

Preliminary Receiver Operating Characteristic Analysis on Voice Handicap Index of Laryngeal Inflammation in Greek Patients

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Abstract

Objective(s): Laryngeal inflammations lead to voice disorders. Medical conditions such as chronic laryngitis, gastroesophageal reflux, laryngopharyngeal reflux, Reinke edema and/or vocal folds hemorrhage, result in diverse symptoms including chronic cough, throat cleaning and dysphonia (e.g. hoarseness). In turn, the dysphonic symptoms can be evaluated via subjective and objective procedures. The objective procedures usually include self-perceived questionnaires like the Voice Handicap Index (VHI). Studies reported that VHI can distinguish objectively dysphonic and non-dysphonic populations using the cut-off points of Receiver Operating Characteristic Curves. The purpose of this study was to calculate the cut-off points for individuals exhibiting voice symptoms which had been developed from laryngeal inflammatory diseases in Greece. **Methods:** One hundred and twelve participants (90 non-dysphonic and 22 dysphonic) filled in the Hellenic Voice Handicap Index (VHI) and the Greek translated version of Voice Evaluation Template (VEF) were administrated. All subjects were evaluated by an Otolaryngologist and a Speech-Language Pathologist. **Results:** The group with voice disorders exhibited higher VHI scores (in total and in its 3 subdomains) compared to non-dysphonic subgroup. Statistical significant differences were found for all VHI's total cut-off point of 19.50 (sensitivity: 0.882, 1-specificity: 0.011) and for its three subdomains [functional 6.50 (sensitivity = 0.636, and 1-specificity

= 0.022); physical 9.50 (sensitivity = 0.636, and 1-specificity = 0.000); emotional 6.50 (sensitivity = 0.455, and 1-specificity = 0.133)]. **Conclusion:** The preliminary results showed that VHI could discriminate individuals having voice disorders from laryngeal inflammations. The Voice Handicap Index can be used as a primary health care tool and a self-monitoring procedure in acute and sub-acute phases of the laryngeal inflammation.

Keywords

Receiver Operating Characteristic, Statistical Analysis, Cut-Off Scores, Voice Handicap Index, Voice Disorders, Laryngeal Inflammatory Diseases

1. Introduction

The laryngeal pathogenesis mechanism, leading to voice problems, is complicated due to the contribution of sufficient aetiologies (anatomic, physical, habitual-functional, and/or environmental) [1]-[9]. A category of aetiologies is laryngeal inflammations which lead to voice disorders [10]-[24]. Examples of inflammatory medical conditions can be Gastroesophageal Reflux (GERD) [10] [11] [12] [13] [14], Laryngopharyngeal Reflux (LRP) [12] [13] [14] [15] [16], Reinke's edema [17] [18] [19] and/or vocal folds haemorrhage [20] [21] [22] [23] [24]. The aforementioned, usually result in diverse symptoms including sore throat, hoarseness, chronic cough and throat cleaning [10]-[25].

Those vocal and laryngeal symptoms affect a person's daily living and soon enough he/she will have to seek for professional evaluation. The evaluation of voice disorders according to European Laryngeal Society (ELS) [26], includes objective [27]-[36] and subjective [37] [38] assessment methods. Particularly, the subjective assessment is usually conducted with the use of self-reporting questionnaires which determine subjects' standpoints for their voice disorder and its impact on their way of living [37] [38].

In the literature, one of the most used self-perceived questionnaires is Voice Handicap Index (VHI) which was developed and standardized in 1997 by Jacobson *et al.* [39]. The VHI is a tool which acquires sufficient and evident data relevant to voice symptoms and the impact on the quality of life [39]. This data can be retrieved from the answers to 30 questions of VHI. The questionnaire is split into three sets of ten questions. Every question is based on a 0 to 4 Likert-type scale. Three sets of ten questions correspond to the three VHI's subdomains (Functional, Physical and Emotional). The total score of VHI varies from 0 (minimum) to 120 points (maximum).

The VHI scale was standardized and cross-culturally validated in many languages [40]-[50], including Greek [51] and recently in Danish [52]. Furthermore, VHI was administered in different populations [40]-[65] and it was proven that it could adequately distinguish between people of and without voice disorders [40]-[65]. This distinguishing capability has been reported in many stu-

dies using ROC analysis [66] [67] [68] [69]. The ROC curve methodology was developed during the World War II and was later adapted by health sciences for determining the threshold of symptoms-pathology due to different medical conditions [70] [71]. Based on the aforementioned significant findings and capabilities of ROC analysis, the aim of this study was to determine the cut-off points of VHI for patients experiencing voice disorders due to laryngeal inflammatory diseases in Greece.

