Correlation of VHI-30 to Acoustic Measurements Across Three Common Voice Disorders

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Summary: Objectives. Voice disorders that affect the quality of voice also result in varying degrees of psychological and social problems. The research question here is whether the correlations between Voice Handicap Index (VHI)-30 scores and objective acoustic measures differ in patients with different types of voice disorders.

Methods. The subjects were divided into three groups: muscle tension dysphonia (MTD), benign mid-membranous vocal fold lesions, and unilateral vocal fold paralysis (UVFP). All participants were male. The mean age for the groups were 32.85 ± 8.6 years in the MTD group, 33.24 ± 7.32 years in the benign lesions group, and 34.24 ± 7.51 years in the UVFP group. The participants completed the Persian VHI-30 questionnaire. PRAAT software was used to obtain acoustic analyses.

Results. There was a significant correlation between the physical subscale of the VHI-30 and the total score of the VHI-30 and maximum phonation time (MPT) in the MTD group. Also, there was a significant correlation between the total VHI-30 score and the MPT value. There were relatively strong and significant correlations between the physical subscale of the VHI-30 with jitter and shimmer, harmonics-to-noise ratio (HNR) for the group with benign lesions such as nodules and polyps. Also, in this group, there was a significant correlation between the total VHI-30 score and the jitter value. The physical scale had strong and significant correlations between jitter, shimmer, and HNR in the unilateral paralysis group.

Conclusions. Findings suggest that although the VHI-30 and the acoustic measurements of voice provide independent information, they are associated to some extent.

Key Words: voice disorders–quality of life–subjective measurements–VHI-30–acoustic measurements.

INTRODUCTION

Voice disorders not only affect the quality of voice, its capabilities, and parameters, but also result in varying degrees of psychological and social limitations. Even though voice problems are typically not life threatening, they can have a substantial impact on an individual's quality of life.[1] Recent emphasis in measuring patients' perceptions of the impact of disease and subsequent treatment stems from the recognized worth of such perceptions in improving clinical care of patients.[2] For the sake of thoroughness of voice evaluations, various quality of life questionnaires have been developed for populations with voice disorders such as the Voice Handicap Index (VHI-30), Voice Handicap Index-10 (VHI-30-10), Voice-Related QOL, Voice Outcome Survey, Voice Activity and Participation Profile (VAPP), and the Voice Symptom Scale (VoiSS).[3–9]

As noted previously, one of the tools for evaluating the perceptions of a person with a voice disorder is the VHI-30 that was proposed by Jacobson et al in 1997.[4] This instrument makes it possible to evaluate the level of self-perceived handicap that patients experience as a result of their voice disorders. The VHI-30 has good internal consistency and reliability, and can accurately reflect the subjective perceptions of patients relative to voice disorder severity.[10]

The Persian-translated version of the VHI-30 scale proposed by Moradi et al[11] proved to have high reliability and validity. They showed that the internal consistency of the VHI-30 had a very high Cronbach alpha coefficient for the total score of the questionnaire (0.87) as well as for the physical (0.84), functional (0.86), and emotional (0.91) subscales. Furthermore, the reliability analysis showed $r = 0.96$ for the total score, and for the three subscales physical, functional, and emotional, the r value was 0.93, 0.93, and 0.94, respectively.

In addition, acoustic and aerodynamic measurements of voice for assessing the patient's voice disorder status have demonstrated sufficient sensitivity to roughly differentiate grossly normal from dysphonic voices.[12–14] However, objective assessments via acoustic or aerodynamic measurements and advanced imaging techniques (video-laryngostroboscopy, kymography, or high-speed videoendoscopy) may not make it possible to assess the level of handicap that patients experience as a result of their voice disorders.[15–17] Previous studies suggest that acoustic measures may not be predictive of the overall VHI-30 score, even if there are significant correlations between items of the VHI-30 and some voice parameters.[18–20] This lack of relationship may be due to participants not being grouped homogenously and the presented voice disorders having different origins.[21] However, this issue may have other reasons; for example, quality of life and object measures are measuring very different things. Objective measures are looking at one moment of time, whereas quality of life questionnaires span over a longer period of time and incorporate patient emotions and personal perceptions. Hsiung et al mentioned that "a patient's subjective feelings regarding his/

