VOCAL CHARACTERISTICS IN INDIVIDUALS WITH AND WITHOUT CERVICAL SPONDYLOSIS

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May 2019

CERTIFICATE

This is to certify that this dissertation entitled **"Vocal characteristics in individuals with and without Cervical Spondylosis"** is a bonafide work submitted in part fulfillment for the degree of Master of Science (Speech-Language Pathology) by the student holding Registration Number: 17SLP030. This has been carried out under the guidance of a faculty member of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru

May, 2019

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CERTIFICATE

This is to certify that this dissertation entitled **"Vocal characteristics in individuals with and without Cervical Spondylosis"** has been carried out under my supervision and guidance. It is also certified that this dissertation has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled **"Vocal characteristics in individuals with and without Cervical Spondylosis"** is the result of my own study under the guidance of Dr. T Jayakumar, Associate Professor in Speech Sciences, Department of Speech-Language Sciences, All India Institute of Speech and Hearing, Mysuru, and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru **Registration Number: 17SLP030**

May, 2019

O GIVE THANKS INTO THE LORD; FOR HE IS GOOD, FOR HIS MERCY ENDURETH FOREVER.

-PSALM: 136:1

Dedicated to

MAMA & DADA

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Chapter 1

INTRODUCTION

Voice is the sound which is delivered as the air passes from the lungs through the larynx. The essential work of the lungs is the transportation of air into and out of the lungs. Securing the airway for an unhindered passage of the air supply is the larynx. Within the larynx there are vocal folds, these are groups of muscle which vibrate.

The vocal folds are separated during inspiration, as it allows a greater volume of air to pass through quickly; during expiration, the folds move slightly toward (adduct) one another. When there is adduction of the vocal folds together, voice will be produced, and it allows the expired air to pass between them and sets the folds into vibration. This vibration produces voice (phonation). As it passes through different sites of vocal tract the phonation will be resonated. With this vibratory sound in the larynx the resonance of the voice will begin, travelling up through the pharynx and as well as oral and nasal cavities. The voice which is heard is the combination of respiratory activation, phonation and amplifying resonance. For most of the people, their voices play a huge portion in who they are, what they do, and how they communicate.

For the production of good voice quality, intrinsic and extrinsic muscles of larynx play an important role, especially keeping larynx in particular position. The posture and active involvement of the muscles helps to produce voice. Spine also plays a role by controlling the external muscles of the larynx. It controls the head position which inturn changes the laryngeal position. There are a few voice therapy techniques which could change the voice quality with change in the head position. For

example, if head protrusion is affected the functioning of anterior neck muscles will also be affected such as sternocleidomastoid, scalene, suprahyoid and infrahyoid which could further lead to alterations in the production of voice. Hence spine and neck position play role in the production of voice quality.

Binder in 2007 said, "Neck pain is otherwise called as Cervicalgia. Neck pain or Cervical pain is attributed to an injury or accident, aging or daily strains. Cervical Spondylosis is chronic Cervical disc degeneration, herniation of disc material, calcification and osteophytic outgrowths. Cervical Spondylosis undoubtedly contributes to burden, and also cause: Radiculopathy due to compression, stretching or angulation of the Cervical nerve roots. Myelopathy due to compression, compromised blood supply or recurring minor trauma to the cord".

"Posterior Cervical muscles such as splenius capitis is arised from ligamentum nuchae and spinous process of C7 to T3 and further it is attached to the lateral part of superior nuchal line of occiput which is on the mastoid processes of the temporal bone. On the spinous processes of T3 to T6 the splenius cervicis is arised and its attached on posterior tubercles of transverse process C1 to T3. Muscles such as splenius cervicis and splenius capitis are superficial to segmental muscles, interspinals, intertransversarii and tranverse spinals and it lies deep inside sternocleidomastoid, trapezius and the rhomboids. On the transverse processes of T6 to T10 arises semispinalis thoracis and attaches on spinous processes of C6 to T4. On the transverse process of T1 to T6 arises semispinalis cervicis and attaches on spinous processes of C2 to C5. More fibres are attached on the axis. On the articular processes of C4 to C6 and transverse process of C7 to T6 semispinals capitis is arised and is attached to either side of mid saggital line which is in between the inferior and superior nuchal lines on the occiput. Deepest muscles are the rotaters. Rotater arises

on the cervical, thoracic and lumbar transverse processes and attaches on lamina and base of spinous process of the vertebra. From one spinous process to the spinous process above runs the interspinal. It is present T11 and L5 and between C2 and C3. Nerve supply: Dorsal rami of thoracic, cervical and spinal nerves.

Cervical Spondylosis is the result of degenerative disc disease and usually present in middle-aged and geriatrics with intermittent neck pain. The pain would react to any movement modification, isometric exercises, neck immobilization, and medication. (McCormack & Weinstein, 1996). The diagnosis is solely based on clinical assessments. The pain is primarily present in the cervical region, and is aggravated by neck movements. A neurological change in all the four limbs will be present in this condition; however, this is accompanied by results in objective testing only in the presence of other complications such radiculopathy or myelopathy, or other conditions. Neurologic symptoms are occasional in individuals presenting with congenital spinal stenosis (McCormack & Weinstein, 1996).

According to Allan (2007), the symptoms of Cervical Spondylosis are as follows, pain in the cervical region which is provoked by any movement, referred pain in the occiput between the shoulder blades, hands, cervical stiffness, temporal pain (C1 to C2), poor balance, undefined numbness, tingling or weakness in the hands, dizziness or vertigo, occasionally, syncope, triggers migraine, “pseudo-angina” (Grosset al,2004). Signs of Cervical Spondylosis are restricted muscular movements, poorly localized tenderness, and secondary neurological alterations like supinator jerks.

Spondylosis is a general term which is used by physicians for age-related deterioration in the spine. The term Cervical Spondylosis is referred to the

degeneration of cartilage, discs and other soft tissue present in the upper cervical region of the spinal column in the neck.