2. Materials and Methods

2.1. Participants

The sample was consisted of one hundred and twelve (112) individuals. Particularly, ninety (90) individuals exhibited no vocal complaints (control group) and twenty-two (22) patients suffered from voice disorders due to laryngeal inflammatory disease (LID). The control group was assembled by patient's caregivers and their accompanied persons, staff and personnel of the ENT clinic and individuals attending the ENT department for other medical reasons. Moreover, were recruited people from the School of Health and Welfare Professions, TEI of Epirus. The LID group included 22 patients [ten (10) with Reinke's edema, three (3) with vocal fold haemorrhage, and nine (9) with chronic laryngitis]. The majority of LID patients attended the ENT clinic of the University Hospital of Crete (15 subjects) and seven (7) subjects a private medical office and SLP office in Ioannina-Greece.

The patients of the LID subgroup, which had previous laryngeal surgery or had other recent surgeries, were not included in this study. All LID patients were diagnosed via video laryngeal endoscopy and stroboscopy. The subjects which served as the control group were recruited based on the absence of the following: 1) history of alcohol or drug abuse, 2) history of gastroesophageal reflux (GERD) and/or laryngopharyngeal reflux disease (LPR), 3) lived or still living under affecting environmental conditions for voice (smoke, dust, chemicals, etc.), 4) upper or lower respiratory system disorder the last two weeks, 5) any laryngeal/vocal symptoms or past voice disorder/s and 6) a previous voice therapy

The eighteen (18) participants, out of the one hundred and eight (108) non-dysphonic participants, did not meet the study's inclusion criteria. The eleven (11) of them had a history of gastroesophageal reflux (GERD) and/or laryngopharyngeal reflux (LRP) disease with history of voice disorders in the past, three (3) cases had a history of alcohol abuse and in one (1) case the use of recreational drugs. Finally, three (3) cases had a history of exposure to noisy-dusty industrial environments.

2.2. Data Collection

All out of the one hundred and twelve (112) participants after signing a written consensus letter, they filled in the Voice Evaluation Template (VET) [72] (which had been translated in Greek) and the Hellenic version of VHI [48]. The VHI is

a self-reported questionnaire which consists of 30 items, which are split into three domains as already aforementioned [functional (VHI-F), physical (VHI-P) and emotional (VHI-E)]. All three domains sub-scores (0 - 40 points equally) additively lead to the VHI total score (VHI-T) with a maximum of 120 points. The VHI assess persons' perception level (awareness) of their voice problem's impact on daily living. The VET is a voice history form originated from the American Speech Hearing Association consensus committee. The VET was used to collect clinical data about the participants. This study was approved by the Ethical Committee of the Medical School of the University of Crete.

2.3. Statistical Analysis

The distribution of the variables was examined using the Kolmogorov-Smirnov and Shapiro-Wilk tests. All skewed variables were expressed through medians (interquartile range) and all normal distributed variables were expressed with means and standard deviations. The comparison between the control group and the LID patients was conducted with Mann-Whitney U test. Finally, ROC curve analysis was employed in order to estimate the cut-off values for VHI and its three domains. All reported P values were two-tailed and the statistical significance was set at $P < 0.005$. The analysis was conducted using SPSS statistical software (version 19.0, Armonk, NY, USA).

3. Results

The sample consisted of 112 participants (90 controls and 22 LID). The LID group had a mean educational level of $M = 11.27$ yrs. ($SD = 4.17$) and the control group had a mean of 13.01 yrs. ($SD = 5.09$). The participants of the LID group smoked for an average of $M = 12.23$ yrs. ($SD = 56.78$) while the participants from the control group did not smoke [$M = 0.00$ ($SD = 0.00$)]. The most of the subjects were married and they lived in urban areas (**Table 1**).

Table 1. Participants demographic data.

