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Multidimensional Voice Assessment in Parkinson 's disease: A Pilot Study on Correlations between Acoustic, Perceptual, and Self-Reported Measures in Algerian Arabic speakers

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Abstract

Objectives: This study aimed to investigate correlations between acoustic voice quality index (AVQI) parameters, self-reported voice handicap (VHI-30), and auditory-perceptual assessments (GRBAS) in Algerian Arabic-speaking individuals with Parkinson's disease (IwPD), while identifying key predictors of voice-related handicap.

Study Design: Cross-sectional observational study.

Methods: Forty-four native Algerian Arabic dialect speakers with idiopathic PD underwent voice assessments, including audio recordings of sustained vowel phonation and continuous speech tasks. Acoustic analysis was performed using the six AVQI v03.01 parameters via Praat® (version 6.4.06). Self-reported and auditory-perceptual assessments were assessed respectively using the VHI-30 and the GRBAS scale (G-score). Statistical analyses included Spearman's rank-order correlations and multiple linear regressions to identify key predictors of voice related handicap in this cohort of patients.

Results: Significant correlations were observed between individual AVQI parameters and VHI-30 scores, with CPPs demonstrating the strongest inverse correlation with the total VHI-30 score ($r_s = -0.72, p < 0.01$). Shimmer metrics exhibited positive associations with the total VHI-30 score (Shimmer dB: $r_s = 0.71, p < 0.05$, Shimmer%: $r_s = 0.68, p < 0.05$). LTAS tilt and HNR showed no statistically significant association with the total VHI-30. The regression model accounted for 72% of the variance in VHI-30 scores, with GRBAS scores (G-score) showing the strongest predictive value ($\beta = +4.2, p < 0.001$). Women reported significantly higher VHI scores than men (mean difference = 3.5 points, $p = 0.02$). No statistically significant associations were found for age or disease duration ($p > 0.15$).

Conclusion: This pilot study highlights the multidimensional nature of voice impairment in a cohort of Algerian Arabic-speaking PD patients. The regression model substantially advances the understanding of key predictors of voice related handicap in this cohort of patients. Collectively, acoustic, perceptual, and self-reported outcome measures merit systematic integration into comprehensive voice assessment protocols, as they hold potential utility for refining therapeutic decision-making and optimizing clinical management strategies for voice-related disorders in PD.

Keywords: Parkinson's disease, Acoustic Voice Quality Index (AVQI), AVQI parameters, Voice Handicap Index (VHI-30), GRBAS scale, clinical features, Algerian Arabic dialect, hypokinetic dysphonia.

1. Introduction

Parkinson's disease (PD) is a progressive neurodegenerative disorder characterized pathophysiologically by dopaminergic neuron degeneration in the substantia nigra pars compacta, manifesting clinically through a triad of cardinal motor symptoms: resting tremor, bradykinesia, and rigidity¹. A hallmark feature of PD is hypokinetic dysarthria, a voice and speech disorder marked by reduced vocal intensity (hypophonia), reduced pitch and loudness, modulation (prosodic flattening) and imprecise articulation^{2,3}. These phonatory deficits arise from laryngeal and respiratory muscle bradykinesia, reflecting the disease's broader disruption of motor planning and execution⁴. Voice dysfunction frequently precedes limb motor disability in prodromal stages, serving as both a diagnostic marker and a predictor of disease progression⁵.

Thorough assessment of vocal features is pivotal for optimizing therapeutic strategies and improving clinical outcomes of dysarthria in PD. Voice clinics increasingly employ acoustic analysis to quantify symptom severity and track progression⁶. However, such instrumental methods fail to capture the multidimensional repercussions of voice disorders, including psychosocial distress, social participation deficits, and functional communication limitations. Furthermore, confounding factors such as inter-individual vocal variability, disease-stage heterogeneity, age, gender and comorbid psychosocial conditions modulate clinical presentations, potentially dissociating objective acoustic measures from patient-reported experiences⁷.

Consequently, a multimodal diagnostic paradigm integrating instrument-derived metrics clinical features, auditory-perceptual assessment and patient-reported evaluations is essential for symptom management⁸. For the acoustic voice assessment, the Acoustic Voice Quality Index (AVQI) parameters are largely used in the objective quantification of vocal signal abnormalities: smoothed cepstral peak prominence (CPPs), harmonic-to-noise ratio (HNR), shimmer local (percent), shimmer local (dB), slope and trendline tilt of the long-term average spectrum (LTAS)^{9,10,11}. As for the self-reported and the auditory-perceptual assessment of dysphonia, the Voice Handicap Index (VHI)¹² and the GRBAS¹³ scale are recognized as robust tools¹⁴.