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her dysphonic problem cannot be evaluated using objective measurements".[18]

The subjects of the current study were Farsi speakers. There are considerable differences in the vowel systems between Farsi and English languages.[22] For instance, the numbers of vowels differ. English has approximately 11 phonetic vowels (not including diphthongs) that are widely distributed across the F1-F2 space,[23] whereas Farsi contains 6 phonetic vowels {/i/, /e/, /æ/, /a/, /o/, /u/}.[24] There are also tense/lax distinctions. The tense/lax vowel pairs in English such as /i/ vs /ɪ/, /e/ vs /ɛ/, /u/ vs /ʊ/ do not exist in the six-vowel system of Farsi. The length of vowels is another factor. Farsi does not have much variation in vowel length, whereas English has so-called long and short vowels.[25] Furthermore, Farsi syllables always take one of the following patterns: CV, CVC, or CVCC.

Stress factors such as syllable-timing vs stress-timing also differ between Farsi and English. According to Windfuhr, Farsi is characterized as a syllable-timed language.[26] In other words, the syllables are said to occur at approximately regular intervals of time, and the amount of time it takes to produce a sentence depends on the number of syllables in the sentence, not on the number of stressed syllables as in stress-timed languages like English and German. Bradlow reported that English vowels (stress-timed) have significantly higher values and a broader acoustic vowel space than their Spanish counterparts that like Farsi is a syllable-timed language.[27]

The aim of the present study was to investigate the relation of the VHI-30-30 results with objective voice measurements for homogenous dysphonic participants having one of three common voice disorders (vocal fold lesions, primary muscle tension dysphonia [MTD], or unilateral vocal fold paralysis [UVFP]). It is worth mentioning that Rosen et al claimed that individual subscales of the VHI-30 (functional, emotional, physical) were not found to be valid as independent, separate factors of the VHI-30.[5] Therefore, investigating correlations between the VHI-30 as a whole and acoustic measures may have more importance and value than the correlations between subscales and acoustic measures.

The purpose of this study was to determine whether the correlations between VHI-30 scores and values of objective measures differ in patients with different voice disorders and etiologies, and whether the correlations were significant and meaningful. Based on the literature review, few studies have attempted to evaluate whether the correlations between VHI-30 scores and objective measures differ in patients with different voice disorders. As noted above, because there are differences in the vowel systems between Farsi and English, acoustic factors are expected to be different because of the different phonetic structures.[22] Thus, a study such as the one presented here using Farsi subjects is necessary to compare results with those performed using English speakers.

MATERIALS AND METHODS

Participants

Participants were over 18 years old, and grouped relative to the primary diagnoses of MTD (group 1, n = 28), benign mid-membranous vocal fold lesions (group 2, n = 27), or UVFP (group 3, n = 27). Diagnosis of primary MTD required dysphonia with normal morphology and movement of the vocal folds.[28] All participants with benign vocal fold lesions were included in the lesion group and participants with UVFP were assigned to group 3. Diagnosis and clinical examinations following routine laryngological examination procedures including video-laryngostroboscopy were performed by two Ear, Nose, and Throat (ENT) specialists (laryngologists) in the ENT ward of Amir Alam Hospital. The specialist examined the larynx by indirect laryngoscopy with a head light and then with laryngostroboscopy. The patients were asked to sustain the vowel /i/ for getting better visualization. It is noted that group 1 may also have included a number of patients with secondary instead of primary MTD, because of the difficulties in diagnosing primary MTD.

