LARYNGEAL DYNAMICS DURING WEIGHT LIFTING TASKS

Liji Antony

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CERTIFICATE

This is to certify that this dissertation entitled **"LARYNGEAL DYNAMICS DURING WEIGHT LIFTING TASKS"** is a bonafide work submitted in part fulfilment for the degree of Master of Science (Speech Language Pathology) of the student Registration No: 12SLP012. This has been carried out the under guidance of a faculty of this institute and has not been submitted earlier to any other university for the award of any diploma or degree

Mysore

May, 2014

Dr. S.R. Savithri
Director
All India Institute of Speech and Hearing,
Manasagangothri, Mysore – 570 006

CERTIFICATE

This is to certify that this dissertation entitled **"LARYNGEAL DYNAMICS DURING WEIGHT LIFTING TASKS"** has been prepared 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 diploma or degree.

Dr. Y.V.Geetha
(Guide)
Professor in Speech Sciences
Department of Speech Language Sciences,
All India Institute of Speech and Hearing,
Manasagangothri,Mysore – 570 006.

Mysore

May, 2014

DECLARATION

This is to certify that this master's dissertation entitled **"LARYNGEAL DYNAMICS DURING WEIGHT LIFTING TASKS"** is the result of my own study under the guidance of **Dr. Y.V. Geetha,** Professor in Speech Sciences, Department of Speech Language Sciences, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier to any other university for the award of any diploma or degree.

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Dedicated to....

My Lord Jesus,

appappan, ammamma, ammachi,
and vavachee

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CHAPTER I

INTRODUCTION

As a multi-structured organ within the vocal tract, larynx functions as a pathway between the upper and lower airway. It plays multiple roles; as a sphincter, closing to guard the lower airways from foreign materials, opening to support breathing, and serving as the sound source for phonation. It acts as a valve-like "guardian" of the lower respiratory tract. It prevents air from escaping the lungs, prevents foreign substances from entering the larynx, and forcefully expels the foreign bodies which threaten to enter the larynx or trachea, by the active closure of the laryngeal valve. Closure of the laryngeal valve prevents escape of air, thus building sub glottal air pressure within the thoracic cavity. When its sturdy musculature shuts off the airway, air can be confined in the lungs, forming a rigid thorax to support firmly, the attached upper extremities during strenuous activities like lifting and pushing. This thoracic fixation facilitates those activities that require elevated sub glottal pressure, such as heavy lifting.

In addition to these primitive capacities, humans have developed the ability to control phonation which resulted in an incredible achievement of human speech, aided by a specialized twin structure projecting into the larynx called vocal folds. Continuous adduction-abduction of the vocal folds is inevitable to optimal voice production for speaking and singing. At the beginning of each phonatory cycle, the vocal folds are close together. The sub glottal air pressure created due to the adduction, forces the vocal folds to move apart, setting them into vibration, thus modulating the air being expelled from the lungs with the subsequent production of voice. Voice production is dependent upon the coordinated functioning of respiratory, phonatory and resonatory systems and is controlled and regulated by the nervous system.

Voice is a mirror of the inner self. It is a reflection of the personality of the individual (Rosen & Sataloff, 1997). Voices are uniquely personal like our faces. Inferences regarding a speaker's age, sex, education, occupation, and regional as well as socioeconomic origins can be inferred from the speaker's voice (Ryan, Giles & Sebastian, 1982). Normal voice is a multidimensional entity that comprises of numerous physical, perceptual and lifestyle aspects.

The voice can be defined as normal when the quality is clear; pitch and loudness are suitable for age, sex and situation; the voice is produced with no undue strain, effort, pain, or fatigue; and the voice is satisfactory to the individual in terms of accomplishing his or her social, emotional and occupational vocal requirements. A normal voice should have a quality that is pleasant, has appropriate pitch, loudness with adequate flexibility and sustainability (Curtis, 2009). Any deviation from this will result in a voice disorder. Therefore, voice disorder is a problem encompassing abnormal pitch, loudness or vocal quality. Although voice is an unseen entity, its absence or malfunction is quite obvious.

Voice disorders can affect individuals across the entire life span-from infancy to old age. According to National Sample Survey Organization (NSSO) 2002, 8.5% of the Indian population suffers from some sort of voice disorders. Under the broad label of dysphonia lie many deviations of phonation usually manifested as a consequence of inappropriate vocal fold approximation (inadequate or excessive). Hyper-function and hypo-function are the two extremes of improper vocal fold functioning. Vocal hyper-function disorders develop from excessive muscle usage in phonation (Boone, 2010) that causes trauma to the structure of the vocal folds. The hyper functional vigorous adduction of the vocal folds will limit the free vocal fold vibration, generating harsh voice. The establishment of laryngeal pathologies like cord thickening, nodules and polyps, often result from excessive force of vocal fold approximation. Another extreme of inappropriate vocal fold approximation is vocal hypo-function demarcated as the lax approximation of the vocal folds as perceived in conditions like breathy voice or in the absence of vocal fold adduction as in adductor vocal fold paralysis, sulcus vocalis, functional aphonia etc. It may also accompany some of the neurological diseases such as Parkinson's disease, multiple sclerosis, cerebral palsy and so forth (Aronson, 1990; Ramig & Scherer, 1992; Smith & Ramig, 1995; Ramig, 1995). Every voice disturbance may present itself with more than one symptom; henceforth no one can link one single vocal symptom with one specific voice disorder.

However, management strategies may overlap in disorders having similar etiologies, but this should not be regarded as a generalized impression. Exceptions exist, and an individualized tailor-made strategy of intervention for each patient will be more suitable than a generalized one. Various management options for vocal fold paralysis include surgical procedures like thyroplasty, Teflon injection, re-innervation techniques, and voice therapy. A pre-surgical trial period of voice treatment is suggested for individuals with unilateral vocal fold paralysis who have a competent cough and do not have aspiration problems (McFarlane, Holt-Romero, Lavorato & Warneret, 1991). Voice therapy techniques usually employed for treating dysphonia secondary to hypo-function include inhalation phonation, coughing, pushing technique etc.

Effort closure or air trapping techniques like pushing and pulling have a long history in the treatment of hypo functional voice disorders, because, even moderate levels of physical activity can facilitate glottal closure. Effort closure techniques have been reported to improve adduction and subsequent voice (Aronson, 1990; Duffy, 2005; Rosenbek & Lapointe, 1985). These techniques are useful not only for improving vocal fold approximation, but also in increasing loudness and improving the quality of voice.

One such technique to improve glottal efficiency is the Pushing technique, which involves a patient pushing against restraint, to generate vocal fold closure. Pulling refers to the opposite maneuvers of pulling up on a very heavy desk, pulling up on a chair that one is sitting in, and the like. Isometric forms include placing the palms of the hand together at the chest height and pressing them together or locking the fingers of the hands together at the chest height and pulling them apart. These maneuvers are designed to create effort closure of the glottis with the larynx in a lowered position. Phonation is paired with the process to make out whether the voice is stronger and less breathy under these conditions. If so, the technique is continued and the pushing is gradually eliminated while the improvement in phonation continues. These have been used successfully to elicit a low pitched phonation in cases of hysterical high pitch and to bring about voicing in patients with psychogenic aphonia (Bangs & Freidinger, 1949).

Bangs and Freidinger (1949) documented a case of hysterical dysphonia who succeeded in developing a normal voice after undergoing a voice therapy program incorporating general relaxation, breathing exercises, pushing exercise regimen (clenching the fists or lifting lightly on the edge of a table), coughing, sighing during prolonged expirations, glottal stops, vocalization, word production, psychiatric follow-up and situational reinforcement. Froeschels, Kastein, and Weiss (1955) discussed 5 case studies (including individuals with vocal fold paralysis, hemi-laryngectomy, Parkinson's disease, and glottal incompetence subsequent to pathology of the central nervous system secondary to viral infection) for whom pushing intervention program was found to be effective in terms of mobility changes in the paralyzed vocal fold with significant improvement in glottal adduction, significant changes in pitch and intensity, enhancement in voice quality, and development of adequate breath control with little fatigue even after prolonged conversation.

Boone (1966) reported two cases of functional aphonia, as having responded to symptomatic voice therapy including the pushing regimen, with complete restoration of normal voice, with no subsequent recurrence of aphonia. Aldes (1981) reported a case study of 40 year old female with a sudden onset of hysterical high pitch for whom pushing approach was employed with success in establishing an appropriate pitch level.

McFarlane (1988) reported a case of unilateral right vocal fold paralysis following thyroid surgery, manifesting a hoarse voice with reduced vocal intensity. The individual achieved a near-normal voice after 14 sessions of voice therapy which encompassed pushing and pulling exercises to improve vocal adduction. Yamaguchi, Yotsukura, Sata, Watanabe and Bless (1993) provided evidence that an exercise program of pushing and phonation can produce positive outcomes if careful documentation and feedback of performance are provided. In three patients with glottal approximation difficulty, pushing technique was used as a specific voice therapy technique which subsequently improved loudness and glottal waveform function.

Ramig, Countryman, Thompson, and Horii (1995) observed that intensive voice and respiration treatment, focusing on increased vocal fold adduction and respiration exercises was more effective for improving loudness in 45 patients with Parkinson's disease than was respiration treatment alone. Combination of increased vocal fold adduction and subglottic air pressure is the prerequisite to generate post treatment increase in loudness of voice in idiopathic Parkinson's disease. Countryman, Hicks, Ramig and Smith (1997) reported an increase in vocal loudness, reduction in supraglottic hyper adduction, improvement in intonation and overall voice quality subsequent to vocal fold adduction therapy in an individual with Parkinson's disease. The client had reduced vocal loudness and supraglottic hyper-adduction, and along with training in sensory perception of the effort experienced, the individual could functionally use and maintain these improvements. Early voice therapy based on effort closure approach, combined with patient cooperation, motivation and understanding in the voice restoration process was documented to bring forth a good chance of vocal fold motility recovery and an improvement in voice quality in individuals with unilateral vocal fold paralysis (Mattioli, Bergamini, Alicandri-Ciufelli, Molteni, Luppi, Grammatica & Presutti, 2011).

Although these techniques have been reported to produce desired results, there are caveats. By their nature they induce hyper function, and therefore should be used cautiously in recognition of their potentially abusive behaviour. The effectiveness of these techniques will be noted fairly quickly, if indeed they are going to be effective. Thus, prolonging their use is usually not necessary.

Despite the evidence supporting the efficacy of effort closure techniques for voice disorders resulting from a glottal insufficiency, especially in cases of unilateral adductor vocal fold paralysis and hysterical dysphonia/aphonia, there have been very few studies documenting the vocal effects produced by other effort closure techniques, such as weight lifting. Orlikoff (2008) showed that simultaneous phonation and weight lifting is associated with increase in the electroglottographic contact quotient and estimated laryngeal airway resistance.

Need for the study

In order to check if, when and how an exercise could be employed in the treatment of voice, we need to be aware of its physiological effects on the body, especially on larynx. Only with a thorough knowledge of the effects of such exercises on the vocal fold physiology would it be possible to device it as a tool for treatment. Understanding their effects in a normal healthy larynx will also help us make a better prediction about how it is going to influence, favourably or adversely, a disordered larynx. Thus voice specialists can come out with new techniques or can refine the existing techniques by incorporating more and more elements to it, thereby improving the effectiveness of different approaches to the treatment of dysphonic voices and also making them individual specific by tailoring it to the needs of each individual. This insight will also endow us with a reference foundation to bring forth better ways to maximize vocal performance when it is accompanied with other forms of physical labour. Very few studies have documented the effects of effortful upper limb activities on the vocal mechanism and functioning, either in individual with dysphonia or in normal individuals.

The present study is an initial step trying to shed light on the possible, though seldom considered, role of a weight lifting and holding activity as a vocal intervention technique. This gives the effort closure techniques a much needed objective dimension - an individualized numerical measure of the amount of weight that will bring about an optimal adduction of the vocal folds. The study is designed to provide preliminary data on vocal functioning for vocally healthy speakers engaged in a weight lifting task.

Aim

The aim of the current study is to explore the effect of weight lifting activity on laryngeal dynamics and various dimensions of voice.

Objectives

- To investigate the effect of weight lifting tasks on aerodynamic parameters relating to voice (viz, Estimated Sub-Glottic Pressure, Mean Air Flow Rate,Laryngeal Airway Resistance) by comparing with and without weight lift positions, with regard to different weight conditions namely, 0 Kg, 1 Kg, 2 Kgs and 3 Kgs each in both arms respectively.
- To examine the effects of lifting of various amounts of weight loads on the different parameters of Electroglottography (EGG).
- To study the gender difference, if any, on voice parameters across various weight loads.

CHAPTER II

REVIEW OF LITERATURE

Voice and its significance

Voice is an essential constituent of the unique human attribute, speech. Voice conveys the message more than the words that we say. Speaking and singing are specialized means of using vocal apparatus and hence mandate an interaction of the mechanisms of respiration, phonation, articulation and resonance. Voice theaters a musical accompaniment to speech, rendering it harmonious, pleasing, comprehensible and coherent, being crucial to efficient communication. Voice is a potential instrument of linguistic and emotional expression that not only delivers the message but also augments its meaning.

Every mature voice has a distinct character. Just like two faces are not the same, neither are two voices. Voice is a mirror image of the personality of the individual (Rosen & Sataloff, 1997; Bruckert, Lienard, Lacroix, Kreutzer & Leboucher, 2008). Voice defines the personality of the speaker more than the words he utters. Nothing so deceives a person as his voice. Voice is a mirror of the inner self. It functions as an affective outlet. The delicate deviations in timbre, speed, inflection, stress and volume contribute to the meaning envisioned by the speaker on the listener. The loud voice of rage, the low soft tones of love and care, the rapid speech of anxiety and the monotonous tones of despair are decipherable.

