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Effect of stuttering on speech & language development and quality of voice: A pilot study

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Abstract
Aim: To examine the impact of stuttering on the development of speech and language and voice quality in stuttering children.
Methods: Two male children between the ages of 7 and 10 were chosen as the study's subjects. The SSI-4 was used to assess the extent of stuttering, and the LPT was used to determine the child's language proficiency (semantic and syntax). Dr. Speech software was used to evaluate the voice's quality. The study was conducted at the speech and hearing unit, CRC, Lucknow, India.
Results: Subject with moderate stuttering had delayed language (semantics and syntax) levels, a minor hoarse voice, and severe breathiness. Only the syntactical skills of the subjects with the most severe stuttering were delayed, and their voice quality was within acceptable ranges.
Conclusion: The children who stutter may experience delayed language development in higher language skills as well as a significant impact on voice quality.

Keywords: Stuttering, language, voice, semantics, development, severity

Introduction

The most prevalent fluency problem, stuttering is an interruption in speech that is marked by particular disfluencies, such as repetitions of sounds, syllables, and monosyllabic words (e.g., "Look at the b-b-baby," "Let's go out-out-out," and "Ssssssometimes we stay home," among others); prolongations of consonants without emphasis; and blocks (i.e., inaudible or silent fixation or inability to initiate sounds). According to the American Speech-Language-Hearing Association (ASHA) [1], these disfluencies can alter the rate and rhythm of speech and may be accompanied by unpleasant reactions to hearing or hearing someone speak, avoidance behaviours (such as avoiding sounds, words, people, or situations where someone is speaking), escape behaviours, such as secondary mannerisms (such as eye blinking and head nodding or other movements of the extremities, body, or face), and physical tension.

According to Campbell and Hill [2], the following are some examples of major disfluency types: i) Hesitation lasting one second or longer; ii) Interjections; iii) Phrase/sentence revision; iv) Unfinished word; v) Phrase/sentence repetition; vi) Word repetition; vii) Part-word repetition; viii) Prolongations; and ix) Block.

The speech motor system fails to generate and/or convey the motor commands to the muscle that are required for fluent speech to continue during the disfluencies that define stuttering [3]. Similar to this, Walsh, Mettel, and Smith [4] noted that "the defining features of stuttering (i.e. sound repetitions, prolongations, and blocks) ultimately represent breaks in the precisely timed and coordinated articulatory movements needed for fluent speech.

Voice: Voice is one of the most fundamental and effective means of expressing feelings and sending messages [5]. According to some descriptions, the human voice serves as an embodiment of the self in social settings, facilitating the expression, perception, and exchange of the self, awareness, inner life, and personhood [6]. If someone has unpleasant feelings or anxiety due to many circumstances, such as stuttering, it may negatively affect their speech features, such as voice quality [7]. The abuse of voice that results from an individual's attempts to mask their stuttering by shifting their pitch or volume to an unsuitable level can cause vocal issues [8].

Parameters of voice in children (Normal Group): The basic frequency of a speech sound is referred to as F0. It corresponds to the roughly periodic structure of spoken speech signals.

The range of SFFs (Speaking Fundamental Frequencies) employed in connected speech is known as frequency variability. Normal voices have some frequency variability, which the listener interprets as acceptable prosodic shifts. A functional biological or neurological basis may be present in abnormal frequency variability. The measurement of frequency variation from the average F0 is done using the term standard deviation (SD). Either the semitones (pitch stigma) or the standard deviation of F0 in Hz (F0SD) can be measured in two days [9]. The International Association of Logopedics and Phoniatrics voice committee's official title, the Voice Range Profile (Phonetogram), was first presented in 1992. It was used to specify the lowest and highest points of a person's voice range. The VRP is graphically represented as a phonetogram. The patient is instructed to phonate the vowel sounds /i/ or /a/ as softly and loudly as they can throughout a range of frequencies (modelled by a tone generator, such as a piano or pitch pipe, or provided by computer software)[9,] as cited in work done by LeBorgne, Titze, & Ferrand [10]. The vocal signal's cycle-to-cycle variability is measured by vocal perturbation metrics. In the typical voice signal, a negligible degree of cycle-to-cycle variability is anticipated. Vocal disturbance is often assessed using sustained vowels or steady-state vowel segments taken from the connected speech. Jitter and shimmer are two measurements of vocal disturbance that are frequently acquired. The fundamental frequency's momentary variability is known as jitter. While the amplitude's short-term fluctuation is known as shimmer. Generally speaking, jitter and shimmer of less than 1.0% and 0.5 dB, respectively, are regarded as typical [11]. Compared to adults, children exhibit more jitter and shimmer.