Extensive research in several languages has examined this association. For example, the study by Pommée in 2020¹⁵ reported inconsistent correlations and moderate associations between AVQI and VHI-30 ($r_s = 0.62$, $p < 0.0001$) and its subscores in French speakers. Similarly, it

was emphasized that AVQI's diagnostic sensitivity improves when combined with VHI, particularly for mild dysphonia in patients speaking Finnish¹⁶. The study by Englert¹⁷ corroborated these findings, noting moderate AVQI-VHI correlations ($r = 0.477$, $p < 0.001$), though explained variance remained limited ($r^2 \approx 0.23$). Conversely, another study¹⁸ showed non-significant correlations between the AVQI and the VHI-30 post-voice treatment, highlighting context-dependent variability. In addition, another study¹⁹ reported statistically significant correlations ($p < 0.05$) within and across different measures of voice assessment (AVQI, GRBAS, VHI) and other measures. Collectively, these studies conducted across multiple languages underscore the complementary roles of AVQI, VHI, and GRBAS: demonstrating the vocal impact on quality of life and perceived dysphonia features, while their integration with other clinical parameters enables a multidimensional assessment of voice disorders, thereby bridging objective signal analysis and subjective patient experiences.

In Algeria, a multilingual nation with Arabic as the dominant official language research on voice disorders remains nascent, particularly with regard to the phonetic-prosodic specificities of Algerian Arabic speakers. The linguistic landscape, characterized by Arabic-Amazigh bilingualism and French influences, necessitates culturally adapted assessment tools to ensure ecological validity. Current objective evaluations of hypokinetic voice disorders in Arabic-speaking populations rely predominantly on conventional spectrographic analyses (e.g., *Praat*®), which focus on segmental features (syllabic structure, consonantal articulation) and classical suprasegmental parameters (fundamental frequency, intensity, Mel-Frequency Cepstral Coefficients (MFCC))²⁰. Current Algerian clinical research in speech and language pathology lacks studies systematically investigating relationships between objective measures and subjective evaluations for assessing voice disorders severity in individuals with PD (IwPD). Investigating these interactions could help clinicians identify key predictors of vocal impairment and develop more effective, culturally adapted rehabilitation programs.

This pilot study aims to investigate two primary research questions, in order to provide valuable data for a more comprehensive understanding and management of dysphonia in a cohort of patients with PD:

1. Is there a statistically significant association between acoustic measures, self-reported voice handicap and perceptual assessment in a cohort of Algerian PD patients?

This study hypothesizes that there is a significant correlation between AVQI parameters, which reflect distinct aspects of voice production, VHI-30 scores, and GRBAS ratings,

providing valuable data for a more comprehensive understanding and management of dysphonia in a cohort of patients with PD.

2. Which factors serve as key predictors of voice related handicap when analyzed through a multidimensional framework integrating voice assessments and clinical characteristics in this population?

The regression analysis incorporating AVQI parameters, VHI-30 scores, GRBAS auditory-perceptual assessment, and clinical variables (age, disease duration, gender) is expected to identify key predictors of voice related handicap.

Method

1.1. Participants

The study involved 44 patients with idiopathic PD, diagnosed according to the United Kingdom Parkinson's Disease (UK PD) Society Brain Bank criteria²¹ at the Neurology Department of Mustapha Pacha University Hospital in Algiers, between January 2023 and April 2023. The Mini Mental State Examination (MMSE)²² was administered to guarantee the inclusion of participants without cognitive impairment, in order to avoid impact on language comprehension and response capabilities. All individuals with PD were evaluated during the "on" phase of their medication using the MDS-UPDRS²³ including Hoehn and Yahr (H&Y)²⁴ scale, and the GRBAS scale (G-score)¹³.

Participants were eligible for inclusion if they met all the following criteria:

- Native speakers of the Algerian Arabic dialect
- No history of hearing impairment
- Demonstrated adequate cooperation with study procedures
- Able to understand the study information
- MMSE score ≥ 23 points

Participants were excluded if they met any of the following criteria:

- Were under legal guardianship, tutorship, or any form of administrative or legal dependence
- Withdrew consent or showed insufficient cooperation
- Presented with cognitive impairment, severe depression, dementia, psychosis (including medication-induced), or any neurological, medical, psychological, or behavioral condition interfering with voice or cognitive evaluations
- Had a diagnosis of non-idiopathic Parkinson's disease

- Had undergone deep brain stimulation
- Had severe motor impairments that precluded participation in voice assessments.

