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Research article

Voice Data on Female Smokers: Coherence between the Voice Handicap Index and Acoustic Voice Parameters

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Abstract: Voice disorders are common in the general population, affecting daily communication for nearly one-third. Prevalence of voice disorders has been studied extensively in certain professions, such as teachers, as well as students. The impact on voice characteristics of different risk factors has been studied and also correlated to cigarette smoking. This study was designed to examine the relationship between Voice Handicap Index and acoustic parameters of voice university student smokers in Greece. One hundred and ten female non-dysphonic students (aged 18 to 34) that smoked were recruited. Participants answered the Voice Handicap Index and their voice was recorded. Acoustic analysis of voice characteristics was performed with Dr. Speech software system. Results indicated that some measures were predictive of overall, functional and emotional Voice Handicap Index scores. Other voice parameters had no cohesive or predictable pattern on Voice Handicap Index scores. Significant relationships between Voice Handicap Index individual statements and smokers' voice characteristics were also observed. Lack of correlation and subsequent clinical implications are discussed, as well as the direction for future research.

Keywords: Dr. Speech; female; smoking; university students; voice characteristics; voice handicap index

Abbreviations

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; VoiSS: Voice Symptom Scale; V-RQOL: Voice Related Quality of Life Measure; VPQ: Vocal Performance Questionnaire; TEI of Epirus: Technological Educational Institute of Epirus; GERD: Gastroesophageal Reflux Disease; LPR: Laryngopharyngeal Reflux; HNR: Harmonic-to-Noise-Ratio

1. Introduction

Voice as an integral part of speech and communication, reveals one's inner self and is a reflection of one's personality [1]. The voice characteristics of tone, intensity and pitch, for example allows us to recognize whether someone is happy or upset. Voice characteristic can be influenced by different factors. For example, health factors like recurrent colds and/or sinus infections, history of reflux, respiratory pathologies (e.g. allergies and asthma) [2–4] or environmental influence factors like talking for long periods of time, and talking over background noise [2,4,5]. Another influence factor that changes voice and its characteristics is smoking [6–8].

Researchers reported the strong correlation between smoking and laryngeal pathologies [8–10]. The tobacco smoking is considered to be a factor in developing vocal polyps [11], Reinke edema [12] or even different laryngeal lesions [13] and vocal fold carcinomas [14–16]. Chronic cigarette smoking also results to inflammation, erythema, or irritation of the laryngeal mucosa [17–19]. All those alterations to laryngeal epithelium could result to changes of voice perceptual, acoustic, and aerodynamic characteristics [17]. Especially for the acoustic parameters a lowering of fundamental frequency (F0) was observed in smokers in different studies [6,20,21]. As well, elevation of vocal perturbation parameters (jitter and shimmer) have been reported [7–8].

Although voice disorders prevalence is a fact, Roy and partners [22] supported that it is difficult to investigate the risk factors of voice disorders of the general population. Voice disorders can result from anatomic, physical, or functional abnormal changes in the voice mechanism [23] leading to vocal malfunction or inefficiency [24]. Previous studies have underlined a wide range of voice disorders occurrence [25,26]. It has been reported that voice disorders affect approximately 9% of the population [27] with women having a higher occurrence of voice disorder than men [28] and professional voice users being at higher risk for developing a voice disorder [29].

Current research illustrated voice complaints when student populations were examined [29–32]. Simberg and partners [31] found 24% of students (N = 226) having voice quality problems. The majority of students mentioned that for a period from one to two weeks, they had one or more symptoms correlated to a voice disorder in the past year. There was a follow-up endoscopic evaluation by an otolaryngologist and 89% were diagnosed with some form of laryngeal pathology (laryngitis). Other research on students attending university programs to become teachers, report a correlation between voice complaints and higher scores in Voice Handicap Index (VHI) questionnaire [32–36].

Persons having voice symptoms can be evaluated with various methods. Those methods include (i) imaging techniques (stroboscopy, electromyography) [37,38], (ii) aerodynamic, acoustic and perceptual analyses [39–41] and (iii) self-evaluation questionnaires, such as Voice Symptom Scale (VoiSS) [42], Voice Related Quality of Life Measure (V-RQOL) [43], Vocal Performance Questionnaire (VPQ) [44] and VHI [45]. VHI is a widely accepted questionnaire for research and clinical use that has been translated and adapted in many languages [47–52] including Greek [53]. Concerning the aerodynamic, acoustic and perceptual analyses, computerized systems can be used. For instance, Dr. Speech as a system voice analysis and rehabilitation includes a module for voice assessments. Therefore, measurements can be taken for habitual F0 (Hz), mean F0 (Hz), percent jitter, percent shimmer, harmonic-to-noise-ratio (HNR in dB) and intensity (dB) [54,55].

