International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Parkinson's Disease: Pilot Single-Subject Research Design

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Abstract:
Parkinson's disease is a progressive degenerative neurological disease that primarily affects the movements. It includes symptoms such as tremors, muscle rigidity, postural instability, changes in gait and bradykinesia, poor voice quality and errors in speech production. In a review done by de Lau and Breteler (2006), it was reported that an estimated 10 million people in the world (i.e., approximately 0.3% of the world population) and 1% of those above 60 years are found to be affected with Parkinsonism.
This study is the Perceptual analysis of voice characteristic of an individual with Parkinson's disease for a period of six months. The participant aged 61 years is diagnosed as 'Multiple system atrophy – Parkinson's type', in the year 2019. A comprehensive statistical analysis of speech components such a evaluation of Maximum Phonation Duration (MPD), s/z ratio, Diadochokinetic syllable rates (DDK) are evaluated every month. Also the individual's voice quality are perceptually analyzed using GRBAS Rating Scale. The study was done for over a period of 6 months i.e from November, 2023 to the April, 2024. On analyzing the results over a period of six months it was observed that there was regression throughout the period. The study shows the distinct patterns of deterioration in vocal characteristics that correlate with the advancement of PD symptoms, including changes in vocal pitch, loudness and articulation.

INTRODUCTION:

Voice Voice is considered a crucial element for communication. Voice can be described as perceptible sound produced by the larynx.
Voice is produced by the vibration of the vocal folds. The sound produced by this vibration is then modified by the vocal tract into different acoustic forms which consequently is perceived by the listener as sound.
Voice involves the function of the following subsystems respiration, phonation, articulation, resonance and prosody.
Respiration plays the most crucial role in speech production. Respiration consists of two phases – inspiration and expiration. Inspiration involves the action of the inspiratory muscles causing an increase in the volume of thoracic cavity and a decrease in the pressure causing the air to move into the lungs down the pressure gradient. Expiration takes place due to a decrease in the lung volume and a

subsequent increase in pressure causing the outward airflow from the lungs to the larynx where the vocal folds vibrate to produce sound.

Phonation is the production of the sound. According to Freed (2020) - phonation is defined as the ability to voice phonemes using voice fold vibrations in the larynx. This procedure begins with the expiration of air through the glottis, where adduction of the vocal folds takes place. Larynx is the principal organ responsible for the vibration of the vocal fold. Voice is produced by the alternating opening and closing of the vocal folds due to the air column disturbance generated under pressure.

Articulation: articulation can be described as the process of production of speech sounds. This process involves organs such as the tongue, lips, and jaws to cause the restriction and displacement of airstreams and vocal tone. Vowels and consonants are the major groups

Resonance: In this process mouth, nose, and throat are the primary organs involved. Resonation helps to impart a unique characteristic of speech sounds and the voice .

Prosody: The rhythm, stress, and intonation of speech. Prosody can help in providing semantic information as well. Prosodic features are also called suprasegmental features. These features influence meaning and help organize what is said.

Voice consists of the following parameters: pitch, loudness, quality, and variability.

Pitch is a perceptual correlate of frequency

Loudness is a perceptual correlate of intensity

Quality is a perceptual correlate of complexity

Variability is a perceptual correlate of variation in the above parameters.

A voice is considered to have normal voice characteristics when the quality of the voice sounds pleasant without atonality and breaks while pitch being age-appropriate and loudness being appropriate to the communication

VOICE PATHOLOGIES:

A voice disorder occurs when voice quality, pitch , and loudness differ or are inappropriate for an individual's age, gender, cultural background or geographical location. (Aronson and Bless,2009; Boone etal ., 2010; Lee et al .,2004).

Classification

Voice disorder is classified as :

- Functional
- Organic
- Neurologic

Based on the systemic classification of American speech language hearing association ,voice disorders are classified into eight major groups:

1. Structural pathology
2. Inflammatory conditions
3. Injury or trauma
4. Systemic condition - affecting voice
5. Aerodigestive - affecting voice
6. Psychiatric or psychological disorders -affecting voice
7. Neurological voice disorder
8. Other disorders of voice

Structural pathology: It includes vocal fold nodules, vocal fold polyps, Reinke's edema , laryngitis (acute and chronic) , contact ulcer or granuloma, sulcus vocalis , presbylaryngis, leukoplakia, hyperkeratosis which are acquired and benign. And congenital pathologies includes laryngeal cleft, laryngo malacia, subglottic stenosis, laryngeal web, laryngeal cyst.
Inflammatory conditions: It comprises Acute laryngitis, Chronic laryngitis, Reinke's edema, laryngitis sicca , pachydermia laryngis.
Trauma: voice pathologies can also happen due to abuse and misuse of voice , surgery, foreign body, endoscopy, thermal or caustic burns , inhalation of irritant gas or fumes
Systemic condition affecting voice: It consist of endocrine disorders (hypothyroidism, hyperthyroidism, sexual hormone imbalances, growth hormone abnormalities) , Immunological disorders (allergy) .
Aerodigestive: Non laryngeal aerodigestive disorders affecting voice comprises respiratory disease (asthma, chronic obstructive pulmonary disease) gastro- oesophageal reflex disease, infectious aerodigestive tract (laryngotracheo bronchitis, mycotic infections)
Psychiatric and psychology disorder: This type of voice disorder can be due to psychogenic aphonia and dysphonia , factitious disorder or malingering , gender dysphonia or gender reassignment.
Neurologic disorders:
This type of classification consist of bilateral or unilateral superior laryngeal nerve paralysis, unilateral or bilateral recurrent laryngeal paralysis, largeal nerve paresis , myasthenia gravis , spasmodic dysphonia , vocal dysphonia, Parkinson 's disease, multiple sclerosis and huntington's chorea.
Other disorders of voice include : Vocal abuse , misuse,and phonotrauma, vocal fatigue, muscle tension dysphonia,Plica ventricularis .

PARKINSONS DISEASE
Parkinsonism can be classified into two major groups: primary and secondary
PRIMARY PARKINSONISM: Primary parkinsonian disorders include Parkinson's disease and atypical parkinsonian disorders.
Parkinson's disease: it's a progressive degenerative neurological disease. It can also be known as idiopathic, typical, or classic Parkinsons. It can cause both motor and non-motor symptoms.
Atypical Parkinsonism disorders: it can also be referred to as Parkinson's plus syndrome. It is a fast-progressive neurological disorder. Symptoms can appear between 1-3 years
Secondary parkinsonism: this type of parkinsonism can be caused by Neurological problems caused by brain tumours, poisons, or drugs
Drug-induced parkinsonism: it is caused due to side effects of the drugs such as antipsychotics which affect the dopamine levels in brain.
Vascular parkinsonism: caused by clotting in the brain from multiple small strokes. People with vascular parkinsonism tend to have more problems with gait than tremor and have more problems in the lower body. The disorder progresses very slowly in comparison to other types of parkinsonism
Parkinson's disease is the second most common chronic progressive neurodegenerative disease that has both motor and non-motor characteristic features. Motor functions include tremor, stiffness, slowness of movement, and postural inability while the non-motor functions include hypersomnia, depression, autonomic dysfunction, and cognitive impairment.
James Parkinson gave the first medical description of Parkinson's disease as "shaking palsy" in 1817.He characterized Parkinson's disease with tremors, hence providing a differential diagnosis from other

diseases such as multiple sclerosis. Parkinsonism is the term used to describe the physical disability resulting from the motor characteristic, which is the key feature of Parkinson's disease, this includes resting tremor, bradykinesia, and muscular rigidity. The symptoms of Parkinson's disease show slow progress, making it increasingly difficult for the affected individual to carry out day-to-day life activities without help.

It is difficult to recognize parkinsonism in its first stages as there will be delays(an average of 10 years) in showing the symptoms. Constipation is the most common symptom. Other symptoms include vague shoulder pain, depression, and rapid eye movement (REM).

In Parkinsons patient ,while conducting the postmortem it was revealed there was an accumulation of a α–synuclein in Lewy bodies and Lewy neurites. Parkinsonism is a multisystem disease as it affects multiple organs, including skin and salivary glands. It was observed that parkinsonism patients will have impaired gait, making it difficult for the patient to keep one step after another for at least 7-10 consecutive steps. When the patient experiences acute or chronic stress situation can worsen.