The symptoms were often were first reported between the age of 20 and 50years. Some of the X-ray studies have shown that above the age of 40 there were 80% of people had evidence of Spondylosis. In the rate of occurence of Spondylosis is also partly a related factor to genetic predisposition as well as injury history. Genetics is also another risk factor. Spinal injury is another risk factor. Injuries can cause intervertebral discs to herniate.

In Spondylosis the spine's intervertebral discs and facet joints can be affected. As a person ages, there will be age-related changes which would be noted in the cellular level, and it can be coupled to what are the effects of wear and tear that can further cause to loosen the discs shape, height and size. When there are structural variations present it will decrease the space between the vertebral bodies and the gap(disc space) between vertebral bodies may reduce because of the structural alterations and eventually the movement of facet joints will be affected. Inflammation and pain is caused when the bone spurs (osteophytes) grow, which might further harm another spinal nerve root.

The changes in cervical spine will result in narrowing of the spinal canal and it leads to the posterior longitudinal ligament thickening and the formation of bone spur and compresses the spinal cord, frequently at the level of C4-C7. Final result is the chronic compression of the spinal cord and nerve roots which would result in the damage to the spinal cord caused by the impaired blood flow and neurological deficit. Radiculopathies can also develop gradually or it can be triggered by a trauma. C6 and C7 are most commonly affected here.

Chapter 2

REVIEW OF LITERATURE

Bigaton et al (2010), studied in dysphonic women and their posture and function of the cranio-cervical region. 28 women participated in the study where, 16 were dysphonic and 12 were normals from the age range of 20-44 years. Perceptual evaluation was carried out using GRBAS and Laryngeal evaluation was done to confirm the presence of bilateral nodules and double slit (8 subjects) or bilateral mucosal thickening and triangular cervice mid-posterior to phonation (8 subjects). Due to a particular female pattern of glottis closure it was decided to study only on females because there is a higher incidence in these genus for all these types of lesions. The exclusion criteria considered was as follows, they should not have attended previous speech or physiotherapy treatment as it can interfere with the treatments for vocal, postural and functional alterations. Subjects should not have any neurological issues and subjects should be within 50 years.

The assessment of the posture of the cervical region was performed by means of photogrammetry and the evaluation of cervical dysfunction by the cranio-cervical dysfunction index (CCI). For statistical analysis Shapiro-Wilk normality test was applied. The correlation between the cranio-cervical dysfunction index and the head protrusion angle was performed using the Spearman Coefficient. Cervical pain which can occur at rest and / or during movements of the cervical region; limitation of the range of movements in the region; articular noises and tension of the muscles of the cervical region, which can be evaluated by the presence of pain and / or muscle condition during palpation. According to the present study with IDCC (Cranio cervical dysfunction index), it was possible to verify that all dysphonic women had

cranio-cervical dysfunction, predominantly moderate to severe dysfunction and control group had mild dysfunction. For cranio-cervical dysfunction to be diagnosed through IDCC, the individual may exhibit one or all of the signs and symptoms described above. In this aspect, it is important to note that the *light* classification, which was observed in all volunteers in the control group, with a score of 1 to 4. Therefore, women with pain on palpation in the trapezius muscle, a common condition in most of the population, have already been classified as with mild dysfunction. On the other hand, the majority of the women in the experimental group (62.5%) were classified as having moderate to severe cranio-cervical dysfunction. That is, they had more alterations in cervical area when compared to the control group. The results found in this study agree with the findings of the literature, which reveal that the tension of the muscles of the cranio-cervical region is strongly associated with dysphonia, even altering vocal production.

According to a study there is a positive correlation between the evaluation of head posture through photogrammetry and radiography, which proves the reliability of the method. For the assessment of cervical posture, photogrammetry was used. The dysphonic women did not show a change in the angle of head protrusion when compared to control group. Cranio-cervical dysfunction, an important index for measuring cervical region function, appears to be more present in dysphonic women than altered posture, according to the present study. Objective studies are needed to deepen this relationship, since clinical observations in the area of Speech-Language Pathology have always been focused on dysphonia-related posture when it is necessary to consider the parameters of cervical dysfunction. Another factor that needs to be highlighted is that in the present study the position adopted by dysphonic women during speech was not evaluated. Therefore, the treatment of dysphonia

should be associated with the treatment of cranio-cervical dysfunction, aiming to reduce the existing muscular tension, as well as the restoration of the normal mobility of this region. However, dysphonic women were classified as having more severe cranio-cervical dysfunction than the clinically normal ones, suggesting that dysphonias are more related to functional alterations of the cervical region than to postural ones of the same region.

According to Badaró, Araújo, Behlau(2014) they studied on the relationship between individuals who had cervical complaints and vocal complaints through a questionnaire. 30 individuals from the age range of 18-65 years participated in the study. Questionnaires such as, The Copenhagen Neck Functional Disability Scale (CNFDS), titled *Escala Funcional de Incapacidade do Pescoço de Copenhagen* (EFIPC), the vocal self-assessment instruments Voice-Related Quality of Life (V-RQOL), and the Vocal Tract Discomfort Scale (VTDS) were used. The inclusion criteria is as follows All participants were required to present with some type of neck complaint; no one had undergone vocal rehabilitation previously, and no one presented with a self-reported neurological or psychiatric impairment. According to the results of The Copenhagen Neck Functional Disability Scale (Escala Funcional de Incapacidade do Pescoço de Copenhagen - EFIPC), the most frequently observed classification is 'moderate which is later followed by 'mild-moderate'. Results of Vocal Tract Discomfort Scale, among the possibilities of discomfort 'dryness' was frequent followed by burning, itching and throat itching. The same hierarchy was followed for the intensity of vocal discomfort. According to Voice Related Quality of Life only 7 did not have any problem regarding their quality of life. Among the 30 participants 96.67% said they experienced manifestations of vocal discomfort. There was no correlation between the EFIPC and the V-RQOL or the VTDS. They found a

negative correlation was observed between the VTDS and the V-RQOL, which demonstrates that the as the occurrence of vocal discomfort manifestations increases the V-RQOL result decreases, and vice-versa. Neverthless the tendency of vocal abnormalities they are liable for cervical discomfort, pain, and fatigue in the area. The EFIPC self-assessment questionnaire was not able to establish a correlation between the vocal discomforts and cervical complaints based on VRQOL and VTDS, which can be due to the methodology used and smaller sample size as the instruments had different ranges of magnitude and was not able to be compared.