The voice can disclose not only an individual's physical state, but also the physical state of the larynx. A bizarre voice can be a grave handicap and embarrassment to the speaker if s/he is cognizant of its impact on his/her audience. It may force him/her to spurn social contacts and to insulate himself/herself. Control of voice is a vital element of the individual's capacity to blend to social circumstances, to make fine interaction and retain equilibrium in relation to the audience, be it one or many. When the voice deteriorates as a consequence of strain or pathology, the entire personality suffers with it, giving rise to feelings of low self-esteem and insecurity.

Production of voice

Larynx, commonly known as voice box, has managed to take up the character of a protector as well as a communicator, in humans. The vital functions of the larynx are to guard the lungs from foreign materials; to allow the organism to clear the airway by throat clearing and coughing; to seize air in the thoracic cage, establishing a firm platform for the upper extremities; and to facilitate compression of the abdominal matters for micturition, defecation, and parturition. In addition to the execution of these life sustaining functions, the larynx also succeeds to swing from the role of guardian of life to a communicator, by generating voice. Voice is the sound generated by the vibrating vocal folds, a twin structure housed within the larynx. The vocal folds are adducted by the adductor intrinsic muscles of the larynx thereby providing resistance to the expired air in their closed phase until the pressure builds up and blows them apart. Then the pressure immediately drops below the folds. The reduced pressure, coupled with the elastic recoil of the vocal folds suck them back to their original position in the midline. Thus air escapes through the glottis in pulses. This process is called phonation and the end product is the voice. This end product voice is then resonated in the vocal tract. Thus, the voice that we hear is produced by coordinated working of respiratory activation, phonation and amplifying resonance.

Normal voice - characteristics

The normal voice is considered to have five features. Firstly, the normal voice must be loud enough to be perceived, referred to as sufficient carrying power, which is a significant component of speech intelligibility. Secondly, the normal voice must be produced in a way that is hygienic, meaning without vocal trauma and subsequent vocal lesions. Thirdly, the normal voice must have a pleasant quality. Fourthly, the normal voice should be flexible enough to express emotion. Lastly, the normal voice should characterize the speaker well in accordance with age and gender. Our voice should not depict us as either older, younger, or as less mature than we actually are. The normal voice represents the speaker faithfully.

Deviant voice - causes

Voice is generated by the movements of the vocal folds intruding the egressive airstream. The movements of the folds are controlled by its biomechanical characteristics, the amount of air pressure underneath the folds, and their neural control. Pathology may affect the vocal fold movements by interfering with any of these variables. Variations in the anatomy, or in the motor control, whether the result of neurological insult, trauma, lesion, will alter the normal physiology. That is, disturbed physiology may be a by-product of pathology. This disturbed physiology will in turn have an influence on the acoustic characteristics of the voice.

Voicing difficulties can be the result of anatomic deviation, or by emotions overriding normal vocal function, or by an alteration of vocal function resulting from misuse and overuse of vocal mechanisms. Voice disorders arise as a consequence of defective structure or function in the vocal tract, in the processes of respiration, phonation, articulation or resonance. When one or more aspects of voice, for instance, loudness, pitch, quality, and resonance are outside of the normal range for the age, gender, or geographic background of the speaker, presence of a voice disorder is reflected. When the voice changes in a deleterious manner, it is considered to be disordered or dysphonic. Dysphonia means any aberration in the normal phonation. Voice disorders can range from a mild hoarseness to complete voice loss, and may bound the intelligibility or effectiveness of oral communication. Patient with dysphonia uses his vocal apparatus in a faulty manner. Although voice is invisible to the eye during speech production, its absence or malfunction is evident.

Classification of voice disorders

As reported, 12% (Shindo & Hanson, 1990) to 35% (Ward, Colton, McConnell, Malmgren, Kashima, & Woodson, 1989) of elderly individuals have disordered vocal function. Herrington-Hall, Lee, Stemple, Niemi and McHone (1988) reviewed 1,262 cases from otolaryngologic practices and reported 21.6% of them as having vocal nodules, 14.1% with edema, 11.4% polyps, 8.1% vocal fold paralysis, and 7.9% as having functional disorders. Patients with voice disorders are likely to present with nine major symptoms namely, hoarseness, vocal fatigue, breathy voice, reduced pitch range, aphonia, pitch breaks or inappropriately high pitch, strain/struggle voice, tremor, pain and other physical sensations. There are four diverse classes of voice problems viz., organic voice disorders, neurogenic voice disorders, psychogenic voice disorders and muscle tension dysphonia.

Neurogenic voice disorders and associated dysphonic features

Neurogenic voice disorders are associated with neurologic conditions which result in a faulty vocal fold closure from either vocal fold paralysis or from other neurological diseases. The muscle control and innervations of the respiratory, phonatory, resonatory and articulatory muscles may be compromised from injury to the peripheral or central nervous system. Vocal fold paralysis or paresis is most frequently the consequence of certain injury to the recurrent laryngeal nerve (RLN), or seldom, the superior laryngeal nerve (SLN) (Meyer, Sulica, & Blitzer, 2007). Disease or trauma to the RLN unilaterally is the most common form of laryngeal paralysis (Case, 2002; Rubin & Sataloff, 2007). When the RLN is compromised on one side, the laryngeal adductor muscles (particularly the lateral cricoarytenoid) are unable to accomplish their adductory role. This retains the paralyzed fold fixed in the paramedian position. This creates certain level of glottal incompetence leading to a myriad of complaints that may include decreased vocal intensity and range, vocal fatigue, breathiness, roughness, diplophonia, and dysphagia. As appropriate neural control of larynx is indispensable to normal voice production, any disruption in that control is a cause for concern. Unilateral adductor vocal fold paralysis causes dysphonia characterized by a weak, breathy, rough, hoarse, diplophonic and aperiodic, unpleasant voice (Boone & McFarlane, 1988).

Yanagihara and Von Leden (1967) conducted a study to determine the vocal function patterns in unilateral paralysis of the vocal folds and reported that the paralyzed vocal fold was fixed in the intermediary position. The outcomes of the study indicated a very high flow rate and a significant decline in the phonation time. As per the results, it was concluded that the disturbances may encompass abnormalities in the expiratory air supply during phonation as well as alterations in laryngeal function. The high airflow rate seemed to be the major factor for the extremely short phonation time.

Dysphonia is considered the inevitable symptom of unilateral vocal fold paralysis (UVFP). Often, patients with vocal fold paralysis present with an asthenic voice quality that is breathy with reduced intensity and intermittent diplophonia. The breathy vocal quality, reduced loudness, and short phonation times can be attributed to leakage of air through an open glottis during phonation. Hoarseness, diplophonia, and pitch breaks can be attributed to the reduced ability to regulate internal tension of the paralyzed vocal fold.

Dysphonia varies in degree, and is likely related to the position of the affected vocal fold and extent of the subsequent glottal gap (Miller, 2004). The more lateral the location of the impaired vocal fold and larger the glottal gap, the more challenging it is to make progress with therapy alone (Schindler, Bottero, Capaccio, Ginocchio, Adorni & Ottaviani, 2008). The nearer the paralyzed vocal fold rests towards the midline, the better the attained glottal closure.

Functional dysphonia/aphonia and associated characteristics

Vocal conversion reactions are a cluster of reactions that give rise to abnormal laryngeal movement, or lack of motility, in the absence of anatomical or neurological pathology of the vocal folds. Moses (1954) stated that the vocal expression of psychoneuroses may vary from alteration of pitch to complete aphonia. While aphonia may be the most extensively reported vocal symptom of conversion, it is not the only one. Aronson, Peterson and Litin (1964) documented a case of hoarseness, breathiness, and falsetto pitch breaks due to emotional problems as those underlying hysterical aphonia. The most significant vocal dysfunction in neurotic conditions is the use of incorrect range. Hysterical high pitch is presented as one of numerous disturbances belonging to the superior classification of vocal conversion reactions. The symptom of no voice in the absence of laryngeal pathology is called hysterical aphonia or functional aphonia, terms being used interchangeably and synonymously

(Aronson, Peterson & Litin, 1964). Often the aphonia links back to a prior physical etiology persisting after the mechanism has recovered. The term hysterical or conversion aphonia is in general employed to describe the conversion reaction which manifests itself within the vocal musculature. Individual with hysterical aphonia converts his emotional problems into a physical or somatic plane (hysterical conversion). The patient will not be concerned about his aphonia for as long as it remains, the emotional disturbance is effectively suppressed (Clerf & Braceland, 1942).

While aphonia and inappropriate high pitch are clearly two distinct entities, several similarities can be noticed when they are regarded as two points on a vocal conversion reaction continuum. Boone (1977) stated that patients with hysterical aphonia often retain their ability to cough and clear their throats and also specified that many of them express strong urge to regain their normal voices. The chief commonality among aphonia and inappropriate high pitch is that both can be manifestations of psychoneurotic conditions.

A triangular parting of the vocal folds posteriorly with good adduction along the anterior two-thirds of the folds is the common laryngoscopic findings of the patient diagnosed as functionally aphonic (Babbett, 1923). Treatment techniques could overlap within a given group of disorders with similar etiologies. However, each case must be investigated separately, taking into account the subject's strengths, weaknesses, and requirements. And from such an analysis should grow a specific therapeutic approach appropriate to the specific individual.

Management of dysphonia associated with vocal fold paralysis - Role of voice therapy

Treatment of dysphonic patient demands an acquaintance on laryngeal anatomy, phonatory physiology and laryngeal pathologies. Whatsoever the management modality be, re-establishment of normal functioning or the closest possible approximation of it, is the goal. There exist numerous options for management of dysphonia associated with unilateral adductor vocal fold paralysis, including intra-cordal teflon injection, thyroplasty, muscle-nerve reinnervation surgery, voice therapy, etc. Since many traumatic vocal fold paralyses are reported to have spontaneous recovery within the first 9-12 months post onset, permanent corrective procedures or surgical measures should be postponed until voice intervention has been tried. Voice therapy (McFarlane, 1988) is aimed to gain advantage of the larynx's facility to reimburse for the paralyzed fold by means of adjustments in laryngeal position, altered subglottic air pressure, pitch, and loudness.

McFarlane, Holt-Romeo, Lavorato and Warner (1991) conducted a study to investigate the effect of three separate treatment methods for vocal fold paralysis (voice therapy, teflon injection, and muscle-nerve re-innervation surgery) on vocal parameters, as judged by three listener groups (9 otolaryngologists, 9 speech-language pathologists, and 9 lay listeners). Voice samples of 6 normal adults and 16 adult patients with vocal fold paralysis (pre- and post-treatment) who had undergone any one of the three different treatment techniques: voice therapy (6 patients), teflon injection (4 patients), muscle-nerve reinnervation surgery (6 patients) and of 6 normal speakers were recorded and rated by the listeners using six vocal parameters - pitch, loudness, hoarseness, vocal roughness, breathiness, and quality, on a 10-point scale. Voice therapy and muscle nerve re-innervation surgery were rated more effective than teflon injection depending on the improvement from pre-treatment to post-treatment voices for all six parameters of voice. The results recommend a conservative approach to the treatment, while waiting for possible spontaneous nerve healing, in unilateral vocal fold paralysis patients who do not experience aspiration problems and who have a competent cough. Voice therapy seems to be the most effective and cost-effective method of treatment and brings little or no risk, unlike surgeries.

There are many more studies that converse the role of voice therapy in intervening vocal fold paralysis and paresis; yet there is very less efficacy data to direct us to specific voice intervention techniques for this population. Voice rehabilitation is extremely individualized. Two patients with the same contributing voice disorder may necessitate a distinctively different amalgamation of therapy tactics.

Schindler et al (2008) conducted a study to analyze vocal changes in patients with UVFP before and after voice therapy. Forty patients with UVFP of different etiology served as participants. Each individual underwent voice therapy with an experienced SLP weekly twice, with the mean number of sessions being 12.6. A multidimensional assessment protocol was employed to carry out pre and post-therapy evaluation. Comparison of the pre- and post-treatment data revealed complete glottal closure in 8 patients before voice therapy and in 14 following voice therapy. Significant increase in mean MPT was noticed. Perceptual assessment revealed an overall decline in severity for all the parameters after voice therapy (Grade, Instability, Roughness, Breathiness, Asthenicity), the only exception being the S (Strained) parameter. A significant improvement was found for the mean values of jitter, shimmer, and noise-to-harmonic ratio in post-therapy vocal assessment. VHI values depicted a clear and significant improvement. Hence, a remarkable progress in voice quality and quality of life in individuals with UVFP after vocal rehabilitation is reasonable.

Behavioral voice intervention could be the only treatment required or it may serve as a provisional measure until medical management is possible. In case the compromised vocal fold is at or near midline, voice therapy possibly will bring utmost success. Balanced airflow can be aimed during phonation to maximize the vocal fold adduction. These goals, based on phonatory physiology, guide the choice of vocal training programs. The prime objective of voice rehabilitation is to enhance the individual's voice quality in the presence of the motion impairment. In doing so, the speech language pathologists work on improving glottic closure, increasing intrinsic muscle strength and agility, and mounting abdominal support for breathing (D'Alatri, Galla, Rigante, Antonelli, Buldrini & Marchese, 2008). D'Alatri et al (2008) conducted a study that evaluated the functional results achieved following voice therapy in patients with unilateral paralysis of the vocal fold caused due to diverse etiologies. Prospective investigation of the outcome of unilateral vocal fold paralysis cases rehabilitated was done. Thirty cases undertook behavioral treatment, within two and six weeks after the onset of vocal fold paralysis. A multi-dimensional assessment was done before, immediately after and six months following the intervention. Subsequent to behavioral therapy, a significant increase in the prevalence of complete glottal closure was reported. Participants' pre-treatment mean values for jitter, shimmer and noise-to-harmonic ratio were significantly different from those obtained both immediately and six months following treatment. Significant improvement in mean values for voice turbulence index was noticed in only six months after therapy. Mean values for grade, breathiness, instability, asthenia and voice handicap index scores were significantly reduced in both post-treatment conditions as compared to the pre-treatment condition.