EPIDEMIOLOGY

Parkinsonism is an age-related disease. According to the research conducted by Radboud university Nijmege, it was found that in some cases (25%) affected individuals are younger than 65 years and some are even below 50. Further investigation found that there was an increase in the incidence rate in China.It is more commonly observed in men than in women .In women, Parkinson's disease showed more severity and included symptoms such as motor or non-motor fluctuations ,dyskinesias was also observed. In a review done by de Lau and Breteler (2006), it was reported that an estimated 10 million people in the world (i.e., approximately 0.3% of the world population) and 1% of those above 60 years are found to be affected with Parkinsonism.

The number of PD patients worldwide has doubled from 2.5 million in 1990 to 6.1 million in 2016, according to the Global Burden of Disease study in 2018.

Causes:

The following can be the contributing factors to Parkinsonism.

Environment interaction: Environment-related factors may cause symptoms that are identical to those of Parkinson's disease. The symptoms shown on the administration of mtpt is similar to those of Parkinson's disease. A research was conducted where the animals were administered with MPTP(1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine) which resulted in similar degeneration of dopamine-producing neurons in substantial nigra as seen in PD. Consequently, we can draw an inference that certain chemicals present in the environment that are similar to MPTP that can induce symptoms similar to PD.

Parkinsonism can also occur in patients exposed to manganese and carbon mono-oxide poisoning

Genetic: mutation in genes SNCA, LRRK2, PRKN, PINKI AMD GBA is also known to cause Parkinson's disease

Traumatic brain injury is also considered to be the leading cause of Parkinsonism.

According to few recent studies it was also seen that COVID-19 can also be the leading cause of Parkinson's disease

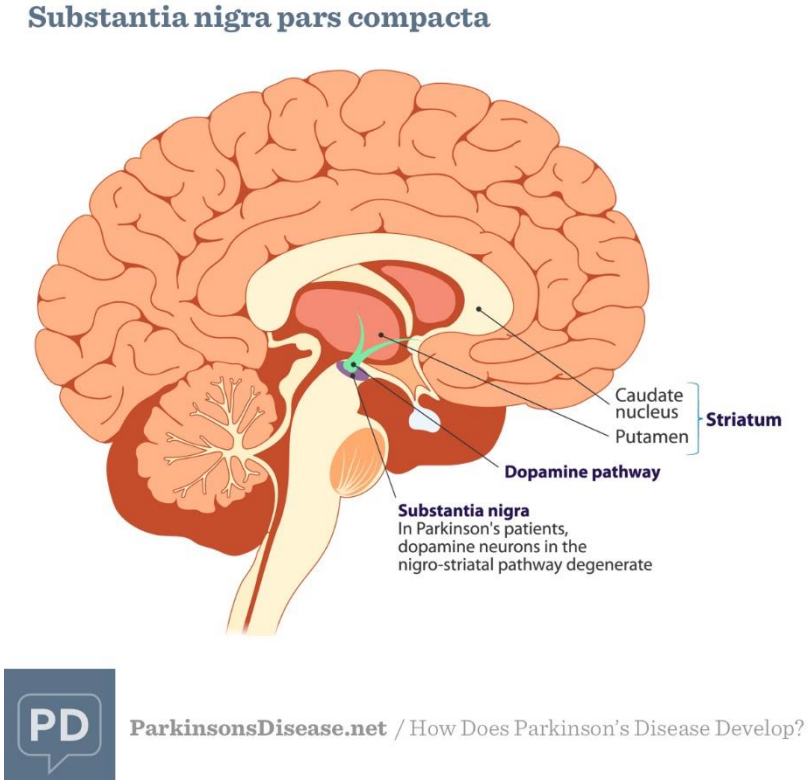
Anatomy and Physiology

Basal ganglia include the caudate nucleus, putamen, and globus pallidus. Substantial nigra and subthalamic nucleus can also be included as they are considered to be functionally related. Putamen and

globus pallidus are together called lentiform nucleus. Since there are some similarities between the caudate nucleus and putamen they are referred to as striatum or neo striatum. The primary function of basal ganglia is to pass and receive information from the cerebral cortex.

The basal ganglia is implicated in numerous movement disorders, but it is most commonly found in Parkinson's disease and Huntington's disease. Except for the connections between the subthalamic nucleus and the globus pallidus, internal part/substantial nigra pars reticulata, all intrinsic basal ganglia connections are inhibitory.

The subthalamic nucleus is reciprocally connected to the globus pallidus and substantial nigra, and it gets input from the motor cortex. The output received from the basal ganglia is primarily derived from the globus pallidus and substantial nigra.



(https://parkinsonsdisease.net/basics/pathophysiology-what-is-it)

Pathophysiology

The abnormalities in the basal ganglia function is considered to be the primary cause of parkinsonism

- Alpha-synuclein aggregation – dysfunction of mitochondria, lysosomes or vesicle transport
- Synaptic transport issues
- Neuroinflammation

  The two major neuropathologies of Parkinsonism disease can be a result of the loss of pigmented dopaminergic neurons in substantial nigra or due to the accumulation of alpha-synuclein (Lewy bodies) which is an intracellular protein. The ventrolateral substantia nigra is the only region of the midbrain where pigmented dopaminergic neurons are lost in the early stages of the disease; other midbrain dopaminergic neurons are mostly spared however, towards the last stage, these pigmented dopaminergic neuron losses become more pervasive. In the initial phases of Parkinson's disease, patients typically encounter motor symptoms only when they have lost approximately 50% to 80% of their dopaminergic neurons, indicating the presence of a compensatory mechanism. This implies

that there is a mechanism at play in the early stages of the disease that helps mitigate the effects of neuron loss until it reaches a certain threshold.

In cases of parkinsonism, there is an aberrant deposition of alpha-synuclein in the cytoplasm of certain neurons in a number of distinct brain areas. Aggregated alpha-synuclein makes up the majority of Lewy bodies. As the condition progresses, limbic and neocortical brain regions are also shown to have Lewy pathology. This pathology primarily affects cholinergic and monoaminergic brainstem neurons as well as neurons in the olfactory system.

A gradient of striatal dopamine depletion is caused by the loss of nigrostriatal dopamine cells which makes an imbalance between direct and indirect pathways through basal ganglia that can result in bradykinesia.

Parkinson's disease symptoms are mostly caused by increased inhibition from the striatum on the lateral segment of the globus palidus and increased excitation from the subthalamic nucleus to the substantial nigra and medial segment of the globus palidus. If proprioception is affected then motor movement or motor signs can be affected. The most prevalent cause of tremors in Parkinson's patients is abnormal electric stimulation in the medial nerve. Proprioception may be affected by the administration of levodopa and dopamine agonists.

Functional changes in Parkinson’s patient is caused due to morphological changes in the brain which can induce a change in neural plasticity

Norepinephrine is a hormone and neurotransmitter that is a part of the sympathetic nervous system. A decrease of this norepinephrine due to the loss of nerve endings gives rise to irregular blood pressure and fatigue and decreased movement of food through the digestive tract in Parkinsonism cases

Problems faced

Motor problems

The term parkinsonism refers to a collection of illnesses marked by slowness of movement and additional symptoms such as tremors, bradykinesia or hypokinesia, flexed posture, loss of postural reflexes, gait impairment, and freezing.

Bradykinesia: Hypokinesia can be referred to as a decrease in the speed and amplitude of repetitive actions and movement. Hypokinesia can also be interchangeably used with the term bradykinesia meaning reduced speed of movement. Most common forms of hypokinesia is found in Parkinson disease. Facial and axial muscles are the most affected hence making it difficult for the individual to perform daily activities . “Festinant gait” is present in Parkinson disease patients that is manifested by tripping and falling due to slowness of postural adjustment with forward flexed posture and shuffling of feet. This is also a reason to why the patient has a tendency to run rather than to walk. Bradykinesia may lead to an expressionless face (hypomimia) and the amplitudes of handwriting become smaller (micrographia)

Tremor : Tremor primarily affects the hands, although it can also be noticed in the face, tongue, and jaw. The inclination of the thumb and index finger to make contact and perform an oscillatory action is referred to as pill rolling, most commonly a resting pill-rolling type of tremor of the hands. Hyperkinesia refers to excessive movement and encompasses a wide range of abnormal involuntary muscle activity, such as tremor or spasm.

Startle and freezing reactions: The Contrary types of orders that originate in the brainstem cause startle and freeze reflexes. The startle response involves the activation of most skeletal muscle, whereas

freezing involves the cessation of all body movement. An example of an unconscious reaction to motor actions is the freezing reaction.