The purpose of this study was to examine the relationship between voice acoustic characteristics with VHI for smoking female students in Greece.

2. Materials and Methods

2.1. Participants

One hundred and ten female SLT students were recruited from the department of speech and language therapy, Technological Educational Institute (TEI) of Epirus, Ioannina Greece. All participants had no former history of any laryngeal or respiratory system disorders (e.g., asthma crisis) two weeks before recordings. Subjects that reported gastroesophageal reflux disease (GERD) or laryngopharyngeal reflux (LPR) or symptoms correlated with those diseases and drug or alcohol, were not included in this study. Smokers were considered participants who smoked, at least, two cigarettes consecutively in the past year [6,56].

2.2. Data Collection

The adapted and validated version of VHI in Greek [53] was administrated to all participants. Specifically, VHI was created to assess the biopsychosocial impact on voice. It consists of 30 statements under three domains: emotional (VHI-E), physical (VHI-P), and functional (VHI-F). Statements used a five-point Likert scale: never (0), almost never (1), sometimes (2), almost always (3), and always (4). The total score (VHI-T) varies between 0 to 120. For each one of the three subdomains the subscore varies between 0 to 40.

Voice Evaluation Form [57] was also administrated to the participants in order to provide further details for their voice and to ensure that no other contributing factor will influence voice measurements such as voice abuse or misuse.

2.3. Measurements

In a quiet room with intensity under 40dB [58] recordings were obtained. Participants were asked to produce the sustained vowel of /a/ and /e/ sounds for at least 5 seconds at a comfortable pitch [59]. Voice measurements were obtained according to "The National Center for Voice and Speech recommendations" [60]. Perturbation analysis was performed with module vocal assessment of Dr. Speech software system (version 4.0 Tiger electronics Inc., MA). In particular habitual F0 (Hz), mean F0 (Hz), percent jitter, percent shimmer, harmonic-to-noise-ratio (HNR in dB) and intensity (dB) were obtained.

2.4. Statistical Analysis

In order to obtain a quantitative measure of the association between the VHI scores and the acoustic measurements the Pearson's product-moment correlation coefficients was used. The coefficients are calculated for each pair of acoustic measurement and the corresponding VHI score of the individual. The results are divided for the cases of sustained vowels /a/ and /e/. Statistically significant results of 0.05 and 0.01 were taken in account and reported. Analyses of data were conducted using *SPSS* statistical software (version 19.0)

3. Results/Discussion

Samples mean age was 22.21 years (SD: ±2.38) and ranged from 19 to 34 years. The average years of smoking was 2.16 (SD: ±1.29) and the numbers of cigarettes per day was 13.19 (SD: 6.65). Voice Handicap Index total score was 32.56 with SD: ±10.29 (min: 12, max: 57), functional subscale mean was 7.91 SD: ±4.62 (min: 3, max: 24), physical subscale mean: 8.16 SD: ±4.51 (min: 4, max: 23) and emotional subscale mean was 8.04 SD: ±4.12 (min: 2, max: 18).

In Tables 1 and 2, correlations are summarized according to the VHI-T as well as to each of the three subscales, VHI-E, VHI-P and VHI-F, individually. A significant positive and weak correlation between HNR and VHI-T (r = 0.209, $p < 0.05$), HNR and VHI-F (r = 0.247, $p < 0.01$), HNR and VHI-E (r = 0.192, $p < 0.05$), was computed. There was no correlation for the rest of acoustic characteristics and VHI total score and subscales, for the sustained voicing of /a/ sound (Table 1).

Likewise, a significant positive and very weak correlation between HNR and VHI-E (r = 0.190, $p < 0.05$) was calculated. No correlation for the rest of acoustic characteristics and VHI total score and subscales, for the sustained voicing of /e/ sound (Table 2).

In Tables 3 and 4 only statistically significant correlations between voice parameters and VHI statements are shown for sustained phonation of vowels /a/ and /e/ correspondingly.

Table 1. Correlation between VHI and Acoustic Measurements per subscale (sustained vowel /a/)

	Habitual F0	Mean F0	Jitter (%)	Shimmer (%)	HNR	SPL
Total					0.209	
Functional					0.247*	
Physical						
Emotional					0.192	

All coefficients have $p < 0.05$; *Coefficients with $p < 0.01$.

Table 2. Correlation between VHI and Acoustic Measurements per subscale (sustained vowel /e/)

	Habitual F0	Mean F0	Jitter (%)	Shimmer (%)	HNR	SPL
Total						
Functional						
Physical						
Emotional			0.190			

All coefficients have $p < 0.05$.