Voice therapy techniques for dysphonia secondary to vocal fold paralysis

Frequently employed voice therapy techniques for unilateral vocal fold paralysis include half-swallow boom, push pull technique, head positioning, chin-tuck, digital manipulation, yawn sigh, and inhalation phonation. Pushing method is a voice intervention technique intended to lessen glottal inefficiency by increasing glottal closure. This routine capitalizes on the mechanism of primitive closure and the recognized principle that for building up thoracic pressure it is essential to close the larynx. The purpose of primitive closure techniques is to make use of primitive closure capabilities of the larynx from activities like lifting, for increasing adduction of the vocal folds for phonatory activities. Thus, the procedure takes advantage of the synchronous responsive adduction of the vocal folds while the neck and the upper arm are intentionally strained in any way demanding intra-thoracic pressure build up.

Pushing exercises-procedure

The pushing exercises were initially proposed by Froeschels (1944) for patients with velar paralysis. Later, Weiss (1971) applied it to the patients with recurrent laryngeal nerve paralysis, while Kastein (1955) protracted and slightly reformed it to serve the requirements of patients with diseases of the central nervous system, concerning the functions of respiration, phonation, and glutination. When there is sudden voluntary contraction of one group of muscles, other muscle groups tend to relax/expand, supporting the function of the first muscle group, (as in grimacing and frowning when lifting a heavy weight, clenching fists when defecating, etc.). The pushing exercises involve synchronized actions of the arms and phonation.

Firstly, the patient is instructed to raise his fists to the chest level and push his arms down in one rapid, elastic sweep. The fingers should be closed during the downward swing of the arms. The arm movements are completed with the palms landing at the front of the thigh. Once this could be done devoid of unnecessary tension on shoulders and upper arms, the patient is asked to say 'AH' at the very instant he starts pushing his arms down. These dynamic motions reinforce the sphincter function of the laryngeal muscles involved in phonation. Once voice is produced, syllables are added, and in due course mono-syllabic words are used. In patients with poor general health, or who are too weak to stand up, a modified technique can be used. The patient can be seated in a chair and instructed to push against the seat of the chair holding the seat with his hands, palms down, and raising himself up against the seat along with phonating vowels or syllables. In patients who are bedridden, pushing can be brought about by having him hold on to a sling, or simply hold on to the extended hands of the SLP.

These exercises need be done, five to ten times at once, every half hour for the initial days and every hour for the remaining days of the initial week. This could then be reduced in accordance with the improvement. As phonation improves and the voice attains more volume and tone, the patient is instructed to push on one sound, syllable, or word and to repeat the same without pushing, attempting to match the intensity of the repeated sounds with those uttered while pushing. The next phase involves thinking of pushing during speaking or reading aloud, instead of actually moving the arms. Breathing exercises to check air wastage and to improve breath control are introduced in this phase to complete the therapeutic program. Throughout the program the patient is prompted to use the voice that he is capable of producing.

Efficacy of pushing exercises in treating dysphonia associated with vocal fold paralysis and functional dysphonia

Efficacy data exists for push-pull therapeutic program, for forms of glottal incompetence subsequent to laryngeal nerve paralysis and sulcus vocalis (Froeschels, Kastein, & Weiss, 1955; Yamaguchi et al., 1993). Froeschels, et al (1955) professed a descriptive procedure for pushing intervention program together with the discussion of 5 case studies (including individuals with vocal fold paralysis, hemi-laryngectomy, Parkinson's disease, and glottal incompetence subsequent to a pathology of the central nervous system secondary to viral infection) for whom this specific voice management routine was tried and was found to be effective. Mobility changes in the paralyzed vocal fold with significant improvement in glottal adduction, enhancement in voice quality, good vocal inflection and statistically significant changes in pitch and intensity, development of adequate breath control with little fatigue even after prolonged conversation were the perceived positive outcomes following the pushing therapeutic intervention program.

Boone (1966) reported two cases (7 years, female and 38 years, male) of functional aphonia, each subsequent to a medical event such as surgery and severe illness (viral encephalitis), as having responded to symptomatic voice therapy with complete restoration of normal voice. Both the child and adult could produce a true-cord cough at the time of the initial voice evaluation, which was used early in therapy as a therapeutic device. After some trials, each patient was able to phonate on inhalation. Once inhalation-phonation was achieved, the patients were asked to match this sound with similar exhaled phonations. Phonation was paired with pushing exercises for the adult subject, as his exhaled phonations were aspirate in quality.

Both the child and adult achieved normal phonation with no subsequent recurrence of aphonia, from an approach providing them a firm psychological support while modifying their nonverbal phonation gradually using inhalation phonation and pushing exercises, until they had achieved a normal voice.

A case of hysterical dysphonia, 13 year old girl, with no precipitating cause, characterized by a sudden inability to speak above a whisper for previous seven years, underwent voice therapy incorporating general relaxation, breathing exercises, pushing exercise regimen (clenching the fists or lifting lightly on the edge of a table), coughing, sighing during prolonged expirations, glottal stops, vocalization, word production, psychiatric follow-up and situational reinforcement. The patient succeeded in developing a normal voice within a period of around ten and half weeks. Follow-up interviews revealed no new conversion symptoms, and two years following the discharge the patient was still maintaining regained voice (Bangs & Freidinger, 1949). Aldes (1981) reported a case study of 40 year old female with a sudden onset of hysterical high pitch and occasional breaks in phonation. Her voice wavered between normal and high pitch level. Indirect laryngoscopy revealed no organic vocal fold pathology. Pushing approach was employed and was successful in establishing an appropriate pitch level and the patient could speak at her customary (normal) pitch level subsequent to therapy.

Yamaguchi and colleagues (1993) presented a report on three cases having an incomplete glottal closure with subsequent vocal dysfunction characterized by an asthenic breathy voice quality (two males with para-median paralysis of the left vocal fold, and a female with incomplete closure due to a sulcus vocalis) were enrolled in a program wherein pushing and phonation was used as a specific voice therapy technique. Four different methods to attain the target closure was demonstrated, which included pushing by interlocking hands and pulling outward; putting hands together and pushing inward with as much vigor as possible; sitting in a chair while clutching the edge of the seat of the chair and pulling upward; pushing the head forward against resistance delivered by the examiner's hands positioned on the forehead of the subject. The subjects along with the clinician selected the one that worked best and sensed most comfortable for them. Finally, while pushing, the individual was asked to phonate as loudly as possible. Upon achieving this, training advanced from sustained vowels, to diphthongs, syllable repetition, oral reading of short sentences, and, finally, connected speech. In all the three subjects, the final evaluation demonstrated an overall increase in vocal intensity, improvement in glottal wave form function and better phonatory control as compared to the pre-treatment condition. In addition, the female subject with sulcus vocalis showed improvements in Maximum Phonation Time (MPT) and glottal closure. The voice improved in all the three subjects at the termination of treatment, even though it did not become normal.

Mattioli et al (2011) conducted a seven years prospective study intended to investigate motility recovery and subsequent vocal improvement, as post-treatment outcomes of patients with unilateral vocal fold paralysis (UVFP) who undertook early voice therapy, centered on primitive closure exercises. The participants were 74 individuals (49 female; 25 male) within the age range 14 – 86 years with UVFP. A pre and post-therapeutic objective voice assessment and self-evaluation of quality of life were made. Out of 74 participants, 51 (68.9%) regained vocal fold motility. There was a statistically significant increase in the mean maximum phonation time (MPT). A statistically significant reduction in fundamental frequency (F0), and improvement for the mean values of Jitter (Jitt %), Shimmer (Shim %) and noise-to-harmonic ratio

(NHR) was reported. Voice Handicap Index (VHI) values revealed a significant improvement in the overall self-perceived quality of life. The results of the study lead to a conclusion that early vocal intervention based on primitive closure techniques, combined with patient motivation and co-operation enhances the probability for recovery of vocal fold mobility and improvement in voice quality in individuals with UVFP.

Caveats of pushing exercises

Indications for pushing therapeutic program include select cases of glottal incompetence based vocal pathologies, viz., unilateral vocal fold paralysis, sulcus vocalis, abnormal glottal chink due to idiopathic reasons and vocal fold atrophy secondary to aging. Contra-indications for this particular vocal intervention routine are assumed to encompass incomplete closure cases having evidence of vocal fold hemorrhage, and cases that have contact ulcers or granulomas. Not all individuals who undergo this specific intervention program, gain vocal improvements.

Although some studies appears to offer some preliminary evidences of the effectiveness of pushing technique, it is still difficult to determine when the techniques would be most favorable. Also, generalization to connected speech is challenging to be accomplished by the pushing technique alone. Likelihood of development of extraneous compensatory movements resulting in hyper function of the supra-glottic structures, such as approximation of the ventricular vocal folds, is high while using this intervention program, implicating the importance of vigilant monitoring of the laryngeal condition throughout the training program which is indeed tedious and expensive. In summary, even though the studies mentioned above lighten up the efficacy of pushing technique in selected cases of glottal incompetence, the technique needs to be used with caution. Patient selection should be carefully done and, during the treatment, signs of hyper function that could pave way for additional laryngeal problems should be carefully monitored.

In spite of the presence of documented efficacy studies supporting the pushing exercises for individuals with glottal incompetence, very few studies report laryngeal and vocal effects of other primitive effort closure techniques, such as weight lifting (Orlikoff, 2008). To consider the possibility of advocating an exercise regimen for the treatment of vocal disturbances, one needs to be conscious of its physiological consequences on the body, particularly in this instance, on the phonatory system. Only with this knowledge, can we proceed towards the development of a new tool meant for vocal rehabilitation of dysphonia subsequent to glottal incompetence. Predictions on how weight lifting task is going to influence, favorably or adversely, a disturbed phonatory system, can be made by being aware of its effects on healthy larynx. Only then new techniques for vocal rehabilitation can be developed and the already existing ones can be modified to meet the individualistic needs of persons with dysphonia, thereby widening the scope and application of the arena.

Studies documenting the effects of effortful limb activities on vocal functioning, either in normal individuals or individuals with voice disorders are scarce. Orlikoff (2008) attempted a study intended to deliver preliminary data on physiologic alterations in voice production associated with weight lifting task. Twenty vocally healthy subjects (10 men and 10 women) between the ages of 25-41 years served as participants. The participants stood erect supporting a fixed weight dumbbell in each hand, with the arms remaining supine and straight in front of them. They were instructed to rest their hands on a padded surface adjusted to his/her height. Each participant phonated the vowel /a/ at a comfortable pitch and loudness as steadily as possible. After 3 seconds of phonation, the participants elevated the dumbbells around 20 cm without intruding phonation with the arms still straight, supine, and parallel to the floor. Phonation was continued for 3 seconds following the lift. This was done for each of the four weight conditions namely, 0, 3, 5, and 7 kgs and Electroglottogram was obtained for all the conditions in both pre-lift and post-lift positions. For estimating sub glottal pressure, flow and laryngeal airway resistance, the participants repeated similar task for each condition while repeating the syllable /pi/. The participants exhibited an increase in the electroglottographic contact quotient, estimated laryngeal airway resistance and long-term F0 variability, which could be attributed to an elevated driving pressure. No statistically significant changes in mean F0, jitter, or phonatory airflow between the pre-lift and lift portions of their voice productions were reported, irrespective of the weights supported. The results indicated that concurrent phonation and weightlifting causes increase in laryngeal airway resistance characterized by medial compression of the vocal folds.

Pushing technique has a risk of inducing supraglottic hyper-function, if not properly monitored. One reason for this consequence may be the lack of knowledge of the amount of force to be applied while pushing. This caveat could be overcome by the application of other effort closure techniques like weight lifting for which an objective dimension, a numerical measure of the amount of weight that can cause an optimal adduction of the vocal folds, could be provided. Hence, more scientific evidences regarding the applicability of other effort closure activities for the management of hypo-functional voice disorders are warranted. Dearth of studies in this domain, especially in the Indian context, provides the motivational rationale for this study.

Hence, the present study is a preliminary attempt to gain insight on the conceivable role of weight holding activity as a vocal rehabilitation regimen, which may provide the primitive effort closure techniques an obligatory objective evidence, a numerical measure of the amount of weight that will bring about optimal vocal fold closure. The current study is designed to deliver preliminary data on vocal functioning in vocally healthy speakers engaged in a weight holding task.

CHAPTER III

METHOD

The current study was undertaken with the main aim of exploring the effect of weight lifting activity on laryngeal dynamics and various dimensions of voice. The study was carried out as follows:

Participants

Thirty individuals (15 males and 15 females), in the age range of twenty to thirty five years were included in the study with the following subject selection criteria.