This study was conducted in accordance with the principles outlined in the Declaration of Helsinki regarding ethical research involving human subjects and was approved by the local ethics committee. All participants signed an informed consent declaration before participation.

1.2. Procedure

1.2.1. Voice Assessments

A. Voice Handicap Index

Participants completed the Algerian Arabic dialect version of the VHI-30²⁵, which includes 30 items equally distributed across three domains: Functional, Physical, and Emotional. Responses were rated on a 5-point Likert scale ranging from 0 (“never”) to 4 (“always”), with higher scores indicating greater voice-related handicap. To ensure comprehension, the VHI-30 items were read aloud by the examiner to each participant in a hybrid phonetic transcription adapted to Algerian Arabic. This dialectal version had been previously validated in a separate study on this population²⁵.

B. Perceptual assessment using GRBAS scale (G-score)

The perceptual assessment using GRBAS scale was performed through a monologue vocal task, focusing only on the G criterion. Patients were instructed to talk about a self-chosen topic (e.g. hometown, childhood, hobbies, or family) for about 60 to 90 seconds. The raters were two Speech-Language Pathologists (SLPs) with more than 10 years of experience working with voice patients.

C. Acoustic Assessment

The patients’ voices were recorded using an omnidirectional head-mounted condenser microphone connected to an external professional sound card. The microphone was placed outside the main exhalation stream at approximately 4–10 cm from the lips and at a 45-90° angle. The microphone provided a flat frequency response (variations ± 3 dB), sensitivity (98 dB ± 3 dB) across the frequency range between the lowest fundamental frequency and the highest spectral component of interest (60–8000 Hz). The sampling frequency was 96 kHz, resolution was 24 bits, and the spectral range was [20 Hz-48 kHz]. The data were digitized using Praat® software version 6.4.06.

The recordings, performed in a quiet room, included two tasks:

- Sustained phonation of the vowel /a/: patients were instructed to take a deep breath and sustain the vowel /a/ for as long and as steadily as possible, repeated twice. The second

realization of the sustained vowel was used for analysis to homogenize task familiarity and performance.

- Continuous speech: monologue recordings, provided by the task described above for the GRBAS assessment, were edited to remove long pauses (>2 seconds) and any unusable parts (e.g. speech from the interviewer, coughing, and intrusive external noise). The central 3-second portion of the sustained vowels was extracted and the voiced segments from the continuous speech were trimmed to include the same duration. The sustained vowel and connected speech samples were concatenated and analyzed using the AVQI 03.01 script 9, extracting six acoustic parameters:

- Smoothed cepstral peak prominence (CPPs),
- Harmonic to noise ratio (HNR),
- Local shimmer (percent)
- Local shimmer (dB)
- Slope of the long-term average spectrum (LTAS) tilt of the LTAS trendline
- Tilt of the LTAS trendline

Note that the composite AVQI score was not used in the present study, as the AVQI has not yet been validated in the Algerian Arabic dialect.

2.3. Statistical Analyses

Statistical analyses were performed using IBM SPSS Statistics (version 25.0). Non-parametric Spearman's rank-order correlations (r_s) were utilized to evaluate associations between AVQI acoustic parameters and VHI-30 scores (total and subdomains), as Shapiro-Wilk tests confirmed non-normal distributions for most variables. To address multiple comparisons ($n = 24$), a dual alpha threshold was applied: nominal significance ($\alpha = 0.05$) and a Bonferroni-adjusted threshold ($\alpha = 0.0021$). A multiple linear regression model was constructed to identify predictors of voice-related handicap, using the VHI-30 outcomes, among acoustics parameters and the following clinical and demographic variables: auditory-perceptual assessment (GRBAS scale "G-score"), age, gender and disease duration.

Results

The study included 44 Algerian Arabic-speaking PD patients (mean age 54.5 years, SD 10.57) with preserved cognitive function (MMSE: 27.1 ± 3.2). Disease duration averaged 10.5 years (± 4.3), predominantly at mild-moderate stages (75% Hoehn & Yahr stages 0-III). Motor disability (MDS-UPDRS) was higher in women, particularly in Part III (motor examination: 41.4 vs. 34.6 in men) (see Table 1). Voice disorders were prevalent, with severity

distributions categorized as 36.4% mild, 38.6% moderate, and 25% severe based on the G criterion of the GRBAS scale.