A significant positive and weak correlation was observed between HNR and functional subscale statements *"My family has difficulty hearing me when I call them throughout the house"* (r = 0.255, $p < 0.01$) and *"My voice problem causes me to lose income"* (r = 0.280, $p < 0.01$). Similarly, a significant weak and negative correlation was demonstrated between Shimmer (%) and functional subscale statement *"I feel left out of conversations because of my voice"* (r = −0.212, $p < 0.05$) (Table 3).

Also, a significant positive and weak correlation was obtained between Mean F0 and VHI-P statement *"I feel as though I have to strain to produce voice"* (r = 0.219, $p < 0.05$). Furthermore, a significant positive and weak correlation was obtained between HNR and VHI-E statements *"I find other people don't understand my voice problem"* (r = 0.210, $p < 0.05$), *"My voice problem upsets me"* (r = 0.231, $p < 0.05$), *"I feel embarrassed when people ask me to repeat"* (r = 0.220, $p < 0.05$), *"I am ashamed of my voice problem"* (r = 0.262, $p < 0.01$) and *"My voice makes me feel incompetent"* (r = 0.195, $p < 0.05$). Additionally, a weak and negative correlation was calculated between Shimmer (%) and VHI-E statement *"My voice makes me feel incompetent"* (r = −0.249, $p < 0.01$) and Mean F0 and *"My voice makes me feels handicapped"* (r = −0.247, $p < 0.01$). There was no correlation for the rest of acoustic characteristics and VHI-F, VHI-P and VHI-E statements, for the sustained voicing of /a/ sound (Table 3).

Table 3. Correlation between VHI and Acoustic Measurements per statement (sustained vowel /a/)

Functional	Habitual F0	Mean F0	Jitter (%)	Shimmer (%)	HNR	SPL
My family has difficulty hearing me when I call them throughout the house					0.255*	
I feel left out of conversations because of my voice				−0.212		
My voice problem causes me to lose income					0.280*	
Physical						
I feel as though I have to strain to produce voice		0.219				
Emotional						
I find other people don't understand my voice problem					0.210	
My voice problem upsets me					0.231	
My voice makes me feels handicapped		−0.247*				
I feel embarrassed when people ask me to repeat					0.220	
My voice makes me feel incompetent				−0.249*	0.195	
I am ashamed of my voice problem					0.262*	

All coefficients have $p < 0.05$; *Coefficients with $p < 0.01$.

Similarly, a significant negative and weak correlation was found between HNR and VHI-F statement *"People have difficulty understanding me in a noisy room"* (r = −0.214, $p < 0.05$). VHI-F statement *"I tend to avoid groups of people because of my voice"* was positively correlated with Habitual F0 (r = 0.266, $p < 0.01$), Mean F0 (r = 0.253, $p < 0.01$), Jitter (%) (r = 0.230, $p < 0.05$) and SPL (r = 0.232, $p < 0.05$) (Table 4).

Equally, for VHI-P statement *"I try to change my voice to sound different"* a negative and weak correlation for Habitual F0 (r = −0.252, $p < 0.01$) and Mean F0 (r = −0.264, $p < 0.01$). As for the statement *"My voice "gives out" on me in the middle of speaking"* a positive and weak correlation was computed for Jitter (%) (r = 0.212, $p < 0.05$) and a negative weak correlation for Shimmer (%) (r = −0.226, $p < 0.05$) (Table 4).

In the same way, a positive and weak correlation was computed between Jitter (%) and VHI-E statement *"My voice makes me feels handicapped"* (r = 0.269, $p < 0.01$). For Shimmer (%), a negative and weak correlation was obtained for statements *"People seem irritated with my voice"* (r = −0.195, $p < 0.05$), *"I feel annoyed when people ask me to repeat"* (r = −0.196, $p < 0.05$) and *"I am ashamed of my voice problem"* (r = −0.194, $p < 0.05$). Finally, a weak and negative was correlation obtained between HNR and VHI-E statement *"I am less outgoing because of my voice problem"* (r = −0.194, $p < 0.05$). No correlation for the acoustic characteristics and the rest of VHI statements, for the sustained voicing of /e/ sound was obtained (Table 4).