	LID Patients (N = 22)	Non-Dysphonic Participants (N = 90)
	Mean (SD)	Mean (SD)
Age	44.54 (18.99)	38.88 (12.11)
Educational Level	11.27 (4.17)	13.01 (5.09)
Years of Smoking	12.23 (6.78)	-
Marital Status		
Married	12	49
Single	10	41
Area of Living		
Urban area	13	57
Suburban area	6	23
Rural area	3	10

The control group exhibited a median of VHI-T at 15.00, for VHI-F at 5.00, for VHI-P at 5.50 and for VHI-E at 5.00. The median score of NVD group's VHI-T was found equal to 25.50, of VHI-F was found as 7.50, for VHI-P was 22.00 and of VHI-E was 16.00. The NVD exhibited higher scores in all comparisons to control group for VHI total score and its three domains: VHI-T [U = 467.000, P < 0.001]; VHI-F [U = 575.500, P < 0.005]; VHI-P [U = 519.500, P < 0.001 and for VHI-E (U = 699.500, P < 0.001) (**Table 2**). The results of VHI (**Figure 1**) and its three domains (**Figures 2-4**) are presented as box plots.

The determination of the cut-off points for VHI and its three domains was accomplished by conducting ROC analysis. A statistically significant positive discrimination between control group and NVD was revealed. Specifically, an excellent effect value was noted for VHI-T (AUC 0.764, P < 0.001), VHI-F (AUC 0.709, P < 0.005), VHI-P (AUC 0.738, P = 0.001) and VHI-E domain (AUC 0.647, P < 0.001) (**Table 3**).

The cut-off point of VHI-T score was equal to 19.50 with sensitivity of 0.636

Table 2. Comparisons of medians between controls and LID for VHI Total score and its domains.

	Controls (N = 90)	LID (N = 22)	Mann-Whitney U	P level
	Median (IQR)	Median (IQR)		
Total	15.00 (13.00 - 17.00)	25.50 (15.25 - 43.50)	467.000	<0.001*
Functional	5.00 (4.00 - 6.00)	7.50 (3.75 - 10.75)	575.500	<0.005*
Physical	5.50 (5.00 - 6.25)	13.50 (4.75 - 18.50)	519.500	<0.001*
Emotional	5.00 (4.00 - 6.00)	6.00 (4.00 - 11.00)	699.500	<0.005*

*p level at P < 0.05. Abbreviations: IQR, interquartile range; VHI, Voice Handicap Index.

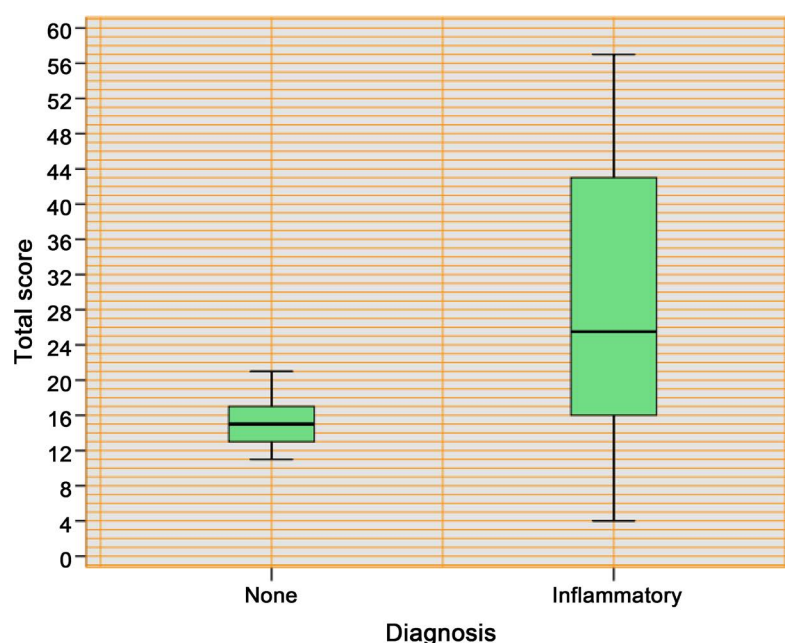


Figure 1. VHI box plot—total score of the two subgroups.