Inclusion criteria

- ✓ Vocally healthy subjects having Body Mass Index (BMI) within normal limits
- ✓ No history of speech, language or auditory pathology
- ✓ No history of respiratory disorders like asthma, bronchitis, pneumonia or allergic diseases
- ✓ No history of receiving any formal vocal or athletic training
- ✓ No history of any surgery or prolonged medication intake
- ✓ No history of alcohol intake, smoking or tobacco use
- ✓ Female subjects not menstruating one week around the procedure

Instrumentation

Table 1: *Instrumentation, specifications and the estimated parameters*

Sl.No	Name of the instrument	Product Information	Purpose
01.	Aeroview Phonatory Aerodynamic System Version:1.6.0	• From Glottal enterprises, used with MS-110 electronics interface • Calibrators: PC-1H, FC-1B • Circumferentially vented (CV) mask (Oro nasal Mask) • With PT-2E and PT-25-S transducers	Measurement of: i. Estimated Sub-Glottic Pressure (ESGP) ii. Mean Air Flow Rate (MAFR) iii. Laryngeal Airway Resistance (LAR)
02	Electroglottograph (EGG)	6103 from Kay Pentax	Measurement of: i. Average jitter ii. Mean fundamental frequency (f0) iii. Contact quotient (CQ)

Procedure

A written informed consent was obtained from all the participants before the study. The check list (see Appendix A) was administered to select the participants based on the criteria and to rule out any associated problems.

The weight of the participants were measured using the weighing machine (Home health, model: MS- Series) and the height was measured using a height chart for adults, which had readings ranging from 0 cm to 200 cm. The Body Mass Index (BMI) was calculated for each participant. For calculating BMI, the individual's body weight was divided by the square of their height using the following formula (WHO, 1995, 2004):

$$BMI = \text{weight (Kg)} / [\text{Height (m)}]^2$$

Following are the established values of BMI:

Table 2: *BMI classification adapted from WHO (1995) & WHO (2004)*

Body weight	BMI
Under weight	< 18.50
Normal	18.50-24.99
Over weight	>25.00
Obese	>30.00

Only those individuals with BMI in the normal range (18.50 - 24.99) were considered as participants for the study. The data was collected from each participant individually. The participant was made to sit while holding weight (fixed weight dumbbell) in each hand, with both arms rested on a flat surface that was adjusted to his/her shoulder level (without lift position - baseline). The arms were held in supine and straight before them in all the conditions namely, 0 Kg, 1 Kg, 2 Kgs and 3 Kgs each, in both arms.

Measurement of Electroglottography parameters

The participants were instructed to phonate vowel /a/ at a self-selected comfortable pitch and loudness for a duration of five seconds in without lift position. The Electroglottogram (EGG), which provides an indirect measure of the surface contact of the vocal folds with no interference on phonation, was obtained for each participant using the Electroglottograph, Model 6103 (Kay PENTAX). The EGG recordings made in this position across all the weight conditions served as the respective baseline for each of the conditions. After the baseline EGG recordings, the participants were instructed to lift the weights approximately 20 cm from the surface, with the arms remaining straight, supine and parallel to the floor. EGG recordings for 5 seconds duration in the lift position were obtained across the four weight load conditions of 0 Kg, 1 Kg, 2 Kgs and 3 Kgs each, in both arms respectively. For 0 Kg condition the participants performed similar task with closed fists without the weights. A minimum of three EGG recordings were obtained from each participant in each of the four weight loading conditions, in both positions.

A minimum rest period of 5 minutes was provided to the participants following each weight lifting episode. The parameters such as average jitter, meanf0, and contact quotient were derived from the Electroglottogram for all the conditions. These measures were calculated from the middle 3 second portion of the 5 second phonation sample in each of the two positions (with and without lift) across the four weight conditions.

Measurement of Aeroview parameters

The estimation of Estimated Sub Glottic Pressure (ESGP), Mean Air Flow Rate (MAFR) and Laryngeal Airway Resistance (LAR) were done, wherein the subjects repeated the syllable /pa/ for 5 seconds, in both with and without weight lift positions, across four conditions, namely 0 Kg, 1 Kg, 2 Kgs and 3Kgs each in both arms respectively. The measures of Estimated Sub-Glottic Pressure (ESGP), Mean Air Flow Rate (MAFR) and Laryngeal Airway Resistance (LAR) were determined by averaging the values obtained in three trials for each participant repeating /pa/ syllable in both the positions across all four conditions.

Analyses

The measured electroglottographic and laryngeal aerodynamic parameters were analyzed and compared between the two positions (without lift vs. with lift) across four weight conditions namely, 0 kg, 1 Kg, 2 Kg, and 3 Kg and between gender (male and female) for any differences.

Statistical analysis

- Descriptive statistical analysis was used to compute the mean and standard deviation of the electroglottographic and laryngeal aerodynamic measures at with and without lift positions in males and females across four weight conditions.
- Mixed ANOVA was used to examine the main effect and interaction effect among the variables-position, condition and gender.
- MANOVA was used to determine the gender differences in the obtained parameters in both positions across four conditions.
- Paired Sample t-test was used to make an independent comparison of the estimated parameters between with and without lift positions across four weight conditions.

CHAPTER IV

RESULTS AND DISCUSSION

The present study investigated the effect of weight lifting activity on the electroglottographic measures (average jitter, mean fundamental frequency and contact quotient) and the laryngeal aerodynamic parameters (Estimated Subglottic Pressure, Mean Air Flow Rate and Laryngeal Airway Resistance). A total of 30 participants (15 males and 15 females) within the age range of twenty to thirty five years served as the participants. The obtained data was subjected to statistical analysis using SPSS version 16.

The results of the present study are discussed under the following two sub-headings:

1. Electroglottographic parameters: The electroglottographic parameters measured from /a/ phonation were average jitter, mean fundamental frequency and Contact Quotient.
2. Laryngeal aerodynamic parameters: The laryngeal aerodynamic parameters measured from /pa/ syllable repetition were Estimated Sub-Glottic Pressure, Mean Air Flow Rate and Laryngeal Airway Resistance.

1. Electroglottographic parameters

1.1. Average Jitter measures

1.1.1. Comparison of average jitter measures between with and without lift positions in males and females across four weight conditions

Average jitter was obtained from the electroglottographic analysis of phonation sample in both with and without lift positions. Table 3 shows the mean and standard deviation values of jitter in with and without lift positions, in males and females, across four weight conditions. While comparing the jitter values between with and without lift positions across all the weight conditions, it was found that the mean jitter values were reduced in with weight lift as compared to without lift position. Regardless of the weight supported by the participants, a reduction in the average jitter measures were evidenced in the with lift position as compared to the without lift position in both the genders.

Table 3: *Mean and SD of jitter in males and females at two positions*

	Average Jitter (%)							
	Males				Females			
	Without lift		With lift		Without lift		With lift	
Weight conditions	Mean	SD	Mean	SD	Mean	SD	Mean	SD
0 Kg	.43	.11	.39	.08	.34	.18	.29	.10
1 Kg	.41	.10	.33	.05	.33	.11	.33	.13
2Kg	.41	.10	.32	.29	.31	.11	.29	.12
3Kg	.40	.10	.30	.07	.33	.11	.30	.09

SD: Standard Deviation

Table 4: *Mixed ANOVA results of jitter in males and females between two positions*

Source	df	F	Sig.
Position	1	17.405	.000 *
Position X Gender	1	5.125	.032*
Condition	3	1.990	.122
Condition X Gender	3	2.067	.111
Position X Condition	3	.548	.651
Position X Condition X Gender	3	2.301	.083

(* indicates statistical significance at 0.05 level)

Table 4 shows the Mixed ANOVA results of average jitter values in with and without lift positions across four different weight conditions, in males and females.Results revealed that there was a significant difference (main effects) obtained only for position [$F (1, 28) = 17.405$, $P < 0.05$]. Also, the test indicated a significant interaction effect for position and gender [$F (2, 84) = 5.125$, $P < 0.05$] and no interaction effect was found for other variables.

The present study found that the average jitter values were lower when the participants phonated /a/ after lifting and supporting the fixed weights in their arms than when they were just holding the weights resting their arms on the surface.

The study interestingly found that there is an effect of position (with lift and without lift) on the average jitter values during the phonation task. The reduced jitter values may be attributed to the increased adduction of the vocal folds during strenuous activities, like weight lifting. As reported by Aronson (1990), activities like coughing, pushing, grunting, and lifting, will elicit an 'effort closure reflex' that enables glottal adduction. This principle forms the basis for the application of pushing method in the treatment of voice disorders subsequent to inadequate vocal fold approximation. The physiological explanation may be that, when there is sudden voluntary contraction of one group of muscles, other muscle groups relax/expand, supporting the function of the first muscle group, (as in grimacing, when lifting a heavy weight, etc.). As pushing exercises involve synchronized actions of the arms and phonation, it will bring about a closure at the level of the glottis, leading to a better voice production.

D'Alatri et al (2008) reported a study wherein, complete glottal closure was noticed subsequent to behavioral voice therapy for unilateral vocal fold paralysis patients, which in turn lead to a reduction in the perturbation measures like jitter and shimmer. Mattioli et al (2011) reported of a reduction in jitter measures in UVFP patients subsequent to voice therapy, centered on primitive closure exercises. Hence, it can be concluded that an improved glottal closure can bring about a reduction in the perturbation measures. The reduction in the jitter values noticed in the with-lift position can be explained based on the above mentioned physiology. Results of the present study is deviant from the results of a study done by Orlikoff (2008), which reported no significant change in the jitter values between the pre-lift and lift portions of the subjects' sustained phonation, regardless of the amount of weight supported. Hence, more investigations are warranted.

1.1.2. Gender difference for average jitter measures in with and without lift positions across different weight conditions

Table 5 shows the MANOVA results of average jitter values in with and without lift positions across four different weight conditions.

Results of MANOVA indicated that a significant difference exists for average jitter measures between males and females, in the weight condition 2 Kg [$F(1, 28) = 6.647$, $P < 0.05$] in without lift position and 0 Kg [$F(1, 28) = 8.657$, $p < 0.05$] in lift position. A difference exists for the jitter values in the weight conditions 1 Kg [$F(1, 28) = 3.666$, $P = 0.0666$] and 3 Kg [$F(1, 28) = 3.297$, $P = 0.080$] in without lift position between males and females, even though it is not significantly different. This gender difference noticed may be attributed to the anatomic and physiologic differences of the vocal mechanism between males and females (Titze, 1988).

Table 5: *MANOVA results for average Jitter in both positions across four conditions*

Source	Variable	df	F	Sig.
Gender	0 kg without lift	1	2.668	.114
	1 kg without lift	1	3.666	.066
	2 kg without lift	1	6.647	.015*
	3 kg without lift	1	3.297	.080
	0 kg with lift	1	8.657	.006*
	1 kg with lift	1	.008	.929
	2 kg with lift	1	.463	.502
	3 kg with lift	1	.000	1.000

(* indicates statistical significance at 0.05 level)

1.1.3. Comparison of average jitter measures in without lift position across different weight conditions in males and females

Table 6 shows the repeated measures ANOVA results of average jitter in males and females, across different weight conditions in without lift position.

Table 6: *Repeated Measures ANOVA results of jitter in without lift position in males and females*

	Males			Females		
Source	df	F	Sig.	df	F	Sig.
Condition	3	.849	.475	3	.301	.825
Condition X Gender	0			0		

Repeated measures ANOVA results revealed no significant difference in the jitter values of males and females across different weight conditions in without lift position.

The results of the present study revealed that there is no difference in the jitter values in without lift position across all the four weight conditions in males as well as females. The reason may be that, the participants are not experiencing the weight as the arms are rested on the surface (since it is without lift position) and hence it is the same across different weight conditions.

These results are in consonance with the findings of the study by Orlikoff (2008) who reported similar findings with his participants. As reported, prior to the lift, no significant difference was reported for any of the measures (Fundamental frequency, long term and short term F0 variation, EGG contact quotient etc.) between the weight conditions in both males and females.

1.1.3. Comparison of average jitter measures in with lift position across different weight conditions in males and females

Tables 7 shows the Repeated measures ANOVA results of average jitter in males and females, across different weight conditions in lift position.

Table 7: *Repeated Measures ANOVA results of jitter for males and females in with lift position*

	Males			Females		
Source	df	F	Sig.	df	F	Sig.
Condition	3	11.376	.000*	3	1.071	.371
Condition X Gender	0			0		

(* indicates statistical significance at 0.05 level)

Repeated measures ANOVA results revealed a significant difference in the jitter values of males across different weight conditions in with lift position [F (3, 42) = 11.376, P < 0.05]. Pair-wise comparison among different weight conditions was done using Bonferroni test. Bonferroni adjustment for multiple comparison revealed there was a significant difference seen between the jitter measures of the weight conditions 0 Kg - 1 Kg, 0 Kg – 2 Kg, and 0 Kg – 3 Kg [$p < 0.05$], in with lift position for males. No significant differences existed between the jitter values of the weight conditions 1 Kg – 2 Kg, 2 Kg – 3 Kg, 1 Kg – 3 Kg in with lift position for males.

The results of the present study revealed that there is difference in the jitter measures in with lift position in males across different weight conditions. This finding could be attributed to the fact that different weight conditions bring about different degrees of glottal closure. Since the jitter values depend on the amount of glottal closure, the different weights supported will lead to different jitter values. These results are contradicting the findings of the study reported by Orlikoff (2008) which reported no change in the jitter measures in the after lift position across the different weight conditions. This may be because of the slight difference in the methodology between the two studies.

The findings of the present study revealed that there is no difference in the jitter values of females in the with lift positions across different weight conditions.

1.1.4. Comparison of jitter measures between with and without lift positions for each weight condition using paired sample t test

Paired sample t-test results revealed a significant difference in the jitter values of 0 Kg [$t = 2.933$, $p < 0.05$], 1 Kg [$t = 4.759$, $p < 0.05$], 2 Kg [$t = 4.254$, $p < 0.05$] and 3 Kg [$t = 4.122$, $p < 0.05$] weight conditions between with and without lift positions in males.

