RESEARCH ARTICLE

Is Computerized Dynamic Posturography Analysis in Dysphonic Patients Different after Vocal Rehabilitation Treatment? A Longitudinal Study

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Abstract

Aim: Vocal pathology and vocal rehabilitation may influence posture, and changes in postural pattern can influence the mechanisms of vocal production. This study aimed to evaluate the postural pattern in subjects with unilateral vocal fold paresis/paralysis before and after speech rehabilitation, using computerized dynamic posturography (CDP).

Materials and methods: This is a prospective cohort study, studying the posture pattern of 16 patients affected by dysphonia, caused by unilateral vocal fold paresis/paralysis, never treated with speech therapy, and by CDP before and after vocal rehabilitation. Each patient underwent videolaryngostroboscopy, acoustic voice analysis, aerodynamic evaluation, GRBAS scale, and voice handicap index questionnaire. Fifteen healthy volunteers were also submitted to a posturographic analysis as a control group.

Results: All patients showed an improvement in voice quality after vocal training. The auditory-perceptual evaluation with the GRBAS scale showed a decrease in all parameters for both vowel (/a/, /i/, /e/) and spontaneous speech ($p < 0.001$ for all). Furthermore, the acoustic analysis showed an improvement in fundamental frequency, shimmer, harmonic-to-noise ratio, and normalized noise energy. Posturographic results showed an improvement in equilibrium score; conditions 1, 2, 4, 5, and 6; and composite score. Strategic analysis results showed an improvement in conditions 2, 5, and 6.

Conclusion: Posturographic analysis showed a significant difference in the proprioceptive, visual, and vestibular component of posture, after voice therapy. These results confirmed an improvement in the postural performance of dysphonic patients after a successful voice treatment.

Clinical significance: The results of this study indicate that modifications of voice production techniques lead to objective and measurable postural changes in dynamic posturographic analysis.

Keywords: Cohort study, Posture, Posturography, Speech rehabilitation, Unilateral vocal fold paresis/paralysis, Voice disorders.

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Introduction

Unilateral vocal fold paralysis is defined as complete immobility of the arytenoid cartilage on the recurrent laryngeal nerve (RLN)-injured side.[1] On the contrary, unilateral vocal fold paresis is considered if there is motion impairment, with preservation of some degree of mobility.[2]

Iatrogenic paresis/paralysis of the RLN post thyroidectomy is one of the most frequent causes of RLN injury.[1,3]

Dysphonia secondary to unilateral vocal fold paresis/paralysis is due to glottic insufficiency and vibratory instability resulting from the vocal fold lateralization and asymmetry in vocal fold tension.[3,4] The severity of the symptoms can range from simple vocal fatigue, shortness of breath during conversation, and difficulty in vocal projection, in cases of mild paresis, to a very breathy and weak voice or aphonia in more severe situations.[1–3] Vocal quality also depends on the muscle tone of the affected vocal fold and the compensatory muscle tension patterns developed by the patient.[3]

Videolaryngostroboscopy evaluation reveals a unilateral vocal fold hypomobility/immobility (decreased adduction, abduction, or decreased movement velocity) and a glottic gap of variable size, with increased amplitude of vibration of the paralyzed vocal fold by vocal muscle atrophy.[2,5] A characteristic chasing wave can translate the vibration asymmetry.[1] Muscle atrophy is also responsible for signs such as unilateral vocal fold bowing.[5] Frequently, a compensatory supraglottic hyperfunction is present, which makes the glottic insufficiency diagnosis difficult.[2] Glottal insufficiency may be a very disabling condition with significant repercussion in patient's quality of life.[6,7]

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Speech therapy has proven to be effective in treating patients with laryngeal mobility pathology, with improvement in vocal quality and in airway protection, especially in cases of paresis/paralysis with mild to moderate glottic gap.[3] Therapy also plays an essential role in reverting compensatory supraglottic hyperfunction mechanisms, which may compromise vocal performance.[3]

Feldenkrais was the first one to establish a relationship between posture and vocal production in 1949.[8] This relationship seems to occur both ways: vocal pathology may cause postural changes, and on the contrary, postural changes may affect voice production.[9,10]