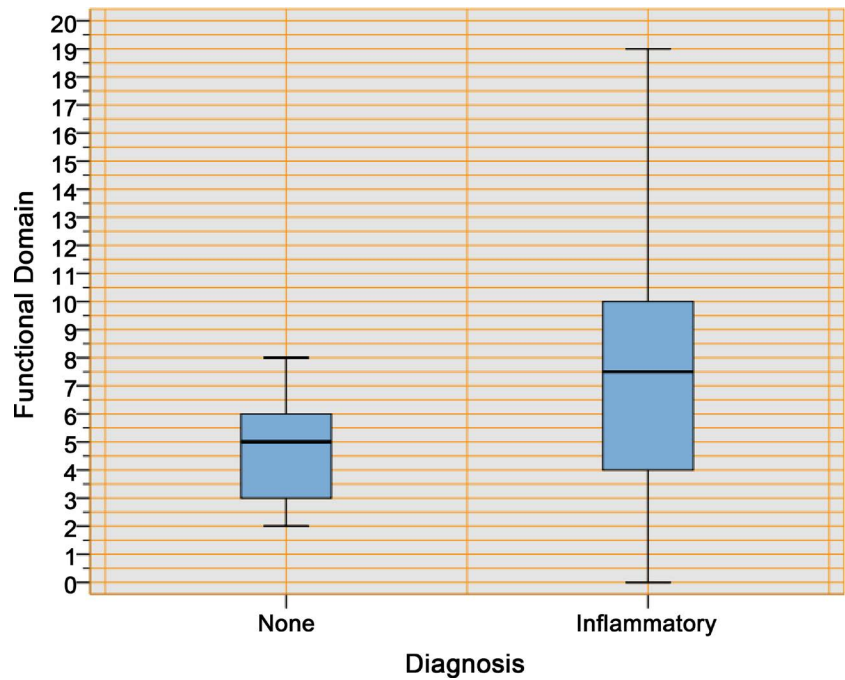


Figure 2. VHI box plot—functional domain’s score of the two subgroups.

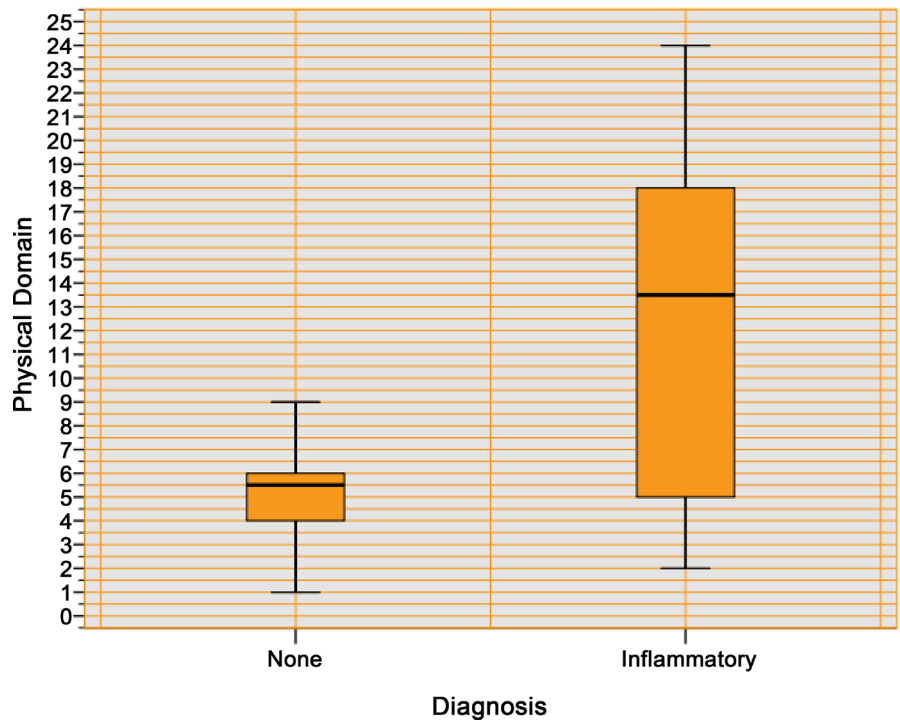


Figure 3. VHI box plot—physical domain’s score of the two subgroups.

and 1-specificity of 0.022 (Figure 5), VHI-F cut-off point was equal to 6.50 with sensitivity of 0.591 and 1-specificity of 0.111 (Figure 6). Also, VHI-P cut-off point was equal to 9.50 with sensitivity of 0.636 and 1-specificity of 0.000 (Figure 7) while VHI-E cut-off point was equal to 6.50 with sensitivity of 0.455 and 1-specificity of 0.133 (Figure 8).