Table 4. Correlation between VHI and Acoustic Measurements per statement (sustained vowel /e/)

Functional	Habitual F0	Mean F0	Jitter (%)	Shimmer (%)	HNR	SPL
People have difficulty understanding me in a noisy room					−0.214	
I tend to avoid groups of people because of my voice	0.266*	0.253*	0.230			0.232
Physical						
I try to change my voice to sound different	−0.252*	−0.264*				
My voice "gives out" on me in the middle of speaking			0.212	−0.226		
Emotional						
People seem irritated with my voice				−0.195		
I am less outgoing because of my voice problem					−0.194	
My voice makes me feels handicapped			0.269*			
I feel annoyed when people ask me to repeat				−0.196		
I am ashamed of my voice problem				−0.194		

All coefficients have $p < 0.05$; *Coefficients with $p < 0.01$.

In this study, it was observed that VHI scores had a correlation with voice characteristics. According to the results, it is pointed out that VHI can be a useful tool for non-symptomatic smokers for measuring functional outcomes for voice disorders. Former studies similarly have found that VHI is useful in measuring voice symptoms [45,61–64].

Regarding the relationship of acoustic measurements and the VHI subscales scores for sustained voicing of the /a/ sound there was a significant correlation found for HNR with VHI-T, VHI-F and VHI-E. No other significant correlations were found which is in agreement to current research [63]. Likewise, for the sustained voicing of the /e/ vowel a significant correlation was observed between Jitter (%) and VHI-E which is reflective of other studies [65,66]. Probably early female smokers perceive the effect of smoking on their voice. The significant correlations between VHI items and acoustic voice parameters justifies this perception even though those correlations are weak. Maybe VHI helped female smokers to understand better the implications of smoking on their voice similarly to dysphonic patients [45].

The rest of the correlations had no cohesive or predictable pattern similar to that reported by Tarazani et al. [67]. As it was observed for early female smokers in this study, Awan et al. [68] reported similarly low to moderate strength correlations between VHI and Jitter (%) for patients with dysphonia. In addition, Schindler et al. [69] found correlations between total VHI and HNR for dysphonic patients which are also in line this study's results. Ziwei, Zheng, and Pin [70] found a weak correlation between VHI-E and voice parameters in patients with voice disorders which corresponded to the results of this study.

Fulljames and Harris [71] and Awan et al. [68] reported strong correlations between VHI-T and F0 range, as well as between VHI-P and shimmer (%) that differ from the results of this study. Probable reasons of the above different findings could be: (i) that VHI is a self-perceived questionnaire and it contains the element of subjectivity on how smoking has impact on voice and (ii) many persons have different social, occupational and personality factors, and thus their perceptions about the impact of smoking on their voice varies. The impact of voice disorders upon daily living and the discrepant scores for VHI were also discussed by Wheeler et al. [63].

In several trans-cultural VHI studies in dysphonic groups the highest average score was found for physical subscale [48,53,66,72,73]. According to the results this study smokers had higher scores in VHI-P subscale followed by VHI-E and VHI-F. The above has also been documented [72] as physical symptoms which have prominent perceptual parameters and, therefore, are more easily to be associated with voice changes.

Finally, female smokers VHI-T mean score was higher compared to cutoff points in two studies for Persian [74] and Polish [75] for dysphonic patients. On the contrary, VHI total score for female smokers was slightly lower compared to means score of other studies [45–47] including Greek dysphonic patients [53]. Taguchi et al [64] stated that female dysphonic patients had a VHI-T score = 44.1 which was higher compared to females smokers score. These comparisons indicated a probability that VHI seems sensitive for female smokers' population even though there were asymptomatic.

4. Conclusions

This study examined the relationship between VHI and acoustic parameters (voice fundamental frequency, fundamental frequency parameters and amplitude parameters) of young female smokers in Greece. Particularly, this study focused on early (<10 years) university student smokers. The results of this study indicated that there is a correlation between (i) HNR and VHI-T, VHI-F; (ii) Jitter (%) and HNR with VHI-E, (iii) individually VHI statements and Habitual F0, Mean F0, Shimmer (%), Jitter (5) and HNR and (iv) VHI-E items individually were significantly correlated with acoustic measures. In contrast, many individual VHI items were not significantly correlated with these studies measurements in any consistent manner. VHI index probably is a sensitive tool for coping female smokers self-perceived opinions about their voice status.

Limitations in this study are as follows: (i) no other factors were taken in account in consideration (e.g. environmental) for influencing voice characteristics; (ii) this study only focused on early female smokers. Therefore, these results may not be generalizable to other populations. In future studies it is suggested to be conducted in males as well as to heavy and light smokers. This study is an initial attempt at understanding the relationship between acoustic measures and handicap indices in that Greek population, and can lead to future research in this area as it is encouraging that acoustic and self-perceived measures can reflect positively to voice therapy.

Conflict of Interest

All authors declare no conflicts of interest in this paper.

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