A group of researchers conducted several studies of normal and healthy individuals about this subject during vocal effort, defining quantitative postural parameters.[11–15] They used a static posturography platform that enabled them to objectively describe postural head and trunk changes of normal subjects during vocal effort.[13]

Bruno et al. studied the postural strategy in dysfunctional dysphonia patients, by static posturography, and concluded that after speech rehabilitation, patients presented an improvement in the proprioceptive component of posture.[10]

Another investigation, also using a static platform, obtained similar results studying hypokinetic dysfunctional dysphonia patients.[16]

However, to adopt and sustain a normal body posture, it is necessary to gather sensorial information from the visual, vestibular, and proprioceptive systems; the integration of that information by the central nervous system and its specific response is directly dependent on an adequate musculoskeletal response.[17]

Therefore, computerized dynamic posturography (CDP) platform evaluation grants a more complete and rigorous study of posture as it allows the evaluation of visual, vestibular, and proprioceptive sensory inputs.

In 2010, a study was published evaluating patients with vocal pathology using for the first time CDP.[18] The authors concluded that after vocal rehabilitation, patients demonstrated significant gains in the vestibular component of balance.[18] It is apparent that alterations in the technique used for the vocal production of sound are associated with specific postural changes, not only in the cervical region and larynx but also in global posture.[10,16,18,19]

A good vocal performance is dependent on respiratory function, larynx position, and vocal resonance.[19] Vocal rehabilitation may include several exercises to improve all these aspects, with an expected change in the global postural pattern of the patient.[19]

Accordingly, this study aimed to clarify if these changes correspond to an improvement in the components of posture by evaluating the postural pattern in subjects with unilateral vocal fold paresis/paralysis before and after speech rehabilitation, using CDP.

Materials and Methods

This prospective cohort study recruited 16 patients and was carried out between March and December 2018. It took place at the Department of Ear, Nose, and Throat (ENT) of CUF Infante Santo Hospital, Lisbon, Portugal.

Patients older than 18 years affected by dysphonia caused by vocal fold paresis/paralysis after unilateral thyroidectomy (surgery performed more than 6 months ago) and never treated with speech therapy/vocal training were recruited consecutively.

Fifteen healthy volunteers age- and sex-matched, without history of voice complains, constituted the control group. All subjects were level 2 and 3 professional voice users of Kauffman classification.[20]

Patients with acute ear, nose, and throat pathologies (rhinosinusitis, pharyngitis, and/or laryngitis), who underwent vocal rehabilitation at any time (speech therapy) or with systemic disease (neurologic, orthopedic, ophthalmologic, or psychiatric diseases), were excluded. To diagnose a systemic disease, each patient underwent a complete physical examination including blood analysis, ophthalmologic, neurologic, and orthopedic examinations.

Patients with smoking or alcohol addiction and with the coexistence of labyrinthine symptoms (vertigo or dizziness) were also excluded.

All subjects, patients, and controls were submitted to a posturographic analysis using a CDP (SMART EquiTest; Neurocom, Clackamas, OR, USA) on the day of recruitment and 4 weeks later. Patients in the study group underwent a speech therapy protocol.

Vocal therapy was performed in 60-minute sessions, twice a week, for four consecutive weeks (eight sessions). Voice training consisted in relaxation of general muscular tone exercises, particularly at cervical and scapular-humeral muscles, pneumophonic coordination and respiratory dynamics exercises, and phono-articulation exercises.

Each patient underwent[4] an accurate voice and ENT anamnesis, a general ENT examination, a rigid and flexible laryngoscopy, a videolaryngostroboscopy, an acoustic voice analysis, an aerodynamic evaluation, a perceptual evaluation of voice using the GRBAS scale,[21] and voice handicap index-30 (VHI-30) questionnaire,[22] before and after vocal therapy.

Videolaryngostroboscopy (Kay-Pentax 9100B, Kay-Pentax 70° SN-2576 rigid laryngoscopy and Pentax VNL-1170K nasopharyngolaryngoscopy) was performed by the same physician, using the same diagnostic protocol. The videolaryngostroboscopy protocol included a neurolaryngeal evaluation (assessment of vocal fold mobility, coordination, and use of accessory muscles of phonation) performed with a flexible laryngoscope to ensure that the mobility dysfunction was diagnosed in the physiological laryngeal position.[2,3,5,23,24] The examination included an observation of the larynx at rest, during inspiration and expiration, and a set of repetitive phonatory tasks that allow the assessment of anatomical and motion asymmetries.[2,3,5,23,24] An RLN paralysis was considered if a vocal fold without mobility was observed, and an RLN paresis was diagnosed if there was hypomobility in vocal fold abduction or adduction during videolaryngostroboscopy.