Vocal Noise measures: The human body is composed of both periodic and aperiodic (harmonic) elements. This is due to the aperiodic nature of vocal fold vibration (irregular). Harmonic components those with more energy should predominate in a voice with normal voice quality (as measured in dB). Researchers have proposed three ratios: the harmonics-to-noise ratio (HNR), the noise-to-harmonics ratio (NHR), and the signal-to-noise ratio in an effort to quantify the link between the harmonic and in-harmonic components (SNR). The dysphonic voice is characterised by a low HNR or SNR and a high NHR, as opposed to the voice with normal quality, which has a high HNR or SNR and low NHR [12].

Physiological and acoustic description of stuttering

Respiration: Breathing problems are one of the early potential causes of stuttering. Consequently, a lot of study has been done on pneumography over the years. Stuttering breathing curves reveal a number of anomalies. These include oppositions between thoracic and abdominal breathing, irregularity of successive respiratory cycles, prolonged inspirations or expirations, complete cessation of breathing, interruption of expiration by inspiration, and attempts to speak while inhaling air.

Phonation: The larynx is a site of aberrant activity during stuttering, according to common clinical observations such glottal fry, stutterers' claims that their "throat closes tightly," and breath-holding. Along with other vocal apparatus components, the larynx is involved in the anomaly of stuttering.

Articulation: Researchers examined the jaw movement that occurs during the production of stop-plosive consonants in the initial position of words in both stuttering and non-stuttering individuals. He discovered that stuttering was characterised, among other abnormalities, by longer time intervals between the onset of jaw movement and the onset of phonation, by more directional changes in jaw movement, and by longer intervals between the initiation and first directional change of jaw movement [13].

Vocal Abnormalities: Numerous atypical vocal and speech characteristics, such as monotony, variations in vocal quality, rapid or slow tempo, strange inflections, and abrupt shifts in pitch level sometimes co-occur with stuttering.

The idea that stuttering is related to linguistic skills has emerged as a result of a number of causes. One reason is that stuttering typically starts between the ages of 2 and 4 years [14], when youngsters are developing their syntactic, morphological, and lexical skills and learning to make increasingly complicated utterances [15].

Stuttering is likely to happen when internal or external demands for fluency exceed a child's capacity in one or more developmental domains (e.g., linguistic, cognitive, motoric, affective), according to the Demands-Capacities (DC) model of stuttering [16, 17]. This shows that a young child may be more prone to stuttering if they have a language impairment [18, 19, 20]. Speech disorders are what stuttering is essentially. However, the field of speech-language pathology has long been intrigued by its connection to language development, and many researchers have looked at the so-called stuttering-language connection [21, 22].

Aim of the Study: The purpose of this study was to examine the impact of stuttering on the development of speech and language and voice quality in stuttering children.

Methods: Two male children between the ages of 7 and 10 were chosen as the study's subjects. The Stuttering Severity Instrument (SSI-4) was used to assess the extent of stuttering, and the Linguistic Profile Test was used to determine the child's language proficiency (semantic and syntax). In order to evaluate the voice's quality, Dr. Speech software was used. The speech and language therapist conducted the study in the speech and hearing department at Composite Regional Centre, Lucknow, India.