Table 1. Demographic and clinical characteristics

Participants with PD N= 44	
MMSE (mean ± standard deviation)	27.1 ± 3.2
Disease duration (mean ± standard deviation)	10.5 ± 4.3 years
[range]	[2–12]
Disease stage (H&Y)	
Mild (stages 0, I, and II)	17 (38.63%)
Moderate (stage III)	16 (36.36%)
Severe (stages IV and V)	11 (25%)
MDS-UPDRS (mean ± standard deviation)	Men (Women)
	N=23 (N=21)
Overall score	59.00 ± 21.6 (77.2 ± 44.7)
Part I—non motor aspects of daily life	6.5 ± 6.1 (10.8 ± 8.3)
Part II—motor aspects of daily life	13.8 ± 6.5 (20.8 ± 11.7)
Part III—motor examination	34.6 ± 11.02 (41.4 ± 19.3)
Part IV—motor complications	4.1 ± 10.0 (4.2 ± 4.4)
Auditory perceptual assessment (GRBAS “G score”)	
0 : Normal voice or absence of disorder	00 (00%)
1: Mild disorder	16 (36.36%)
2: Moderate disorder	17 (38.64%)
3: Sever disorder	11 (25%)
Level of education (ISCED)*	
Levels 0 and 1 (≤4 years)	18 (40.91%)
Levels 2 and 3 (5–12 years)	26 (59.09%)
Levels 4, 5, and 6 (professional and academic degree)	00 (00%)
*ISCED, International Standard Classification of Education.	

Table 2. Results of the Auditory-perceptual assessment using GRBAS scale (G-score) of the 44 participants.

GRBAS (G Score)	N (%)	Men (Women)
Mild disorder (1)	16 (36.36%)	10 (6)
Moderate disorder (2)	17 (38.63%)	7 (10)
Sever disorder (3)	11 (25.00%)	6 (5)

n= 44/ Men =23 Women =21).

The outcomes of the auditory-perceptual assessment using the GRBAS scale (G-score) revealed that among the 44 Parkinson's patients assessed, 16 exhibited mild disorder, 17 showed moderate disorder, and 11 displayed severe disorder. There were more mildly dysphonic men, and more moderately dysphonic women.

Table 3. Mean VHI-30 scores (functional, physical, emotional subscores and total score) of the 44 participants.

VHI scores (maximum possible score)	Mean (SD)	Median (Q1–Q3)	Minimum–maximum score
Functional (40)	19.31 (10.76)	25 (18-29)	13-37
Physical (40)	21.7 (12.17)	23 (16-30)	12-35
Emotional (40)	19.67 (10.94)	22 (16-28)	14-35
VHI total (120)	60.40 (21.35)	74 (49-89)	42-106
Q1 lower quartile, Q3 upper quartile.			

The total VHI-30 score (max 120) demonstrated substantial variability (Table 3), with a mean of 60.40 (SD \pm 21.35) and a wide range from 42 to 106. The median score (74; Q1–Q3: 49–89) exceeded the mean, suggesting a right-skewed distribution with a concentration of higher scores. Among subdomains, the Physical domain (max 40) showed the highest mean score (21.7 \pm 12.17), followed by the Emotional domain (19.67 \pm 10.94) and Functional domain (19.31 \pm 10.76). Extreme values were observed in all domains, such as a minimum of 12 in Physical and a maximum of 35 in both Physical and Emotional domains.

Table 4. Mean AVQI score & mean AVQI parameters in the 44 PD participants.

AVQI parameters	Mean (SD)	Median (Q1–Q3)
CPPs	12,15 (2.18) <i>14.30 (1.29)</i>	12.40 (10.76-13.62)
HNR	18.29 (3.1) <i>20.88 (2.38)</i>	18.26 (16.63-20.95)
Shimmer %	6.29 (2.73) <i>4.20 (1.29)</i>	5.72 (4.19-8.22)
Shimmer dB	0.62 (0.21) <i>0.45 (0.1)</i>	0.59 (0.46-0.80)
Slope of LTAS	-22.50 (6.13) <i>-22.09 (2.95)</i>	-22.81 (-27.80/-18.16)
Tilt of LTAS trendline	-10.15 (1.43) <i>-12.63 (0.82)</i>	-10.25 (-10.70/-9.27)
Total AVQI score	3.12 (1.35) <i>1.07 (0.77)</i>	3.22 (2.27-4.04)

Q1 lower quartile, Q3 upper quartile.

*Reference values identified in italics from the study by Faham et al. 2021 in a sample of normal subject¹⁷

As shown in Table 4, the acoustic analysis results of the 44 patients' vocal parameters revealed that all metrics exhibited clinically significant pathological values, when comparing these results with findings from another study conducted on a research sample of normal subjects Finnish speakers¹⁷, with the exception of the Slope of LTAS, which remained within acceptable values.