All participants were evaluated before thyroid surgery, as part of the ENT Department protocol, and a normal videolaryngostroboscopy examination was confirmed at that time.

Vocal samples of all the patients were recorded in a silent room by speech therapists with experience in voice assessment. A microphone (Electret Condenser CM-903) was attached to a computer to collect the voice samples and was placed 15 cm from the subject's lips. The participants were required to speak at a comfortable volume and pitch during the sustained emission of vowels /a/, /e/, and /i/ for 5 seconds and in a spontaneous speech for 60 seconds (the patients were invited to speak freely about "What did you do yesterday?"). Dr Speech software (Version 4; Tiger Electronics, Seattle, WA, USA) was used for computerized acoustic vocal assessments. The vocal parameters analyzed were the fundamental frequency (F0) average, F0 maximum, F0 minimum, F0 standard deviation (SD), F0 tremor, jitter, shimmer, normalized noise energy, and harmonic-to-noise ratio.

Aerodynamic evaluation included maximum phonation time measurement. All subjects were required to speak at comfortable loudness and pitch during the sustained emission of vowels /a/ and /i/ as long as possible, after a deep inspiration. Three tests were performed, with a 3-minute interval between them, and the best duration of sound emission was considered.

The audio-perceptual assessment was conducted using the same voice samples using the grade (G), roughness (R), breathiness (B), asthenia (A), strain (S), and GRBAS scale.[21] All the parameters were quantified through a 0–3 severity score (0: absent; 1: mild; 2: moderate; and 3: severe) by three professionals with experience in voice assessment. The samples were presented in a random order. The professionals were blinded about who the exam belonged to and were unaware if the exams had been performed before or after treatment. During the evaluation, at least two of the professionals had to agree on all the evaluated parameters.

All the participants received the VHI-30 form translated and validated into Portuguese.[22]

The sensory organization test (SOT) was conducted on a CDP platform. During the SOT, the patients were instructed to maintain an upright stance and look straight ahead during three trials of 20 seconds each under six different conditions (1: eyes open and stationary platform; 2: eyes closed and stationary platform; 3: eyes open with visual surround moving and stationary platform; 4: eyes open and moving platform; 5: eyes closed and moving platform; and 6: eyes open with visual surround moving and moving platform). The equilibrium score was calculated by comparing the patient's anteroposterior sway during each trial to the maximal theoretical sway limits of stability (based on the individual's height and the size of the support base).[25]

The somatosensory contribution to postural control was calculated using the ratio of condition 2 to condition 1, the visual contribution was represented by the ratio of condition 4 to condition 1, and the vestibular contribution was represented by the ratio of condition 5 to condition 1. The ability to rely on visual orientation cues for postural control, or visual preference, was evaluated by the ratio of the sum of conditions 3 and 6 to the sum of conditions 2 and 5.

The composite equilibrium score was automatically calculated by independently averaging the three scores for conditions 1 and 2; adding these two mean scores to the three equilibrium scores from each trial of sensory conditions 3, 4, 5, and 6; and dividing the sum by 14 (the total number of trials).[25]

Strategic analysis of SOT quantifies the use of hip and ankle movement relative to the patient amplitude of anteroposterior sway. In each of the six conditions described, the strategy score measured the horizontal shear force exerted by the patient's feet against the support surface during sway. Strategy scores of ~100% correspond to minimal horizontal shear force and slow ankle-centered sway movement and scores approaching 0% indicate maximum amplitude shear forces and maximum hip and upper body sway movements.[25]

Regarding data analysis, an exploratory study was carried out for all variables. Continuous variables were described with mean and SD, median and interquartile range (25th percentile–75th percentile) or median and range (min, max), as appropriate. To compare study parameters before and after treatment, paired *t* test, exact Wilcoxon test, or sign test was applied, as appropriate. To assess normality, Shapiro–Wilk test and Quantile–Quantile plots were applied. A level of significance $\alpha = 0.05$ was considered. For data analysis, R software was used (R: A Language and Environment for Statistical Computing, R Core Team, R Foundation for Statistical Computing, Vienna, Austria, year = 2019, http://www.R-project.org.).