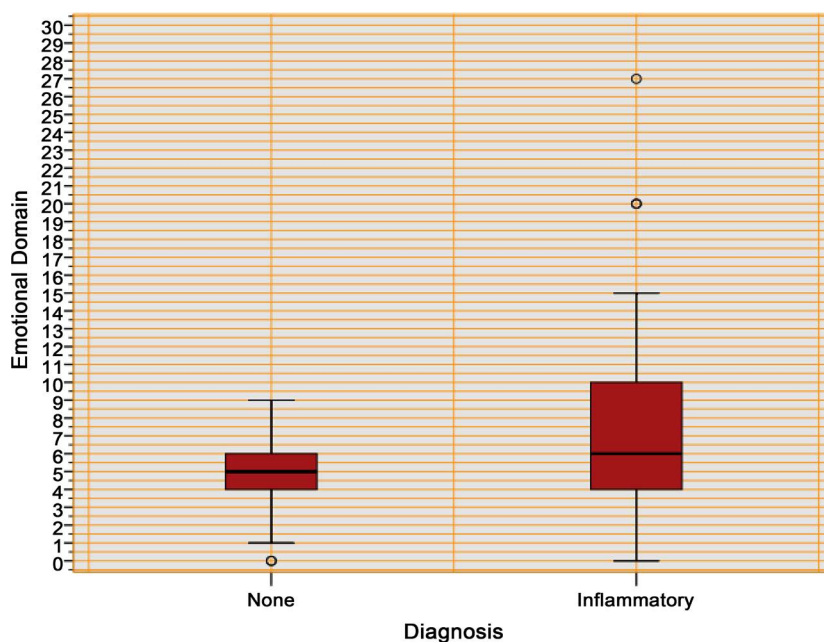


Figure 4. VHI box plot—emotional domain’s score of the two subgroups.

Table 3. Details of IVD and non-dysphonic curve for VHI Total score and its 3 domains.

	AUC	SE	P level	95% CI
Total	0.764	0.080	<0.001*	0.607 - 0.921
Functional	0.709	0.085	<0.005*	0.543 - 0.876
Physical	0.738	0.079	= 0.001*	0.583 - 0.983
Emotional	0.647	0.033	<0.005*	0.487 - 0.807

*p level at P < 0.05. Abbreviations: AUC, area under curve; CI, confidence interval; SE, standard error; VHI, Voice Handicap Index.

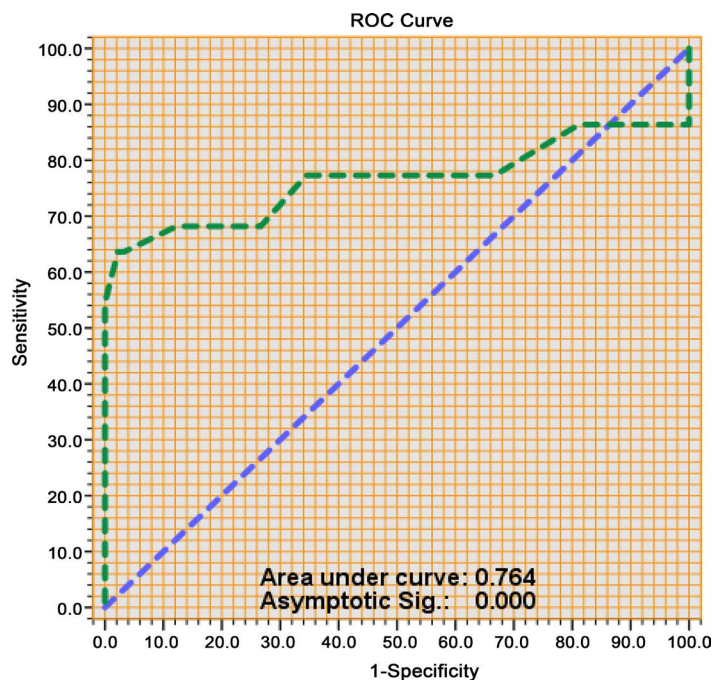


Figure 5. ROC curve of Voice Handicap Index—Total Score (VHI-T).

