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Vocal Fatigue Inventory Measures in Individuals Exposed to Laboratory Chemicals

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Abstract

Introduction

When an individual is unable to continue the task at a predetermined level due to feeling weariness can be considered as fatigue. The main causes for vocal fatigue include overuse of voice, vocal abuse or misuse. Other causes may include smoking consumption of alcohol or exposure to dust and chemical irritants.

Aim

The study aims at understanding the self-perceived vocal fatigue after the exposure to chemicals.

Method

The study contained two groups between the age ranges of 20 to 25 years. A sampling of 40 individuals who have clinically normal voice were selected as Group 1 for the study and 42 subjects who were continuously exposed to chemicals for 3 hours were taken as group 2.

Voice fatigue inventory was used for the current study to identifying persons with vocal fatigue and characterizes their complaints. It was administered on Group 1 post exposure to chemicals in laboratory for 3 hours and in Group 2 subjects.

Result

A difference $p<0.05$ between the groups showed that group 1 individuals had positive vocal fatigue symptoms following continuous lab procedures.

Conclusion

The study further aims at counselling and providing awareness regarding the protection of voice from chemical irritants by using face mask during the procedure, importance of water intake and need to monitor the vocal changes such as feeling of fatigue

Keywords: Vocal fatigue, Laboratory chemicals, Vocal Fatigue Inventory

Introduction

Vocal folds are triple layered muscle tissue of the larynx responsible to vibrate continuously when the pulmonary-air stream passes through the glottis. The vocal folds are open at rest and facilitate in air movement for breathing. While vocalizing, brain gathers information and co-ordinates a sequence of programmes which in turn causes the vocal cords to vibrate and produce the sound. These sound signals are reshaped to meaningful utterance by resonating cavities like throat, nose and also the articulators within the mouth.

When an individual is unable to continue the task at a predetermined level due to weariness, can be considered as fatigue. This is clinically diagnosed with a name *phonaesthesia*. Fatigue is been analyzed by different studies as a physiological, psychological or pathological cause with respect to entire body parts. There are few studies which focus on the fatigue related to speech production specifically the vocal fatigue which a person may experience after a period of voice use. Vocal fatigue is defined as a negative vocal adaptation that occurs as a consequence of prolonged voice use. (Scherer, 1987).

Potential mechanism pertaining to vocal fatigue is not very clear. Researches gave several neuromuscular and biomechanical factors causing fatigue (Colton & Estill, 1981). This included fatigue of laryngeal and respiratory muscles, vocal fold tissues and changes in viscous properties of vocal folds. These are peripherally mediated which affects nerves and in turn affects the muscles. There are also centrally mediated factors such as a feeling of mental fatigue where an individual may self perceive an increased effort after a period of muscle activity. The most common cause for this fatigue is injudicious vocal habits such as voice overuse, speaking with excessive loudness or producing the voice with more stress and tension; other indirect causes may also include exposure to environmental irritants or use of particular medicines.

Vocal fatigue is usually assumed to be myogenic, wherein, the thyroarytenoid muscle which plays a prominent role in maintaining the phonatory style is mainly affected. The strained phonatory habit may cause fatigue in these muscles and the vocal folds may become bowed during phonation. Voice fatigue may affect different aspects of voice including the vocal pitch; this is the most commonly cited factor in voice disorders or voice fatigue. Many of the electromyography and laryngeal research shows a direct relationship between the fundamental frequency of the voice and the underlying tension in the speaker's muscles. The activity of vocal fold muscles increases with a rise in pitch which may be causing the vocal tiredness. A study explained the relation between vocal fatigue and changes in the pitch (Stone & Sharf, 1973). The subjects with low pitch voice were more affected due to vocal fatigue than compared to those with high pitched voice. Speaker with clinically normal voice may relate this voice fatigue characteristics during the episode of any allergy or infection when the vocal fold are prone to inflammation. They also may complain of worsening of voice, feeling of breathiness or roughness with aggravated use of voice.