This study was approved by the Ethics Research Committee of CUF Infante Santo Hospital, and written informed consent was obtained from all the participants before study enrollment. All the procedures were performed in accordance with the 1964 Declaration of Helsinki.

Results

Eight participants were female, and eight were male, patients with a mean age of 56.1 (14.6) years, and controls with a mean age of 55.5 (13.6) years. ENT examination did not reveal significant pathology in patients or controls. Videolaryngostroboscopy revealed the presence of unilateral vocal fold paresis in 10 of the selected patients and unilateral vocal fold paralysis in 6 patients. All patients showed an incomplete glottic closure (12 cases of a spindle-shaped glottal gap, 2 cases of bowing gap, and 2 cases of posterior chink[26]). None of the patients showed symptoms or signs of laryngopharyngeal reflux. All patients showed some degree of supraglottic hyperfunction.

All patients showed a clinical improvement in voice quality after vocal training.

The GRBAS scale showed a decrease in all parameters in each vowel (/a/, /i/, /e/) and in spontaneous speech ($p < 0.001$ for all; Table 1).

Table 1: Comparison of GRBAS parameters before and after treatment

	Median		
	Pre	*Post*	
GRBAS	*[min, max]*	*[min, max]*	*p value**
G_a	2.0 [1.0, 3.0]	0.5 [0.0, 2.0]	<0.001
G_e	2.0 [1.0, 3.0]	1.0 [0.0, 2.0]	<0.001
G_i	2.0 [1.0, 3.0]	0.0 [0.0, 2.0]	<0.001
G_{ss}	2.0 [1.0, 3.0]	0.0 [0.0, 2.0]	<0.001
R_a	2.0 [1.0, 3.0]	0.5 [0.0, 2.0]	<0.001
R_e	2.0 [1.0, 3.0]	1.0 [0.0, 2.0]	<0.001
R_i	2.0 [1.0, 3.0]	0.0 [0.0, 2.0]	<0.001
R_{ss}	2.0 [1.0, 3.0]	0.0 [0.0, 2.0]	<0.001
B_a	2.0 [1.0, 3.0]	0.5 [0.0, 2.0]	<0.001
B_e	2.0 [1.0, 3.0]	0.0 [0.0, 2.0]	<0.001
B_i	2.0 [1.0, 3.0]	0.0 [0.0, 2.0]	<0.001
B_{ss}	1.5 [1.0, 3.0]	0.0 [0.0, 2.0]	<0.001
A_a	2.0 [1.0, 3.0]	0.0 [0.0, 2.0]	<0.001
A_e	2.0 [0.0, 3.0]	0.0 [0.0, 2.0]	<0.001
A_i	1.5 [0.0, 3.0]	0.0 [0.0, 2.0]	<0.001
A_{ss}	1.0 [1.0, 3.0]	0.0 [0.0, 2.0]	<0.001
S_a	2.0 [1.0, 3.0]	1.0 [0.0, 2.0]	<0.001
S_e	2.0 [1.0, 3.0]	1.0 [0.0, 2.0]	<0.001
S_i	2.0 [1.0, 3.0]	0.5 [0.0, 2.0]	<0.001
S_{ss}	2.0 [1.0, 3.0]	0.0 [0.0, 2.0]	<0.001

Results are expressed as mean (standard deviation) or median [P_{25}, P_{75}] as appropriate. **p* values were obtained by paired *t* test, exact Wilcoxon test, or sign test as appropriate.

GRBAS scale. G, grade; R, roughness; B, breathiness; A, asthenia; S, strain. a: vowel /a/. e: vowel /e/. i: vowel /i/. ss: spontaneous speech

Videostroboscopy evaluation after treatment showed a reduction in the glottal gap dimension in all patients, with complete closure in 10 patients. A reduction of supraglottic contraction of the ventricular folds was also observed after therapy.

The acoustic analysis (Tables 2 and 3) showed an improvement in several parameters, such as fundamental frequency average, maximum and minimum, vowels /e/ and /i/; Shimmer and Harmonic-to-noise ratio in vowel /a/; and normalized noise energy in all vowels.