Silverio, Siqueira, Lauris, Brasolotto (2014), studied on dysphonic women and musculoskeletal pain. 60 women participated in the study and they were divided into non-dysphonic of the age range from 18-45 years and functional or organo-functional dysphonic group of the age range 21-44 years. Musculoskeletal Pain Questionnaire was used to examine the frequency and location of pain. They examined the frequency of pain in addition to parts such as submandibular area, larynx, neck, front area, masseters, temporal region using Nordic Questionnaire on Musculoskeletal Disorders. The subjects were asked to mark regarding the pain even during usage of voice. When the frequency and intensity was compared between dysphonic and non-dysphonic group, it was found to be greater in dysphonic group and there was a significant difference in areas that was closer to the cervix, larynx and scapular waist. Women were studied because the voice problems are more common in women due to the pattern to glottis proportion. According to the results, women presented with scapular waist and cervical region. When the intensity of pain was examined it was found that the pain was greater in areas such as larynx and back of the neck. It can be because of influencing factors such as the sample size. This study explains the relationship between the poor vocal behaviour and pain in the musculoskeletal areas

such as scapular waist, larynx and the cervix. In the dysphonic group commonly pain is found to be observed in areas such as front of the neck, submandibular and the larynx, and these presenting pains can be the feature of dysphonia. In dysphonia caused due to vocal abuse or misuse the extrinsic laryngeal muscles would be imbalanced and rigid. Another limitation of the study could be the examined group was heterogeneous, and physical exercise, vocal habits and health was not examined. The results of this study are support the literature wherein, the dysphonia is associated with the pain found in the cervical region. As the frequency and intensity of pain in the laryngeal and cervical areas will be intense it should be examined in subjects with dysphonia. In Speech language therapy to support muscle relaxation and analgesia treatment for pain should be considered with treatment for voice.

Menoncin, Jurkiewicz, Silvério, Camargo, Wolff (2014) studied on the women presenting with voice disorders and to examine their Cervical abnormalities. 50 participants from the age range of 25-55 years participated in the study. Questionnaire was used in the study. Perceptual voice assessment as carried out and the voice was also recorded using the MDVP software. GRBAS was used for perceptual evaluation. Results show that the laryngeal sensations examined through a questionnaire are as follows, irritation, dryness, phlegm and itchy and sore throat. There was statistical difference between experimental and control group in regard to examination of X-Ray of Cervical spine. With examination of postural data there anterior cervical spine posture which was observed in the dysphonic group. Women were selected for this study as women mostly present with voice problems/complaints. Radiological examination was also carried out to find any bone lesions and reasons for pain the neck and shoulder regions. According to this study women with and without dysphonia had changes in the cervical region. In the dysphonic group there a greater

number positional variation but it cannot be taken into attribute for the dysphonic group so the dysphonia as a precipitating cause of postural change. In accordance with the literature it is found in this study that in dysphonic group there was shortening of the trapezius muscle, and also agree with no lesion in the vocal folds in videolaryngoscopy evaluation. If there is cervical or lumbar lordosis, if the thoracic kyphosis has increased, or any change in the position of the head it can lead to compensation in the larynx and Cervical area.

Need for the study

From the above literature, it is evident that position of the body, head and neck plays a important role in the production of voice and its quality. When there is deviation in the above it alters the laryngeal position and also the gap between the various parts of voice production system. The condition called Cervical Spondylosis alters the neck, head and body position which will possibly affect the voice quality. Cervical Spondylosis is a condition, wherein there would be degeneration of cartilages, joints and other soft tissue which in turn leads to pain in the cervical region of the spinal cord. There would be indirect involvement of this condition on voice, elevation of larynx. The disturbance in the voice production / quality is evident through voice questionnaire studies. There are also radiological evidences in the variation of laryngeal muscles in case with cervical neck pain. There are few studies of dysphonia and laryngeal and cervical pain but no perceptual or acoustic analysis was carried out. There is a need to evaluate the voice in this population and create awareness regarding management of voice along with postural modifications. There are no much studies which investigated about the vocal characteristics in individuals with Cervical Spondylosis. Therefore it needs to be assessed and evaluated acoustically and perceptually.

Aim of the study

To investigate the change in vocal characteristics in individuals with Cervical Spondylosis using perceptual and acoustic measures.

Objectives

1. To compare the perceptual parameters between normal and Cervical Spondylosis.
2. To compare the following acoustic voice parameters between normal and Cervical Spondylosis
    a) Average Fundamental frequency (Mean Fo)
    b) Standard deviation of Fo (STD)
    c) Fo Tremor frequency (Fftr)
    d) Amplitude Tremor Frequency (Fatr)
    e) Jitter percentage (Jitt)
    f) Relative Average Perturberation (RAP)
    g) Fundamental Frequency Variation (vFo)
    h) Shimmer percentage (Shim)
    i) Amplitude Perturberation Quotient (APQ)
    j) Noise to Harmonic Ratio (NHR)
    k) Voice Turbulence Index (VTI)
    l) Fo – Tremor Intensity Index (FTRI)
    m) Amplitude Tremor Intensity Index (ATRI)

Chapter 3

METHOD

Research design: The present study used the Standard group comparison type of research.

Participants: The present study included a total of 60 participants. Participants were further divided into clinical group (N=30) with the age range of 30-50 years with mean age of 36 years, and age and gender matched normal individuals acted as a control group (N=30) with mean age of 35 years. Clinical group considered were individuals with Cervical Spondylosis. The participants were recruited from a clinic in Bangalore and Mysore, Karnataka. The clinical group participants were further classified as Grade I, Grade II, Grade III based on the severity of Cervical Spondylosis.

Inclusion criteria for clinical group

- Individuals diagnosed as Cervical Spondylosis by a Chiropractor based on CT, MRI and X-RAY
- No history of hearing and psychological problems
- No signs and symptoms of upper respiratory tract infection during recording
- Should be non smokers and non alcoholics
- No history of hormonal problems
- Clients who had not undergone Cervical spine surgery will be included in the study

Inclusion criteria for normal group

- No history of hearing and psychological problems
- No signs and symptoms of upper respiratory tract infection during recording
- Should be non smokers and non alcoholics
- No history of hormonal problems

Procedure

A written consent was obtained from all the participants before involving in the study.