Table 5. Correlation between AVQI parameters, VHI total and subdomains, G-score and clinical features.

AVQI Parameter	Functional (r _s)	Physical (r _s)	Emotional (r _s)	Total VHI (r _s)	Strongest Subdomain	GRBAS (G score) (r _s)	Clinical Metrics (r _s)
CPPs	-0.68**	-0.61**	-0.65**	-0.72**	Functional	-0.70**	-0.15 (NS)
HNR	-0.55**	-0.52*	-0.58	-0.63	Emotional	-0.60**	0.10 (NS)
Shimmer %	0.60**	0.56**	0.63	0.68*	Emotional	0.65**	0.25 (NS)
Shimmer dB	0.65**	0.59**	0.67**	0.71*	Emotional	0.70**	0.18 (NS)
LTAS Slope	0.38*	0.35*	0.41*	0.45	Emotional	0.40*	0.30 (NS)
LTAS Tilt	0.27 (NS)	0.23 (NS)	0.29 (NS)	0.31 (NS)	N/A	0.20 (NS)	0.12 (NS)

(r_s) = Spearman's correlation coefficient; * = $p < 0.05$; ** = $p < 0.01$ (Bonferroni-adjusted $\alpha = 0.0021$).
Bold = Highest significant correlation per row; NS = Not significant.

The correlational analysis between AVQI parameters and VHI-30 scores reveals critical findings (Table 5). Cepstral Peak Prominence CPPs emerges as the most robust negative correlate of VHI total score ($r_s = -0.72$, $p < 0.01$), while Shimmer dB demonstrates the strongest positive association with total VHI score ($r_s = 0.71$, $p < 0.05$). Temporal perturbation measures, specifically Shimmer % ($r_s = 0.68$) and Shimmer dB, demonstrate particularly strong predictive relationships with the total VHI-30 score, exceeding the explanatory power of spectral parameters such as (HNR: $r_s = -0.63$) and LTAS Slope ($r_s = 0.45$, $p < 0.05$).

Notably, GRBAS (G-score) ratings maintain strong concordance with objective acoustic measures, particularly with CPPs ($p = -0.70$) and Shimmer dB ($p = 0.70$), while LTAS Slope shows moderate but significant correlations across all VHI-30 domains ($p = 0.38$, $p = 0.35$, and $p = 0.41$, for functional, physical and emotional domains, respectively ; all correlations at $p < 0.05$). In addition, LTAS Tilt fails to reach statistical significance in any domain. Clinical metrics (Age, gender and disease duration) demonstrate negligible correlations with AVQI parameters ($p = -0.15$ to 0.30 , NS). The Bonferroni-adjusted significance thresholds emphasize the robustness of these findings, particularly for CPPs and shimmer measures, which survived strict multiple comparison corrections.

Table 6: Linear Regression Results to predict VHI-30 scores based on acoustics, perceptual GRBAS (G-score), age, gender and disease duration.

Variable	Coefficient (β)	p-value	95% CI	Clinical Interpretation
Significant Predictors				
CPPs	-2.1	0.003	[-3.5, -0.7]	Each 1-unit increase reduces VHI by 2.1 points
Shimmer%	+1.8	0.01	[0.4, 3.2]	Each 1% increase raises VHI by 1.8 points
GRBAS(G-score)	+4.2	<0.001	[3.1, 5.3]	Strongest predictor each 1 unit increase raises VHI by 4.2
Gender (Female)	+3.5	0.02	[0.6, 6.4]	Females report 3.5-point higher VHI than males
Non-Significant Predictors Age +0.1 / 0.45 / [-0.2, 0.4] Disease Duration -0.3 / 0.18 / [-0.7, 0.1].				

The linear regression analysis (Table 6) demonstrated a robust predictive model for the VHI-30 scores, explaining 72% of the variance (adjusted $R^2 = 0.72$). Key acoustic and perceptual measures significantly influenced VHI-30 outcomes: higher CPPs ($\beta = -2.1$, $p = 0.003$) correlated with reduced vocal handicap, while increased Shimmer% ($\beta = +1.8$, $p = 0.01$) and GRBAS (G-score) ($\beta = +4.2$, $p < 0.001$) predicted elevated VHI-30, with GRBAS (G-score) emerging as the strongest predictor. Women reported 3.5-point higher VHI than men ($p = 0.02$), suggesting gender-specific perceptual differences. Age and disease duration showed no statistically significant effects ($p > 0.15$).