Shouting or speaking with greater loudness is the most common vocal behavior which causes fatigue and damages vocal behavior (Masuda, Ikeda, Manako, & Komiyama, 1993). Holbrook in his

study experimented on 12 teachers who were given a portable throat microphone which was connected to dual time meter. Teachers were asked to wear it for 5 days and experimenters calculated the amount of time they spent in talking; daily phonation time and daily loud phonation time (75dB and above). The study concluded that the amount of loud speaking was related to excessive vocal fatigue when compared to a normal conversation. The conclusion here is that excessive vocal loudness seems to be the cause for vocal fatigue along with the changes seen such as vocal pitch elevation or hard vocal attacks. Managing the voice intensity by regulating the respiration is very important to avoid vocal fatigue (Holbrook, 1977).

Voice is considered as a primary work tool for many of the professionals. Professional voice users like lawyers, teachers, actors, barristers cannot work without using their voice. There are very few professions who require minimal use of voice, but still complaints of voice problems. Medical literature has few experiments and research on the voice disorders related to chemical exposure at work. General medical conditions like GERD or use of medicine like inhaled steroids are suspected to cause laryngitis, but occupational causes are less documented. Risk factors developed in the workplace are classified under physical and chemical hazards. Physical hazards include trauma to the vocal folds, reduced ventilation in the workplace, inadequate luminosity and sudden change in temperature. Chemical hazards include exposure to upper airway irritants such as metal fumes, solvents, poisonous gases, presence of dust or smoke in the workplace.

Many studies and investigations were carried out to rule out the effects of different chemicals on the individual's voice. A case-control study was conducted wherein an association was found between Vocal Cord Dysfunction (VCD) and environmental exposure in 11 cases. The comparison between VCD and Irritant Exposed Vocal Cord Dysfunction (ICVD) cases revealed that varied irritant exposures were associated with ICVD. The study also suggested that ICVD should be considered in patients with respiratory complaints that have occurred after irritant exposure (Perkner et al., 1998). In another case study, the occupational exposure to Freon gas caused oedematous pharyngo-laryngitis in a client, along with multiple symptoms such as odynophagia, dysphonia, and breathlessness (Tanturri, Pia, & Benzi, 1988).

Another research reported a case that was exposed to formaldehyde for 9 years and complained of prolonged hoarseness, chest tightness, and episodes of aphonia along with pharyngeal irritation. These symptoms subsided when the client was asked not to get exposed to formaldehyde for a certain period of time (Roto & Sala, 1996). Chronic exposure to mercury caused symptoms of dysphonia and dysphagia in a farmer (Brown, 1954).

It was recognized that occupational exposure to sulphuric acid causes a high-risk factor in the development of laryngeal carcinoma and also leading to laryngitis (Steenland, 1997). Many of the individuals are aware of experiencing vocal fatigue and are able to explain how it feels like; the symptoms may include vocal tiredness and weak voice after a period of voice use. Current clinical care services give more importance to the subject's self-perception of the problem and to improve the quality of life measures in them. However, a standard procedure needs to be carried out to

perceptually relate the fatigue, in any group of individuals to support literature. Voice fatigue inventory is a validated tool for assessing VF where the individuals can self-rate their fatigue based on the questions given. Further, the effect of vocal fatigue on an individual's life is commonly underestimated by clinicians and lay people, often increasing the affected individual's level of frustration and even despair (McCabe & Titze, 2002)

Aim And Objective

There is very limited literature on the acoustic and perceptual analysis of voice in subjects who are exposed to chemical irritants. Literature does give some of the case studies who have voice complaints due to exposure to different vocal irritants. The nonvocal professionals whose voice is indirectly affected due to exposure to chemicals and their self-perception and awareness regarding the same are yet not much involved in the spotlight of research.