Based on the estimates from past research on acoustic and aerodynamic voice measures with an alpha of 0.05, a sample size of almost 30 participants in each voice disorder group was needed to achieve 80% statistical power to detect a significant correlation with a modest effect size (between 0.45 and 0.50). Thus, group 1 consisted of 28 people, group 2 consisted of 27, and group 3 consisted of 27. Diagnosis of pathology and classification of participants were performed by an ENT specialist. All participants were male (chosen for homogenous gender reasons relative to acoustic measures, and because males constitute a more convenient clinical population in Iran). Mean age was 32.85 ± 8.6 years (range, 18–48 years) in group 1, 33.24 ± 7.32 years (range, 18–49 years) in group 2, and 34.24 ± 7.51 years (range, 18–49 years) in group 3.

Procedures

The participants completed the Persian VHI-30-30 questionnaire. This tool consists of 30 questions divided into three equal subscales: functional, emotional, and physical. Its total score ranges from 0 to 120, and a higher score indicates a more strongly perceived handicap resulting from the voice disorder. Patients were audio-recorded while producing the vowel / â / using a comfortable loudness level and a constant pitch as long as possible, repeated twice with about 5 seconds between trials. The microphone (ECM-717 electret condenser microphone, Sony Corporation, Minato, Tokyo, Japan) was positioned approximately 10 cm from the mouth. All recordings were made in a quiet acoustically treated room. The room noise level was determined by a sound level meter (model: CEL-450, product of Casella CEL, Regent House, Kempston, Bedford, UK) with room noise measured as Min LA: 28.0 dB and Min LC: 40.8 dB. All of the stimuli were type I (nearly periodic signals).[29] Measures of fundamental frequency (F0), types of jitter such as local, Relative Average Perturbation (RAP), five-point Period Perturbation Quotient (PPQ5), Difference of Differences of Period (DDP), types of shimmer such as local, three-point Amplitude Perturbation Quotient (APQ3), Five-point Amplitude Perturbation Quotient (APQ5), 11-point Amplitude Quotient (APQ11), Difference of Differences of Amplitude (DDA), and harmonics-to-noise ratio (HNR) were obtained over the middle 3 seconds of the recordings. The values for each of the three tokens were averaged together to create the representative value for that patient. Finally, the maximum phonation time (MPT) was determined by measuring the duration of the sustained /â/ productions, and the longest of the three productions was taken as the representative MPT.

Instrumentation

Recordings and analyses were carried out using PRAAT software version 5.3.13[30] installed on a laptop (Dell Inspiron 6400, Dell Inc., Round Rock, TX; sound card Sigmatel STAC92XX C-Major HD, Audio Sigmatel Corp, Austin, TX). The acoustic signal was captured with an ECM-717 electret condenser microphone (Sony Corporation; frequency response 100–15,000 Hz). The microphone was placed in front of the mouth on a stand and a 10-cm mouth-to-microphone distance was maintained for all recordings.

Statistical analysis

The Kolmogorov-Smirnov test was used to assess the normality of the VHI-30 and objective scores distributions, which were found to be normal. One-way between-groups ANOVA was used to test mean differences of VHI-30 and its subscales among the three groups of patients. The correlations between MPT, perturbation analyses, and VHI-30 data of the three groups of patients were measured using Pearson correlation. A significance level of 0.05 for all tests was used. The ranges of correlation were as follows: <0.3, poor; 0.3–0.5, fair; 0.5–0.7, good; and 0.7–0.9, very good. Statistical analyses were performed using the SPSS 22 package (SPSS Science, Chicago, IL).

RESULTS

Mean (M) and standard deviations (SD) of F0, jitter, shimmer, HNR, and MPT in three groups are summarized in Tables 1 and 2. There was no significant difference across the three groups for the total VHI-30 score and for each of the three subscales using one-way between-groups ANOVA. The VHI-30 mean scores and the standard deviation for each of the three patient groups are illustrated in Table 3**.** The correlations between the VHI-30 scores and the acoustic analyses for the three groups (MTD, benign organic lesions, and UVFP) are shown in Tables 4–6. As given in Table 4, there was a significant correlation between the physical subscale and MPT in the MTD group ($P < 0.05$). The correlation value was relatively weak, however: r = −0.29. This result suggests that, with increase of the VHI-30 physical scale value, the MPT value tends to decrease. As noted, there was a significant ($P < 0.05$) correlation between the Total VHI-30 score and the MPT value, again with a relative weak negative correlation of −0.36. Thus, although the result is significant, the relationship is too weak to suggest that the relationship is highly meaningful.