Rigidity: Stiffness of movement is seen usually in the case of Parkinson patient due to muscle rigidity. Cogwheel rigidity is an abrupt feeling in an arm or leg that is experienced while passively flexing and extending or supinating and pronating the affected limb or joint. Cogwheel rigidity is seen due to a decrease in tone.

Swallowing: Swallowing problems can arise at any stage of Parkinson's disease. Aspiration pneumonia caused by swallowing problems is the major cause of death in Parkinson's disease. Dysphagia, or difficulty swallowing, can occur at any stage of Parkinson's disease. The following signs and symptoms can range from minor to severe: trouble swallowing specific meals or beverages, coughing or throat clearing during or after eating/drinking, and the sensation that food is becoming trapped. As the condition advances, swallowing becomes increasingly difficult, and food/liquid can enter the lungs, resulting in aspiration pneumonia. Aspiration pneumonia is the primary cause of death in Parkinson's disease.

Non-motor problems

Speech: The most frequent speech impairments in patients with Parkinson's disease are reduced volume (hypophonia), restricted pitch range (monotone), and difficulty articulating words or syllables (dysarthria). In essence, the patients cannot talk as loudly as others, they would struggle to communicate emotion , and they struggle to produce the words.

Language: Language is a cognitive ability that can exist even if the patient has difficulty expressing themselves. Word-finding and grammatical issues are one of the major problems faced by the Parkinson patient. They mostly would prefer to use simplified sentence structures with a higher ratio of open-class items such as nouns, verbs, adjectives, to closed-class items like determiners, auxiliaries, prepositions, etc and an increase in the frequency and duration of hesitations and pauses. Listening to others speak might be difficult for people with Parkinson's disease since they employ intricate words to convey their ideas. As a result, people with Parkinson disease can have substantial challenges in both language production and understanding.

Cognition : Cognitive decline is normally gradual and subtle but it can be sudden in exceptional circumstances. Cognitive impairment occurs in people with Parkinson's disease, ranging from subjective cognitive decline (SCD) to mild cognitive impairment (PD-MCI) to dementia (PDD). The main regions affected include planning, working memory, and executive dysfunction that is connected with the frontal lobe-striatum, loop combined with lower dopamine levels and the other is disturbances of attention, semantic verbal fluency, and visual-spatial ability with involvement of both temporal lobe and the posterior cortical dysfunction.

METHODOLOGY

Aim: This research aims to examine the vocal characteristics exhibited by individuals with Parkinson's disease. This study also focuses on understanding and comprehending the underlying physiological and neurological mechanisms that can result in speech impairments

Objectives:

- To collect the voice samples of the participant with Parkinsonism aged 61 who has been seeking medication since 2019
- To evaluate voice using DDK(Diadochokinetic syllable rates)

- To evaluate voice using MPD(maximum phonation duration)
- To evaluate voice using S/Z RATIO
- To evaluate voice using GRBAS(GRADE ROUGHNESS BREATHINESS ASTHENIA STRAIN)
- To compare the progressiveness of the disease in a time period of 6 months

CASE HISTORY

The participant (male) aged 61 was diagnosed with multiple system atrophy – Parkinson's type, 5 years (2019) ago. The presenting complaints as stated by the family members included unclear speech and poor understanding of the participant's speech. The participant had undergone physiotherapy sessions for the past 4 years. While taking the physical examination of the participant it was observed that the participant showed right side drooping accompanied by tremors. Reduced function of articulators was also observed. Inadequate pitch and loudness range was noted.

MATERIALS:

- Consent form
- Case history
- GRBAS(GRADE ROUGHNESS BREATHINESS ASTHENIA STRAIN) was used for the perceptual evaluation of voice
- Stopwatch was used for measuring time
- Recorder

Procedure :

The procedure of the study was explained to the participant and written consent was obtained. This was further succeeded by a detailed case history. The case history had the following sections- demographic data, medical history, voice complaints, and lifestyle were taken into consideration.

Diadochokinetic syllable rates (DDK) was administered to the patient. The DDK rate measures how quickly an individual can accurately repeat a series of rapids. Diadochokinetic syllable rate was assessed by counting the number of syllables spoken in a given time period. Three samples of both SMR(Sequential motion rates) and AMR(alternating motion rate) were recorded within a given time. While taking the assessment of SMR the patient was asked to phonate /pa/,/ta/, and /ka/individually within a period of 10 seconds. The syllables produced were counted and assessed individually. While administering AMR the patient was instructed to phonate /pa ta ka/ in a series motion within a given period of 10 seconds. The number of sequence produced was counted and assessed.

To analyse the glottal efficiency maximum phonation duration (MPD) was administered. Maximum phonation duration measures the maximum time (calculated in seconds) an individual can sustain a vowel that is produced in a single breath in natural pitch and loudness. For the administration of MPD the patient was asked to phonate /a/,/i/, and /u/ in a single breath and sustain to for as long as possible. The duration of the phonation was measured using a stopwatch. Three trials of /a/, /i/, and/u/ were recorded with adequate breaks given to the participant between them. The patient was first instructed to take a breath and then phonate /a/ and sustain for as long as possible. This procedure was repeated for the other phonemic vowels /i/ and /u/. The samples were then assessed individually.

To check the phonatory and respiratory issues S/Z ratio was administered to the patient. The patient was asked to inhale deeply and sustain /s/ (voiceless) and /z/ (voiced) individually at a comfortable pitch and loudness in a single breath. The measurement was taken thrice individually for each sound with a break

in between. The time taken to complete the phonation was noted using a stopwatch. The s/z ratio was the calculated by dividing the maximum duration of /s/ by the time of maximum duration of /z/.
The voice samples were collected and analysed perceptually that evaluated in a quiet room using GRBAS.
GRBAS Scale is a standard scale used to rate the voice quality of an individual. This scale assesses the five characteristics of voice qualities Grade, Roughness, Breathiness, Asthenia, and Strain. The characteristics are given a numerical score ranging from '0' to '3'. '0' indicates no abnormality, '1' indicates mild abnormality, '2' indicates moderate degree of abnormality, and '3' indicates severe abnormality in that particular characteristic. The components were assessed and were given the corresponding scores accordingly.

ANALYSIS:
Perceptual analysis was done using GRBAS.

STATISTICAL ANALYSIS:
The data obtained were subjected to statistical analysis to establish the progressiveness of the disease that has affected the voice characteristics of the individual within a period of 6 months. The average values of parameters-perceptual, MPD, S/Z RATIO, and DDK were taken to understand the progressiveness of the disease.

RESULT AND DISCUSSION
Aim: This study aims to evaluate the vocal characteristics of voice in Parkinson's disease to understand the perceptual and other vocal parameters.
The results of the study were obtained using statistical analysis.
The following parameters were considered:

- DDK- Diadochokinetic syllable rates
- MPD- maximum phonation duration
- S/Z RATIO
- GRBAS – Grade Roughness Breathiness Asthenia Strain

The results are presented below.

MAXIMUM PHONATION DURATION
Maximum phonation duration is the maximum duration that an individual can maintain a phonation after a deep inhalation.
Maximum phonation duration was done for the vowels /a/,/i/, and /u/ were analysed.