Voice and speech sample recording

The participants were seated comfortably and were instructed to phonate vowel /a/ at their comfortable loudness and pitch level for minimum of 5 seconds. Also the spontaneous speech sample and sentences suggested by Consensus Auditory Perceptual Evaluation of Voice (CAPE-V) was recorded. The task was demonstrated to the participants in prior. The recordings were done individually using directional microphone with sampling rate of 44.1 KHz with constant microphone and head distance of 15 cm in an acoustically acceptable ambience. The instrument used for the recording was Olympus LS-100. The recording was done at quite room condition.

Analysis

The Multi-Dimensional Voice Program (MDVP) was performed to obtain the objective acoustic analysis of voice. MDVP provides many parameters which can be classified under frequency measures, perturbation measures, noise measures, tremor

measures and voice irregularity measures. Perceptual analysis of voice was done using Consensus Auditory Perceptual Evaluation of Voice (CAPE-V).

Multi-Dimensional Voice Program Analysis

The recorded phonation sample was transferred into Multi-Dimensional Voice Program (MDVP) software, from the phonation sample mid portion of the phonation was taken for analysis by leaving the initial and final portion. The researcher made sure that a minimum of 3-4 seconds was present for MDVP analysis. The MDVP analysis was performed for participants with Cervical Spondylosis and control group. The following MDVP parameters were considered for further analysis

a. Average Fundamental frequency (Mean Fo)
b. Standard deviation of Fo (STD)
c. Fo Tremor frequency (Fftr)
d. Amplitude Tremor Frequency (Fatr)
e. Jitter percentage (Jitt)
f. Relative Average Perturberation (RAP)
g. Fundamental Frequency Variation (vFo)
h. Shimmer percentage (Shim)
i. Amplitude Perturberation Quotient (APQ)
j. Noise to Harmonic Ratio (NHR)
k. Voice Turbulence Index (VTI)
l. Fo – Tremor Intensity Index (FTRI)
m. Amplitude Tremor Intensity Index (ATRI)

The results was tabulated and subjected to statistical analysis in Statistical Package for the Social Sciences (SPSS) software package (Version 20.0).

Consensus Auditory Perceptual Evaluation of Voice Analysis (CAPE-V)

The phonation and speech sample was subject to perceptual evaluation using CAPE-V protocol. The phonation sample of vowel /a/ recorded for objective analysis was utilized. Also the sentences/speech sample was also recorded as per the protocol of CAPE-V. It is a visual analog 100mm line scale used to assess six quality features. The features that were evaluated in CAPE-V were overall severity, roughness, breathiness, strain, pitch and loudness. This CAPE-V protocol also included some of the unlabeled features based on the perceptual aspect of client voice such as degree of nasality, spasm, tremor, intermittent aphonia, falsetto, glottal fry or weakness. Five experienced professionals in the field of voice science/voice disorder served as judges. They evaluated the samples on CAPE-V protocol. All the judges had a minimum of 5 years experience in the field of speech pathology.

Statistical Analysis

The obtained MDVP and CAPE-V parameters were tabulated and subjected to statistical analysis using Statistical Package for the Social Sciences (SPSS) software package (Version 21.0). Shapiro Wilk's test was used to test the normality. As the obtained data was non-normalized non-parametric test was performed. Descriptive statistics was performed to calculate mean, standard deviation and median. Mann-Whitney U test was done to calculate across group comparison.

Chapter 4

RESULTS

The present study aimed at investigating the vocal characteristics of individuals with and without Cervical Spondylosis through perceptual and acoustic measures. The study included two groups (Group 1- normal control, Group 2- Cervical Spondylosis). Perceptual analysis was done using CAPE-V protocol and was rated by 5 judges. Acoustic analysis was done using MDVP module of CSL and the data of both the perceptual and acoustic analysis were fed into SPSS software for statistical analysis.

The following statistical analysis were carried out

1) Shapiro-Wilk's test of normality
2) Descriptive statistics of perceptual and acoustic parameters for participants with and without Cervical Spondylosis
3) Comparison between normal and Cervical Spondylosis
4) Comparison between normal and Cervical Spondylosis males
5) Comparison between normal and Cervical Spondylosis females
6) Comparison between acoustics and perceptual measures between mild and moderate Spondylosis.
7) Inter-rater reliability of CAPE-V parameters

Shapiro-Wilk's test of normality

Perceptual and acoustic analysis data were fed into SPSS software version 21.0 and the Shapiro Wilk's test was done to check for normality and the data was found to be non-normally distributed in majority. Hence non-parametric test was done for the comparison between the groups.

Descriptive statistics of perceptual and acoustic parameters for participants with and without Cervical Spondylosis

The mean and standard deviation for the acoustic and perceptual parameters were obtained using descriptive statistics. Both the mean and SD in Cervical Spondylosis were higher compare to normals in majority of acoustic and perceptual parameters. In perceptual evaluation, males always scored for less compare to female in both normal as well as Cervical Spondylosis. Table 1 shows the mean and SD (standard deviation) values of acoustic and perceptual parameters for Cervical Spondylosis and normal group.

Table 1: Mean and SD values of acoustic and perceptual parameters for Cervical Spondylosis and normal group.