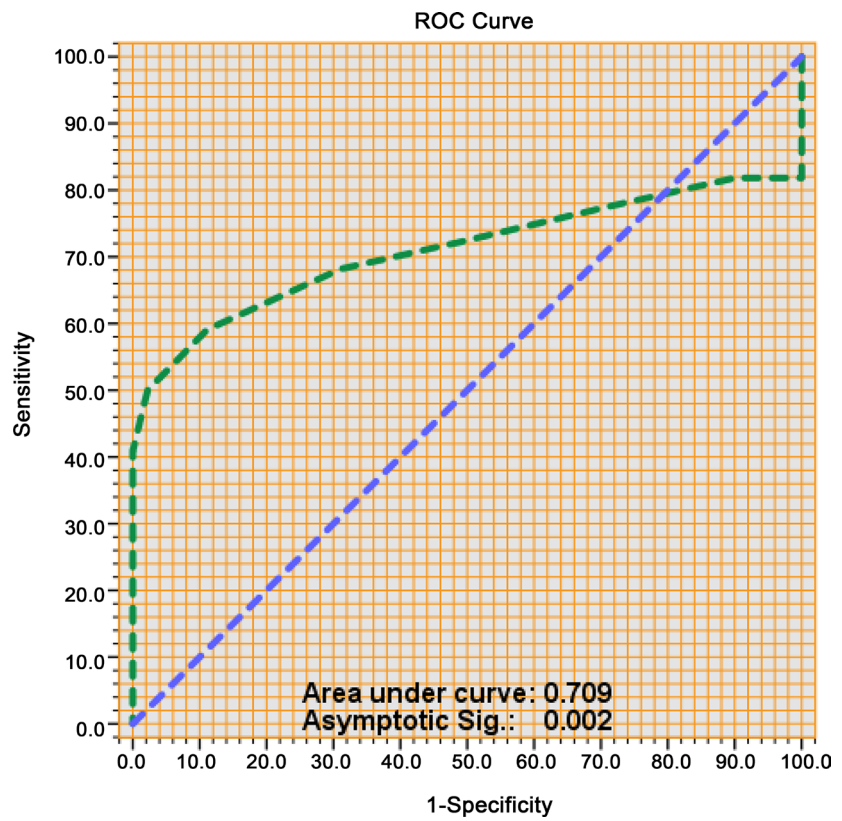


Figure 6. ROC curve of Voice Handicap Index—Functional Domain (VHI-F).

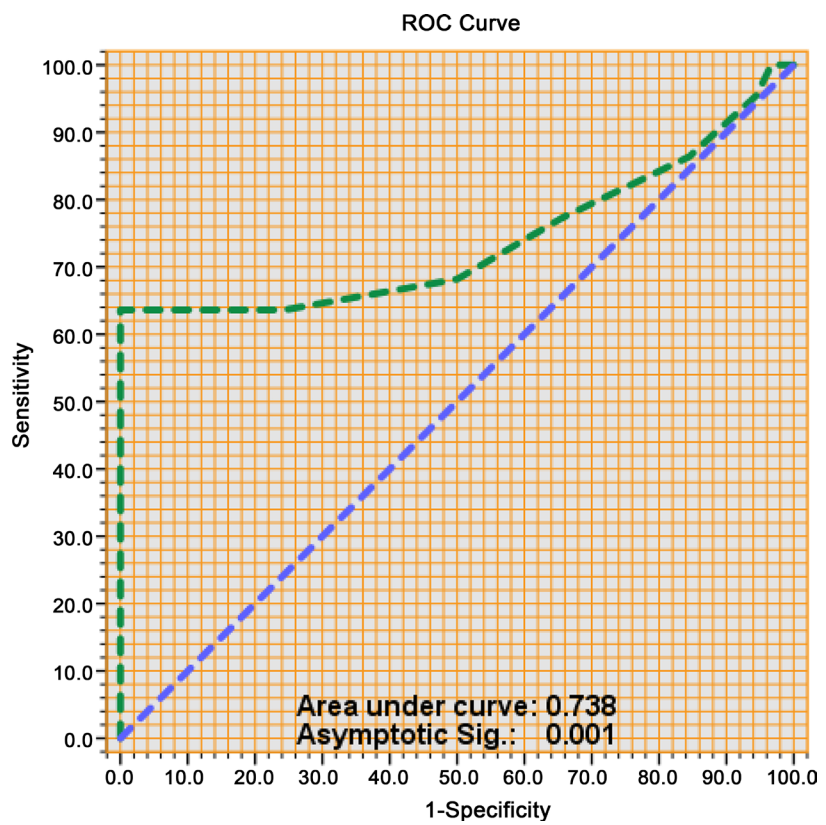


Figure 7. ROC curve of Voice Handicap Index—Physical Domain (VHI-P).