The present study aims at understanding the self-perceived vocal fatigue in subjects exposed to laboratory chemicals post exposure. The objective of the present study is to compare self-perceived vocal fatigue in subjects exposed to chemicals and normal individuals and also to understand if there is any positive correlation between chemical exposure and its effect on the voice.

Method

The study protocol was approved by the institutional Scientific and Ethical committee. The study involved a cross-sectional design and convenient sampling was used where 82 subjects between the mean age range of 20 to 25 years where selected. These subjects were further divided into two groups. Group1 involved 42 students who were pursuing their Master's degree in Chemistry, and were continuously exposed to different chemical fumes such as conc. HCl, conc. H_2SO_4, H_2S, Ammonia, Acetic acid, conc. HNO_3 for 3 hours/day, thrice a week, since 2 years. Group 2 involved 40 subjects with clinically normal voice within the same age range who were not exposed to any chemicals or irritants nor had excessive voice use.

While investigating voice problems related to the occupational cause, it is necessary to exclude common medical conditions that impair voice quality or strength. Thus subjects who had a previous history of voice problems, usage of masks while doing the laboratory procedure, the presence of active cold, exposure to smoking, alcohol, GERD, attending voice therapy previously, actively involved in professional voice usage and singers were excluded from the study of both the groups.

Consent forms were taken from both the groups to participate in the study, and it was ensured that their identity will be kept confidential and data will be used for study purpose without disclosing any personal details of the subjects. To assess the vocal fatigue in both the groups, VFI (voice fatigue inventory) is a self-report questionnaire and is used for the current study. It helps in identifying persons with vocal fatigue and characterizes their complaints (Nanjundeswaran, Chayadevie, Jacobson, Gartner-Schmidt, & Verdolini Abbott, 2015)

The questionnaire consisted of demographic details of subjects and questions related to the exclusionary criteria. Based on these responses, 20 subjects from group 1 and 20 subjects from group 2 were selected for the study.

Table 1: Represents demographic details of the participants

Subjects Involved	Total number of subjects (N)	Age range in years	Number of males	Number of females	Mean age in years
Chemistry students (Group 1)	20	20 – 25	10	10	22.5
BA students (Group 2)	20	20 – 25	10	10	22.5

VFI had a total of 19 questions related to vocal fatigue where all the questions were mandatory to be filled by the subjects. The responses had a 5-point rating scale with respect to increased severity of fatigue perception where 0 being 'never' and 4 being 'always'. (0—never, 1—almost never, 2—sometimes, 3—almost always, and 4—always). Subjects from both the groups were asked to read the instructions and questions and were asked to rate their vocal fatigue based on self-perception. Total test time required was 10 to 15 minutes.

Results and Discussion

In the present study, the ratings given by both the groups for VFI were tabulated in SPSS 17.0 software for statistical analysis. Initially, descriptive statistics were applied to summarise the data. In order to check the effect of chemical exposure on voice, the VFI score of subjects who were exposed to chemicals was compared to that of normal individuals. Independent test was done to compare scores between the groups. The descriptive statistics for Group 1, with an overall mean VFI score, was 30.02 (SD =13.05) and VFI mean score for group 2 was 20.34 (SD = 9.73). The overall mean score for perceived vocal fatigue was higher for group 2 individuals after the exposure to chemicals than compared to that of normal individuals.

Independent test showed that there was a significant difference $p<0.005$ between the groups, which showed there was an effect of chemicals on perceived voice fatigue when compared with that of individuals with a clinically normal voice.