As shown in Table 5, for the benign lesion group there were relatively strong and significant ($P < 0.05$) correlations between the physical subscale of the VHI-30 with jitter (local, RAP, PPQ), shimmer (local, APQ3, APQ11, DDA), and HNR, with correlations ranging from 0.401 to 0.747 (with 6 of the 8 greater than 0.70). Also, there was a relatively strong and significant ($P < 0.05$) correlation between the Total VHI-30 score and jitter (RAP, r = 0.668) for this group.

TABLE 1.
Mean (M) and Standard Deviations (SD) of Fundamental Frequency (F0), Jitter, and Shimmer in Three Groups

Parameters	F0		Jitter								Shimmer									
			Local		RAP		PPQ5		DDP		Local		APQ3		APQ5		APQ11		DDA	
Subjects	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
MTD	134.21	1.09	0.52	.05	0.45	.04	0.48	.04	0.48	.07	4.63	.07	4.19	.2	5.26	.03	7.01	.2	5.25	.01
Benign lesions	125.34	1.2	0.65	.03	0.5	.03	0.54	.03	0.57	.05	5.37	.1	4.22	.12	5.54	.1	7.44	.5	5.28	.037
UVFP	110.6	2.1	1.10	.02	1.27	.16	1.25	.09	1.36	.08	7.38	.5	5.81	.36	6.86	.5	8.97	.31	7.32	.04

TABLE 2.
Mean (M) and Standard Deviations (SD) of Harmonics-to-Noise Ratio (HNR) and Maximum Phonation Time (MPT) in Three Groups

Parameters / Subjects	HNR		MPT	
	M	SD	M	SD
MTD	17.60	.51	22.6	1.28
Benign lesions	15.42	0.4	12.2	2.1
UVFP	12.41	1.2	7.5	1.3

For the UVFP group, Table 6 gives the correlation values between the VHI-30 and acoustic analyses. Again the physical scale had strong and significant ($P < 0.05$) correlations between jitter (local, RAP, PPQ, and DDP), shimmer (local and DDA), and HNR, with correlations ranging from 0.61 to 0.83. The correlation between the physical subscale and MPT was also high and significant (r = –0.75).

DISCUSSION

There were no significant differences found across the three groups of patients for the total VHI-30 score and its three subscales, suggesting that the three groups of patients had similar severity of perceived voice-related disability. This finding decreases the possibility that the different correlations between objective measures and VHI-30 score were related to the severity of the voice disorder among groups.

In the MTD group, the MPT was the significant (but relatively weak) measurement inversely related to the self-perception rating of the physical domain and the total VHI-30 values. The negative correlation finding is parallel with the results of the Schindler et al study.[21] They found significant correlations between MPT and the functional and physical VHI-30 domains for patients with functional dysphonia. A common complaint of patients with MTD is vocal fatigue.[31] Vocal fatigue frequently results in a prominent increase in speaking fundamental frequency and an anterior glottal chink as well as a reduced MPT.[21–34] It is stressed, however, that the relationship in this present study is weak and thus should not be taken as highly meaningful.

For patients with vocal fold tissue lesions, the nodules and polyps were mostly exophytic. This is the more common type of polyp, histologically.[36] The self-perceived functionality of the voice was highly related to jitter, shimmer, and HNR, suggesting that discomfort and an auditory sense of a voice problem increase as the instability and noise of the voice signal increase. In the study of Hsiung et al,[18] there was one low but significant correlation (0.270) between the functional subscale and the HNR measure. Woisard et al[19] studied the relationship between the VHI-30 and several voice laboratory measurements in a multidimensional voice assessment. They found "fair but significant correlations" between minimal fundamental frequency and the physical score (0.360), functional score (0.309), and total score (0.362), and fundamental frequency range and the physical score. Also, Schindler et al[21] reported relatively strong correlations between the physical VHI-30 domain and jitter, shimmer, and noise-to-harmonic ratio. The current study supports relatively large and significant correlations between both the physical score and the total VHI-30 score, with the acoustic characteristics supporting these earlier results for vocal fold lesion cases.