The details of the subject as per details from the case history and medical report:

Table 1: The details of the subject as per details from the case history and medical report

Details	Subject A	Subject B
Provisional Diagnosis	Stuttering (?)	Stuttering (?)
Age/Sex	7 Years/Male	7 Years/Male
Parents Education	Mother- Intermediate Father-High school	Mother- B.A Father- B.Sc
Occupation of Parents	Mother- Housewife Father-Bussiness	Mother-Housewife Father-Private job

Economic status	APL	APL
Complaint	Child stammers for the past two years	Inability to speak fluently
Any other associated problems reported by Parents	Nil	Nil
Education	1st standard at Manipuria Inter College	1st standard at R.D Memorial Inter College
Language level as per LPT	Part I semantics: 4.5-5 years Part I syntax: 4-4.5 years	Part I semantics: 6-7 years Part II syntax: 4.5-5 years
Communication skills	The child prefers to stay alone and faces difficulty in interacting with new people Mostly his communication partners are his family members	The child does not hesitate to interact with new people. Communication partners include parents, family members, and teachers
Behavioral problem	No such any	The child is a little aggressive
Sensory Issue (report to be reviewed)	The child has low vision so he wear spectacle since four years of age	No such issue
Dysfluency	The child is nonfluent	The child is nonfluent
Stuttering behaviors 1) Core behavior: 2) Secondary behavior:	1) Repetitions, prolongations, blocks 2) Head nodding, leg tapping, interjections	1) Blocks, Filled pauses, Repetitions, prolongations 2) Hand clenching, body movement, leg tapping, facial grimaces

The SSI-4 measures the severity of stuttering. - It is a norm-referenced stuttering assessment that is trustworthy and valid and can be applied in both clinical and research settings. It assesses the severity of stuttering in four domains of speech behaviour in both children and adults: 1) Regularity 2) Timeframe 3) Physical comorbidities 4) The speech of the individual is natural. For this study, the SSI-4 was used to assess the severity of stuttering.

Due to their difficulties with reading tasks, we requested both of the children to narrate a tale that they felt comfortable doing in order to administer the SSI-4. SLPs then recorded their samples using the smartphone's built-in phone recorder on a POCO X3 with 128 GB of RAM.

The story narrated by subject A and the subject had 48 words, 94 syllables, and 75 words, 126 syllables respectively and by this, we found core behaviors like repetitions, prolongations, and blocks, Assessment was performed during observation of subjects for secondary behavior and by analyzing tape recordings by the SLPs and after that scoring was done and points were assigned accordingly. Linguistic Profile Test (LPT): The LPT is a thorough, norm-referenced Kannada language evaluation tool[23]. LPT was designed to evaluate and analyze adequate language samples at the phonological, syntax, and semantic levels. A parallel version of the test was also developed in Hindi[24]. For young children aged 3 to 7 years old, a picture-based test has been created. The range of activities covered by the approaches in these parts includes pointing, repetitions, naming, indicating the acceptability of grammar and semantics, listening for lexical categories, sentence completion, matching synonyms and antonyms, etc [25].

Here LPT was administered on subject A and subject B individually on all items, of part I- Semantics and part II- Syntax by using a pictured version of the test for finding out the language level.

DR. Speech Software: There are several different graphic displays (spectrogram, F0, intensity, etc.) and parameter options (jitter, shimmer, NNE, etc.). It is used to measure hoarse, harsh, and breathy voices in order to support diagnostic evaluations for vocal problems. It offers information on laryngeal function signals (voice signals, laryngeal acoustics signals, and speech signals) for diagnosis and rehabilitation. It makes advantage of exact signal processing and detection. This software is capable of performing sophisticated multidimensional voice parameter identification and analysis. Using acoustic metrics such as jitter, shimmer, fundamental frequency tremor, amplitude tremor, normalised noise energy (NNE), harmonic-to-noise ratio (HNR), and signal-to-noise ratio, it gives a thorough report for evaluating voice quality (SNR). Patients with minor roughness, moderate hoarseness, and severe breathiness can benefit from it [26].

