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Language in India www.languageinindia.comISSN 1930-2940 Vol. 21:5 May 2021
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Effect of Hyperbaric Oxygen Therapy on Speech Production in Children with Cerebral Palsy

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Abstract

Introduction

Cerebral palsy (CP) is non-progressive, non-contagious, permanent neurological abnormality. It is caused by damage to or abnormalities inside the developing brain that disrupt the brain's ability to control movement and maintain posture and balance. CP is associated with a peri-natal hypoxic event, placental abnormalities, prolonged labor, or infection transmitted during delivery.

Studies which investigate acoustic characteristics in CP are both challenging and informative. Children with CP have a smaller overall vowel space and more variability of formant values of individual vowels and the vowel space of individual vowels thus overlap more.

Hyperbaric oxygen therapy (HBOT) uses a pressurized chamber, which may be rigid or flexible construction and means of delivering 100% oxygen.100% oxygen under increased pressure saturates bodily fluids and tissue with 10 to 20 times more oxygen. Many researchers have shown HBOT has effective outcome in CP children.

In Indian scenario there is little documentation for the effect of HBOT on speech and language CP children.

Aim

The aim of the study is to observe the changes in acoustic characteristics of vowels before and after the oxygen therapy in CP children.

Methodology

Prior to HBOT speech sample was collected from seven Malayalam speaking CP children. The age range of the subject was 3-8 years. The subjects chosen had normal hearing sensitivity and with borderline or mild intellectual. Stimuli taken were the most familiar words with CVC or CCVC combination. For the spectral characteristics both audio and visual presentation was done and recorded with PRAAT. The vowels selected were 5 cardinal vowels /a/, /e/, /i/, /o/, /u/ and 5 sustained vowels /a:/, /e:/, /i:/, /o:/ and /u:/. The selection of stimulus was done on the basis of familiarity rating.

Acoustic analysis consisted of extracting the formant frequencies F1 and F2. For vowel spacing the psychological distance between f1 and f2 formant frequency data was converted to Barks scale and plotted. Finally, vowel space areas based on bark values were derived from each vowel by both the groups.

Results and Discussions

After HBOT, for vowels like |a|, |e|, |i|, |a:|, |i:| &|u:| had inconsistent variation in formant frequencies. However, there was a consistent pattern of variation in vowels like |o|,|u|,|e:|,|o:|. The maximum change in formant frequency is seen for the vowels like |a|, |i|, |u:|.

Conclusion

The subjective impression on vowel space following the treatment showed improvement in the distinctiveness of production, there by indicating better speech intelligibility. Overall, the results of the current study compliment the effectiveness of the HBOT on speech production in children with Cerebral Palsy.

Keywords: Cerebral Palsy, Oxygen therapy, HBOT, Vowels, Acoustics. Malayalam-speaking CP children.

Introduction

Cerebral Palsy (CP) is a collective term encompassing a group of neurological syndromes resulting from abnormalities in the brain development or an acquired non-progressive cerebral lesion (Bax,1964; Bobath,1980; Platt & Pharoah,1995). In the industrialized world, the prevalence of cerebral palsy is about 2 per 1000 live births. About 20% of children who have cerebral palsy acquire the disorder after birth, while 80 percent of cases are congenital. Meningitis, encephalitis, and trauma cause most of the acquired cases. According to the National Institute of Neurological Disorders and Stroke, until recently, the belief that birth complications cause most cases of cerebral palsy was widespread. Then, in the 1980s, a careful study of 35,000 births showed that fewer than 10 %of children with cerebral palsy had a history of birth complications such as rubella or other infections during pregnancy, jaundice, Rh in compatibility, asphyxia (oxygen shortage), or head trauma during labor and delivery (Kumari,A. & Yadav, 2012). Most children with congenital cerebral palsy do not have a history of any of these conditions. Premature birth and low birth weight predispose to cerebral palsy, but the reason for this association is not clear.

CP is characterized by anomalous control of movement or posture (Palisano, 1997). The condition typically originates during the antenatal, peri-natal, or postnatal periods (Denhoff, 1976). Dysarthria is characterized by disturbances in speech muscular control due to paresis, paralysis, slowness, in-coordination, or aberrant tone of muscles (Duffy, 1995). Dysarthric speech may indicate impairment of one or more motor processes of speech production, including respiration, phonation, resonance, articulation, and prosody. The execution of individual speech musculatures may be slow, weak, and uncoordinated (Duffy 1995). Among all the modalities involved in speech production, the respiratory system was most often found to be compromised in the CP population (Wolfe, 1950). A topographic distribution of the motor disorders, such as the differentiation among Hemiplegia, diplegia, and tetraplegia, is often used to locate the various sites of the Neuromotor disorders (Colver & Sethumadhavan, 2003). Based on the characteristics and manifestations of neuromotor disorders of the limbs, CP can also be classified based on the characteristics of muscle movements and tonicity. There are three major types of CP, namely, spastic, athetoid, and ataxic. Athetoid CP and ataxic CP affect approximately 10 to 20% and 5 to 10% of the cases respectively (Cerebral Palsy Society of India, 2007) Spastic CP is the most common type of CP, affecting approximately 70 to 80% of all cases (Cerebral Palsy Society of India, 2007; Colver & Sethumadhavan, 2003). Spastic Diplegia is the main form of CP related to low gestational age.