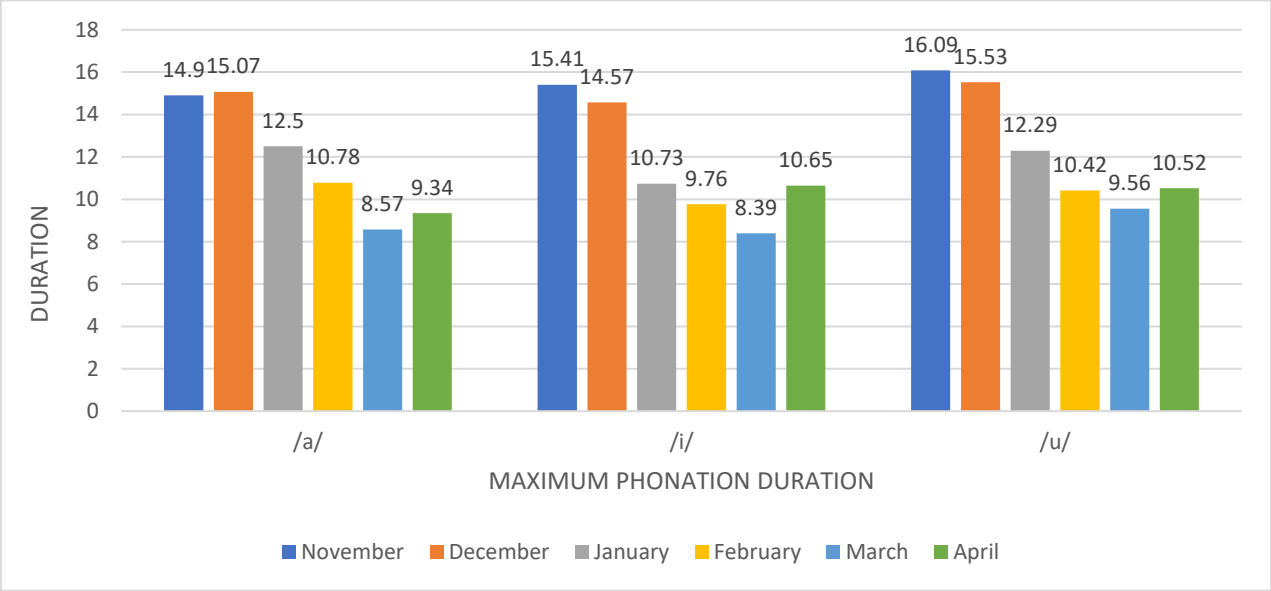
MONTH	NOVEMBER		DECEMBER		JANUARY		FEBRUARY		MARCH		APRIL	

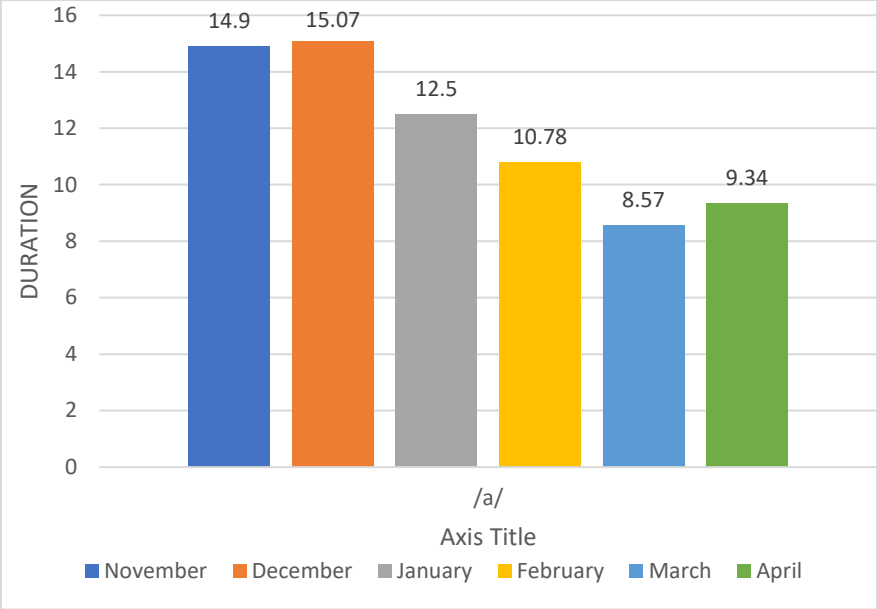
/a/	14.90	0.17	15.07	-2.57	12.50	-1.72	10.78	-2.21	8.57	0.77	9.34	-5.56
/i/	15.41	-0.84	14.57	-3.84	10.73	-0.97	9.76	-1.37	8.39	2.26	10.65	-4.76
/u/	16.09	-1.37	15.53	-3.24	12.29	-0.87	10.42	-0.86	9.56	0.96	10.52	-5.57

Table 1.1

Clinical data are shown in the above table 1.1. While assessing the phonemes, there was not much difference in values in the first two months. A continuous regression was seen in the following three months of January, February, and March due to the inconsistency in therapy sessions attended. A slight progression was again observed as the participant resumed the therapy session with LSVT being the primary therapy technique used.

The following graphs shows the result Maximum phonation duration of the participant in a span of 6 months.

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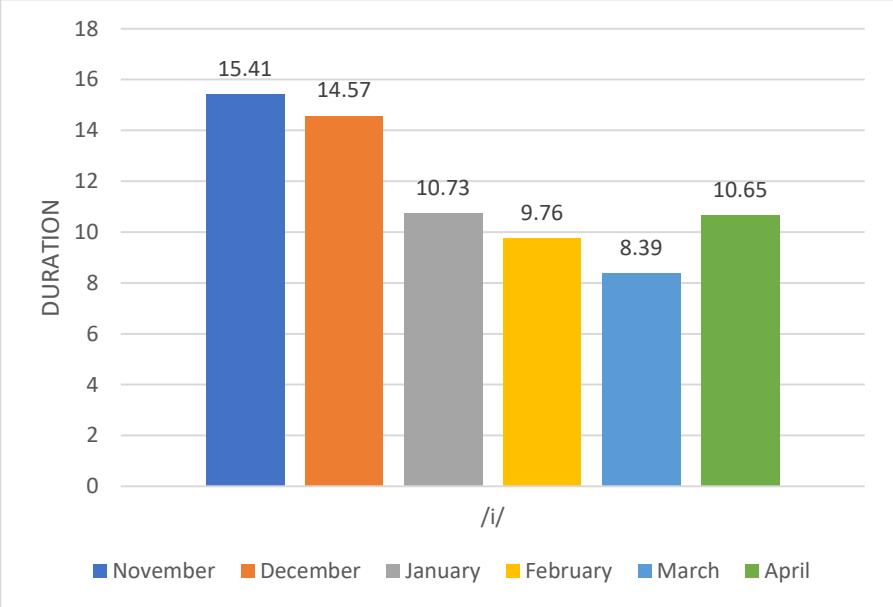
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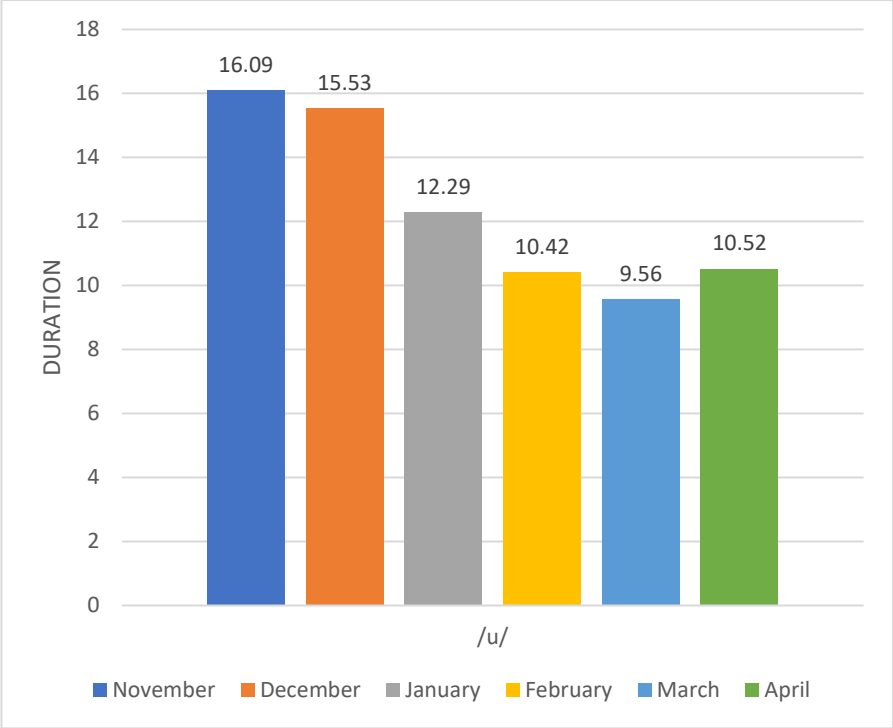


The data recorded for the phoneme /a/ in the month of November is 14.90, for December it was 15.07 .For the month of January it was recorded to be 12.50 while in the month of February, it was recorded as 10.78. For the month of March it was 8.57 and for the month of April, it was recorded to be 9.34. The significant difference between the month of November and December was found to be 0.17, between December and January it was found to have a difference of -2.57. the difference between January and February it was found to be -1.72 while between February and march it was -2.21 and between march and April it was found to have a difference of 0.77. The significant difference between April and November was found to be -5.56 .