Results

Table 2: Comparative scores of Language level, stuttering severity, and voice quality

Parameters	Case A	Case B
Language ability as per LPT	Part I semantics: 4.5-5 years Part I syntax: 4-4.5 years	Part I semantics: 6-7 years Part II syntax: 4.5-5 years
Stuttering Severity as per SSI-4	Total Score-17 Moderate	Total Score-32 Very Severe
Voice quality as per Dr. Speech	Mild Hoarseness and Severe Breathiness in the voice.	Normal

SSI-4

SSI- For measuring the severity of stuttering in both Subject A and Subject B we have used the speaking task of nonreaders table from SSI-4, as the child has very poor reading skills. The scoring has been done as per the SSI-4 norms.

Table 3: The scoring has been done as per the SSI-4 norms

S.No	Parameters	Score	
		Case A	Case B
1.	**Frequency**		
a)	Prolongation	3	14
b)	Repetitions	2	1
c)	Blocks	3	9
d)	SS (percentage-%)	9.57	19.04
2.	Duration	6	10
3.	Physical concomitants	2	3
4.	Total score	17	32
5.	Results (stuttering severity)	Moderate	Very severe

Language level of the Child: LPT (as in amppendix1)

Voice Analysis: Here is the result of the voice analysis of Subject A and Subject B as per Dr. Speech software.