In the current study, similar to group 2, group 3 (patients with UVFP) results showed relatively strong correlations between the physical subscale and jitter (local, RAP, PPQ, and DDP), shimmer (local and DDA), HNR, and MPT. Schindler et al[21] reported good to excellent correlations between the physical VHI-30 domain and jitter, shimmer, and noise-to-harmonic ratio in their UVFP group (r = 0.58, 0.77, 0.76, respectively). The current study also found good to excellent correlations between the physical VHI-30 domain and jitter, shimmer, and HNR, and a strong inverse correlation between the physical VHI-30 domain and MPT. In summary, the results of the current study showed that based on nonorganic etiologies such as primary MTD, there were weak correlations between acoustic factors (MPT) and perceptual factors (physical subscale and total score of VHI-30). On the other hand, in organic etiologies such as benign lesions and UVFP, there were strong relations between acoustic factors such as HNR, MPT, and indexes of stability of phonation (jitter and shimmer) with self-perceptual factors.

CONCLUSIONS

In conclusion, the findings of this study indicate that although the VHI-30 and the acoustic measurements of voice provide independent information, that is, self-perceptual vs objective-acoustic, they are associated to some extent. In the MTD group, the physical limitation of the voice appeared to be related more to MPT. In patients with vocal fold tissue lesions or UVFP, the self-perceived functionality of the voice was related to the acoustic stability of phonation and MPT.

In general, patients pay attention to certain elements of their voice disorder and their consequences, as reflected by the VHI-30 questionnaire, depending on the etiology of dysphonia. The primary finding here was the VHI-30 ratings for MTD, benign

TABLE 3.
Mean, Standard Deviation of Total VHI-30 Scores, Emotional, Physical, and Functional Subscale Scores in the Three Different Groups of Dysphonic Patients

Subjects / VHI-30	MTD	Benign Organic Disorders	UVFP
Physical VHI-30	18.14 ± 4.27	17.89 ± 4.60	19.00 ± 4.47
Functional VHI-30	17.93 ± 3.87	17.81 ± 4.60	18.44 ± 3.91
Emotional VHI-30	17.82 ± 4.31	18.37 ± 4.93	19.19 ± 4.81
Total VHI-30	53.89 ± 11.93	54.07 ± 13.71	56.63 ± 12.76

TABLE 4.
Correlation Between VHI-30 and Acoustic Analyses in the MTD Group

VHI-30 \ Parameters		Jitter				Shimmer							
		Local	RAP	PPQ5	DDP	Local	APQ3	APQ5	APQ11	DDA	HNR	F0	MPT
Functional	r	–0.025	–0.030	–0.042	–0.027	0.122	0.158	0.125	0.52	0.151	–0.131	–0.18	–0.254
	P value	0.87	0.82	0.79	0.83	0.49	0.38	0.48	0.51	0.37	0.42	0.25	0.16
Physical	r	–0.108	–0.121	–0.145	–0.115	0.025	0.035	–0.004	–0.132	0.072	0.001	0.151	**–0.289**
	P value	0.51	0.48	0.32	0.38	0.72	0.81	0.91	0.63	0.92	0.38	0.32	**0.045***
Emotional	r	0.132	0.141	0.121	0.141	0.182	0.212	0.185	0.120	0.211	–0.252	–0.220	–0.391
	P value	0.52	0.48	0.39	0.51	0.81	0.79	0.91	0.41	0.23	0.14	0.19	0.08
Total	r	0.019	0.02	0.001	0.025	0.141	0.172	0.131	0.037	0.178	–0.171	–0.221	**–0.364**
	P value	0.83	0.81	0.91	0.87	0.41	0.31	0.42	0.81	0.31	0.32	0.23	**0.049***

The bold values are significant.
* Significant at the $P < 0.05$ level.