Dysarthria is the very common speech disorder associated with CP (Hardy, 1983). An approximate of 30% to 90% of individuals with CP was considered to expose reduced speech intelligibility and some form of dysarthric speech (Yorkston, Beukelman, & Bell,1988;

Kennes, 2002; Hustad, 2003). Individuals with CP often present with spastic or weak muscle tone, resulting in in-coordinated speech patterns, as shown in the presence of imprecise consonants, short phrases, and reduced rate of speech (Hardy, 1983; Love, 1992; Rutherford, 1950; Workinger, 2005). It appears that both articulatory control and oral-laryngeal co-ordination in individuals with CP are susceptible to disturbances in the speech muscular control including control of respiratory musculatures (Bobath, 1980; Love, 1992; Hardy, 1983; Solomon & Charron, 1998; Workinger, 2005). The talkers with cerebral palsy exhibited smaller vowel working space areas compared to ten age-matched controls. (Liua, Tao, & Kuhll, 2005) The distorted vowels of talkers with cerebral palsy compose a smaller acoustic space that results in inter vowel perceptual distances for listeners.

Hyperbaric Oxygen Therapy (HBOT) is a form of medical treatment in which the patient breathes 100% pure oxygen at a pressure greater than the atmospheric pressure, usually twice the level, bringing the plasma oxygen level to 200% more than that achieved by any other method. The therapy is administered as one hour session which involves oxygen managed under pressure to ease hypoxia at the cellular level. The basic conceptual understanding behind HBOT for the treatment of anoxic brain insults is that, to increase the oxygen delivery, and therefore, increasing the metabolic activity of inactive brain cells (Kumari & Yadav, 2012). The insights of physiological processes comply that, following an injury or infarct, brain matter dies and is replaced by glial cells. The area around the gliosis, the peri-infarctional zone, appears as gliosis on scans, but may in fact be viable for years following the initial insult (Sahni, Kukku, Jain & Prasad,2004). HBOT delivers high doses of oxygen to these peri-infarctional zone cells surrounding the dead neurons and may be causing these cells to become metabolically active (Neubauer&Colleagus,1994). Even brain scans like SPECT were able to identify potentially recoverable brain tissues and predict neurological improvement after repetitive HBOT. (Harch, Meter, Staab, and Gottlieb, 20013). The possible mechanism of action of HBO in neurological disorders is relief of hypoxia, improvement of microcirculation and cerebral metabolism, reduced cerebral edema by vaso constrictive effect, increases the permeability of the blood-brain barrier and preservation of partially damaged tissue and prevention of further progression of secondary effects of cerebral lesions. Evidence now shows that HBO therapy may dramatically improve some CP symptoms – spasticity, vision, hearing, and speech (Sahni, T. Hukku & Jain, 2014). Even some of the cognitive measures were improved after HBO2 (Collect, Vanessa, 2001). There were overall some degrees of development in motor, mental and speech characteristic together after 2 days of oxygen therapy (Chavdarov 2002). Recent advance in HBOT may dramatically improve some cerebral palsy symptoms –spasticity, vision, hearing, and speech. The improvement will vary from patient to patient. Most common improvement reported is an increased muscular flexibility (Mikado, 1989). The children with spastic CP had their muscular flexibility increased, the frequency of epileptic seizures also seemed to be diminished (Qibiao, 1995) The functional diagnosis of spastic diplegic CP showed reduced spasticity and significant improvements in gross and fine motor function. Anecdotal studies report greater concentration, increased vigilance, and better speech articulation, but these studies provide converting and determinate the evidence. However, it is reasonable to believe that these cognitive and motor improvements are potentially induced by HBOT. As an outcome of knowing that cerebral plasticity in child's brain increases the potential for recovery. Reactivation of cerebral area early life could have a major impact on intellectual and physical functioning. The children with CP had potential recovery brain tissue and improvement in articulatory system leading to correct way of articulators for speech production (Harch, Meter, Staab, & Gottlie,20013). Post-HBOT there was improvement in motor skills, attention, and language and play. However, they still continue to have CP components (Packard.M, 2000). It is not necessary that there is always improvement after HBOT. When short duration of HBOT was provided there is no improvement in gross motor function, activities of daily life, attention, working memory, speech, and language (Collet and his colleagues, 2001)

The effect of cerebral palsy on speech and language development seems to be devastating, ranging from no speech output to speech with poor articulatory precision depending on the site involved in the brain. Therapy for the cerebral palsy child integrates physical, occupational and speech therapy. Early treatment gives a child a better chance to overcome disabilities. Many studies have revealed the positive effect of HBOT on speech intelligibility in CP children. The promising role of HBOT on speech aspect in children with cerebral palsy needs to be documented with the high level of confidence. It requires well controlled empirical evidence to support the success of HBOT in speech aspects of cerebral palsy. However, literature search revealed that there is limited number of published studies documenting the precise aspects of speech production and perception in cerebral palsy following HBOT. Hence the present study aims to compare the acoustic characteristics of vowels before and after HBOT.