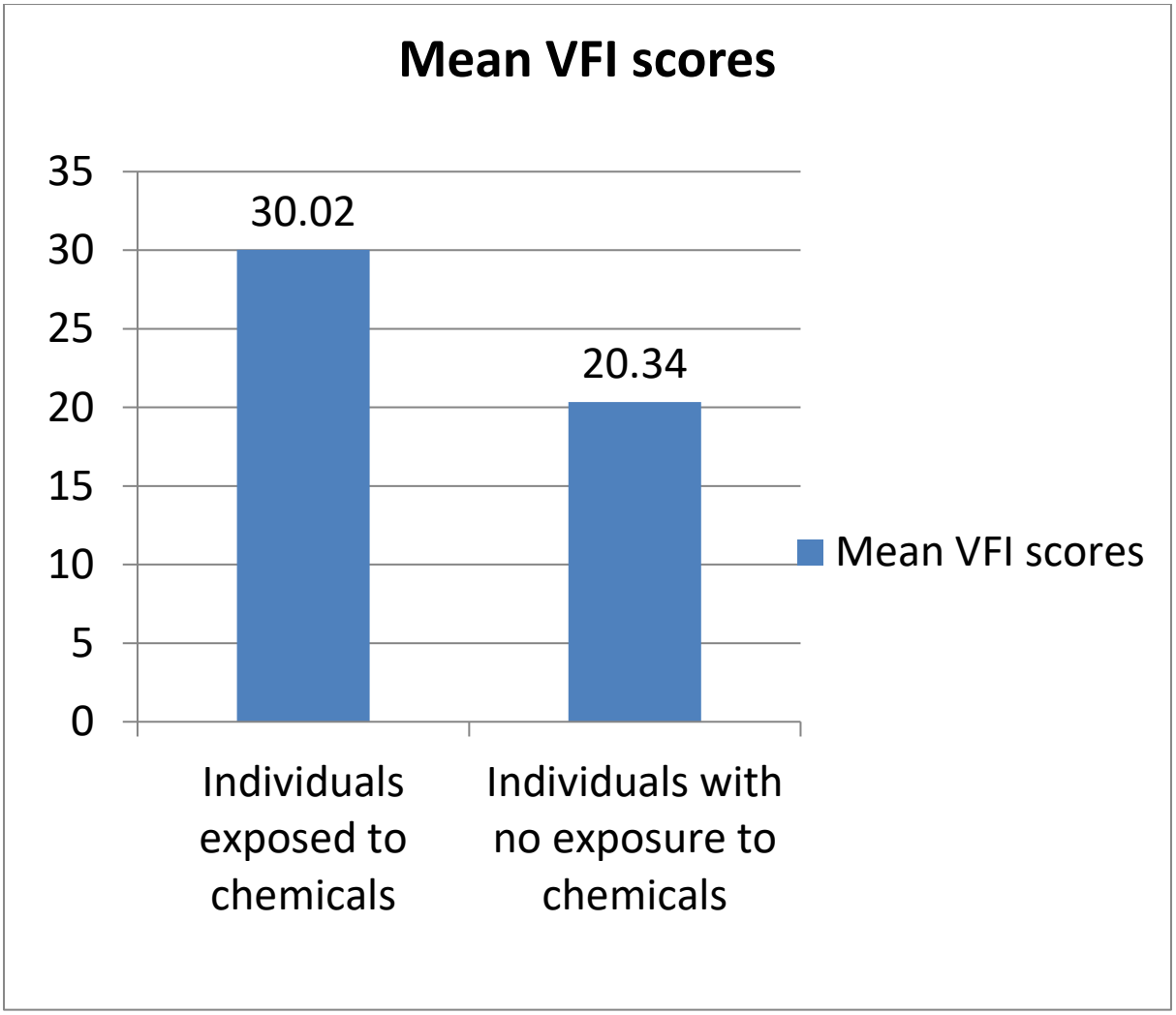

Figure: Mean VFI scores of both groups

The purpose of the present study was to investigate if there are any self-perceived voice fatigue and awareness or the conscious observation with respect to chemical exposure and its effect on voice in subjects who are exposed to laboratory chemicals. The primary subjects of interest were the students who were continuously exposed to different chemicals in the laboratory. These subjects did complaint of vocal dryness and respiratory distress following the chemical exposure. Primary expectation of the study was to get a positive relation between vocal fatigue syndrome in chemically exposed subjects when compared to clinically normal individuals. There was a significant difference in group 2 subjects who had lesser VFI scores, compared to that of group 1 subjects who were exposed to lab chemicals and had higher scores for the same. Group 1 individuals had positive vocal fatigue symptoms following continuous lab procedures.