	Normal				**Cervical Spondylosis**			
	Male		**Female**		**Male**		**Female**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
MDVP parameters								
MeanF0	122	20.46	209.2	26.79	112.4	17.8	206	27.9
STD	1.28	0.449	2.93	1.196	3.14	5.76	4.03	2.19
Fftr	2.91	1.48	4.29	2.51	3.73	2.34	3.54	1.57
Fatr	2.79	1.24	2.41	1.20	3.13	1.02	2.70	0.978
Jitt	0.577	0.309	1.25	0.522	1.21	0.608	1.89	0.955
RAP	0.340	0.186	0.762	0.313	0.725	0.372	1.14	0.578
vF0	1.09	0.486	1.42	0.599	2.72	4.67	1.92	0.882
Shim	2.78	1.33	2.88	0.598	4.76	1.50	4.46	1.44

APQ	2.17	0.913	2.14	0.520	3.98	1.13	3.13	1.02
NHR	0.130	0.025	0.123	0.020	0.130	0.03	0.143	0.022
VTI	0.034	0.013	0.035	0.009	0.033	0.01	0.035	0.017
FTRI	0.221	0.132	0.278	0.225	0.291	0.171	0.261	0.129
ATRI	2.41	1.55	2.01	1.39	4.03	1.67	3.03	1.75
CAPE-V parameters								
Overall severity	7.63	4.18	15.4	7.59	15.6	8.83	26.6	9.36
Roughness	6.21	4.93	11.1	7.39	18.0	9.59	23.2	8.35
Breathiness	4.35	3.29	14.1	8.75	12.4	7.83	26.8	9.06
Strain	5.95	2.98	12.5	7.11	12.7	7.60	23.6	11.0
Pitch	4.09	3.23	8.76	6.32	9.11	6.18	16.9	6.46
Loudness	2.27	1.94	6.38	4.68	8.35	5.04	16.07	6.22

Comparison between normal and Cervical Spondylosis

Mann-Whitney U test were done to compare between normal and Cervical Spondylosis. Results of voice parameters showed that STD (Z= -2.09; p= 0.036), Jitt (Z= -3.09; p= 0.002), RAP (Z= -3.0.; p= 0.002), vF0 (Z= -2.98; p= 0.003), Shim (Z= -5.14; p= 0.000), APQ (Z= -5.17; p= 0.000), ATRI (Z= -3.09; p=0.002) showed significant difference between the normal and the Cervical Spondylosis. Similarly, all the CAPE-V parameters such as overall severity (Z= -3.58; p= 0.000), roughness (Z= -4.77; p=0.000), breathiness (Z= -3.70; p=0.000), strain (Z= -3.48; p=0.000), pitch (Z= -3.53; p=0.000) and loudness (Z= 4.57; p=0.000) show significant difference. Table 2 shows statistical output of comparison between acoustic and perceptual parameters between groups. Figure 1a shows the error bar which compares the CAPE-V between normal and Cervical Spondylosis. Figure 1b shows that error bar which compares MDVP parameters between normal and Cervical Spondylosis.

Table 2: Z and /p/ value acoustic and perceptual parameters of normal and Cervical Spondylosis

	Z - value	p - value
MDVP Parameters		
MeanF0	-0.547	0.584
STD	-2.09	0.036*
Fftr	-0.118	0.906
Fatr	-1.55	0.120
Jitt	-3.09	0.002**
RAP	-3.03	0.002**
vF0	-2.98	0.003**
Shim	-5.14	0.000**
APQ	-5.17	0.000**
NHR	-1.22	0.222
VTI	-0.658	0.510
FTRI	-1.10	0.271
ATRI	-3.09	0.002**
CAPE-V parameters		
Overall severity	-3.58	0.000**
Roughness	-4.77	0.000**
Breathiness	-3.70	0.000**
Strain	-3.48	0.000**
Pitch	-3.53	0.000**
Loudness	-4.57	0.000**

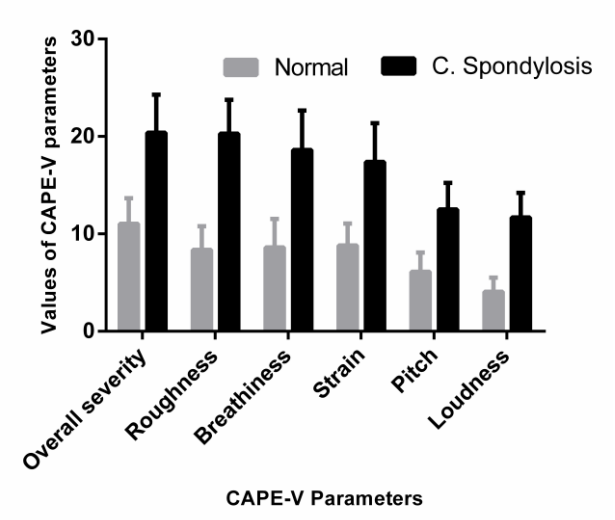

Figure 1a: Error bar comparison of CAPE-V parameters between normal and Cervical Spondylosis

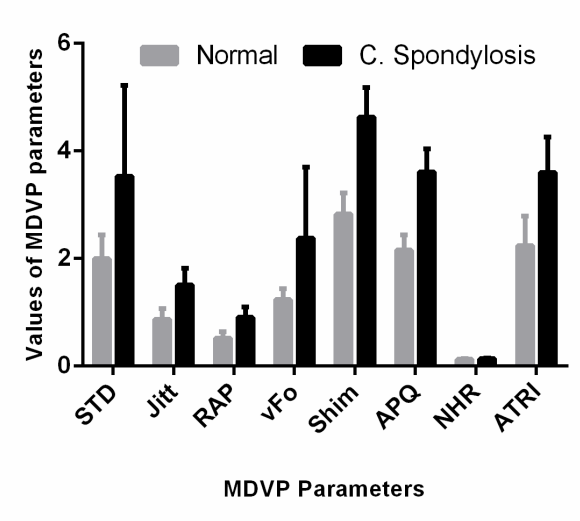

Figure 1b: Error bar comparison of MDVP parameters between normal and Cervical Spondylosis

Comparison between normal and Cervical Spondylosis males

Mann- Whitney U test was done to compare males between groups. The result of Mann Whitney U test showed statistically significant differences were observed for STD (Z=-2.53; p= 0.011), Jitt (Z=-3.25), RAP (Z=-3.15), vF0 (Z=-2.70), Shim (Z=-3.87), APQ (Z=-4.21), ATRI (Z=-2.73). The Z value is higher for APQ followed by Shim, Jitt, RAP, ATRI and vF0.Result does not show significant difference for MF0, Fftr, Fatr, NHR, VTI, and FTRI (p>0.05) between the groups. In the CAPE-V parameters, all the parameters showed significant difference between normal and Cervical Spondylosis males. It shows that the Z value is higher for breathiness, overall severity, strain, loudness, roughness and pitch. Table 3 shows comparison of males between normal and Cervical Spondylosis group. Figure 2 shows the error bar comparison between male of normal and Cervical Spondylosis group.