Although without statistical significance ($p = 0.226$), the VHI score decreased from a mean value of 21.2 (14.2) to the mean value of 16.7 (14.2) after treatment (Table 4).

Maximum phonation time measurement did not show statistically significant results after treatment (vowel /a/: $p = 0.354$; vowel /i/: $p = 0.260$).

Posturography results revealed an improvement in the equilibrium score after vocal training, in all patients, in conditions 1, 2, and 6. Although with weak statistical evidence, an improvement in conditions 4 and 5 was also observed. These results are confirmed by the improvement in the composite score achieved (Table 5).

Strategy score improved in conditions 2, 5, and 6, reflecting a better postural alignment of the different body segments (Table 5).

This improvement means an increase in the proprioceptive, visual, and vestibular components of posture, after vocal training.

Table 2: Comparison of acoustic analysis parameters before and after treatment

Acoustic analysis	Median Pre	Post	*p value**
$F0_a$	147.2 (46.0)	154.4 (46.0)	0.099
$F0_e$	155.2 (45.3)	169.4 (45.3)	<0.001
$F0_i$	163.3 (50.0)	181.6 (50.0)	<0.001
$F0Max_a$	165.2 [121.3, 189.0]	173.6 [127.0, 185.0]	0.889
$F0Max_e$	163.7 (47.3)	175.8 (47.3)	0.003
$F0Max_i$	169.8 (53.0)	189.3 (53.0)	<0.001
$F0Min_a$	140.7 (43.4)	147.2 (43.4)	0.154
$F0Min_e$	149.6 (44.2)	163.6 (44.2)	<0.001
$F0Min_i$	157.3 (48.9)	176.7 (49.0)	<0.001
$F0SD_a$	1.7 [1.3, 2.8]	2.8 [1.5, 3.2]	0.607
$F0SD_e$	1.9 [1.4, 2.7]	1.5 [1.2, 2.4]	0.208
$F0SD_i$	1.8 [1.3, 2.2]	1.4 [1.2, 2.2]	0.302
$F0T_a$	1.6 [1.0, 2.6]	1.4 [1.0, 2.2]	0.754
$F0T_e$	1.5 [1.0, 2.4]	1.5 [1.2, 2.8]	1.000
$F0T_i$	1.1 [1.0, 1.7]	1.5 [1.1, 1.9]	0.910

Results are expressed as mean (standard deviation) or median [P_{25}, P_{75}] as appropriate. **p* values were obtained by paired *t* test, exact Wilcoxon test, or sign test as appropriate. F0, fundamental frequency average; $F0_{Max}$, fundamental frequency maximum; $F0_{Min}$, fundamental frequency minimum; $F0_{SD}$, fundamental frequency standard deviation; $F0_T$, fundamental frequency tremor; a, vowel /a/; e, vowel /e/; i, vowel /i/

Regarding the control group, posturographic results revealed no differences between the first and the second evaluations (Table 5).

Discussion

According to the European Laryngological Society,[4] unilateral vocal fold paresis/paralysis represents an ideal patient population to study voice outcomes following a therapeutic intervention, since it represents, physiologically, a single homogeneous disease.

In this study, the authors followed a voice assessment protocol, as recommended by the European Laryngological Society,[4] including the systematic use of VHI, perceptive analysis using GRBAS scale, acoustic analysis, and aerodynamic studies using maximum phonation time evaluation.

Table 3: Comparison of acoustic analysis parameters before and after treatment (continuation)

Acoustic analysis	Median Pre	Post	*p value**
J_a	0.37 [0.27, 0.49]	0.23 [0.18, 0.45]	0.315
J_e	0.25 [0.21, 0.31]	0.20 [0.17, 0.28]	0.791
J_i	0.19 [0.17, 0.24]	0.15 [0.13, 0.18]	0.180
Sh_a	3.73 (1.09)	2.80 (1.09)	0.002
Sh_e	2.14 (0.58)	1.94 (0.58)	0.283
Sh_i	1.41 [1.06, 1.65]	1.30 [0.80, 1.52]	1.000
NNE_a	−8.10 (5.10)	−11.48 (5.10)	0.019
NNE_e	−9.11 (4.50)	−11.70 (4.50)	0.024
NNE_i	−6.94 (4.70)	−10.40 (4.70)	0.007
HNR_a	19.17 (3.77)	21.32 (3.77)	0.013
HNR_e	24.00 (3.01)	22.97 (3.01)	0.208
HNR_i	28.26 (5.26)	27.88 (5.26)	0.731