Table 8:*Results of Paired t-test for comparison of average jitter measures between different positions across each weight condition*

	Conditions	Males			Females		
		t	df	Sig. (2-tailed)	t	df	Sig. (2-tailed)
Pair 1	0 Kg without lift - 0 Kg with lift	2.933	14	.011*	1.036	14	.318
Pair 2	1 Kg without lift- 1 Kg with lift	4.759	14	.000*	.143	14	0.888
Pair 3	2 Kg without lift - 2 Kg with lift	4.254	14	0.001*	1.00	14	0.334
Pair 4	3 Kg without lift- 3 Kg with lift	4.122	14	0.001*	1.281	14	0.221

(* indicates statistical significance at 0.05 level)

The results of the present study indicated that there is a significant difference in the jitter values when comparison is made for each of the weight condition between with and without lift positions, in males. These findings contradict the findings of the study done by Orlikoff (2008), wherein jitter values did not differ significantly from the pre-lift data during the weight support task.

Results of paired sample t-test revealed no significant difference in the jitter measures of any of the weight conditions between with and without lift positions in females.

1.2. Mean Fundamental Frequency

1.2.1. Comparison of mean fundamental frequency (f0) measures between with and without lift positions in males and females across four weight conditions

Table 9 shows the mean and standard deviation of mean f0 values during with and without lift positions in males and females across four weight conditions.

Table 9: *Mean and SD of mean f0 in males and females between two positions*

	Mean f0 (Hz)							
	Males				Females			
	Without lift		With lift		Without lift		With lift	
Weight conditions	Mean	SD	Mean	SD	Mean	SD	Mean	SD
0 Kg	126.10	14.94	126.24	15.29	206.21	18.90	206.57	20.10
1 Kg	126.86	13.00	126.37	13.99	211.16	17.60	211.73	18.03
2Kg	126.20	13.36	126.34	14.41	208.50	18.92	209.72	18.81
3Kg	125.65	13.78	126.92	14.67	208.41	19.09	212.60	18.12

SD: Standard Deviation

While comparing the mean f0 values between with and without lift positions across all the weight conditions, slight difference was noticed in both males and females.

Table 10 shows the Mixed ANOVA results of mean f0 values in with and without lift positions across four different weight conditions, in males and females.

Table 10: *Mixed ANOVA results of mean f0 in males and females between two positions*

Source	df	F	Sig.
Position	1	5.731	.024*
Position X Gender	1	5.225	.030*
Condition	3	2.319	.081
Condition X Gender	3	2.009	.119
Position X Condition	3	5.270	.002*
Position X Condition X Gender	3	3.158	.029*

(* indicates statistical significance at 0.05 level)

Results of Mixed ANOVA revealed that there was a significant difference (main effects) obtained for position [$F(1, 28) = 5.731$, $P < 0.05$]. Also, the test indicated a significant interaction effect for position and gender [$F(1, 84) =$

5.225, $P < 0.05$], position and condition [$F (3, 84) = 5.27$, $P < 0.05$], and position, condition and gender [$F (3, 84) = 3.158$, $P < 0.05$].

The study interestingly found that there is an effect of position (with lift and without lift) on the mean f0 values during the phonation task. This may be attributed to an increased subglottic air pressure subsequent to increased adduction and tensing of the vocal folds during strenuous activities, like weight lifting.

Due to an increase in the degree of adduction at the glottal level and increased tension of the vocal folds during weight lifting, elevated subglottic pressure is built up to break the laryngeal air way resistance and to facilitate the vocal fold vibration. This will bring about a subsequent variation in the f0 (Titze, 1989).

A statistically significant change in fundamental frequency (f0) was reported by Mattioli et al. (2011) in patients with UVFP after attending voice therapy centered on primitive closure exercises. Use of pushing method with individuals having hysterical high pitch has reported positive outcomes in terms of bringing about a change in their abnormally high pitch to a normal level (Bangs & Freidinger, 1949; Aldes, 1981). These findings are in consonance with the findings of the current study which reports a variation in the f0 in lift position as compared to that in without lift position.

Results of the present study is deviant from the results of the study done by Orlikoff (2008), which reported no significant change in the mean f0 values between the pre-lift and lift portions of the subjects' phonation, regardless of the amount of weight supported. It may be because of minor methodological differences between these two studies. Hence, further investigations regarding this are warranted.

1.2.2. Gender difference for mean f0 measures in with and without lift positions across different weight conditions

Table 11 shows the MANOVA results of mean f0 values during with and without lift positions across four different weight conditions.

Table 11: *MANOVA results for mean f0 in both positions across four conditions*

Source	Variable	df	F	Sig.
Gender	0 kg without lift	1	165.718	.000*
	1 Kg without lift	1	222.459	.000*
	2kg without lift	1	189.375	.000*
	3kg without lift	1	185.287	.000*
	0kg with lift	1	151.635	.000*
	1kg with lift	1	209.709	.000*
	2kg with lift	1	185.626	.000*
	3kg with lift	1	206.838	.000*

(* indicates statistical significance at 0.05 level)

Results of MANOVA indicated that a significant difference exists for mean f0 measures in all the weight conditions, 0 Kg [F (1, 28) = 165.718, P < 0.05], 1Kg [F (1, 28) = 222.459, P < 0.05], 2 Kg [F (1, 28) = 189.375, P < 0.05, and 3 Kg [F (1, 28) = 185.287, P < 0.05], in without lift position and in all the weight conditions, 0 Kg [F (1, 28) = 151.635, P < 0.05], 1Kg [F (1, 28) = 209.709, P < 0.05], 2 Kg [F (1, 28) = 185.626, P < 0.05], and 3 Kg [F (1, 28) = 206.838, P < 0.05] in with lift position between males and females.

The present study showed a significant difference in f0 between males and females in all the weight conditions during lift and without lift positions. This gender difference noticed may be attributed to the anatomic and physiological differences in the vocal mechanism between males and females (Titze, 1988).

1.2.1. Comparison of mean f0 measures in without lift position across different weight conditions in males and females.

Tables 12 shows the repeated measures ANOVA results of mean f0 for males and females, across different weight conditions in without lift position.

Table 12: *Repeated Measures ANOVA results of mean f0 for males and females in without lift position*

	Males			Females		
Source	df	F	Sig.	df	F	Sig.
Condition	3	1.964	.134	3	.538	.659
Condition X Gender	0			0		

Repeated measures ANOVA results revealed that no significant difference exists in the mean f0 values of males and females across different weight conditions in without lift position.

The results of the current investigation revealed no significant difference in the mean f0 values in without lift position, across all the weight conditions, in males as well as females. This may be because the participants do not experience the weights of the dumbbells in this position since they are resting their arms on the surface while phonating.

1.2.2. Comparison of mean f0 measures in lift position across different weight conditions in males and females

Tables 13 shows the repeated measures ANOVA results of mean f0 in males and females, across different weight conditions in lift position.

Table 13: *Repeated Measures ANOVA results of mean f0 in males and females in lift position*

	Males			Females		
Source	Df	F	Sig.	df	F	Sig.
Condition	3	3.503	.023*	3	.070	.976
Condition X Gender	0			0		

(* indicates statistical significance at 0.05 level)

Repeated Measures ANOVA results revealed that a significant difference exists in the mean f0 values of males across different weight conditions in lift position [F (3, 42) = 3.503, P < 0.05]. Bonferroni adjustment for multiple comparison revealed there was a significant difference seen only between the mean f0 measures of the weight conditions 0 Kg - 3 Kg [p < 0.05], in lift position for males.

The current investigation indicated a significant difference between the mean f0 values of the weight conditions 0 Kg -3 Kg, in lift position, for males. This may be explained based on the assumption that, may be, higher the amount of weight supported, more is the variation in the f0 as compared to the least supported weight. That is, the variation in f0 is more evident while comparing the least and the highest supported weight. These results are contradicting the findings of the study reported by Orlikoff (2008) which reported no change in the f0 measures in lift position across the different weight conditions. This may be because of the slight difference in the methodology between the two studies. Hence, more studies are needed to make a conclusion in this area.

Results of the repeated measures ANOVA indicated no significant difference across the mean f0 values in females in lift position. The current investigation indicated no significant difference between the mean f0 values of any of the weight lift positions for females. This result is in agreement with the findings of the study reported by Orlikoff (2008) which reported no change in the f0 measures in the after lift position across the different weight conditions.

1.2.3. Comparison of mean f0 measures between with and without lift positions in each weight condition using paired sample t-test

Table 14:*Results of Paired t-test for comparison of mean f0 measures between different positions across each weight condition*

Conditions		Males			Females		
		T	df	Sig. (2-tailed)	t	df	Sig. (2-tailed)
Pair1	0 Kg without lift- 0 Kg with lift	-.651	14	.525	-.363	14	.722
Pair2	1 Kg without lift- 1 Kg with lift	-.841	14	.415	.844	14	.413
Pair3	2 Kg without lift- 2 Kg with lift	-1.545	14	.145	-.287	14	.778
Pair4	3 Kg without lift- 3 Kg with lift	-3.224	14	.006*	-.606	14	.554

(* indicates statistical significance at 0.05 level)

Paired sample t-test results revealed a significant difference only in the mean f0 values of 3 Kg weight condition [$t = -3.224$, $p < 0.05$], between with and without lift positions for males. That is, only in the 3 Kg weight condition, there was a significant difference between the mean f0 values between positions. May be, at least 6 Kg weight (3 Kg in each arm) is required to cause a variation in f0 in lift position as compared to that in the without lift position.

Results of paired sample t-test revealed no significant difference in the mean f0 measures of any of the weight conditions between lift positions for females. This finding is in consonance with the results of the study by Orlikoff (2008) wherein no significant difference in f0 was reported between the before and after lift positions across all the weight conditions.

1.3.Contact Quotient (CQ)

1.3.1. Comparison of CQ measures between with and without lift positions in males and females across four weight conditions

Table 15: *Mean and SD of CQ in males and females between two positions*

	Contact Quotient							
	Males				Females			
	Without lift		With lift		Without lift		With lift	
Weight conditions	Mean	SD	Mean	SD	Mean	SD	Mean	SD
0 Kg	42.46	4.15	43.39	4.03	44.11	3.91	44.87	4.19
1 Kg	44.10	4.12	45.26	3.83	45.02	4.01	45.86	4.14
2Kg	45.05	3.32	46.36	3.47	44.62	3.51	46.29	3.41
3Kg	45.74	3.43	47.31	3.17	45.14	3.52	46.80	3.49

SD - Standard Deviation

While comparing the CQ values between positions across all the weight conditions, it was found that the CQ values increased in the lift position as compared to without lift position. This may be elucidated based on the physiological explanation that effort closure techniques like pushing, pulling, weight lifting etc. bring about adduction at the level of glottis, which will be reflected in the electro-glottographic results as an increase in the contact quotient of the vocal folds. This finding is in agreement with the findings of the study by Orlikoff (2008), which reported an increase in the CQ values in after lift position as compared to before lift across all weight conditions, as well as an increase in CQ values along with increment in the amount of weight supported.

Table 16 shows the Mixed ANOVA results of CQ values for both positions across four different weight conditions, in males and females.

Table 16: *Mixed ANOVA results of CQ in males and females between two positions*

Source	df	F	Sig.
Position	1	173.462	.000*
Position X Gender	1	.005	.945
Condition	3	26.846	.000*
Condition X Gender	3	5.482	.002*
Position X Condition	3	5.715	.001*
Position X Condition X Gender	3	.927	.431

(* indicates statistical significance at 0.05 level)

Results of mixed ANOVA revealed that there was a significant difference (main effects) obtained for position [$F(1, 28) = 173.462$, $P < 0.05$] and condition [$F(3, 84) = 26.846$, $P < 0.05$]. Also, the test indicated a significant interaction effect for condition and gender [$F(3, 84) = 5.482$, $P < 0.05$] and position and condition [$F(3, 84) = 5.715$, $p < 0.05$]. Bonferroni adjustment for multiple comparison revealed that there was a significant difference seen between the CQ measures of the weight conditions 0 Kg - 1Kg, 0 Kg - 2Kg, 0 Kg – 3 Kg, 1 Kg - 3 Kg, and 2 Kg – 3 Kg [$p < 0.05$] between the positions. No significant differences existed between the CQ values of the weight conditions 1 Kg – 2 Kg.

A statistically significant position and condition effect was indicated for CQ measures with and without lift positions in both males and females. An increase in EGG CQ suggests that upper-limb weight lift and support caused greater medial compression during phonation. Naito and Niimi (2000) endoscopically noted increased glottal closure consistently at the moment of maximum exertion in 12 healthy participants as they executed various strenuous activities involving the upper limbs, like pushing themselves up onto a horizontal bar, striking an object etc.

An increment in the amount of glottal closure was reported subsequent to the treatment of vocal fold paralysis patients following the use of effort closure voice therapy techniques like pushing and pulling manoeuvers, coughing etc. (Schindler et al, 2008; Froeschels, Kastein, & Weiss, 1955; Yamaguchi et al., 1993; Mattioli et al. 2011). The present study results are in consonance with the findings of these previous investigations on strenuous effort closure voice rehabilitation techniques.

1.3.2. Gender difference for average CQ measures in with and without lift positions across different weight conditions

Table 17 shows the MANOVA results of CQ values for with and without lift positions across four different weight conditions.

Table 17: *MANOVA results for CQ in both positions across four conditions*

Source	Variable	df	F	Sig.
Gender	0 kg without lift	1	1.259	.271
	1 kg without lift	1	.385	.540
	2 kg without lift	1	.120	.732
	3 kg without lift	1	.228	.637
	0 kg with lift	1	.968	.334
	1 kg with lift	1	.168	.685
	2 kg with lift	1	.003	.954
	3 kg with lift	1	.180	.675

Results of MANOVA indicated that no significant difference exists for CQ values in any of the weight conditions, between males and females, at both with and without lift positions.