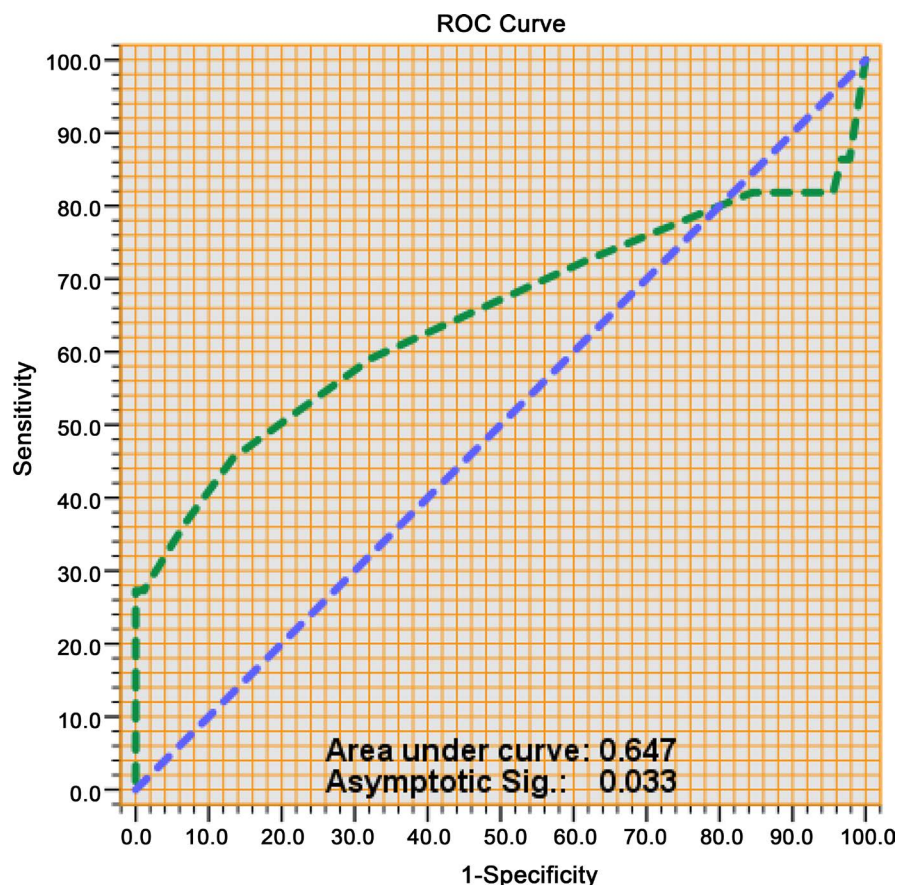


Figure 8. ROC curve of Voice Handicap Index—Emotional Domain (VHI-E).

4. Discussion

This study showed that LID patients exhibited higher median scores in VHI compared to the control group. The same result was reported from other studies that compared diverse voice disordered population to non-dysphonic subjects [39]-[52] and other populations [60] [61] [62] [63] [64]. Particularly, the physical domain had the highest mean score in comparison to functional and emotional domain [39]-[52]. This is in agreement with other cross-validated versions of the VHI and probably reflects that patients are aware of their vocal physical symptoms better in contrast to emotional and functional symptoms [39]-[52].

Additionally, the VHI scores for Greek LID patients with voice disorders are different in comparison to other studies [39]-[52]. Those differences, were expected since similarly results appeared in studies of populations with diverse vocal symptoms [39]-[59]. Furthermore, the aforementioned indicate the dynamics/ability of the questionnaire to obtain data about the impact of voice disorder on Quality of Life (QoL) from different real conditions that someone experiences [39]-[59]. Lastly, the above are consistent with other cross-cultural versions of VHI questionnaires [39]-[59] signifying the potentiality of the VHI being probably a strong screening tool [38]-[59] [68] [69]. According to the above is that Cohen, Dupont and Courey [73] in a Meta-analysis study presented

that patients with inflammatory voice disorders exhibited more changes in their social functioning than patients without vocal symptoms. Albeit this comparison had no statistically difference between the two subgroups, nevertheless, the voice disordered individuals had a decrease in their social interaction due to inflammatory processes. Moreover, it is reported that populations, with different etiology of voice disorders, perceived variations in the level of QoL handicap when compared to those with LID [73].

