective sensation of vocal improvement after FK and improvement in the harmonic energy in espectrographies, although the correlation with the replacement of harmonics by the medium frequency noise in SNB.

There were not found in literature works that have addressed such correlations, requiring more researches, using different assessment tools and different study groups, including dysphonic, for increasing knowledge about the effects and effec-tiveness of the FK technique, allowing the expansion of the discussions on this topic.

CONCLUSION

In general, after the FK, the SBW showed increased stroke color and increased F tracing definition, increase of high frequencies stroke color and improvement of tracing regularity. There was no change of F bandwidth, in F1 tracing definition and in the presence of noise in the high, medium and low frequencies. However, there was an increase in the presence of noise at high frequencies and a worsening of tracing regularity.

SNB showed an increased stroke color of high frequencies and of the entire spectrogram, improvement of tracing regularity, and improvement of harmonics spectrum. There was no change in the presence of noise between the harmonics of high and low frequencies, in the replacement of harmonics by noise of high, medium and low frequencies and in the entire spectrogram as well as in the presence of sub-harmonics. However, there was a worsening in the presence of noise between the harmonics. The vocal self-evaluation showed better voice after FK.

There was a positive correlation between self-evaluation of better voice and the increase of F3 in the BW stroke color and between the self- evaluation of better voice and the increase of tracing definition, of the number of harmonics, despite the positive correlation with the replacement of harmonics by noise in the medium frequencies of the SNB.

It is possible that FK increases the harmonic energy, projection and stability of the emission, providing better quality voice to the subject.

RESUMO

Objetivo: correlacionar modificações vocais acústicas espectrográficas e autoavaliação após o *finger kazoo*. **Métodos:** análise de /a:/ de 46 mulheres sem queixas vocais ou afecções laríngeas pelo *Real Time Spectrogram®* e autoavaliação antes (Momento 1 – M1), após o *finger kazoo* (Momento 2 – M2) e após cinco minutos de silêncio (Momento 3 – M3). Teste *Kappa*, Qui-quadrado, *Spearman*. **Resultados:** melhora da intensidade do escurecimento do traçado dos formantes (F) e das altas frequências, regularidade do traçado e definição dos harmônicos. Melhora na autoavaliação vocal, conforme aumento da intensidade do escurecimento do traçado de F3, da definição do traçado, do número de harmônicos e redução da substituição de harmônicos por ruídos nas médias frequências. **Conclusões:** após o *finger kazoo*, aumentou a intensidade da cor do traçado, a regularidade e definição nas espectrografias e houve melhora na autoavaliação vocal.

DESCRITORES: Voz; Fonação; Reabilitação; Acústica da Fala

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