The data recorded for the phoneme /i/ in November is 15.41, for December it was recorded as 14.57. For the month of January, it was recorded as 10.73, in the month of February, it was recorded as 9.76. For the month of March, it was recorded as 8.39 and for the month of April, it was recorded to be 10.65. The significant difference between the month of November and December was found to be -0.84, between December and January it was found to have a difference of -3.84. the difference between January and February it was found to be -0.97 while between February and march it was -1.37 and between march and April it was found to have a difference of 2.26. The significant difference between April and November was found to be -4.76 .

The data recorded for the phoneme /u/ in the month of November is 16.09 and for December it was 15.53. In the month of January, it was recorded as 12.29, in the month of February, it was recorded as 10.42. For the month of March, it was recorded 9.56 and for the month of April, it was recorded to be 10.52. The significant difference between the month of November and December was found to be -1.37, between December and January it was found to have a difference of -3.24. The difference between January and February it was found to be -0.87 while between February and march it was -0.86 and between march and April it was found to have a difference of 0.96. The significant difference between April and November was found to be -5.57 .

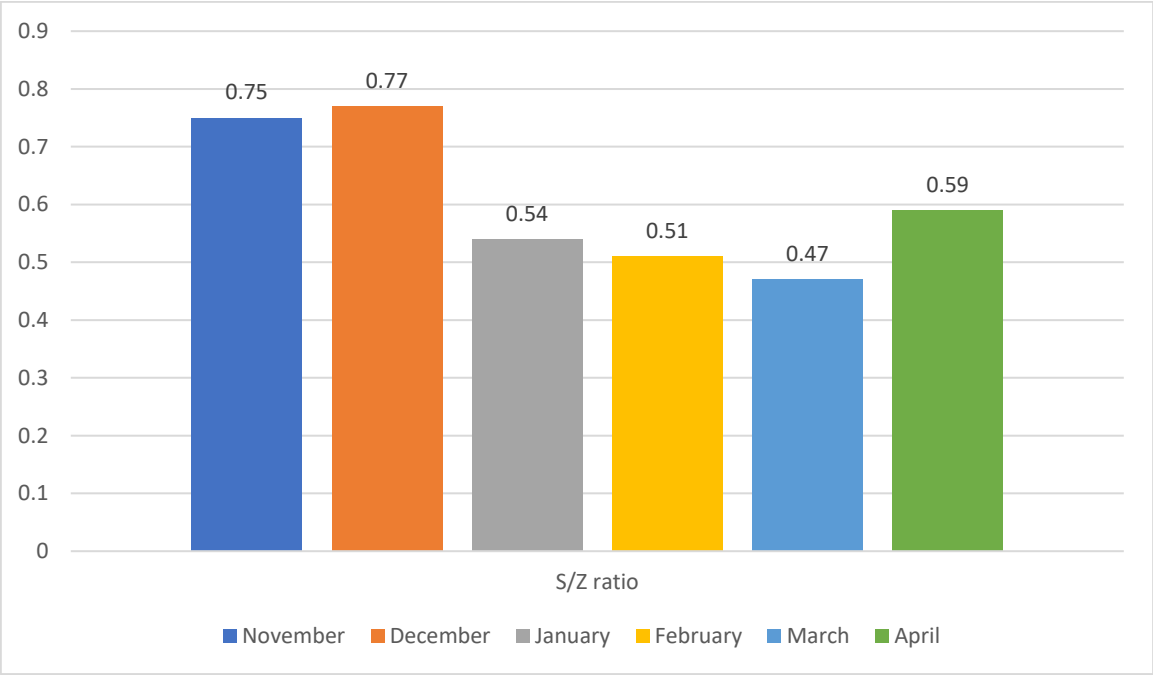
S/Z RATIO

S/Z ratio can be used to assess the respiratory and phonatory issues. The values of s/z is provided in the table 1.2. The highest s/z ratio was seen in the month of December and lowest in the month of March.

MONTH	NOVEMBER		DECEMBER		JANUARY		FEBRUARY		MARCH		APRIL	
S/Z Ratio	0.75	0.02	0.77	-0.23	0.54	-0.03	0.51	-0.04	0.47	0.12	0.59	-0.16

There was a continuous regression seen in the following three months due to the inconsistency in attending the therapy sessions. There was a slight progress in the s/z ratio as the patient resumed the therapy session in the month of April.

Table 1.2 ***The following graph shows the graphical representation showing the statistical data of s/z ratio collected over a period of 6 months.***



For s/z ratio, the following data was recorded. In the month of November the data was recorded to be 0.75 while in December the data was recorded 0.77. In the month of January, the recording was 0.54, in February the data was recorded as 0.51. In the month of March, the data was recorded to be 0.47 and in the month of April the recorded data was 0.59.

The significant difference between the month of November and December was found to be 0.02, between December and January it was found to have a difference of -0.23. The difference between January and February it was found to be -0.03 while between February and march it was -0.04 and between march and April it was found to have a difference of 0.12. The significant difference between April and November was found to be -0.16

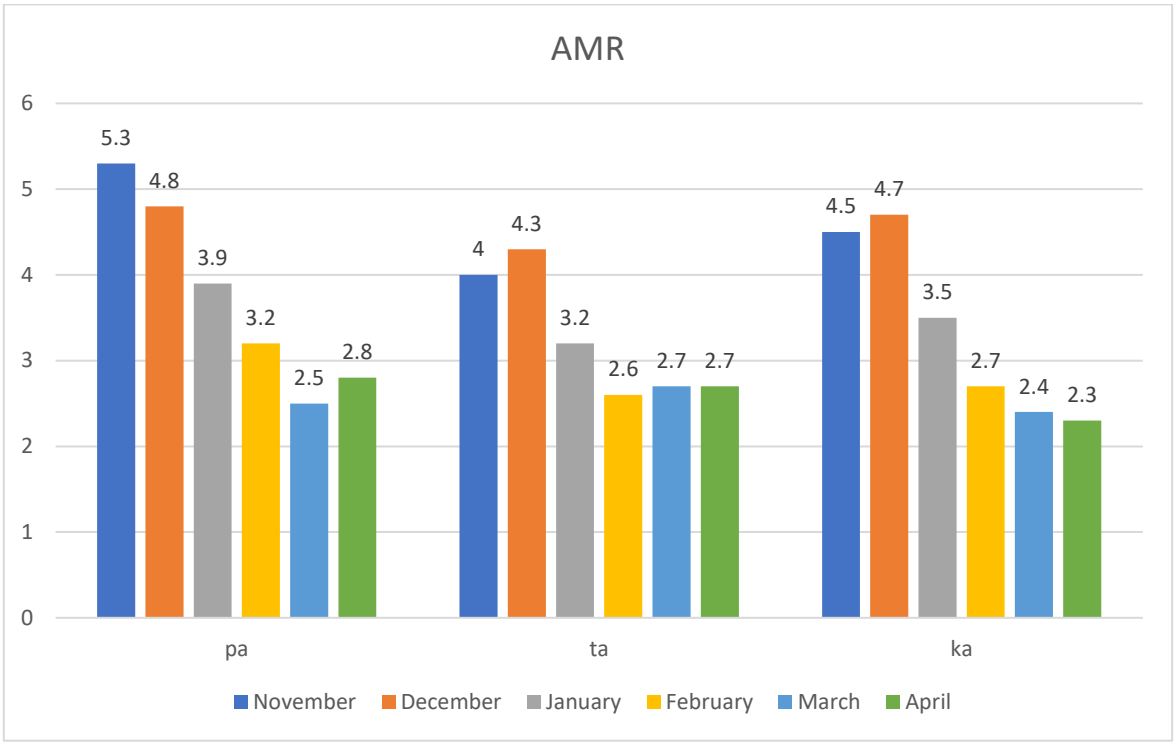
Diadochokinetic rate (DDK):