Figure 1- Voice Data of Subject A

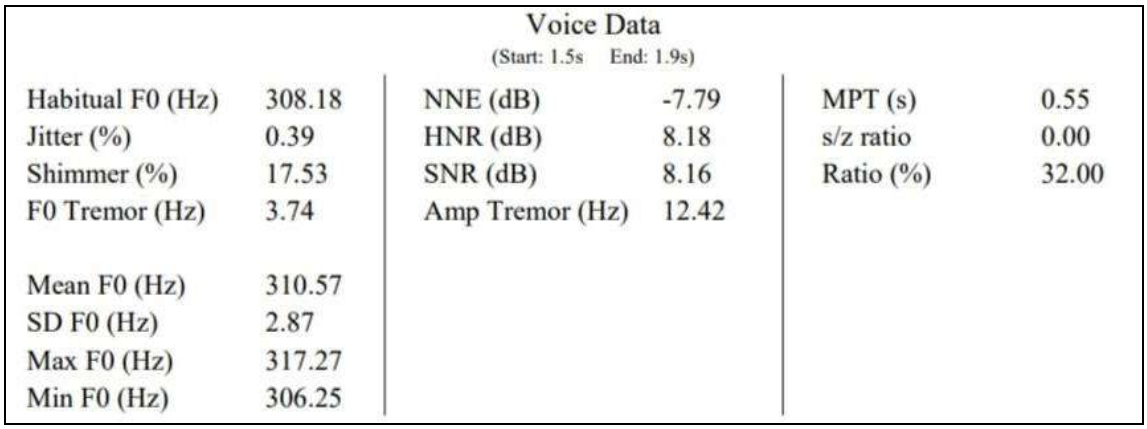

Fig 1: Voice Quality of Subject A

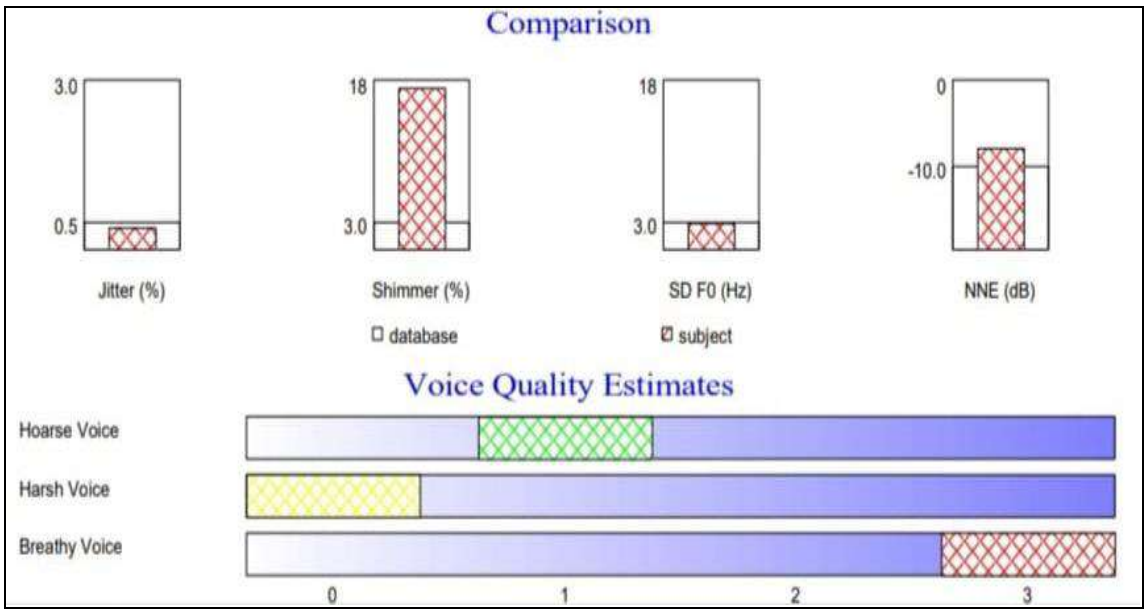

Fig 2: Voice Data of Subject A

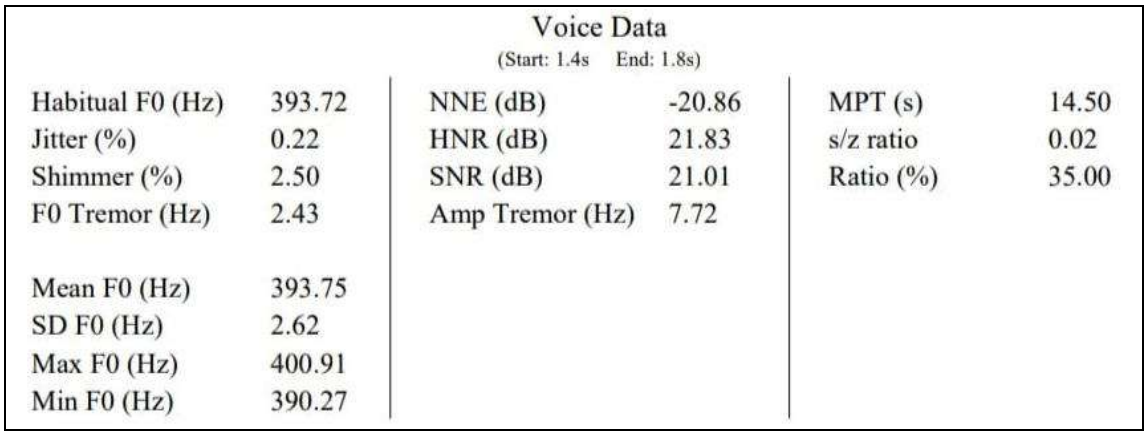

Fig 3: Voice Quality of Subject B

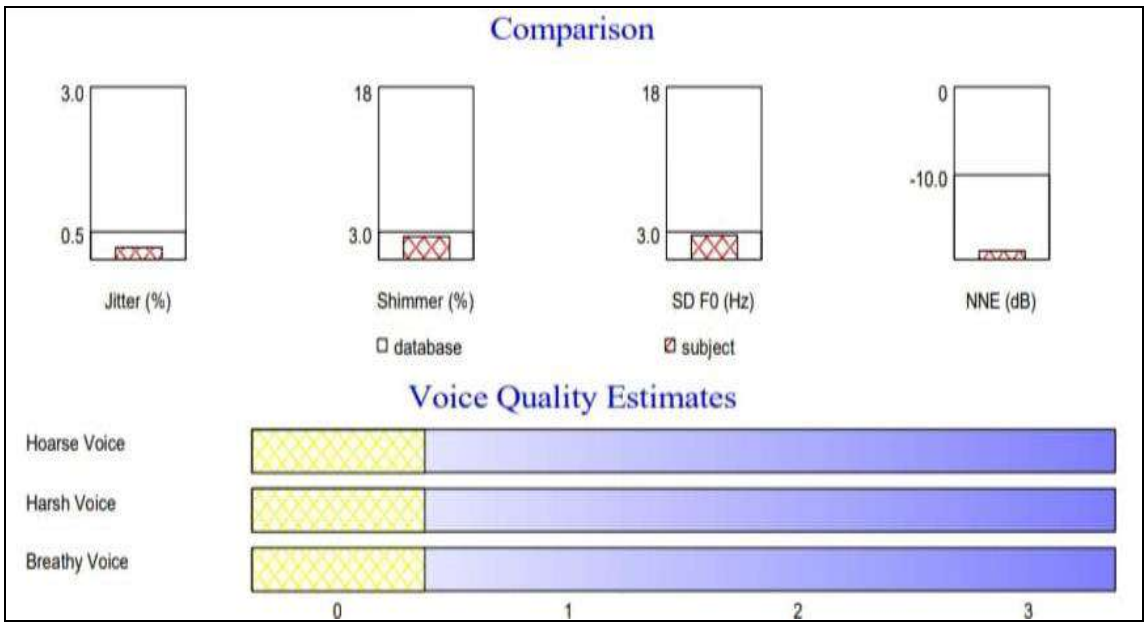

Fig 4: Voice Data of Subject B

Table 4: Comparative table of voice parameters

Parameters	Normative (Children 4-8 years, boys)	Subject A	Subject B
Habitual F0(Hz)	262	308.18	393.72
Jitter (%)	1.55-1.609	0.39	0.22
Shimmer (%)	0.52	17.53	2.50
Mean F0(Hz)	243	310.57	393.75
HNR(dB)	7-12	8.18	21.83
S/Z Ratio	1.0	0.00	0.02

Table 1 summarizes the basic parameters of voice variables and by observing table 1 we have found that the value of F0 was found higher for subject A and subject B than the normative value for the similar age range. Between subject A and subject B, the value of F0 is greater for the child with very severe stuttering than for the child with moderate stuttering. The jitter in % values was found lowest in subjects with very severe stuttering. The value of shimmer in % is found higher for both the subjects as compared with the normative value, the subject with moderate stuttering has the highest value of shimmer. The value of mean F0 in Hz is highest for the subject with very severe stuttering. The value of HNR in dB is highest for the subject with very severe stuttering. A lower value of the S/Z ratio is found in subjects with severe stuttering while in subjects with moderate stuttering S/Z ratio could not be calculated as the child was not able to articulate the Z phoneme.

Discussion

The findings of various research reviewed by Nippold [27] showed that children who stammer have linguistic difficulties, but children who do not stutter exhibit similar patterns. In our study, we looked at stuttering children and discovered that their language development was delayed. Children that stammer in our study do not have receptive and expressive abilities that are within normal ranges. Rommel, Hage, Kalehne, and Johannsen [28] demonstrated that young children with stuttering had receptive and expressive language skills that were well within normal ranges. Watkins [29] came to the conclusion that "there is

virtually no evidence that language development is vulnerable in any significant number of young children who stutter" after discussing her longitudinal studies of language development in children who stutter. However, in our study, we have found that language development may be vulnerable to some extent in children who stutter.

Some academics claim that children who stutter collectively are more likely to have language deficits (language disorders) than children who do not stutter [30, 31]. Similar to this, our study revealed that stuttering children learn their language (semantics and syntax) later.

