Dysphonia Severity Index in Typically Developing Indian Children

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Summary: Background. Dysphonia is a variation in an individual's quality, pitch, or loudness from the voice characteristics typical of a speaker of similar age, gender, cultural background, and geographic location. Dysphonia Severity Index (DSI) is a recognized assessment tool based on a weighted combination of maximum phonation time, highest frequency, lowest intensity, and jitter (%) of an individual. Although dysphonia in adults is accurately evaluated using DSI, standard reference values for school-age children have not been studied.

Aim. This study aims to document the DSI scores in typically developing children (8–12 years).

Method. A total of 42 typically developing children (8–12 years) without complaint of voice problem on the day of testing participated in the study. DSI was computed by substituting the raw scores of substituent parameters: maximum phonation time, highest frequency, lowest intensity, and jitter% using various modules of *CSL 4500* software.

Results. The average DSI values obtained in children were 2.9 (1.23) and 3.8 (1.29) for males and females, respectively. DSI values are found to be significantly higher ($P = 0.027$) for females than those for males in Indian children. This could be attributed to the anatomical and behavioral differences among females and males. Further, pubertal changes set in earlier for females approximating an adult-like physiology, thereby leading to higher DSI values in them.

Conclusion. The mean DSI value obtained for male and female Indian children can be used as a preliminary reference data against which the DSI values of school-age children with dysphonia can be compared.

Key Words: Dysphonia Severity Index (DSI)–Highest frequency–Lowest intensity–Jitter %–Maximum phonation time.

INTRODUCTION

Acoustic and aerodynamic measures are regularly used to document normal and pathological characteristics of voice.[1–5] Vocal imaging techniques such as video-laryngoscopy study vocal physiology and vocal fold structures. Acoustic and aerodynamic measures are simple in administration and interpretation, economical in terms of time and cost, and hence, are more commonly used by professionals.[1] Even though they provide objective, accurate, and noninvasive analysis of the vocal folds and have better signal detection and processing techniques, they still fail to serve as a reliable predictor of normal and disordered voices.[6] The validity of these measures in terms of their correlation with the perceptual severity of dysphonia is questioned by several studies.[2] The poor correlation between acoustic and perceptual measures makes it difficult to use these measures for documenting therapeutic and surgical outcome. Hence, it is essential to have a parameter that is reliable and correlates well with the perceptual severity of dysphonia.

Wuyts et al[7] proposed the Dysphonia Severity Index (DSI), which is a multiparametric measure based on the weighted combination of highest frequency (HF_0), lowest intensity (LI_0), maximum phonation time (MPT), and jitter (%). It is an easily obtained multiparametric measure in daily clinical practice.[8] The DSI is calculated using the following equation:

$$\mathrm{DSI} = 0.13 \times \mathrm{MPT} + 0.0053 \times (\mathrm{HF_0}) - 0.26 \times (\mathrm{LI_0}) - 1.18 \times \mathrm{Jitter}\,(\%) + 12.4$$

Mean DSI and its components highest F_0 (HF_0) and MPT values remain steady over time, making it a viable tool for baseline assessment and intervention outcomes.[9] It strongly links with the standardized assessment tools for voice measurement like Voice Handicap Index (VHI),[10,11] posture index,[12] and Grade, Roughness, Breathiness, Asthenia, and Strain (GRBAS).[7] Whereas, VHI is a patient-based self-assessment tool, posture index and GRBAS are clinician-based perceptual assessment tools. The inter-rater reliability of the DSI and VHI is good,[10,11] and comparing the G of GRBAS and the DSI reveals that both measures represent the severity of dysphonia in a similar pattern.[11] Even in the presence of an overall perceptually good speaking voice, the DSI is sensitive to the minute variations in vocal quality. Good correlation to other perceptual scales is indicative of the fine specificity of the index.

The DSI is extensively used as a parameter for voice quality assessment and treatment outcome. The DSI has been used as a tool to quantify the impact of vocal training by Awan and Ensslen,[13] where a mean score of 6.48 was seen in trained vocalist and 4 in untrained subjects, explaining that direct vocal training leads to a significant rise in the DSI scores. Further, Aghadoost et al[14] used the DSI to compare the voice quality of female teachers with and without voice complaint, and the result showed that there was a significant difference in vocal quality between the two groups. Later, the DSI was used to measure the intervention efficacy in patients with voice disorders: attending voice therapy, undergone phonosurgery, and no intervention. It was concluded that the DSI is applicable in clinical practice for objective evaluation of voice.[11]

Although the DSI is found to be a robust measure, it may be influenced by factors such as age, gender, and instrument. Dwire and McCauley[15] conducted repeated measures of vocal fundamental frequency perturbations using Visi-Pitch and confirmed that correlation coefficients on repeated measurement (interval of 1 week) were poor for females and good for males. Bough