Table 3: Z and /p/ value for acoustics and perceptual parameters of normal males and Cervical Spondylosis males

	Z - value	p –value
MDVP parameters		
MeanF0	-1.15	0.249
STD	-2.53	0.011
Fftr	-0.569	0.570
Fatr	-1.62	0.105
Jitt	-3.25	0.001**
RAP	-3.15	0.002**
vF0	-2.70	0.007**
Shim	-3.87	0.000**
APQ	-4.21	0.000**
NHR	-0.138	0.890
VTI	-0.155	0.877
FTRI	-1.17	0.242
ATRI	-2.73	0.006**
CAPE-V parameters		
Overall severity	-2.97	0.003**
Roughness	-1.97	0.049*
Breathiness	-3.19	0.001**
Strain	-2.81	0.005**
Pitch	-2.18	0.029*
Loudness	-2.72	0.006**

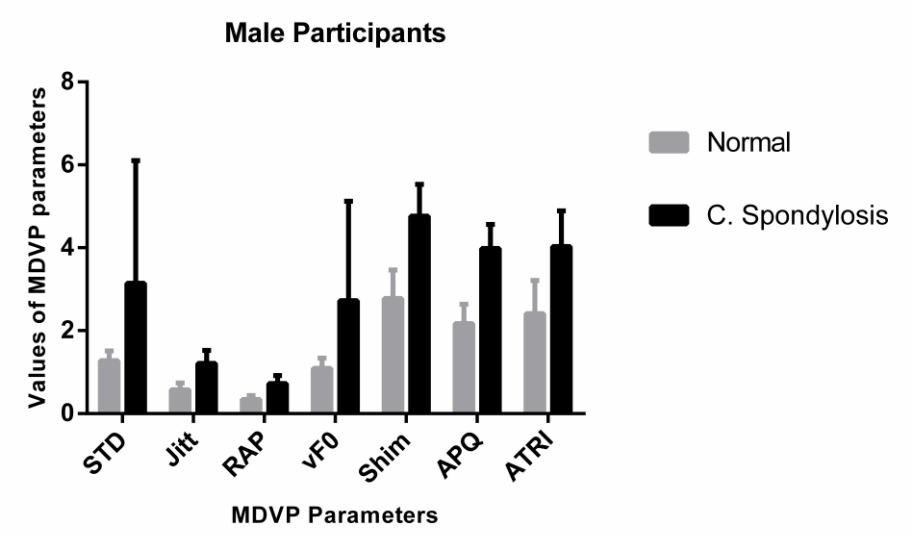

Figure 2: Error bar comparison of significant differences of MDVP parameters between normal males and Cervical Spondylosis males.

Comparison between normal and Cervical Spondylosis females

Mann- Whitney U test was done to compare females between the groups. There was significant difference observed in Jitt (Z=-1.92; p= 0.054), RAP (Z=-1.92; p= 0.054), vF0 (Z=-1.66; p=0.096), Shim (Z=-2.94; p=0.003), APQ (Z=-2.94; p=0.003), and NHR (Z=-2.01; p=0.044). All the CAPE-V parameters such as overall severity (Z= -2.80; p=0.005), roughness (Z= -3.23; p=0.001), breathiness (Z= -3.03; p=0.002), strain (Z= -2.74; p=0.011), pitch (Z= 2.74; p=0.006), loudness (Z= -3.39; p=0.001), show significant difference between female normal and Spondylosis. In the MDVP parameters significant difference is higher in the Shim and APQ and followed by Jitt, RAP, vF0, NHR. Table 4 shows the comparison between females in normal and Cervical Spondylosis group. Figure3 shows the error bar comparison between females of normal and Cervical Spondylosis group.

Table 4: Z and /p/ values of normal females and Cervical Spondylosis females

	Z - value	p –value
MDVP parameters		
MeanF0	-0.128	0.898
STD	-1.41	0.158
Fftr	-1.10	0.270
Fatr	-0.539	0.590
Jitt	-1.92	0.054*
RAP	-1.92	0.054*
vF0	-1.66	0.096*
Shim	-2.94	0.003**
APQ	-2.94	0.003**
NHR	-2.01	0.044*
VTI	-0.821	0.412
FTRI	-0.385	0.701
ATRI	-1.61	0.106
CAPE-V parameters		
Overall severity	-2.80	0.005**
Roughness	-3.23	0.001**
Breathiness	-3.03	0.002**
Strain	-2.54	0.011**
Pitch	-2.74	0.006**
Loudness	-3.39	0.001**

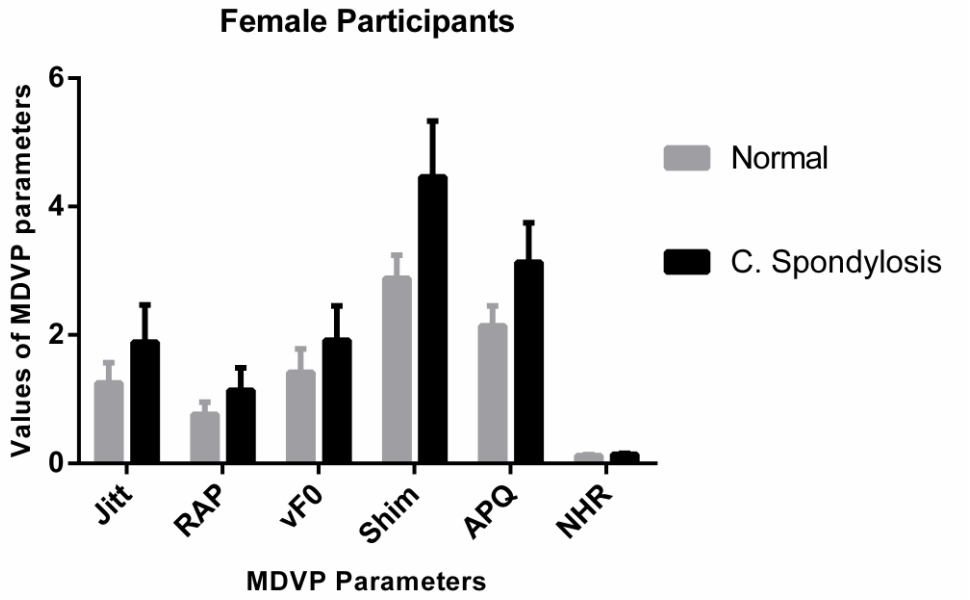

Figure 3: Error bar comparison of significant difference of MDVP parameters between normal females and Cervical Spondylosis females.