Results are expressed as mean (standard deviation) or median [P_{25}, P_{75}] as appropriate. **p* values were obtained by paired *t*-test, exact Wilcoxon test, or sign test as appropriate. J, jitter; Sh, shimmer; NNE, normalized noise energy; HNR, harmonic-to-noise ratio; a, vowel /a/; e, vowel /e/; i, vowel /i/

Table 4: Comparison of VHI scores before and after treatment

Patient	*Diagnosis*	*VHI pre*	*VHI post*
1	Paralysis RN	48	2
2	Paresis RN	39	19
3	Paresis RN	1	4
4	Paresis RN	25	21
5	Paresis RN	21	13
6	Paralysis RN	47	25
7	Paresis RN	25	30
8	Paralysis RN	4	16
9	Paralysis RN	2	2
10	Paralysis RN	9	8
11	Paresis RN	0	0
12	Paralysis RN	16	13
13	Paresis RN	48	54
14	Paresis RN	27	34
15	Paresis RN	15	18
16	Paresis RN	12	8

RN, recurrent laryngeal nerve; VHI, voice handicap index; Pre, before treatment; Post, after treatment

Table 5: Comparison of equilibrium score and strategy analysis results before and after treatment in patients and controls

		Equilibrium score				*Strategy analysis*			
		Patients		*Controls*		*Patients*		*Controls*	
Condition		*Mean/median*	**p values*	*Mean/median*	**p values*	*Mean/median*	**p values*	*Mean/median*	**p values*
1	Pre	94.0 [92.8, 94.3]	0.006	95.5 (0.7)	0.850	98.4 (1.4)	0.346	98.9 (1.0)	1.000
	Post	94.5 [93.0, 95.0]		95.5 (0.7)		98.7 (1.4)		98.7 (1.0)	
2	Pre	91.0 [89.0, 93.0]	<0.001	93.0 [91.5, 94.0]	1.000	96.8 (1.2)	<0.001	98.0 [97.5, 99.0]	0.250
	Post	93.0 [90.0, 94.0]		93.0 [91.5, 94.0]		98.0 (1.2)		98.0 [97.0, 98.5]	
3	Pre	90.5 [87.8, 92.3]	0.124	91.3 (1.8)	0.250	96.4 (1.8)	0.135	98.0 [97.5, 98.0]	0.125
	Post	92.0 [87.8, 93.3]		90.9 (1.8)		97.3 (1.8)		98.0 [94.0, 98.0]	
4	Pre	87.0 [81.8, 88.3]	0.059	87.8 (4.6)	0.250	83.5 [82.8, 87.3]	0.081	85.0 (5.5)	0.394
	Post	89.0 [83.8, 90.3]		88.6 (4.6)		86.0 [82.5, 87.3]		85.9 (5.5)	
5	Pre	66.0 [54.8, 72.5]	0.074	74.5 (6.6)	0.556	68.6 (6.5)	<0.001	71.0 [70.0, 81.5]	0.250
	Post	74.0 [64.3, 77.5]		74.3 (6.6)		75.9 (6.5)		76.0 [71.0, 82.0]	
6	Pre	66.5 [57.8, 74.3]	0.022	77.7 (4.5)	0.167	73.1 (7.38)	<0.001	80.0 [69.5, 83.5]	0.057
	Post	75.5 [65.0, 80.3]		79.5 (4.5)		78.7 (7.4)		80.0 [77.0, 83.5]	
Comp	Pre	81.0 [74.0, 83.5]	0.010	84.9 (2.7)	0.334				
	Post	83.0 [78.0, 86.0]		84.8 (2.7)					

Results are expressed as mean (standard deviation) or median [P_{25}, P_{75}] as appropriate. **p* values were obtained by paired *t* test, exact Wilcoxon test, or sign test as appropriate. Pre, before treatment; Post, after treatment. Condition 1: eyes open and stationary platform; Condition 2: eyes closed and stationary platform; Condition 3: eyes open with visual surround moving and stationary platform; Condition 4: eyes open and moving platform; Condition 5: eyes closed and moving platform; Condition 6: eyes open with visual surround moving and moving platform. Comp: Composite equilibrium score—independently averaging the three scores for conditions 1 and 2, adding these two mean scores to the three equilibrium scores from each trial of sensory conditions 3, 4, 5, and 6, and dividing the sum by 14 (total of trials)