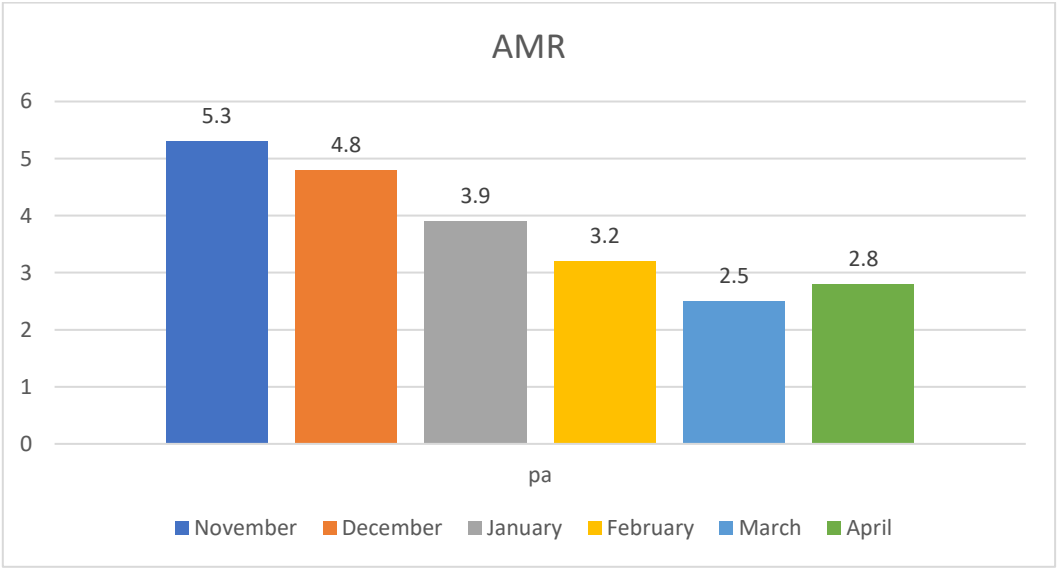
DDK was administered to assess the regularity and rate of the repetitive movements with accuracy. On assessing the data it was observed that there was not much difference seen in the first two months but in the following three months, there was a continuous decline seen due to the inconsistency in the therapy

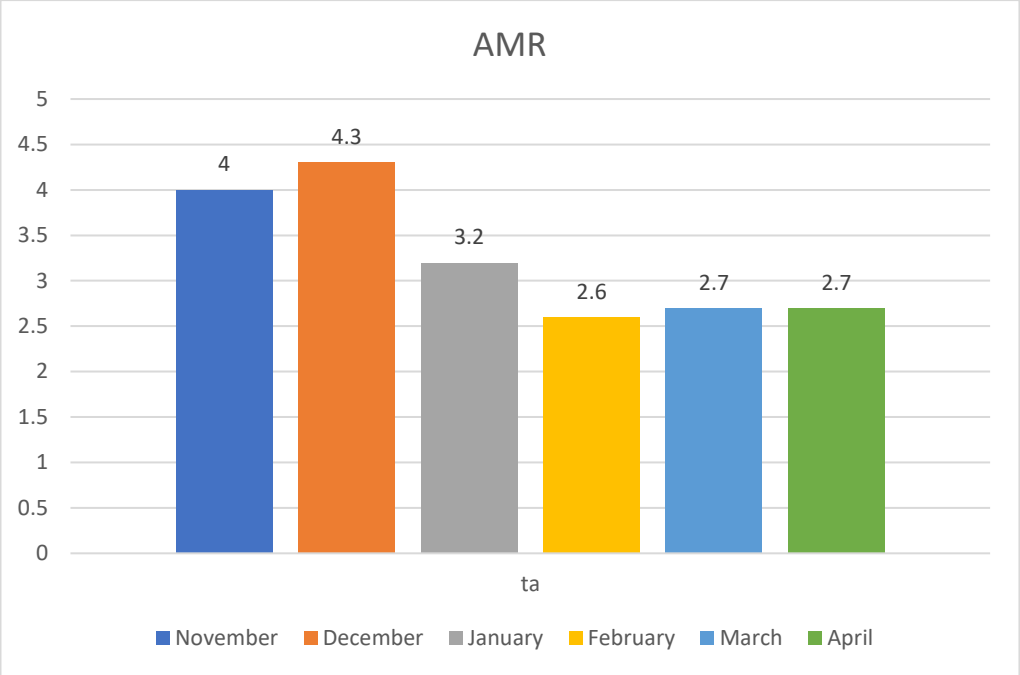
session attended by the participant. The participant resumed the therapy session due to which there was a slight increment in the values in the month of April. The highest value was seen in the month of November and the lowest was seen in the month of March

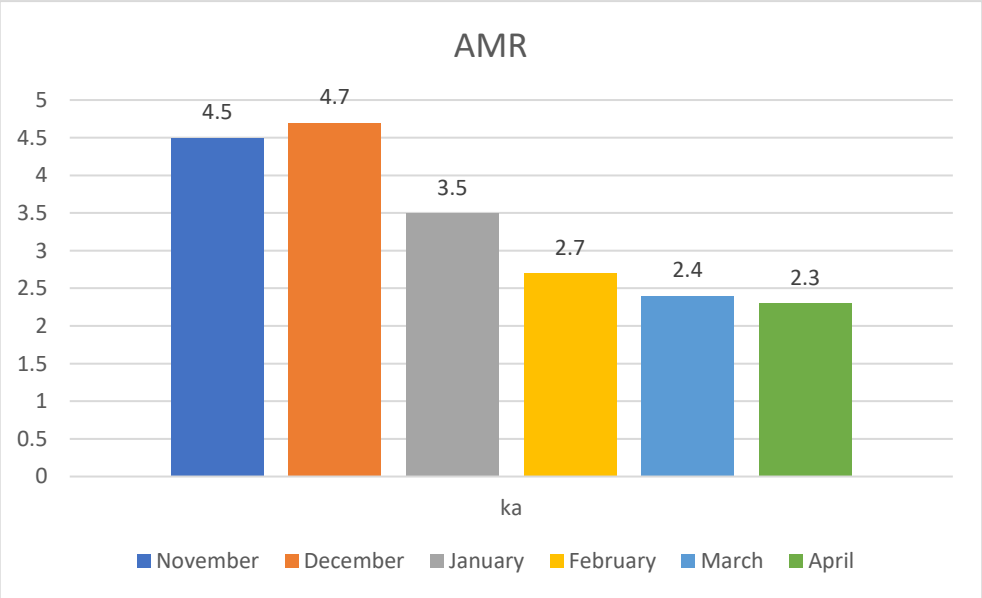
MONTH	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL
/pa/	5.3	4.8	3.9	3.2	2.5	2.8
/ta/	4.0	4.3	3.2	2.6	2.7	2.7
/ka/	4.5	4.7	3.5	2.7	2.4	2.3
/pa ta ka/	4.6	4.2	3.8	3.5	3.4	3.9

The following graph shows the graphical representation of the results of AMR over a period of 6 months









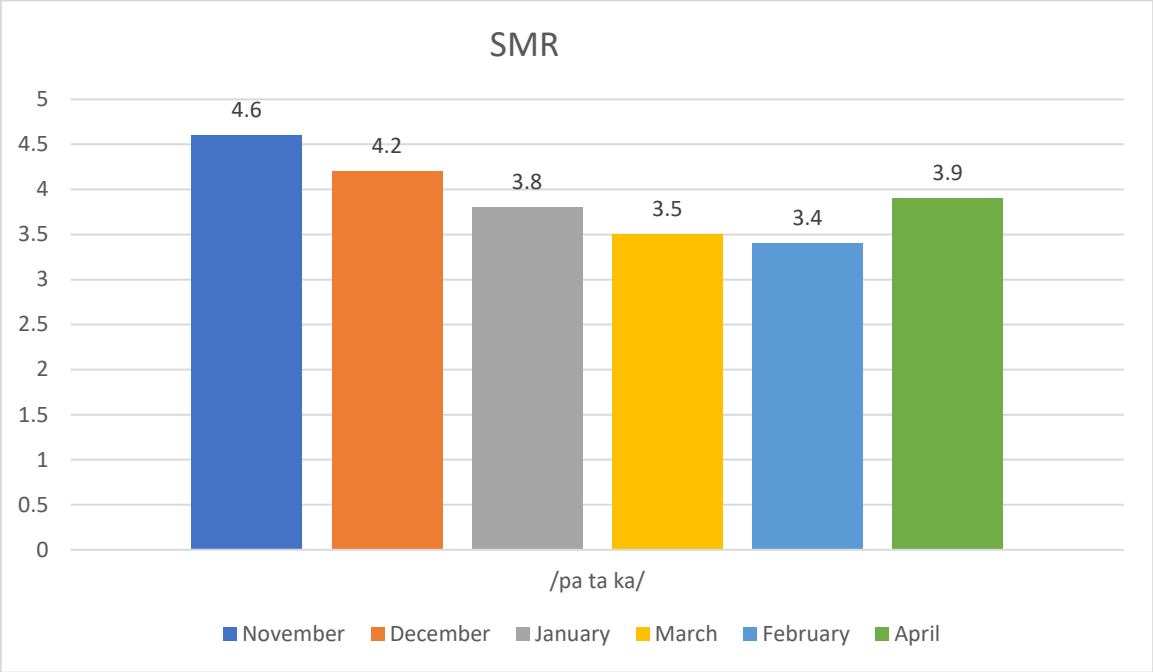
For the syllable /pa/, the following data was recorded. In the month of November the data was recorded to be 5.3, for December the data was recorded to be 4.8. in the month of January, the recording was 3.9, in February the data was recorded as 3.2. In the month of March the data was recorded to be 2.5 and in the month of April the recorded data was 2.8.