Comparison between acoustics and perceptual measures between mild and moderate Spondylosis

The mean and standard deviation value for acoustic and perceptual parameters were obtained using descriptive statistics and Mann-Whitney U test was done to compare between mild and moderate severity in Cervical Spondylosis individuals. In the MDVP parameters only the NHR (Z= 2.39; p=0.017) shows significant difference between the mid and moderate severity. The mean for CAPE-V parameters are found to slightly higher in moderate group compared to mild group. However no significant difference was found. Table 5 shows the mean and SD for mild and moderate

severity in Cervical Spondylosis. Table 6 depicts the Z and /p/ values for acoustic and perceptual parameters for the comparison of mild and moderate Cervical Spondylosis.

Table 5: Mean and SD for mild and moderate Cervical Spondylosis

	Degree			
	Mild		**Moderate**	
	Mean	**SD**	**Mean**	**SD**
MDVP parameters				
MeanF0	159	56.8	149	52.04
STD	3.07	2.67	2.60	1.15
Fftr	4.43	2.17	3.56	1.48
Fatr	2.66	0.912	2.86	0.705
Jitt	1.48	1.02	1.56	0.753
RAP	0.891	0.622	0.940	0.461
vF0	1.72	0.927	1.81	0.642
Shim	4.61	1.37	4.44	1.03
APQ	3.58	1.03	3.41	0.794
NHR	0.150	0.022	0.122	0.030
VTI	0.038	0.012	0.033	0.015
FTRI	0.311	0.151	0.281	0.154
ATRI	3.08	1.71	3.88	1.79
CAPE-V parameters				
Overall severity	19.2	12.7	21.3	9.62
Rough	17.5	9.53	22.01	9.70
Breathy	19.1	13.8	19.04	9.64
Strain	18.1	12.4	16.8	10.1
Pitch	11.5	8.85	12.3	6.55
Loud	9.91	7.12	12.5	6.56

Table 6: Z and /p/ value for mild and moderate Cervical Spondylosis:

	Z - value	p - value
MDVP parameters		
MeanF0	-0.488	0.626
STD	-0.488	0.626
Fftr	-0.513	0.608
Fatr	-0.098	0.922
Jitt	-0.488	0.626
RAP	-0.488	0.626
vF0	-0.781	0.435
Shim	-0.049	0.961
APQ	-0.244	0.807

NHR	-2.39	0.017**
VTI	-1.70	0.087
FTRI	-0.537	0.591
ATRI	-0.878	0.380
CAPE-V parameters		
Overall severity	-0.708	0.479
Roughness	-1.24	0.213
Breathiness	-0.36	0.714
Strain	-0.098	0.922
Pitch	-0.636	0.525
Loudness	-1.32	0.187

Inter-rater reliability of CAPE-V parameters

Cronbach's Alpha test was performed to test for inter-rater reliability across 5 judges. All the values were >0.7 except for pitch and loudness. Table7 shows the Cronbach's alpha value for CAPE-V parameters.

Table 7: Cronbach's alpha values for inter rater reliability of CAPE-V parameters.

CAPE-Parameters	Cronbach's alpha values
Overall severity	0.758
Roughness	0.733
Breathiness	0.760
Strain	0.743
Pitch	0.563
Loudness	0.535

Chapter 5

DISCUSSION

The present study aimed to obtain the perceptual and acoustic parameters of voice in individuals with and without Cervical Spondylosis. A total of sixty participants participated in the study of which thirty were present in the clinical and thirty in the control group.

Perceptual analysis of voice was carried out using Consensus Auditory Perceptual Evaluation of Voice (CAPE-V) for the phonation, spontaneous speech and sentences suggested by CAPE-V. Mann-Whitney U test was used to compare between the groups.

Perceptual measures (CAPE-V)

The results shows that all the CAPE-V parameters such as overall severity, roughness, breathiness, strain, pitch and loudness showed significant difference between normal and Cervical Spondylosis group in both males and females. The results indicate that there was a change in the voice production in Cervical Spondylosis as there was involvement of cervical and anterior neck muscles. This can be attributed to the voice changes which were significant in Cervical Spondylosis individuals because of the involvement of cervical muscles attach to laryngeal muscles and if there is any alteration or tension in these muscles, the production of voice is affected due to the abnormal vocal fold vibration and incomplete closure of the vocal folds. Excessive tension in the muscles creates inappropriate/in-coordination movement of the laryngeal and neck muscles which can further affect the production of voice. Due to this roughness, breathiness, hoarseness, was perceived in our study.

Since sternocleidomastoid contributes to head and neck movement and stability. This is supported by a study done by Ceilo, A. C, et al (2014), stating the sternocleidomastoid and scalene muscle facilitate in contraction of muscles. When there is extension of cervical muscle the anterior neck muscles gets stretched and become weakened and the suboccipital muscle gets shortened. The shape of the larynx is further changed due to the above changes it tightens the larynx and the adduction of the vocal folds is seen and even the resonance will be altered. This can cause an influence on the production of voice which is caused by the cervical posture of the individual. This result is congruent to result of another study done by Bigaton et al,(2010) on dysphonic women. It was found that head protrusion affected the anterior neck muscles such as sternocleidomastoid, scalene, suprahyoid and infrahyoid which further results in alteration in the production of voice. When there is alteration in the quality of voice due to the involvement of cervical neck muscles studies have supported stating that it could be related to the shortening of the sternocleidomastoid and trapezius muscle (Anelli W, Xavier C, 1995). If there are any changes in the head position can lead to compensation in the Cervical region and even the laryngeal region (Grini M N, Oaknine N, Giovanni A, 1998).