In this study, electromyography was not used. Evaluation by electromyography remains controversial because it is an invasive technique with subjective interpretation.[5] This technique seems to be useful in defining the prognosis of the lesion and in the differential diagnosis, namely with cricoarytenoid disarticulation.[2,3,6] However, these objectives were beyond the scope of this study, and the etiology of the paresis/paralysis was known from the beginning. Furthermore, it is accepted that if it is not possible to use all the existing methods to evaluate these patients, a diagnosis based on clinical history, videolaryngostroboscopy observation, and response to treatment is acceptable.[2] A recent study showed that 72% of laryngologists base the diagnosis of laryngeal hypomobility on videolaryngostroboscopy alone and consider it effective.[27,28]

Our videolaryngostroboscopic protocol was performed with a flexible endoscope, permitting laryngeal mobility evaluation under physiological conditions, while the patient performs a series of repetitive tasks that demonstrate paresis/paralysis.[2,3,5,23,24]

The relationship between postural control and vocal function has been studied in a previous study. Body posture interferes with larynx position, respiratory function, and vocal tract shape, influencing vocal production and performance, in normal and in dysphonic patients.[9,19]

Computerized dynamic posturography is considered the state of the art in posture global evaluation as it allows visual, vestibular, and proprioceptive sensory input analyses.

In this study, using CDP, the authors analyzed the postural pattern of dysphonic patients, affected by unilateral vocal fold paresis/paralysis and never treated with speech therapy. Speech therapy efficiency was proved by the improvement in videolaryngostroboscopic evaluation and in perceptive (GRBAS scale) and acoustic voice analysis.

Posturographic analysis showed a significant difference in the proprioceptive, visual, and vestibular components of balance, after voice therapy.

These results showed that dysphonic patients caused by unilateral vocal fold paresis/paralysis improved their postural performance after a successful voice treatment.

In a previous study,[29] these authors found the same results upon analyzing the postural pattern of hyperfunctional dysphonia patients (vocal fold nodule, cyst, and polyp) before and after a successful vocal rehabilitation.

In both studies, an improvement in the ability and strategy of equilibrium after vocal training was found.[29]

It seems that vocal technique improvement acquired after speech therapy in dysphonic patients (organic vocal fold pathology and unilateral vocal fold paresis/paralysis) is accompanied by a more effective postural strategy, obtained by improving the proprioceptive, visual, and vestibular sensorial inputs.[29]

As in the previous investigation,[29] posturographic results in the control group revealed no differences between the first and the second evaluation, 4 weeks later, proving that the improvement in postural parameters in the study group was not dependent on a learning process resulting from the repetition of the task.

Although the limitation of this study is the small sample size, based on these results we propose a CDP evaluation of dysphonic patients to help correcting specific postural alterations and guide vocal treatment.

Conclusion

The association between posture patterns and voice production is accepted across the scientific literature. Dysphonia and vocal pathology can cause posture alterations, whereas modification in posture pattern can affect voice quality.

The results of this study seem to indicate that modifications of voice production techniques lead to objective postural pattern changes. Therefore, postural evaluation should be considered as an important part of voice patient evaluation.

Clinical Significance

From the above, CDP may be considered a useful tool in making a postural global evaluation in dysphonic patients, before and after vocal rehabilitation.

Authors' Contribution

Maria CRC Caçador, Ana Papoila, and João Paço carried out the study design. Maria CRC Caçador, Carlos Garcia, Tânia Constantino, and Mafalda Almeida performed data collection. Ana Papoila and Carlos Brás-Geraldes performed statistical analysis. Maria CRC Caçador, Carlos Garcia, and João Paço performed data interpretation. Maria CRC Caçador, Ana Papoila, Carlos Brás-Geraldes, and João Paço performed manuscript preparation. Maria CRC Caçador performed literature search.

Statement of Ethics

Subjects have given their written informed consent. The study protocol has been approved by the research institute's committee on human research.

Public Trials Registry Number

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