1.3.3. Comparison of CQ measures in without lift position across different weight conditions in males and females

Tables 18 shows the repeated measures ANOVA results of CQ for males and females, across different weight conditions in without lift position.

Repeated Measures ANOVA results revealed that no significant difference exists in the CQ values of males and females across different weight conditions in without lift position.

Table 18: *Repeated Measures ANOVA results of CQ for males and females in without lift position*

	Males			Females		
Source	df	F	Sig.	df	F	Sig.
Condition	3	18.924	.23	3	3.631	.13
Condition X Gender	0			0		

As per the results of the present study, no significant difference is reported between the CQ measures of both males and females, in without lift position, across all the weight conditions. This is in agreement with the results of the study by Orlikoff (2008). This may be because during without lift position across all the weight conditions, the participants do not experience the weight of the dumbbells, since they are resting their arms on the surface while phonating.

1.3.4. Comparison of CQ measures at with lift position across different weight conditions in males and females

Tables 19 shows the repeated measures ANOVA results of CQ for males and females, across different weight conditions in with lift position.

Table 19: *Repeated Measures ANOVA results of CQ for males and females in with lift position*

Source	Males			Females		
	df	F	Sig.	df	F	Sig.
Condition	3	29.741	.000*	3	5.029	.005*
Condition X Gender	0			0		

(* indicates statistical significance at 0.05 level)

Repeated Measures ANOVA results showed that a significant difference is present in the CQ values of males across different weight conditions in with lift position [$F (3, 42) = 29.741$, $P < 0.05$]. Bonferroni adjustment for multiple comparison indicated a significant difference between the CQ measures of all the weight conditions; 0 Kg - 1 Kg, 0 Kg – 2 Kg, 0 Kg – 3 Kg, 1 Kg – 2 Kg, 1 Kg – 3 Kg, 2 Kg – 3 Kg, [$p < 0.05$], in lift position for males.

Repeated Measures ANOVA results showed that a significant difference is present in the CQ values of females across different weight conditions in lift position [$F(3, 42) = 5.029$, $P < 0.05$]. Bonferroni adjustment for multiple comparison indicated a significant difference only between the CQ measures of the weight conditions 0 Kg – 3 Kg, [$p < 0.05$], in lift position for females.

The results of the present study revealed that there is a significant difference in the CQ measures in lift position, in both males and females, across different weight conditions. This finding can be attributed to the fact that, different weight conditions bring about different degrees of glottal closure. Since the CQ values depend on the amount of glottal closure, the different weight supported will lead to different CQ values. These results are in consonance with the findings of the study by Orlikoff (2008) which reported an increase in the CQ measures in the after lift position across the different weight conditions.

1.3.5. Comparison of CQ measures with and without lift positions at each weight condition using paired sample t test

Paired sample t-test results revealed a significant difference in the CQ values of 0 Kg [$t = -3.872$, $p < 0.05$], 1 Kg [$t = -4.701$, $p <0.05$], 2 Kg [$t = -5.743$, $p < 0.05$] and 3 Kg [$t = -8.944$, $p < 0.05$] weight conditions between with and without lift positions for males. Results of paired sample t-test indicated significant difference in the CQ measures of all the weight conditions, 0 Kg [$t = -3.310$, $p < 0.05$], 1 Kg [$t = -3.371$, $p < 0.05$], 2 Kg [$t = -6.440$, $p < 0.05$] and 3 Kg [$t = -7.108$, $p < 0.05$] weight conditions between with and without lift positions for females.

Table 20:*Results of Paired t-test for comparison of Contact Quotientbetween different positions across each weight condition*

Conditions		Males			Females		
		t	Df	Sig. (2-tailed)	t	df	Sig. (2-tailed)
Pair 1	0 Kg without lift- 0 Kg with lift	-3.872	14	.002*	-3.310	14	.005*
Pair 2	1 Kg without lift- 1 Kg with lift	-4.701	14	.000*	-3.371	14	.005*
Pair 3	2 Kg without lift- 2 Kg with lift	-5.743	14	0.000*	-6.440	14	.000*
Pair 4	3 Kg without lift- 3 Kg with lift	-8.944	14	0.000*	-7.108	14	.000*

(* indicates statistical significance at 0.05 level)

The results of the present study indicated that there is a significant difference in the CQ values when comparison is made for each of the weight condition, with and without lift positions, in males as well as females. These findings are in agreement with the findings of the study done by Orlikoff (2008), wherein CQ values increased significantly in the lift condition as compared to the pre-lift data, during the weight support task. This may be attributed to the increased glottal closures which accompany the performance of strenuous effort closure activities, which is reflected as an increase in the electroglottographic Contact Quotient.

2. Laryngeal Aerodynamic Parameters

2.1. Estimated Subglottic Pressure (ESGP)

2.1.1. Comparison of ESGP measures with and without lift positions in males and females across four weight conditions

Table 21: *Mean and SD of*ESGP *in males and females between two positions*

	Estimated Subglottic Pressure (ESGP) (cm of H_2O)							
	Males				Females			
	Without lift		With lift		Without lift		With lift	
Weight conditions	Mean	SD	Mean	SD	Mean	SD	Mean	SD
0 Kg	5.32	.87	5.44	.84	5.30	.85	5.54	.85
1 Kg	5.53	.92	5.85	.88	5.42	.85	5.82	.84
2Kg	5.7	1.07	6.29	1.07	5.59	.87	6.11	.86
3Kg	5.89	1.15	6.71	1.09	5.75	.89	6.61	.82

SD: Standard Deviation

Table 21 shows the mean and standard deviation of ESGP values in with and without lift positions in males and females across four weight conditions.

While comparing the ESGP values with and without lift positions across all the weight conditions, a slight increase in ESGP values was noticed in with lift position as compared to without lift position. This may be ascribed to the fact that increased glottal closure during weight lifting will result in the building up of higher levels of subglottic pressure to overcome the elevated laryngeal resistance for phonation to take place.

Table 22 shows the Mixed ANOVA results of ESGP values for with and without lift positions across four different weight conditions, in males and females.Results of mixed ANOVA revealed that there was a significant difference (main effects) obtained for position [$F (1, 28) = 123.872$, $P < 0.05$] and condition [$F (3, 84) = 95.434$, $P < 0.05$]. Also, the test indicated a significant interaction effect for position X condition [$F (3, 84) = 43.715$, $p < 0.05$]. Bonferroni adjustment for multiple comparison revealed that there was a significant difference seen between the ESGP measures of all the weight conditions 0 Kg - 1 Kg, 0 Kg – 2 Kg, 0 Kg – 3 Kg, 1 Kg – 2 Kg, 1 Kg - 3 Kg, and 2 Kg – 3 Kg [$p < 0.05$].

Table 22: *Mixed ANOVA results of ESGP in males and females between two positions*

Source	df	F	Sig.
Position	1	123.872	.000*
Position X Gender	1	.273	.605
Condition	3	95.434	.000*
Condition X Gender	3	1.318	.274
Position X Condition	3	43.715	.000*
Position X Condition X Gender	3	.649	.586

(* indicates statistical significance at 0.05 level)

A statistically significant position and condition effect was indicated for ESGP measures with and without lift positions in both males and females. This result is in agreement with the findings of the study by Orlikoff (2008), wherein a significant increase in ESGP was reported as the participants supported weights. An increase in vocal loudness was reported in patients with UVFP, Parkinson's disease, sulcus vocalis etc., subsequent to voice therapy incorporating effort closure regimens like pushing method (Froeschels, Kastein, & Weiss, 1955; Yamaguchi et al., 1993). This increase in vocal loudness can be attributed to the building up of subglottic pressure while executing effort closure activities, meaning vocal intensity is directly proportional to the subglottic air pressure (Plant & Younger, 2000).

2.1.2. Gender difference for ESGP measures with and without lift positions across different weight conditions

Table 23 shows the MANOVA results of ESGP values for with and without lift positions across four different weight conditions.

Table 23: *MANOVA results for ESGP in both positions across four conditions*

Source	Variable	df	F	Sig.
Gender	0 kg without lift	1	0.002	.967
	1 kg without lift	1	.106	.747
	2 kg without lift	1	.121	.731
	3 kg without lift	1	.149	.703
	0 kg with lift	1	.101	.753
	1 kg with lift	1	.013	.910
	2 kg with lift	1	.242	.627
	3 kg with lift	1	.074	.788

Results of MANOVA indicated that no significant difference for ESGP values in any of the weight conditions in both with and without lift positions between males and females.

2.1.3. Comparison of ESGP measures without lift position across different weight conditions in males and females

Tables 24 shows the repeated measures ANOVA results of ESGP in males and females, across different weight conditions in without lift position.

Repeated measures ANOVA results revealed that no significant difference exists in the ESGP values of males and females across different weight conditions in without lift position.

Table 24: *Repeated Measures ANOVA results of ESGP for males and females in without lift position*

	Males			Females		
Source	df	F	Sig.	df	F	Sig.
Condition	3	14.588	.17	3	29.138	.25
Condition X Gender	0			0		

As per the results of the present study, no significant difference is reported between the ESGP measures of both males and females, in without lift position, across all the weight conditions. This is in agreement with the results of the study by Orlikoff (2008). This may be because, during without lift position across all the weight conditions, the participants do not experience the weight of the dumbbells, since they are resting their arms on the surface while phonating.

2.1.4. Comparison of ESPG measures at with lift position across different weight conditions in males and females

Tables 25 shows the Repeated Measures ANOVA results of ESGP in males and females, across different weight conditions at with lift position.

Table 25: *Repeated measures ANOVA of ESGP in males &females in lift position*

	Males			Females		
Source	df	F	Sig.	df	F	Sig.
Condition	3	61.464	.000*	3	50.097	.000*
Condition X Gender	0			0		

(* indicates statistical significance at 0.05 level)

Repeated Measures ANOVA results showed that a significant difference is present in the ESGP values of males across different weight conditions in with lift position [$F(3, 42) = 61.464$, $P < 0.05$]. Bonferroni adjustment for multiple comparison indicated a significant difference between the ESGP measures of all the weight conditions; 0 Kg - 1 Kg, 0 Kg - 2Kg, 0 Kg – 3Kg, 1 Kg – 2 Kg, 1 Kg – 3 Kg, and 2 Kg – 3 Kg [$p < 0.05$], in with lift position for males.

Repeated Measures ANOVA results showed that a significant difference is present in the ESGP values of females across different weight conditions in with lift position [$F (3, 42) = 50.097$, $P < 0.05$]. Bonferroni adjustment for multiple comparison indicated a significant difference between the ESGP measures of all the weight conditions; 0 Kg - 1 Kg, 0 Kg - 2Kg, 0 Kg – 3Kg, 1 Kg – 2 Kg, 1 Kg – 3 Kg, and 2 Kg – 3 Kg [$p < 0.05$], in with weight position for females.

The results of the present study revealed that there is a significant difference in the ESGP measures at with lift position, in both males and females, across different weight conditions. This finding can be attributed to the fact that, different weight conditions bring about different degrees of glottal closure, leading to varying amounts of ESGP build up. Hence, the different weights supported will lead to different ESGP values. These results are in consonance with the findings of the study reported by Orlikoff (2008) which reported an increase in the ESGP measures in the after lift position across the different weight conditions as compared to that in before lift position.

2.1.5. Comparison of ESGP measures at with and without lift positions at each weight condition using paired sample t test

Paired sample t-test results revealed a significant difference in the ESGP values of 0 Kg weight condition [$t = -4.954$, $p < 0.05$], 1 Kg weight condition [$t = -7.758$, $p <0.05$], 2 Kg weight condition [$t = -7.090$, $p < 0.05$] and 3 Kg weight condition [$t = -9.792$, $p < 0.05$] between with and without lift positions for males.

Results of paired sample t-test indicated significant difference in the ESGP measures of all the weight conditions, 0 Kg weight condition [$t = -3.033$, $p < 0.05$], 1 Kg weight condition [$t = -5.071$, $p < 0.05$], 2 Kg weight condition [t = -

5.282, $p < 0.05$] and 3 Kg weight condition [$t = -7.326$, $p < 0.05$] between with and without lift positions for females.

Table 26:*Results of Paired t-test for comparison of ESGPbetween different positions across each weight condition*

Conditions		Males			Females		
		t	Df	Sig. (2-tailed)	t	df	Sig. (2-tailed)
Pair 1	0 Kg without lift- 0 Kg with lift	-4.954	14	.000*	-3.033	14	.009*
Pair 2	1 Kg without lift- 1 Kg with lift	-7.758	14	.000*	-5.071	14	.000*
Pair 3	2 Kg without lift- 2 Kg with lift	-7.090	14	0.000*	-5.282	14	.000*
Pair 4	3 Kg without lift- 3 Kg with lift	-9.792	14	0.000*	-7.326	14	.000*

(* indicates statistical significance at 0.05 level)

The results of the present study indicated that there is a significant difference in the ESGP values when comparison is made for each of the weight conditions at with and without lift positions, in males as well as females. These findings are in agreement with the findings of the study done by Orlikoff (2008), wherein ESGP values increased significantly in the after lift condition as compared to the pre-lift data, during the weight support task. This may be attributed to the increased glottal closures which accompany the performance of strenuous effort closure activities, leading to an increased subglottic pressure build up.

2.2. Mean Air Flow Rate (MAFR)

2.2.1. Comparison of MAFR measures between with and without lift positions in males and females across four weight conditions

Table 27 shows the mean and standard deviation of Mean Air Flow Rate (MAFR) values in with and without lift positions in males and females across four weight conditions.