The data recorded for the syllable /ta/ in the month of November was recorded to be 4.0 and for December it was recorded as 4.3. In the month of January, it was recorded as 3.2, in the month of February, it was recorded as 2.6. For the month of March, it was recorded as 2.7 and for the month of April, it was recorded to be 2.7

For the syllable /ka/, the following data was recorded. In the month of November the data was recorded to be 4.5 while in December the data was recorded 4.7. In the month of January, the recording was 3.5,

in February the data was recorded as 2.7. In the month of March, the data was recorded to be 2.4 and in the month of April the recorded data was 2.3.

The following graph shows the graphical representation of the results of SMR over a period of 6 months



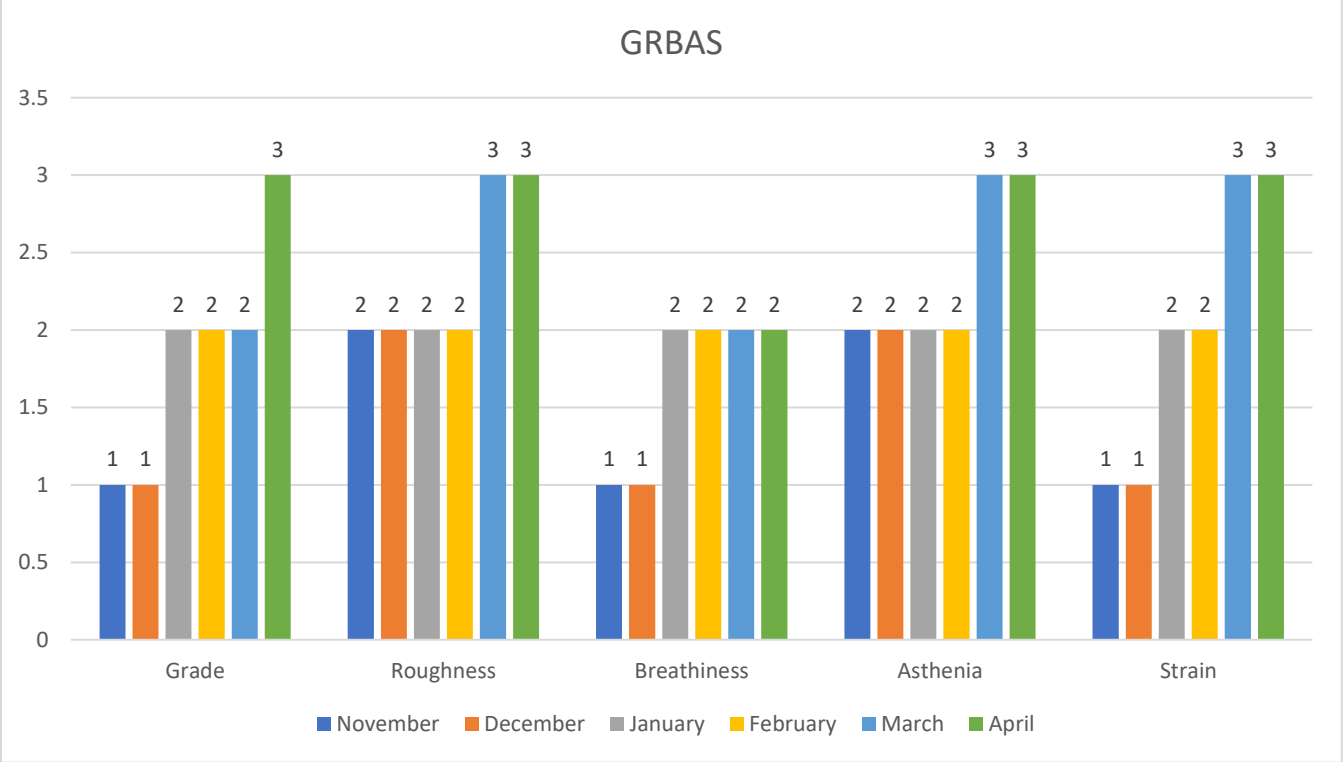
For the sequential motion rate, the data was recorded as the following. For the month of November, it was recorded as 4.6 and for December as 4.2 .While in the month of January, it was recorded to be at 3.8, and in February it was recorded at 3.5. in the month of March it was recorded at 3.4 and in April it was recorded to 3.9

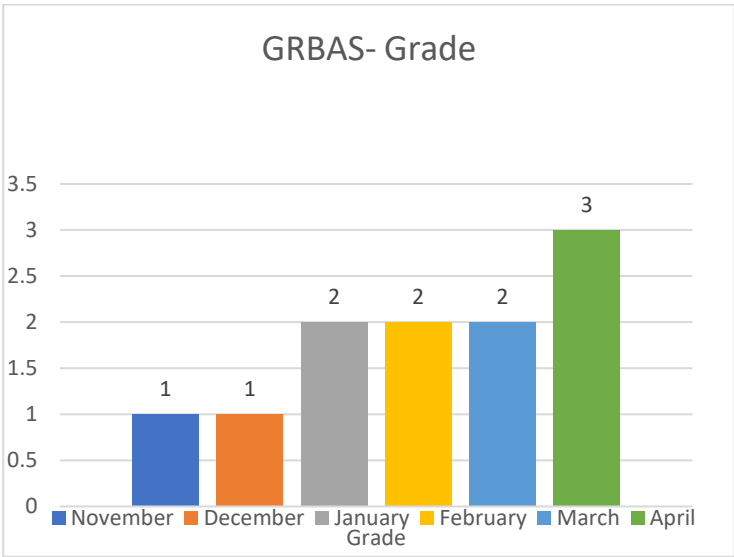
GRBAS

GRBAS was perceptually assessed using the GRABS test material. The differences in the severity of voice quality over a period of 6 months were determined using the scores. On analysing the scores it was observed that the voice impairment was moderate. No significant difference in the voice quality was seen over the span of 6 months when perceptually observed.

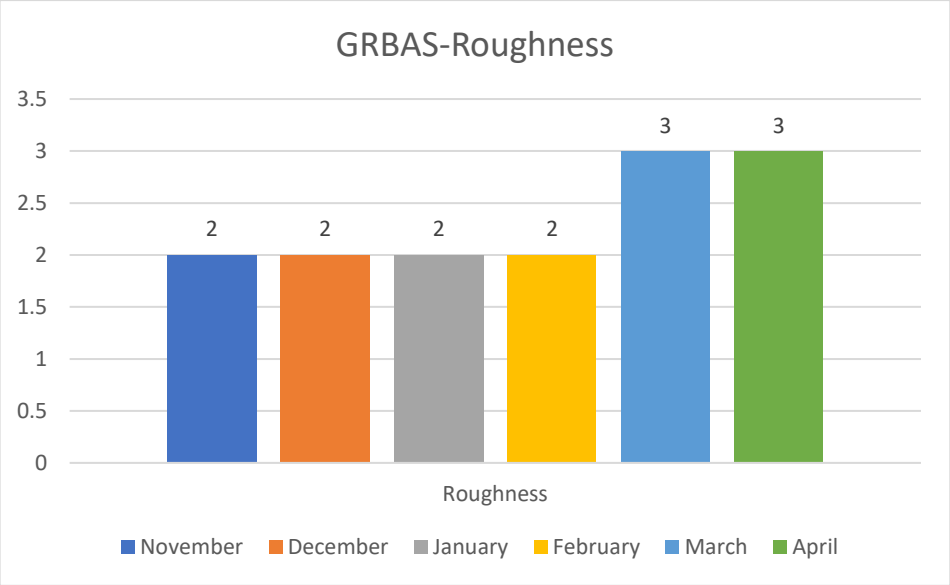
	November	December	January	February	March	April
Grade	1	1	2	2	2	3
Roughness	2	2	2	2	3	3
Breathiness	1	1	2	2	2	2
Asthenia	2	2	2	2	3	3
Strain	1	1	2	2	3	3