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et al[16] investigated interdevice reliability from two voice analysis devices, revealing poor to moderate correlation in jitter measurement, but good correlation in frequency measurement. Lee et al[17] demonstrated good reliability for a test-retest experiment concerning jitter% and MPT measurements for healthy female subjects. Jayakumar and Savithri[18] estimated the DSI values in adult Indian population in the range of 18–25 years. The participants included in the study were rated with a G_0 on GRBAS scale and were nonsmokers with no vocal complaints, voice disorders, motor speech disorders, or hearing problems. They concluded that there is an obvious difference between Indian and European population on MPT, HF_0, and the DSI values. Geographic and ethnic variations have an impact on the values of the DSI; hence, it is erroneous to generalize the DSI value developed for specific population. The DSI values vary with change of instrument, and hence, the hardware and software standards should be specified.[19]

Children are a novice population for whom there are very few standardized norms owing to the continuously changing voice quality as their growth changes are rapid and frequent. Voice differs in children and adults in terms of their vocal capacity, economy, stability, frequency, and intensity range.[20–22] These variations can be attributed to structural and physiological differences in laryngeal and respiratory subsystems.[23–26] Layered structure of vocal folds is simple in newborns with uniform mucosa of lamina propria progressing into a layered vocal ligament between ages 6 and 12 and a distinct three-layered structure of lamina propria at the age of 15.[27] Vocalis muscle is thin in newborns and fully develops around the age of 25.[23,28] The short and small vocal folds in children create a higher fundamental frequency than those in adults.[25,29] The short membranous portion of vocal folds[23] in children restricts their physiologic range of production for phonation.[30] Gradual development in the anatomical structure with age changes the physiological characteristics of voice.

Hoarse voice is a commonly identified symptom of dysphonia in children. In 3–9% of the pediatric population showing symptoms of dysphonia, male children are more affected than female children.[31–33] The primary causes of pediatric dysphonia are vocal trauma, vocal fold lesions, vocal cord polyp, vocal fold paralysis, extrinsic trauma, gastroesophageal reflux disease, and velopharyngeal insufficiency.[26,32,34–38] Vocal trauma frequently seen in children is mainly due to upper respiratory tract infection, hearing loss, laryngitis, allergic reaction, and asthma.[32] Although yelling on the playground or creating play sounds are commonly cited as vocally traumatic in young children, hoarseness can also be due to speaking in too high or too low of a pitch or loudness level, use of inappropriate respiratory patterns, or tense voice. Thus, there is an emerging need to quantify the voice disorders in children for early intervention.

McAllister et al[39] used Voice Range Profile (VRP), which provided the intensity measurements at the lowest and highest frequencies in the total pitch range of an individual. He concluded that young children had constrained dynamic vocal capabilities shown by the compressed VRP contours in comparison with adults. Schneider et al[40] used VRP percentile for estimating the vocal parameters of a child and explained that vocally trained children had a broader range compared with their peers. An attempt was made to assess severity of pediatric voice disorders using Acoustic Voice Quality Index,[41] and it was found that the AVQI has diagnostic precision for pediatric population, but it does not always correlate with the perceptual findings derived from ratings scales like GRBAS.[42] Even though DSI has good correlation with perceptual scales, the normative studies are confined to adults.

Hakkesteegt et al[10] have estimated the DSI values for 118 participants in the age range of 20–79 years without any voice complaint. They found that with the increase in age, the HF_0 decreased in both genders; however, LI_0 decreased only in females. Based on gender, males had high MPT, whereas females had elevated HF_0. Jayakumar and Savithri[18] found that Indian population has lesser DSI scores than European populations, claiming differences between these populations in height, chest dimension, and speaking style. It is implied that Indian children might have different DSI scores from European children. Due to the anatomical and physiological variations in the subsystems of voice production such as lung capacity, vocal fold structure, volume of the vocal tract-in children and adults, the DSI values may vary in children. Currently, assessment scales and indices are available to assess the nature and extent of dysphonia both subjectively and objectively in adults. Although there are tools available that assess the dysphonia in children, there is no standardized index to suggest the acoustic reference for typically developing school-going children especially in children in the Indian population. Therefore, the present study is aimed at documenting the DSI scores in Indian children in the age range of 8–12 years.

METHOD

Participants

A total of 42 typically developing children, including 25 males and 17 females in the age range of 8–12 years, participated in the study. Native Kannada-speaking children were randomly selected from schools in Mysore. Participants with no complaints of hearing problems, upper respiratory tract infections, or voice problems on the day of evaluation were included for the study. The following criteria were adhered to while selecting the participants: (1) The participants were subjected to Ear Nose Throat (ENT) evaluation to rule out the presence of any ear infection, upper respiratory tract infections, or voice problems. (2) The participants had no history of neurological, oromotor, communicative, cognitive, sensori-motor, and academic impairment. This was ensured using the "WHO Ten-question disability screening checklist."[43] (3) The participants had age-adequate language abilities ascertained by Assessment Checklist for speech-language domain.[44] All ethical standards were met for participant selection and their participation. Before testing, a written consent was obtained from the parents of the participants after explaining the purpose of the study.

Procedure

Raw scores of MPT, HF_0, LI_0, and Jitter% were obtained to construct the DSI. All the measures were obtained in a quiet room, with the participant seated comfortably using a dynamic microphone Shure SM48 (Shure Incorporated Product Support,