Scholars have argued that stuttering, over time, could restrict a child's language development [32, 33]. In our study also as per The Linguistic profile test that we have performed for assessing the language level of children, we can say stuttering may be a considerable reason for delayed language development in children.

As per the current study, there is little evidence to support the claims that CWS are more likely than CWNS to have language impairments that language deficiencies precede the beginning of stuttering, or that stuttering limits language development over time. The research indicates that stuttering has minimal to no effect on language development and that CWS, like CWNS, exhibits the complete spectrum of language abilities (high, average, and low), even at the time of stuttering initiation.

In order to assess how frequently language problems and stuttering co-occur, several studies have polled SLPs who are currently in practise about the kids on their caseloads. This data supports the idea that CWS is more likely than CWNS to have language issues [34, 35, 36]. The current study also lends credence to the notion that stuttering kids are more prone to experience language difficulties.

According to Arndt and Healey [32], a significant portion of CWS suffer from a language issue. Additionally, they asserted that their findings supported the DC model, saying that "problems or difficulties in expressive language abilities might be a by-product of stuttering for several years" and that "some preschool children might be vulnerable to developing poor expressive language if the stuttering persists into the elementary school-age years." Additionally, we discovered in the current study that children who stutter have language difficulties and may have acquired poor language as a result of their chronic stuttering into their elementary school years. Stuttering can cause language impairment if it persists over time. In our research, stuttering over time may cause a linguistic impairment [32].

According to a study by Nevzeta Salihovic from the Faculty of Education and Rehabilitation at the University of Tuzla [37], among students in grades 1 to 4, F0 was highest in normally fluent speakers (271.08 Hz), while stuttering students had similar values of F0 (F0 was 264.13 Hz in children with mild stuttering, and F0 was lowest in children with severe stuttering – 262.9 Hz).

While in our case the value of F0 was found highest for the subject with a very severe degree of stuttering, lower for the subject with moderate stuttering, and lowest for normative as per table 1.1.

In participants with severe stuttering, jitter in% values was observed to be highest. The patients with the most severe stuttering showed the smallest changes in the vocal tone's amplitude (measured as a shimmer in dB-ShdB) (0.07 dB). If we talk about shimmer, which is a brief variation in amplitude in the vocal tone, we have calculated the shimmer in% value here and the value was found highest for the subject with moderate stuttering, lower for the subject with very severe stuttering and lowest shimmer in % values for normative given in table 1.1.

Measurement of friction /z/ duration represents expiratory control measurement, whereas friction of /s/represents addition to the laryngeal assignment component. Researchers suggest these instruments should be used for examination of laryngeal and expiratory contribution to phonation problems, and they also reported similar friction duration of /s/ and /z/ in normally fluent speakers. Subjects with mild stuttering achieved a slightly longer duration of /z/ friction. Other studies reported s/z friction of 1, with a slightly longer duration of /z/ friction, which concurs with the data in this study. In the present study, the subject with moderate stuttering was unable to articulate /z/ while the subject with very severe stuttering has an S/Z ratio value of 0.02. Normally fluent speakers had the longest maximum phonation time, and S/Z ratio in these subjects approached to the ideal value of 1. In generally fluent schoolchildren, Bolfan-Stoi [38] found that the maximum phonation time was 12.07 seconds, the friction time for the /s/ sound was 8.23 seconds, and the friction time for the /z/ sound was 11.02 seconds.

Conclusion: It has been concluded from our study that stuttering may have a considerable impact on language development and the quality of voice. Whenever subjects with stuttering are taken as the experimental group, we should also take into consideration the language development and voice parameters of the subjects.

Limitations

- The limited number of participants was one drawback. However, the small sample size made it easier to compare the two illnesses to each other and to normative data.
- It would be necessary to get participants from different regions or from cities that speak a variety of dialects. To establish a comparison for the current study, a small-scale survey of the immediate area was required.

Conflict of Interest: Nil

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Written consent was taken from the mother of both children to conduct the study and present the findings.

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