The following graph shows the graphical representation of the results of analysis of GRBAS over a period of 6 months

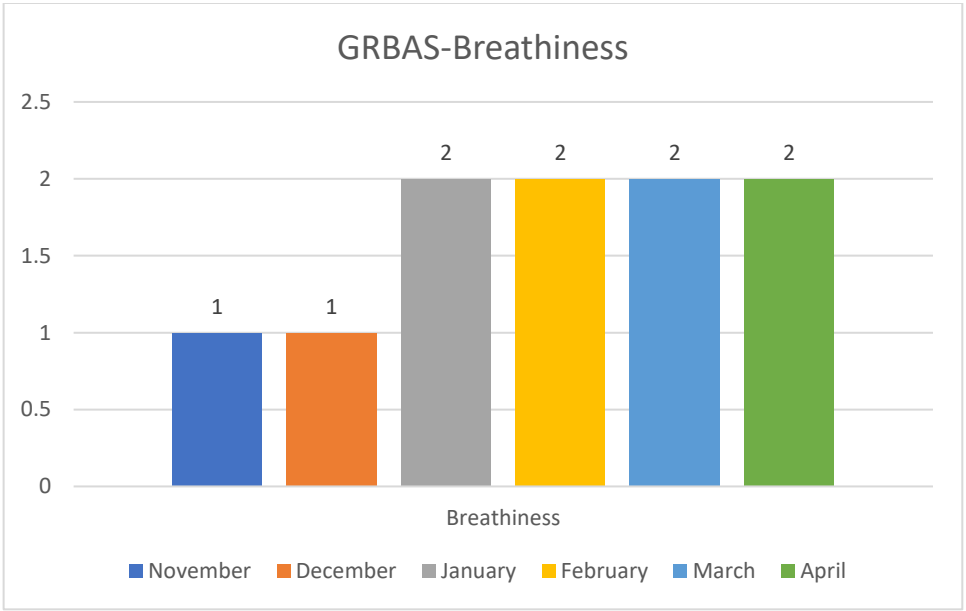




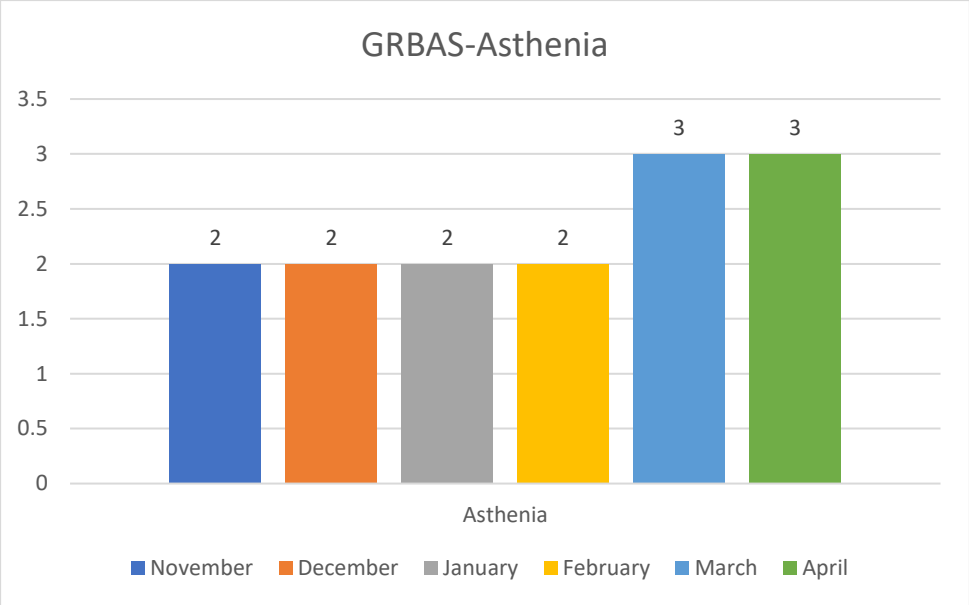
The data recorded for the perceptual analysis of the voice quality for Grade is as follows For the month of November, it was recorded as 1 and for December as 1 .While in the month of January, it was recorded to be at 2, and in February it was recorded at 2. in the month of March it was recorded at 2 and in April it was recorded to 3



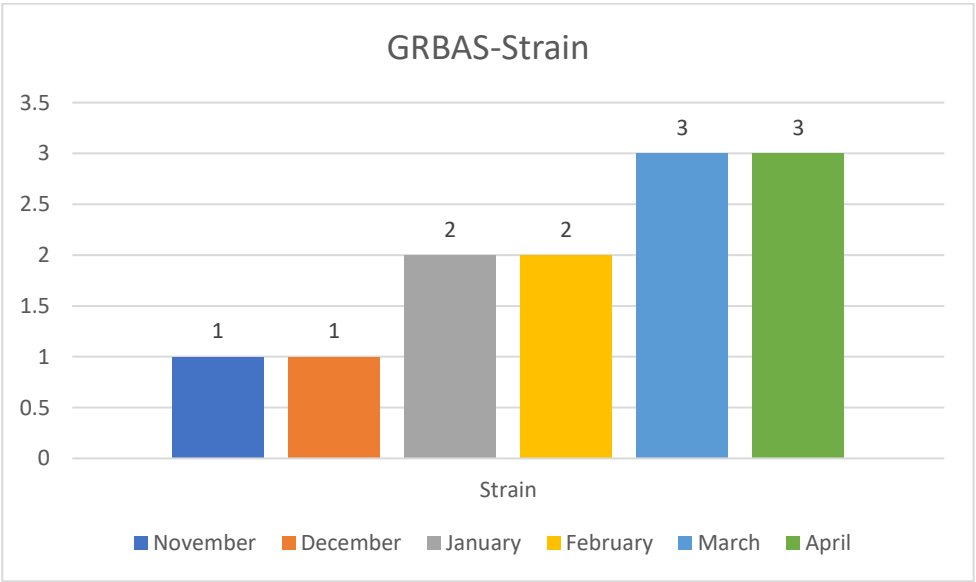
The data recorded for the perceptual analysis of the voice quality for Roughness is as follows For the month of November, it was recorded as 2 and for December as 2 .While in the month of January, it was recorded to be at 2, and in February it was recorded at 2. in the month of March it was recorded at 3 and in April it was recorded to 3



The data recorded for the perceptual analysis of the voice quality for Breathiness is as follows For the month of November, it was recorded as 1 and for December as 1 .While in the month of January, it was recorded to be at 2, and in February it was recorded at 2. in the month of March it was recorded at 2 and in April it was recorded to 2



The data recorded for the perceptual analysis of the voice quality for Asthenia is as follows For the month of November, it was recorded as 2 and for December as 2 .While in the month of January, it was recorded to be at 2, and in February it was recorded at 2. in the month of March it was recorded at 3 and in April it was recorded to 3



The data recorded for the perceptual analysis of the voice quality for strain is as follows For the month of November, it was recorded as 1 and for December as 1 .While in the month of January, it was recorded to be at 2, and in February it was recorded at 2. in the month of March it was recorded at 3 and in April it was recorded to 3

DISCUSSION

This study aims to understand the progression of vocal characteristics of an individual with Parkinson's disease in a span of 6 months. The result showed a significant difference in values for each month.

Through comprehensive analysis and studies, It was observed distinct patterns of deterioration in vocal characteristics that correlate with the advancement of PD symptoms, including changes in pitch, intensity, and articulation.

The following were the reasons that were considered as the contributing factors for the deterioration of vocal qualities in the individual.

The muscles used to produce speech are impacted by motor symptoms such as tremors, bradykinesia (slowed movement), and rigidity. Speech may become increasingly difficult to understand as a result of decreased vocal energy, dysarthria (difficulty articulating words), and a monotonous or harsh voice.

incomplete glottic closure and vocal fold hypo-adduction/bowing to can also account for these voice changes

As the disease progresses, the vocal cord undergoes modifications. The vocal muscle tends to become thinner and less tense due to which hence reduced vibration of vocal cords occurs. A space is also created between the vocal cords resulting in a hoarse voice due to the escaping air.

respiratory dysfunction was observed. Reduced lung capacity and muscle strength played a role in compromising vocal quality due to decreased breath support for sustaining the phonation for an extended period.