Table 27: *Mean and SD of MAFR in males and females between two positions*

Mean Air Flow Rate (MAFR) (L/sec)								
	Males				Females			
	Without lift		With lift		Without lift		With lift	
Weight conditions	Mean	SD	Mean	SD	Mean	SD	Mean	SD
0 Kg	.28	.09	.27	.09	.40	.16	.38	.14
1 Kg	.27	.09	.24	.07	.38	.14	.33	.12
2Kg	.25	.08	.21	.05	.36	.12	.29	.09
3Kg	.25	.06	.18	.04	.34	.10	.24	.07

While comparing the MAFR values between with and without lift positions across all the weight conditions, a decrease in MAFR values was noticed in with lift as compared to without lift position. Regardless of the weight supported by the participants, a reduction in the MAFR was evidenced in with lift as compared to the without lift position. This may be ascribed to the fact that increased glottal closure during weight lifting will result in elevated laryngeal resistance leading to a reduction in MAFR.

Table 28 shows the Mixed ANOVA results of MAFR values for with and without lift positions across four different weight conditions, in males and females.

Table 28: *Mixed ANOVA results of MAFR in males and females between two positions*

Source	df	F	Sig.
Position	1	116.407	.000*
Position X Gender	1	7.138	.012*
Condition	3	51.998	.000*
Condition X Gender	3	4.403	.006*
Position X Condition	3	98.633	.000*
Position X Condition X Gender	3	3.831	.013*

(* indicates statistical significance at 0.05 level)

Results of mixed ANOVA revealed that there was a significant difference (main effects) obtained for position [F (1, 28) = 116.407, P < 0.05] and condition [F (3, 84) = 51.998, P < 0.05]. Also, the test indicated a significant interaction effect for position and gender [F (1, 84) = 7.138, p < 0.05], condition and gender [F (3, 84) = 4.403, p < 0.05], position and condition [F (3, 84) = 98.633, p < 0.05], and position and condition and gender [F (3, 84) = 3.831, p < 0.05].

Bonferroni adjustment for multiple comparison revealed that there was a significant difference seen between the MAFR measures of all the weight conditions 0 Kg - 1 Kg, 0 Kg - 2Kg, O Kg – 3Kg, 1 Kg – 2 Kg, 1 Kg - 3 Kg, and 2 Kg – 3 Kg [p < 0.05] between with and without lift positions.

A statistically significant position and condition effect was indicated for MAFR measures in with and without lift positions for both males and females. This result is not in agreement with the findings of the study by Orlikoff (2008), wherein no significant change in MAFR was reported as the participants supported weights.

An increase in MPT, and adequate breath control with less fatigue was reported in patients with UVFP, Parkinson's disease, sulcus vocalis etc. subsequent to voice therapy incorporating effort closure regimens like pushing method (Froeschels, Kastein, & Weiss, 1955; Yamaguchi et al., 1993; Mattioloi et al, 2011). This can be attributed to the reduced MAFR due to an improvement in glottal closure subsequent to voice therapy centred on effort closure regimens.

2.2.2. Gender difference for average MAFR measures in with and without lift positions across different weight conditions

Table 29 shows the MANOVA results of MAFR values in with and without lift positions across four different weight conditions.

Table 29: *MANOVA results for MAFR in both positions across four conditions*

Source	Variable	df	F	Sig.
Gender	0 kg without lift	1	6.840	.014*
	1kg without lift	1	6.561	.016*
	2kg without lift	1	7.918	.009*
	3kg without lift	1	8.030	.008*
	0kg with lift	1	6.565	.016*
	1kg with lift	1	6.282	.018*
	2kg with lift	1	6.894	.014*
	3kg with lift	1	6.729	.015*

(* indicates statistical significance at 0.05 level)

Results of MANOVA indicated that a significant difference exists for MAFR values in all the weight conditions in both with and without lift positions between males and females. This may be attributed to the anatomic and physiologic differences between the two genders (Titze, 1988).

2.2.3. Comparison of MAFR measures at without lift position across different weight conditions in males and females.

Table 30: *Repeated Measures ANOVA results of MAFR for males and females in without lift position*

	Males			Females		
Source	df	F	Sig.	df	F	Sig.
Condition	3	11.527	.14	3	16.562	.85
Condition X Gender	0			0		

Tables 30 shows the Repeated Measures ANOVA results of MAFR for males and females, across different weight conditions in without lift position.

Repeated Measures ANOVA results revealed that no significant difference exists in the MAFR values of males and females across different weight conditions in without lift position. As per the results of the present study, no significant difference is reported in the MAFR measures of both males and females, in without lift position, across all the weight conditions. This is in agreement with the results of the study by Orlikoff (2008). This may be because, during without lift position across all the weight conditions, the participants do not experience the weight of the dumbbells, since they are resting their arms on the surface while phonating.

2.2.4. Comparison of MAFR measures in with lift position across different weight conditions in males and females

Tables 31 shows the Repeated Measures ANOVA results of MAFR in males and females, across different weight conditions in with lift position.

Table 31: *Repeated Measures ANOVA results of MAFR for males and females in with lift position*

	Males			Females		
Source	df	F	Sig.	df	F	Sig.
Condition	3	27.212	.000*	3	41.294	.000*
Condition X Gender	0			0		

(* indicates statistical significance at 0.05 level)

Repeated Measures ANOVA results showed that a significant difference is present in the MAFR values of males [F (3, 42) = 27.212, P < 0.05] and females [F (3, 42) = 41.294, P < 0.05] across different weight conditions in with lift position. Bonferroni adjustment for multiple comparison indicated a significant difference between the MAFR measures of all the weight conditions; 0 Kg - 1 Kg, 0 Kg - 2Kg, 0 Kg – 3Kg, 1 Kg – 2 Kg, 1 Kg – 3 Kg, and 2 Kg – 3 Kg [p < 0.05], in with lift position for males and females .

The results of the present study revealed that there is a significant difference in the MAFR measures in with lift position, of both males and females, across different weight conditions. This finding can be attributed to the fact that, different weight conditions bring about different degrees of glottal closure, leading to varying amounts of laryngeal resistance, and a subsequent reduction in MAFR. Hence, the different weights supported will lead to different MAFR values. These results are in contrary to the findings of the study reported by Orlikoff (2008) which reported no significant difference in MAFR measures in the after lift position across the different weight conditions as compared to that in before lift position.

2.2.3. Comparison of MAFR measures at with and without lift positions at each weight condition using paired sample t test

Table 32:*Results of Paired t-test for comparison of MAFRbetween different positions across each weight condition*

Conditions		Males			Females		
		t	Df	Sig. (2-tailed)	t	df	Sig. (2-tailed)
Pair 1	0 Kg without lift- 0 Kg with lift	5.752	14	.000*	4.393	14	.001*
Pair 2	1 Kg without lift- 1 Kg with lift	6.180	14	.000*	7.427	14	.000*
Pair 3	2 Kg without lift- 2 Kg with lift	6.736	14	0.000*	7.113	14	.000*
Pair 4	3 Kg without lift- 3 Kg with lift	7.021	14	0.000*	9.719	14	.000*

(* indicates statistical significance at 0.05 level)

Paired sample t-test results revealed a significant difference in the MAFR values of 0 Kg weight condition [$t = 5.752$, $p < 0.05$], 1 Kg weight condition [$t = 6.180$, $p < 0.05$], 2 Kg weight condition [$t = 6.736$, $p < 0.05$] and 3 Kg weight condition [$t = 7.021$, $p < 0.05$] between with and without lift positions for males.

Results of paired sample t-test indicated significant difference in the MAFR measures of all the weight conditions, 0 Kg weight condition [$t = 4.393$, $p < 0.05$], 1 Kg weight condition [$t = 7.427$, $p < 0.05$], 2 Kg weight condition [$t = 7.113$, $p < 0.05$] and 3 Kg weight condition [$t = 9.719$, $p < 0.05$] between with and without lift positions for females.

The results of the present study indicated that there is a significant difference in the MAFR values when comparison is made for each of the weight condition between with and without lift positions, in males as well as females.

These findings are in contradiction with the findings of the study done by Orlikoff (2008), wherein MAFR values had no significant difference in the after lift condition as compared to the pre-lift data, during the weight support task.

2.3. Laryngeal Airway Resistance (LAR)

2.3.1. Comparison of LAR measures between with and without lift positions in males and females across four weight conditions

Table 33 shows the mean and standard deviation of LAR values in with and without lift positions in males and females across four weight conditions.

Table 33: *Mean and SD of* LAR *in males and females between two positions*

Laryngeal Airway Resistance (LAR)(cm H_2O/L/s)								
	Males				Females			
Weight Condition	Without lift		With lift		Without lift		With lift	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
0 Kg	20.49	6.18	21.55	6.63	14.97	6.15	16.32	6.70
1 Kg	21.83	6.70	26.13	7.75	15.87	6.27	19.70	8.07
2Kg	23.65	7.27	31.18	9.01	16.95	6.18	23.20	8.52
3Kg	24.79	7.59	37.27	9.83	18.20	6.23	29.55	9.36

SD: Standard Deviation

While comparing the LAR values between with and without lift positions across all the weight conditions, an increase in LAR values was noticed in with lift position as compared to without lift position. This may be attributed to the physiological explanation that increased glottal closure during weight lifting will result in elevated LAR to the flow of air through the glottis. Table 34 shows the Mixed ANOVA results of LAR values at with and without lift positions across four different weight conditions, in males and females.

Table 34: *Mixed ANOVA results of* LAR *in males and females between two positions*

Source	df	F	Sig.
Position	1	247.162	.000*
Position X Gender	1	.711	.406
Condition	3	235.165	.000*
Condition X Gender	3	3.190	.028*
Position X Condition	3	181.941	.000*
Position X Condition X Gender	3	1.135	.340

(* indicates statistical significance at 0.05 level)

Results of mixed ANOVA revealed that there was a significant difference (main effects) obtained for position [F (1, 28) = 247.162, P < 0.05] and condition [F (3, 84) = 235.165, P < 0.05]. Also, the test indicated a significant interaction effect between condition and gender [F (3, 84) = 3.190, p < 0.05] and position and condition [F (3, 84) = 181.941, p < 0.05]. Bonferroni adjustment for multiple comparison revealed that there was a significant difference seen between the LAR measures of all the weight conditions 0 Kg - 1 Kg, 0 Kg - 2Kg, O Kg – 3Kg, 1 Kg – 2 Kg, 1 Kg - 3 Kg, and 2 Kg – 3 Kg [p < 0.05].

A statistically significant position and condition effect was indicated for LAR measures at with and without lift positions in both males and females. This result is in agreement with the findings of the study by Orlikoff (2008), wherein a significant increase in LAR was reported as the participants supported weights. This may be attributed to the increased glottal closure during weight lifting which leads to an elevated laryngeal resistance to the flow of air.

2.3.2. Gender difference for LAR measures in with and without lift positions across different weight conditions

Table 35 shows the MANOVA results of LAR values in with and without lift positions across four different weight conditions.

Table 35: *MANOVA results for LAR in both positions across four conditions*

Source	Variable	df	F	Sig.
Gender	0 kg without lift	1	6.023	.021*
	1kg without lift	1	6.319	.018*
	2kg without lift	1	7.392	.011*
	3kg without lift	1	6.750	.015*
	0kg with lift	1	4.608	.041*
	1kg with lift	1	4.952	.034*
	2kg with lift	1	6.209	.019*
	3kg with lift	1	4.853	.036*

(* indicates statistical significance at 0.05 level)

Results of MANOVA indicated that a significant difference exists for LAR values in all the weight conditions in both with and without lift positions between males and females.

2.3.3. Comparison of LAR measures in without lift position across different weight conditions in males and females.

Tables 36 shows the Repeated Measures ANOVA results of LAR for males and females, across different weight conditions in without lift position.

Repeated Measures ANOVA results revealed that no significant difference exists in the LAR values of males as well as females across different weight conditions in without lift position.

Table 36: *Repeated Measures ANOVA results of LAR for males and females in without lift position*

	Males			Females		
Source	df	F	Sig.	df	F	Sig.
Condition	3	45.992	.52	3	72.547	.41
Condition X Gender	0			0		

2.3.4. Comparison of LAR measures in with lift position across different weight conditions in males and females

Tables 37 shows the Repeated Measures ANOVA results of LAR in males and females, across different weight conditions at with lift position.

Table 37: *Repeated Measures ANOVA results of LAR for males and females in with lift position*

	Males			Females		
Source	df	F	Sig.	df	F	Sig.
Condition	3	120.516	.000*	3	119.885	.000*
Condition X Gender	0			0		

(* indicates statistical significance at 0.05 level)

Repeated Measures ANOVA results showed that a significant difference is present in the LAR values of males [$F(3, 42) = 120.516$, $P < 0.05$] as well as females [$F(3, 42) = 119.885$, $P < 0.05$] across different weight conditions in with lift position. Bonferroni adjustment for multiple comparison indicated a significant difference between the LAR measures of all the weight conditions; 0 Kg - 1 Kg, 0 Kg - 2Kg, 0 Kg – 3Kg, 1 Kg – 2 Kg, 1 Kg – 3 Kg, and 2 Kg – 3 Kg [$p < 0.05$], in with lift position for males and females.

The results of the present study revealed that there is a significant difference in the LAR measures at with lift position, in both males and females, across different weight conditions. This finding can be attributed to the fact that, different weight conditions bring about different degrees of glottal closure, leading to varying amounts of laryngeal resistance. Hence, the different weights supported will lead to different LAR values. These results are in consonance the findings of the study reported by Orlikoff (2008) which reported a significant increase in LAR measures in the after lift position across the different weight conditions as compared to that in before lift position.