TABLE 5.
Correlation Between VHI-30 and Acoustic Analyses in the Benign Vocal Fold Lesion Group

VHI-30 \ Parameters		Jitter				Shimmer							
		Local	RAP	PPQ5	DDP	Local	APQ3	APQ5	APQ11	DDA	HNR	F0	MPT
Functional	r	–0.421	–0.411	–0.410	0.441	–0.240	–0.491	–0.414	–0.238	–0.491	0.381	–0.291	0.338
	P value	0.22	0.23	0.25	0.23	0.53	0.175	0.261	0.52	0.17	0.30	0.46	0.37
Physical	R	**0.721**	**0.747**	**0.738**	0.755	**0.598**	**0.716**	0.681	**0.401**	**0.705**	**0.735**	0.228	–0.372
	P value	**0.03***	**0.023***	**0.028***	0.09	**0.037***	**0.048***	0.30	**0.037***	**0.03***	**0.033***	0.52	0.30
Emotional	r	–0.506	–0.546	–0.510	–0.546	–0.327	–0.511	–0.414	–0.253	–0.510	0.524	–0.442	0.191
	P value	0.16	0.13	0.16	0.12	0.39	0.15	0.27	0.51	0.17	0.16	0.14	0.58
Total	r	0.647	**0.668**	0.651	0.669	0.465	0.652	0.577	0.343	0.651	0.644	0.646	–0.321
	P value	0.07	**0.049***	0.06	0.055	0.21	0.06	0.10	0.36	0.06	0.06	0.36	0.39

The bold values are significant.
* Significant at the $P < 0.05$ level.

TABLE 6.
Correlation Between VHI-30 and Acoustic Analyses in the UVFP Group

VHI-30 \ Parameters		Jitter				Shimmer							
		Local	RAP	PPQ5	DDP	Local	APQ3	APQ5	APQ11	DDA	HNR	F0	MPT
Functional	r	0.54	0.25	0.28	0.44	0.54	0.32	0.65	0.35	0.34	0.37	0.29	0.43
	P value	0.56	0.42	0.35	0.09	0.31	0.17	0.18	0.28	0.65	0.12	0.45	0.44
Physical	r	**0.73**	**0.81**	**0.61**	**0.83**	**0.68**	0.48	0.88	0.37	**0.75**	**0.71**	0.45	**–0.75**
	P value	**0.03***	**0.042***	**0.048***	**0.025***	**0.016***	0.052	0.06	0.51	**0.032***	**0.044***	0.57	**0.018***
Emotional	r	–0.63	0.62	–0.42	0.51	0.37	0.27	0.18	0.41	–0.51	0.35	0.17	0.12
	P value	0.33	0.53	0.51	0.64	0.57	0.25	0.36	0.37	0.35	0.39	0.56	0.78
Total	r	0.47	0.41	0.38	0.41	0.38	0.29	0.47	0.31	0.36	0.35	0.25	–0.45
	P value	0.052	0.32	0.31	0.35	0.051	0.31	0.54	0.42	0.72	0.51	0.57	0.057

The bold values are significant.
* Significant at the $P < 0.05$ level.

lesions, and UVFP correspond mostly to the physical domain of the VHI-30 and MPT. Similar findings in the literature[19,21] support those in the present study, which were obtained by subjects who speak Farsi. It thus becomes clear that although self-perception of disability and acoustic measures appears independent, there are measurable relations for individuals. However, this claim needs to be supported by additional studies with large sample sizes.

Future work should include participants' qualitative descriptions that clarify their perceptions of discomfort, quality of life, and other aspects associated with their disorders, to obtain a more complete interpretation of the connections between self-perception of voice and acoustic analyses of the stability of the vocal signal. Because of cultural problems,[3] there was not the possibility of enrolling female patients in the current study. Thus, a comparison study with findings from female patients is important as well.

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