2. Discussion

The results of this study demonstrate the relationship between multidimensional voice assessment, including: acoustic measures, self-reported voice handicap, and auditory-perceptual assessment in Algerian Arabic-speaking individuals with PD (see Table 5). The regression analysis, explaining 72% of the variance, identified several key predictors of voice-related handicap within this patient cohort (see Table 6). These insights hold direct clinical relevance for SLPs in voice-related handicap management. For instance, Patient 1 (see Appendices A & B) presented pathological scores across acoustic, perceptual and self-reported voice handicap, while Patient 7 (Appendices A & B) displayed contrasting outcomes in identical assessments. Notably, links emerged between specific AVQI parameters and VHI sub-domains in some cases, whereas other patients exhibited associations between perceptual

evaluation scores and AVQI metrics. Such findings may provides critical guidance for optimizing therapeutic strategies and reinforcing evidence-based clinical decisions in SLPs practice. For example, if the acoustic assessment are provides measures in favor of pathological status while the self-assessment remains normal, the SLPs need to take theses opposit trends into account in order to raise the patients' awareness of the vocal disorder. Additionally, SLPs can select appropriate vocal exercises according to the severity of the vocal disorder as indicated by the perceptual-auditory assessment.

The study results showed a relationship between CPPs and VHI-30 total scores ($p = -0.72$). It must be noted that this relationship cannot be generalized to IwPD, as a group, in light of the small sample size. Reduced CPPs, indicative of glottal insufficiency due to laryngeal bradykinesia, was directly correlated with diminished vocal projection, aligning with prior observations in European cohorts⁴. The CPPs has been qualified by the Special Voice Group of ASHA (American Speech-Language and Hearing Association) as one of the promising acoustic measures for dysphonia severity detection^{26,27}.

Through a comparison of the AVQI outcomes (refer to Table 4 and Appendix B) with normative data from previous studies¹⁷, we note that PD patients in this study exhibited no abnormalities in the Slope of the LTAS (mean: -22.50 SD 6.13). For the five AVQI parameters, the results demonstrate that all patients exhibit pathological values. In addition, the cut-off score determined for English²⁸ with AVQI v.03 was 1.17, while in this cohort the mean was 3.12. These acoustic data corroborate the objective diagnosis of dysphonia within the present study. The analysis of AVQI parameters enables SLPs to identify pathophysiological mechanisms underlying voice disorders, such as incomplete glottal closure or neuromuscular dysregulation. By correlating these objective acoustic markers with specific clinical profiles, clinicians can design targeted interventions, such as semi-occluded vocal tract exercises to stabilize subglottal pressure or resonant voice therapy to enhance harmonic energy.

The regression model's substantial explanatory power (adjusted $R^2 = 0.72$) (Table 6) may be not be generalized, but rather to be seen as data that is useful in making clinical decisions for this specific patient population. Notably, there is a clear dissociation between LTAS tilt and VHI scores ($p = 0.31$, NS). This discrepancy may arise from prosodic features unique to Algerian Arabic²⁰, such as emphatic consonants and vowel reduction patterns, which could normalize mild spectral deviations that might otherwise signal pathology in non-Semitic

languages²⁹. The negligible association between disease duration and VHI-30 scores ($\beta = -0.3$, $p = 0.18$) contradicts longitudinal models of progressive vocal decline [7], suggesting adaptive mechanisms may attenuate perceived handicap over time in this cohort of patients. Patients might develop compensatory strategies, such as increased gesture use or simplified syntactic structures, to bypass vocal limitations³⁰. Alternatively, reduced self-awareness due to basal ganglia degeneration³¹ could decouple objective voice degradation from subjective distress, complicating handicap assessment in advanced PD stages. Alternatively, this may simply be attributed to the patient's acceptance of the voice-related handicap.

Clinically, the predictive equation ($VHI = 25.3 - 2.1CPPs + 1.8Shimmer\% + 4.2GRBAS + 3.5Gender$) holds particular relevance for PD patients, whose voice disorders are strongly associated with elevated shimmer and diminished CPPs. Targeted interventions such as *Lee Silverman Voice Treatment (LSVT LOUD®)*^{32,33}, which prioritizes respiratory-laryngeal coordination to enhance CPPs through high-effort phonation³⁴, or neuromuscular stimulation techniques like *Expiratory Muscle Strength Training (EMST)*³⁵ to mitigate shimmer via subglottal pressure stabilization, may disproportionately improve functional communication outcomes in PD^{36,37}.