The possible explanation for this can be that vocal fold is made of layers of individual epithelial cells combined by junction complexes composed of unique interface with the external environment. This provided structural stability and protects the vocal fold from any continuous exposure to environmental irritants. Sustained exposure to irritants causes insult to this complex

protein junction and reduces the protective function offered by this important barrier, which in turn effects movement of vocal folds and may cause vocal fatigue.

Different studies do support such explanations. Many different chemicals are said to be affecting the voice directly or indirectly. Occupational exposure to hazardous chemical fumes or odors has been reported to cause a sore throat and laryngitis (Williams, 2002).

Industrial fumes such as woodworking pulp mills and burning of multiple irritants such as nitrogen oxide, volatile organic compounds are also linked with these causes. Multiple chemicals like organic solvents filter materials and inks have been reported to cause chronic pharyngitis in people with multiple chemical sensitivity syndromes (Renner, Mueller & Shephard, 2012).

The effect of nitrogen tetroxide was associated with the complaint of a sore throat in 24% subjects who were exposed to the same (Bauer, Berg, Kohn, Meriwether, & Nickle, 1998) Studies on cutaneous burns following inhalation of chemical products causing different respiratory and vocal symptoms was carried out. They also suggested protecting the effected tissues from secondary injury due to resuscitation which may worsen the problem (Moylan & Alexander, 1978).

Chemical choking agents like chlorine and phosgene which are used industrially are said to be denser than the air that accumulates close to ground level. Low to moderate level of exposure of these toxins are said to cause a cough, bronchospasm and eye pain. Higher exposure may also be reported causing laryngospasms (Geoghegan & Tong, 2006). Most substance when burnt produce materials which are toxic to the respiratory tract. This toxin smokes damages epithelial and capillary endothelial cells of the respiratory system. Histological changes resemble tracheobronchitis (Dries & Endorf, 2013). The duration and amount of exposure can also have difference in effect on vocal or respiratory symptoms. Thus our current study also focuses on prevention of vocal symptoms by creating awareness to the lab officers and students regarding the effects of chemicals on vocal output. Subjects in the present study where involved in burning different chemical components in the lab procedures for continuous 2 years in their academic years. This also may cause fatigue post exposure.

Summary and Conclusion

The result of present study found a significant effect of chemicals on vocal fatigue. That is, the subjects had vocal fatigue symptoms following the exposure to laboratory chemicals, which in turn gave us an insight into the risk of development of voice problems in these subjects. These chemicals are said to injure the pulmonary tissues which must be protected from secondary injury due to resuscitation. Thus, the study further aims at counselling and providing awareness regarding the protection of voice from chemical irritants by using face mask during the procedure, the importance of water intake to reduce vocal dryness, and also to continuously monitor the vocal changes such as feeling of fatigue or voice change after the chemical exposure so that early care can be taken to prevent the occurrence of voice problems. This study also showed us the importance of questions regarding occupational history while taking a case history. Voice problem is described as

self-reported symptoms as well as the clinical signs involved. Thus, when a person perceptually finds the voice to be affected or changed due to chemical exposure, their opinions cannot be ignored.

Self-perceived vocal fatigue in subjects exposed to chemicals is studied rarely. The present study gave an insight to self-perceived voice problems due to chemical irritants. It is further necessary to carry out advanced acoustic analysis and to find any correlation between subjective voice complaint and acoustic objective observation. This will further help us in development of appropriate diagnostic and management measures for chemical exposed subjects.

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