2.3.5. Comparison of LAR measures at with and without lift positions at each weight condition using paired sample t test

Table 38:*Results of Paired t-test for comparison of LARbetween different positions across each weight condition*

Conditions		Males			Females		
		T	Df	Sig. (2-tailed)	t	df	Sig. (2-tailed)
Pair 1	0 Kg without lift- 0 Kg with lift	-5.237	14	.000*	-4.229	14	.001*
Pair 2	1 Kg without lift- 1 Kg with lift	-6.306	14	.000*	-6.971	14	.000*
Pair 3	2 Kg without lift- 2 Kg with lift	-10.242	14	0.000*	-9.134	14	.000*
Pair 4	3 Kg without lift- 3 Kg with lift	-12.785	14	0.000*	-12.318	14	.000*

(* indicates statistical significance at 0.05 level)

Paired sample t-test results revealed a significant difference in the LAR values of 0 Kg [$t = -5.237$, $p < 0.05$], 1 Kg [$t = -6.306$, $p <0.05$], 2 Kg [$t = -10.242$, $p < 0.05$] and 3 Kg weight conditions [$t = -12.785$, $p < 0.05$] between with and without lift positions for males and females (0 Kg [$t = -4.229$, $p < 0.05$], 1 Kg [$t = -6.971$, $p < 0.05$], 2 Kg [$t = -9.134$, $p < 0.05$] and 3 Kg weight conditions [$t = -12.318$, $p < 0.05$]).

The results of the present study indicated that there is a significant difference in the LAR values when comparison is made for each of the weight condition between with and without lift positions, in males as well as females. These findings are in agreement with the findings of the study done by Orlikoff (2008), wherein LAR values increased significantly in the after lift condition as compared to the pre-lift data, during the weight support task. This may be attributed to the increased glottal closures which accompany the performance of strenuous effort closure activities, leading to an elevated LAR.

The test – retest reliability was checked using Cronbach's Alpha and was found to be in good agreement for all the parameters [Cronbach's alpha > 0.6, $p < 0.05$].

To summarize, the findings of the present study revealed a significant difference in all the parameters between with and without lift positions, in males. A significant difference was obtained only for CQ, ESGP, MAFR and LAR between with and without lift positions, in females. A significant difference was noticed for all the parameters across the weight conditions with lift position for males. In females, a significant difference was obtained only for CQ, ESGP, MAFR and LAR across the weight conditions within with lift position. No significant differences were noticed in any of the parameters in without lift position across all the four weight conditions in both genders. A significant gender difference existed for average jitter, mean f0, MAFR, and LARmeasures in both positions. No significant gender differences were observed in CQ and ESGP in both positions.

CHAPTER V

SUMMARY AND CONCLUSION

Humans are gifted with the ability to speak. The major elements of human speech production are voice, articulation and language. Voice is the component of speech which offers the speaker a vibratory signal on which speech is superimposed. Voice plays a dual role as a powerful communication aid and as a medium of artistic and emotional expression. The generator of voice is a pair of vocal folds housed within the larynx. The vocal folds vibrate to produce voice. The end product voice is then resonated in the vocal tract. Thus, the voice that we hear is the product of coordinated working of respiratory, phonatory and resonatory systems. Voice reflects the personality of an individual. When the voice deteriorates as a consequence of strain or any pathology, the entire personality suffers with it, giving rise to feelings of low self-esteem. When an individual's pitch, loudness and quality of voice differ from those of others of similar age, gender, cultural background and geographic location, then a voice disorder is considered to exist.

According to National Sample Survey Organization (NSSO) 2002, 8.5% of the Indian population suffers from some sort of voice disorders. Dysphonia encompasses many deviations of phonation usually manifested as a consequence of inappropriate vocal fold approximation (inadequate or excessive). Hyper function and hypo function are the two extremes of improper vocal fold functioning. Vocal hypo function is the lax approximation of the vocal folds as seen in conditions like vocal fold paralysis, Parkinson's disease etc. This glottal gap can lead to the perception of disordered voice characteristics like breathy or hoarse voice quality, asthenia, aperiodicity, diplophonia etc.

Many treatment options are available for the treatment of hypo functional voice disorders, which includes surgical, medical and behavioural rehabilitation. A pre-surgical trial period of voice therapy is often recommended for individuals with unilateral vocal fold paralysis who have a competent cough and do not have aspiration problems (McFarlane, Holt-Romero, Lavorato & Warner, 1991). Some of the voice intervention techniques used for the vocal rehabilitation in UVFP, Parkinson's disease, sulcus vocalis, functional aphonia etc. are pushing and pulling effort closure maneuvers, coughing, half swallow boom etc.

Even moderate levels of physical activity facilitates glottal closure, which is why effort closure or air trapping techniques like pushing and pulling are used in the treatment of hypo functional voice disorders. Effort closure techniques have been reported to improve adduction and subsequent voice **(**Froesehels, Kastein & Weiss, 1995; Mattoli et al, 2011). These techniques are useful not only for improving vocal fold approximation, but also in increasing loudness, reducing pitch and improving the quality of voice. Efficacy studies have been reported regarding the use of pushing method in the treatment of functional aphonia, hysterical high pitch, sulcus vocalis etc. (Boone, 1966; Aldes, 1981; Froeschels, Kastein, & Weiss, 1955).

Although pushing and pulling techniques have been reported to produce desired results, there are caveats. By their nature they induce hyper function, and therefore should be used cautiously in recognition of their potentially abusive behaviour.

The present study made an attempt to investigate the possible role of a weight holding activity as a vocal intervention technique. The study was designed to provide preliminary data on vocal functioning of vocally healthy speakers engaged in a weight lifting task.

Thirty vocally healthy individuals (15 males and 15 females), in the age range of twenty to thirty five years, with BMI in the normal range, served as participants for the study. The participant was made to sit while holding weight (fixed weight dumbbell) in each hand, with both arms rested on a flat surface that was adjusted to his/her shoulder level (without lift position - baseline). The arms were held supine and straight before them in all the conditions namely, 0 Kg, 1 Kg, 2 Kgs and 3 Kgs each, in both arms. The participants were instructed to phonate vowel /a/ at a self-selected comfortable pitch and loudness for a duration of five seconds in without lift position. The Electroglottogram (EGG), was obtained for each participant using the Electroglottograph, Model 6103 (Kay PENTAX). The EGG recordings made in this position across all the weight conditions served as the respective baseline for each of the conditions. After the baseline EGG recordings, the participants were instructed to lift the weights approximately 20 cm from the surface, with the arms remaining straight, supine and parallel to the floor. EGG recordings for 5 seconds duration in the lift position were obtained across the four weight load conditions of 0 Kg, 1 Kg, 2 Kgs and 3 Kgs each, in both arms respectively. For 0 Kg condition the participants performed similar task with closed fists without the weights. A minimum of three EGG recordings were obtained from each participant in each of the four weight loading conditions, in both positions.

A minimum rest period of 5 minutes was provided to the participants following each weight lifting episode. The parameters such as vocal F0, contact quotient and mean percent jitter were derived from the Electroglottogram for all the conditions. These measures were calculated from the middle 3 second portion of the 5 second phonation sample in each of the two positions (with and without lift) across the four weight conditions.

The estimation of Estimated Sub Glottal Pressure (ESGP), Mean Air Flow Rate (MAFR) and Laryngeal Airway Resistance (LAR) were done, wherein the subjects repeated the syllable /pa/ for 5 seconds, in both with and without weight lift positions, across four conditions, namely 0 Kg, 1 Kg, 2 Kgs and 3 Kgs each in both arms respectively. The measures of Estimated Sub-Glottic Pressure (ESGP), Mean Air Flow Rate (MAFR) and Laryngeal Airway Resistance (LAR) were determined by averaging the values obtained in three trials for each participant repeating /pa/ syllable in both the positions across all four conditions.

The data was subjected to statistical analysis to find significant main effect and interaction effect (Mixed ANOVA), to find gender difference (MANOVA), to find the difference in the estimated parameters across different weight conditions in each position for both genders separately (Repeated Measures ANOVA), to find the difference in parameters across each weight condition between with and without lift positions (Paired sample t-test).

The results of the present study revealed several points of interest as follows:

1. Regardless of the amount of weight supported by the participants, a significant reduction in the average jitter measures were evidenced in the lift position as compared to the without lift position. The reduced jitter values may be attributed to the increased adduction of the vocal folds during strenuous activities, like weight lifting.
2. The study revealed a significant difference in the jitter measures within lift position in males across different weight conditions and also between with and without lift positions. No significant difference in the jitter measures within lift positions or between the lift and without lift positions were noticed in females across different weight conditions.

3. Minimal difference was noticed in the mean f0 values between with and without lift positions in both males and females, across all the weight conditions (Descriptive statistics).
4. The study indicated a significant difference between the mean f0 values of the weight conditions 0 Kg - 3 Kg, in lift position, for males. This may be explained based on the assumption that, may be, higher the amount of weight supported, more is the variation in the f0 as compared to the least supported weight.
5. No significant difference was observed between the mean f0 values in both positions across all the weight conditions in females.
6. Contact Quotient (CQ) values were increased in the lift position as compared to without lift position regardless of the weight conditions (Descriptive statistics). This may be elucidated based on the physiological explanation that effort closure techniques like pushing, pulling, weight lifting etc. bring about adduction at the level of glottis, which will be reflected in the electroglottographic results as an increase in the contact quotient of the vocal folds.
7. A significant difference was shown in the CQ measures in lift position, in both males and females, across different weight conditions. This finding can be attributed to the fact that, different weight conditions bring about different degrees of glottal closure. Since the CQ values depend on the amount of glottal closure, the different weight supported will lead to different CQ values.
8. While comparing the ESGP values in with and without lift positions across all the weight conditions, a slight increase in ESGP values was noticed in with lift position as compared to without lift position (Descriptive statistics).

9. The results of the study indicated a significant difference in the ESGP measures in with lift position, across different weight conditions, in both males and females.
10. Regardless of the weight supported by the participants, a reduction in the MAFR was evidenced in with lift as compared to the without lift position. This may be ascribed to the fact that increased glottal closure during weight lifting will result in elevated laryngeal resistance leading to a reduction in MAFR.
11. The study revealed a significant difference in the MAFR measures in with lift position, of both the genders, across different weight conditions.
12. An increase in LAR values was noticed in with lift position as compared to without lift position across all the weight conditions in both genders. This may be attributed to the physiological explanation that increased glottal closure during weight lifting will result in elevated LAR to the flow of air through the glottis.
13. A significant difference exists in the LAR measures in with lift position, across different weight conditions in both males and females.
14. No significant differences were noticed in any of the parameters in without lift position across all the four weight conditions in both genders. This could be because, the participants were not experiencing the weight in the arms as they were rested on the surface. These findings support the findings of Orlikoff (2008).
15. A significant gender difference existed for average jitter, mean f0, MAFR, and LAR measures in both positions which could be attributed to the anatomic and

physiological differences between the genders. No significant gender difference were observed in CQ and ESGP in both positions.

Hence, the conclusion from the present study is that there is an effect of weight lifting and supporting, on electroglottographic and laryngeal aerodynamic measures of voice. Hereafter attempts should be made by the voice professionals to investigate the possible role of effort closure techniques other than pushing method, in bringing about optimum glottal closure for appropriate voice production in individuals with hypo-functional voice disorders.

Implications of the study

1. The results of the present study would provide an insight upon the laryngeal and aerodynamic consequences of a weight lifting activity.
2. The study results can open a window to a new research zone wherein the possible, but, seldom considered role of effort closure techniques other than isometric pushing and pulling as a vocal intervention technique, for certain cases of hypo-functional voice disorders, could be investigated.

   Results of this investigation could be considered a stepping stone towards the idea of providing an objective dimension to the existing effort closure voice therapy techniques.
3. The study findings could direct speech and language professionals in making predictions on when and how an effort closure activity could be employed in the treatment of voice disorders.
4. Hence, the current study may evoke interest in the voice professionals for conducting more investigations regarding the development of new methods of vocal intervention.

Limitations of the study

1. A smaller number of participants were included for the study.
2. In the present study, limited number of parameters are considered for electroglottographic and aerodynamic assessment.
3. The estimation of various parameters is limited to only two positions viz. with and without lift. No parameters were analysed during lifting.
4. The present study is limited only to weight lifting and supporting activity. The effects of other strenuous effort closure techniques on the laryngeal dynamics are not considered.
5. The changes at the level of the larynx could not be visualised in the study. Hence, it is not known whether the participants experienced a supraglottic constriction during the weight lifting activity.

Future research directions

1. Additional work is required to extend this study to other forms of strenuous effort closure activities.
2. Since the literature base is limited, more investigations needs to be conducted in vocally healthy individuals to validate the results.
3. Systematic study on individuals with dysphonia needs to be conducted to check the efficacy of the weight lifting activity in bringing about optimum glottal approximation.
4. Incorporation of videostroboscopy or laryngoscopy could provide valuable insight regarding the glottal dynamics and the rate of vocal fold approximation. It could also provide information regarding the occurrence/non-occurrence of supraglottic hyper-adduction.

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APPENDIX A

Subject selection questionnaire

Name: Age:

Gender: Education:

Height: Weight:

BMI:

Date of procedure:

Yes/No

- Have you undergone any formal vocal or athletic training?
- Do you have history of any auditory pathology?
- Do you have history of any speech or language difficulties?
- Do you have any sort of voice problem?
- Do you have any history of respiratory disorders like asthma, bronchitis,pneumonia or allergic diseases?
- Do you have gastric problem?
- Have you undergone any surgery?
- Are you under any medication?
- Do you consume alcohol; how much, how frequently?
- Do you smoke?
- Do you have your menstrual cycle around this week?