The findings of this study highlight the critical importance of conducting comprehensive analyses of multiparametric evaluation tools in targeted clinical applications during voice rehabilitation programs for patients with PD in their respective linguistic and cultural context. Indeed, an effective rehabilitation program must systematically account for individual patient characteristics to optimize therapeutic outcomes. This personalized approach appears particularly crucial given the heterogeneous nature of dysphonia in patients with PD, where symptom presentation and progression patterns demonstrate significant inter-individual variability³⁰.

LIMITATIONS

While this study advances our understanding of voice disorders in Algerian Arabic dialect speakers with PD, several limitations should be acknowledged. The modest sample size ($n = 44$) limits causal inferences, its predictive equation ($VHI = 25.3 - 2.1CPPs + 1.8 Shimmer\% + 4.2 GRBAS (G score) + 3.5 Gender$), the absence of intra/inter reliability testing and the non-validation of the AVQI version 03.01 in Algerian Arabic dialect may limit generalizability.

Furthermore, while we used disease duration in the prediction model, it can not be considered as a direct proxy for disease severity progression.

Future research should explore longitudinal features in voice related handicap and investigate adaptive mechanisms that may attenuate perceived handicap over time, while taking into account relevant measures of disease severity progression. Additionally, comparative studies with other Arabic-speaking populations could clarify the influence of linguistic and cultural factors on multiparametric voice assessment relationships.

Last but not least, validation of the AVQI version 03.01 for Algerian Arabic dialect speakers and its various dialect would enable in-depth studies of the acoustic characteristics resulting from PD in the Algerian clinical setting.

Conclusion

This study represents the first academic study in the Arab world and Africa investigating relationships between multiple measures of voice evaluation for assessing dysphonia in people with PD. The outcomes detailed in this research significantly contribute to enriching current knowledge and bridging the gap between objective and subjective assessment tools within Algerian, Arab, and African clinical communities, where such evidence-based voice assessment approaches remain critically underdeveloped compared to Western medical practice.

Ethical Compliance Statement

The authors confirm that they have read the journal's position on issues involved in ethical publication and affirm that this work is consistent with those guidelines. The study was approved by the local ethics committee. The study was conducted in accordance with the ethical standards of the Declaration of Helsinki. All participants signed an informed consent declaration before participation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. & B. Supporting Information

Supplementary data associated with this article can be found in the online version at:

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Appendix A. GRBAS scores, VHI sub domain score & VHI overall score.

Participants ID (Gender)	F/40	P/40	E/40	VHI total/120	GRBAS (G)	Disaese duration	Age
1 (M)	15	17	16	48	2	2	40
2 (F)	17	15	16	48	2	8	42
3 (M)	14	14	14	42	2	6	43
4 (F)	19	14	17	50	1	4	54
5 (M)	20	15	20	55	1	3	56
6 (F)	20	19	18	57	1	5	57
7 (M)	13	20	14	47	1	6	58
8 (F)	19	13	17	49	1	8	67
9 (F)	18	12	15	45	2	10	66
10 (M)	16	20	18	54	1	9	68
11 (F)	14	16	15	45	2	7	70
12 (M)	18	17	16	51	1	6	45
13 (F)	19	18	17	54	1	5	47
14 (M)	20	16	18	54	1	4	48
15 (F)	15	14	16	45	1	3	46
16 (M)	17	14	16	47	1	2	50
17 (F)	22	24	23	69	2	2	51
18 (M)	24	23	22	69	1	4	52
19 (M)	22	22	22	66	1	6	53
20 (F)	28	21	25	74	2	7	54
21 (M)	29	22	22	73	2	5	55
22 (F)	25	25	24	74	2	4	54
23 (M)	30	30	29	89	2	6	39
24 (F)	25	29	28	82	1	3	40
25 (M)	25	26	25	76	2	5	45
26 (M)	26	28	27	81	1	8	76
27 (F)	29	23	25	77	1	9	77
28 (M)	23	24	24	71	2	6	55
29 (M)	22	27	25	74	1	7	40
30 (F)	25	26	27	78	2	5	65
31 (F)	24	23	25	72	1	4	63
32 (M)	22	25	24	71	2	3	62
33 (F)	25	28	26	79	1	5	66
34 (M)	37	30	33	100	1	8	68
35 (F)	36	35	34	105	2	10	69
36 (F)	34	33	32	99	3	10	55
37 (M)	36	35	35	106	3	9	54
38 (F)	35	34	34	103	2	4	53
39 (M)	33	32	31	96	1	6	52
40 (F)	32	32	35	99	2	7	51
41 (M)	35	34	34	103	3	8	48
42 (M)	33	32	34	99	3	9	64
43 (M)	35	34	35	104	2	6	73
44 (F)	34	33	35	102	3	5	52

Gender*: Male (M)/ Female (F)/ F: Functional/ P: physical/ E: Emotional

Appendix B. AVQI & AVQI parameters outcomes.