The cut-off point of VHI-T (19.50) for this study was within the range of 12 to 20 that other studies reported with satisfactory AUCs as this study did [68] [69]. Particularly, this study is in agreement with the Swedish [43] and Norwegian [47] versions of VHI with VHI-T scores of 20 (sensitivity of 0.77 and 1-specificity of 0.87) and 19 (95% sensitivity) respectively. Likewise, Solomon *et al.* [59] set a cut-off value of VHI total score of 18 points for people with organic dysphonia after thyroidectomy. Moreover, Tafiadis *et al.* found a cut-off point of 19.5 [68] [69] for female and male smokers which is equal to the estimated score of this study.

Furthermore, other researchers proposed lower VHI-T cut-off scores which were not in agreement to the score of this preliminary study. Gräßel *et al.* [42] (for the German Version of VHI) calculated a cut-off value of 12 points. Equally, for the Polish version of VHI, Niebudek-Bogusz *et al.* suggested a VHI-T of 12 points (sensitivity = 0.98 and 1-specificity = 0.95) [46]. Similarly, to the above Behrman, Rutledge, Hembree and Sheridan (which studied only women under combined therapeutic program) computed a VHI-T cut-off score of 11.5 [53] which is obviously lower in comparison to the proposed cut-off value of this research for LID patients. Also, for the Persian version of VHI, the cut-off value was equal to 14.5 (sensitivity = 92% and 1-specificity = 95%) which has again not in agreement to the score of this research [67]. Lastly, Van Gogh *et al.* [65] set a threshold of VHI-T equal to 15 (sensitivity = 0.97 and 1-specificity = 0.86) by comparing patients, exhibiting cancer in glottic area, to subjects with laryngeal lesions of early stages. The aforementioned conflicts of scores are probably due to recruitment differences (size of sample, diverse voice pathologies and different cross-cultural adaptations) of the studied populations [47].

Finally, as many studies calculated the cut-off points of VHI total score [42] [43] [46] [47] [53] [59] [65] [66] [67] [68] [69], this research is one of the few that computed and discussed thresholds based on ROC analysis for the three VHI domains (VHI-F, VHI-P, VHI-E) as other studies did [68] [69]. Tafiadis *et al.* underlined the adequate diagnostic value of the three domains [68] [69]. Similarly, Karlsen *et al.* [47] underlined that VHI-F seems to have good discrimination between dysphonic and non-dysphonic patients. Additionally, Sorensen *et al.* [53] in their study suggested that VHI-F and VHI-P has also this probable discriminant ability. The above results are in agreement to this research. Nevertheless, this study is the only one so far which provides and has already processed the data regarding the group of LID patients with vocal symptoms.

Nevertheless, the daily clinical practice needs more specialization (*i.e.* the health professionals need more evidence based data). In turn, this preliminary research delivers to an adequate point the previous necessary information. This information will lead to better screening and monitoring of LID populations as it is already suggested by other studies regarding other populations [68] [69].

5. Conclusion

The main aim of this study was to estimate the VHI's total cut-off point as well as the cut-off points of the three subdomains for dysphonic populations with laryngeal inflammatory diseases. As it is shown, VHI can distinguish the perception scores between the LID dysphonic and non-dysphonic populations. Additionally, it can serve as a screening tool and it could provide data for better re-evaluation and therapy planning. The VHI's cut-off points for LID patients have the limited validity of the small sample of this study. Further research is suggested to be conducted in larger populations with LID. In the long run, this could help in order to specify better and to enrich the VHI's thresholds for LID patients with different etiologies. Also, a future application would be the electronic screening evaluation of potential voice disordered patients [74] by using automatic decision making based on this study's results. This technology could be even implemented inside LEED buildings [75] utilizing enhanced wireless and electronic technologies [76] [77] [78].

Conflict of Interest

All authors declare no conflicts of interest in this manuscript.

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Abbreviations List

ASHA = American Speech Hearing Association

ENT = Ear Nose Throat

ELS = European Laryngeal Society

GERD = Gastroesophageal Reflux

LID = Laryngeal Inflammatory Disorders

LRP = Laryngopharyngeal Reflux

ROC = Receiver Operating Characteristic

SLP = Speech Language Pathologist

TEI of Epirus = Technological Educational Institute of Epirus

VET = Voice Evaluation Template

VHI = Voice Handicap Index

VHI-E = Voice Handicap Index—Emotional

VHI-P = Voice Handicap Index—Physical

VHI-F = Voice Handicap Index—Functional

VHI-T = Voice Handicap Index—Total score