Additional features such as hoarseness, asthenia, and pitch instability were also present in the voice of Cervical Spondylosis individuals which is related to abnormality in vocal vibration and glottis closure. As sternocleidomastoid also accessory muscle for respiration this could have caused asthenia. According to our study hoarseness of voice could be due to the restriction of vocal fold adduction. As the regular vocal fold vibration is affected hoarseness in voice is perceived. Similar results have been found by a study done by Menoncin et al (2010), wherein the

muscular and skeletal changes in cervical dysphonic women was assessed and they have found that there was presence of hoarseness.

Acoustic Measures (MDVP)

Acoustic analysis for the phonation samples were done using Multi-Dimensional Voice Program (MDVP) to compare between the normal and Cervical Spondylosis group. The MDVP parameters such as STD, vF0, Jitt, Shim, RAP, APQ, NHR and ATRI showed significant differences between the groups. The parameters which showed the significance difference are classified under perturbation measures (STD, Jitt, vF0, Shim, RAP, APQ), noise related measures (NHR) and tremor related measures (ATRI).

Perturbation measures

In comparison between normal and Cervical Spondylosis in the perturbation measures Shim and APQ shows higher significance followed by Jitt, RAP, vF0, STD. In the present study, Jitt, Shim, vF0, RAP, APQ,STD, was increased in the Cervical Spondylosis group compared to normals, as it was associated with the instability of vocal fold vibration and the individuals with Cervical Spondylosis had breathy and hoarse voice. This is supported by a study stated by Munzo. J et al, (2003) where they have compared pathological voices and there was a presence of rough voice quality and it was related to Jitt and RAP. Similar results have been found even in our study. There is increase in the shimmer in Cervical Spondylosis group it can be related with breathiness of voice which is supported by a study done by Wolfe et al (1997) stating that the amplitude perturbation measures strongly correlates with breathy and hoarse voice.

Noise related measures

In the noise related measures NHR shows significant difference between the groups. In the present study as the individuals with Cervical Spondylosis present with poor adduction of the vocal folds the random noise was present in the voice production and it increased the NHR values compared to normals. In the acoustic analysis no significant difference was found across all the parameters but it was found that the major parameters focusing on the voice quality has shown significant difference. As seen in the present study, there is muscle disturbance in Cervical Spondylosis individuals there is a significant difference present in the perturbation measures and noise related measures. This is a supported by a study done by Silverio et al (2010), which states that they have found that when there is musculoskeletal disturbance observed in areas such as larynx, Cervical region and the scapular waist it was associated with the inadequate vocal behaviour.

Tremor related measures

In the tremor related measures ATRI showed significant difference between normal and Cervical Spondylosis group. It was seen that even in female with Cervical Spondylosis there was significant difference compared to normal females. As the vocal fold vibration was not maintained vocal tremor can be present. This is supported by a study done by Silverio, Siqueira, Lauris, Brasolotto (2014), there was inability in maintaining vocal fold vibration in women who had musculoskeletal pain and voice change due to the pattern of glottis proportion.

Perceptual and Acoustic measures of Mild - Moderate and severe Cervical Spondylosis

The results of perceptual analysis shows that there is no significant difference in the perceptual parameters between mild and moderate Cervical Spondylosis but there is a significant difference found in the breathiness in severe Cervical Spondylosis. This may be due to stiffness of cervical muscles affecting the laryngeal muscles which can further lead to the greater instability in the vocal folds and breathy voice quality. Similar results have been found in the study done by Lopes, Cavalcante, Costa, (2013) where the authors have reported instability of vocal fold folds and breathiness in women with history of increased tightness of the laryngeal system. And the authors explained that this may be due to rigidity in the entire laryngeal system, which increases the pressure and reduction in the contact of the vocal folds.

The results of acoustic analysis reveals that between mild vs moderate Cervical Spondylosis group there was a significant difference present in the NHR values across mild and moderate Cervical Spondylosis. Initially the stability was be affected so even the jitter and shimmer values were affected as the severity increases from mild to moderate i.e., when the severity increases. There is also notable difference present in the severe group.

The findings from the present study reveal that on comparison of voice between normal and Cervical Spondylosis group, it was found that the voice parameters in CAPE-V and MDVP showed significant difference between the clinical population in both Males and Females. In general, from the perceptual and acoustic findings it is obvious that the voice production in compromised in the individuals with Cervical Spondylosis.

Chapter 6

SUMMARY AND CONCLUSION

The present study aimed at investigating the vocal characteristics in normals and Cervical Spondylosis individuals. A total of 60 participants (30 normals and 30 Cervical Spondylosis individuals) were recruited for the study. Speech and voice samples were collected from normal and Cervical Spondylosis and further subjected to perceptual and acoustic analysis. In the collected phonation sample, spontaneous speech and sentences of CAPE-V parameters were qualified and MDVP parameters were measured for both the groups. The CAPE-V parameters showed significant difference in all the parameters between groups in both males and females. Similarly, in MDVP analysis, Jitt, Shim, APQ, NHR, STD, vF0, RAP and ATRI showed significant difference between the groups as well as between males and females. The abnormality of voice quality in Cervical Spondylosis is attributed change in the position and shape of the larynx due to tightens the larynx and the adduction of the vocal folds which may be caused by affected the anterior neck muscles such as sternocleidomastoid, scalene, suprahyoid and infrahyoid which further results in alteration in the production of voice in the Cervical Spondylosis. Noise related measures and tremor related measures were found to be affected in Cervical Spondylosis. Severity of Cervical Spondylosis also showed relation with voice quality parameters also it was not statistically significant.

The implications of the study

1. The current study will help us to understand the nature of voice characteristics in Cervical Spondylosis individuals.

2. It will be helpful in the management of voice in Cervical Spondylosis.

Future directions

Studies on aerodynamics can also be done as respiratory system will also be affected.

Pre-post analysis of voice and aerodynamics can be assessed.

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