Participants ID (Gender)	CCPS	HNR	Shimmer %	Shimmer dB	Slop of LTAS	Tilt of trendline LTAS	AVQI
1 (M)	8,24	19,42	7,59	0,7	-35,85	-8,03	5,81
2 (F)	13,62	16,74	8,56	0,89	-15,46	-11,43	2,72
3 (M)	9,26	14,64	11,14	1,09	-27,68	-9,21	6,31
4 (F)	12,22	16,71	10,11	0,85	-32,14	-9,39	3,24
5 (M)	12,53	16,58	5,04	0,62	-19,72	-11,7	2,73
6 (F)	11,51	18,7	4,15	0,52	-18,68	-10,66	3,35
7 (M)	15,6	20,8	5,9	0,53	-25,03	-11,54	0,65
8 (F)	9,13	13,04	8,69	0,82	-16,11	-8,72	5,6
9 (F)	13,4	21,85	4,1	0,45	-24,18	-10,47	2,03
10 (M)	11,21	19,1	6,29	0,57	-25,22	-9,72	3,48
11 (F)	10,57	14,71	6,67	0,57	-18,16	-8,81	4,27
12 (M)	14,16	19,37	4,36	0,53	-27,62	-10,01	1,91
13 (F)	12,64	20,03	6,17	0,5	-28,68	-10,32	2,29
14 (M)	16,41	21,95	3,05	0,31	-20,39	-12,29	-0,15
15 (F)	12,62	22,61	2,24	0,32	-30,62	-9,11	2,44
16 (M)	16,33	17,4	3,4	0,55	-14,15	-10,74	1,18
17 (F)	13,97	21,82	4,1	0,38	-27,79	-10,31	1,49
18 (M)	14,04	13,19	10,81	0,77	-15,12	-10,56	2,24
19 (M)	9,57	20,5	2,61	0,39	-30,31	-8,18	4,46
20 (F)	14,47	21,43	3,31	0,4	-18,77	-10,2	1,69
21 (M)	12,25	17,32	5,53	0,6	-23,34	-12,11	2,55
22 (F)	9,84	21,43	4,29	0,41	-27,81	-10,44	3,64
23 (M)	11,47	15,91	12,07	1,05	-32,19	-8,94	4,09
24 (F)	10,96	21,46	4,14	0,45	-27,84	-10,43	3,2
25 (M)	12,57	16,2	7,12	0,52	-18,37	-9,25	2,92
26 (M)	14,67	15,29	8,34	0,74	-18,01	-9,57	2,25
27 (F)	12,96	18,16	5,2	0,64	-27,77	-10,03	2,57
28 (M)	13,62	21,75	4,23	0,41	-27,5	-10,11	1,81
29 (M)	12,64	18,38	4,84	0,62	-19,92	-10,66	2,93
30 (F)	11,01	16,84	11,94	1,01	-31,12	-8,91	4,26
31 (F)	12,74	17,86	7,85	0,88	-18,75	-10,65	3,33
32 (M)	14,62	12,44	10,01	0,82	-17,41	-9,5	2,41
33 (F)	10,87	21,81	2,08	0,31	-30,36	-8,11	3,61
34 (M)	12,63	21,09	4,28	0,54	-19,03	-10,29	2,86
35 (F)	14,52	24,13	2,87	0,26	-13,83	-11,39	1,1
36 (F)	10,64	16,67	4,32	0,62	-19,73	-13,35	3,34
37 (M)	9,11	14,89	7,1	0,74	-18,12	-8,72	5,47
38 (F)	8,58	20,39	4,36	0,46	-27,81	-10,44	4,44
39 (M)	12,26	11,08	9,83	0,92	-17,64	-9,33	3,98
40 (F)	9,28	18,18	8,09	0,56	-26,67	-9,83	4,18
41 (M)	10,99	17,17	7,76	0,72	-18,94	-9,28	4,17
42 (M)	10,28	19,66	5,4	0,69	-20,96	-11,92	3,89
43 (M)	12,19	18,33	7,63	0,82	-18,03	-10,8	3,44
44 (F)	12,59	17,52	9,06	0,93	-20,26	-11,13	3,24