Methodology

Participants

7 children with varying degree and type of cerebral palsy within the age range of 4 to 8 years were taken as participants in the study.

Stimulus

5 cardinal vowels /a/, /e/, /i/, /o/, /u/ and their longer counterparts were taken as the

stimulus. A word list was formed in Malayalam, in which all the vowels were embedded in a meaningful, picturable word. Words formed were in CVC combination to maintain the uniformity. Familiarities rating of all the words were performed by 3 Speech Language Pathologists with native language being Malayalam.

A female talker of 20 years read the words. A Sony microphone was kept at a distance of 6-8 cm in a sound-treated room.

Instrumentation

The subjects were asked to see the picture displayed in personal computer.They were asked to repeat it back which was recorded in Praat.

Software: Praat

Speech sample was recorded and analysed in Praat software. It is a freeware program and a flexible tool for the analysis and reconstruction of acoustic speech signals. It can be used on different operating systems. It offers a wide range of standard and non-standard procedures, including spectrographic analysis, articulatory synthesis, and neural networks.

Acoustic Analysis

For the purpose of acoustic analysis, the target vowels were extracted from the sentence. The acoustic analysis of the target vowel was done using Praat software (Boersma, & Weenink 2008). The main acoustic features that were analyzed were steady –state formant and dynamic formant movement. Vowel duration measurement was made from both the spectrogram and waveform view. It was measured as the time difference between the starting of first glottal pulse after the consonant till the sharp drop in the amplitude associated with the beginning of the final consonant. Steady and dynamic formant frequencies measurements were derived from the LPC formant tracking and then manually placing the cursor at the desired point to get the formant frequencies. In cases where vocal irregularities affected the clarity of the site of vowel formants, the cursor was moved until the formants were clearly visible. Values of the first two formants (F1 and F2) were extracted from the vowel duration (following Hillenbrand, Getty, Clark &Wheeler, 1995) and at the vowel steady state. In order to normalize psychological distance over F1 and F2 (Kewley-Port & Zeng,1999), formant frequency data were converted to Barks scale where Fi is the frequency. Finally, vowel space area based on the bark values were derived from each vowel produced in each of the two speaking styles for comparison. Dynamic formant frequencies measurements were done by measuring the spectral change. Spectral change corresponded to the sum, in Barks, of the absolute formant frequency shift for F1 and F2.

Procedure

In order to check the effectiveness of HBOT on speech production, speech sample was elicited and analyzed before and after ten sessions HBOT. Each session of HBOT sessions lasted for 1.5 ATA/60 minutes, six days a week. The stimulus was presented in auditory and visual mode simultaneously, the word was recorded directly into computer disk at 16-bite accuracy using creative sound card at a sampling rate of 44100 Hz. using PRAAT software (Boresma, & Weenink, 2008). The vowel duration measurement was made from both spectrogram and waveform view. It was measured as the time difference between the starting of first glottal pulse after the consonant till the sharp drop in the amplitude associated with the beginning of the final consonants. Values of the first two formants (F1 and F2) were extracted from formant tracks at the vowels steady state. In order to normalize psychological distance over F1 and F2 (Kewley-Port &Zeng, 1999), formant frequency data were converted to Barks. Finally, vowels space area based on the Bark values were derived from each vowel for pre and post HBOT sessions.

Results and Discussion

The results obtained from acoustic analysis of the vowels are presented below:

Vowel space in CVC context

Figure 1 depicts the vowel space area for short and long vowels pre and post HBOT. The five point vowel space produced in CVC context words for short vowels by Malayalam speakers the vowels are |u|, |o|, |a|, |e|, |i| in clockwise direction.

The vowel spaces were expanded in post HBOT for short and long vowels, when compared to pre HBOT session. This indicates that the area bounded by corner vowels /i/, /a/, /e/, /u/, and /o/, has been observed to be increased, thereby reflecting more distinctiveness in the vowel compared to the compressed vowel space before the treatment. More the distinctiveness in the vowel betters the speech intelligibility. Liu et al (2005) reported that children with CP have a smaller overall vowel space and more variability of formant values of individual vowels and the vowel space of individual vowels thus overlap more. However, in the present study similar result was noted for pre HBOT data, whereas post HBOT the vowel space area increased, indicating more distinctiveness in the vowel. This is in accordance with the studies conducted by Packard. M (2000), Harch. G. P., et al. (1999) who reported improvements in motor skills, attention, language and play following HBOT in children with CP.

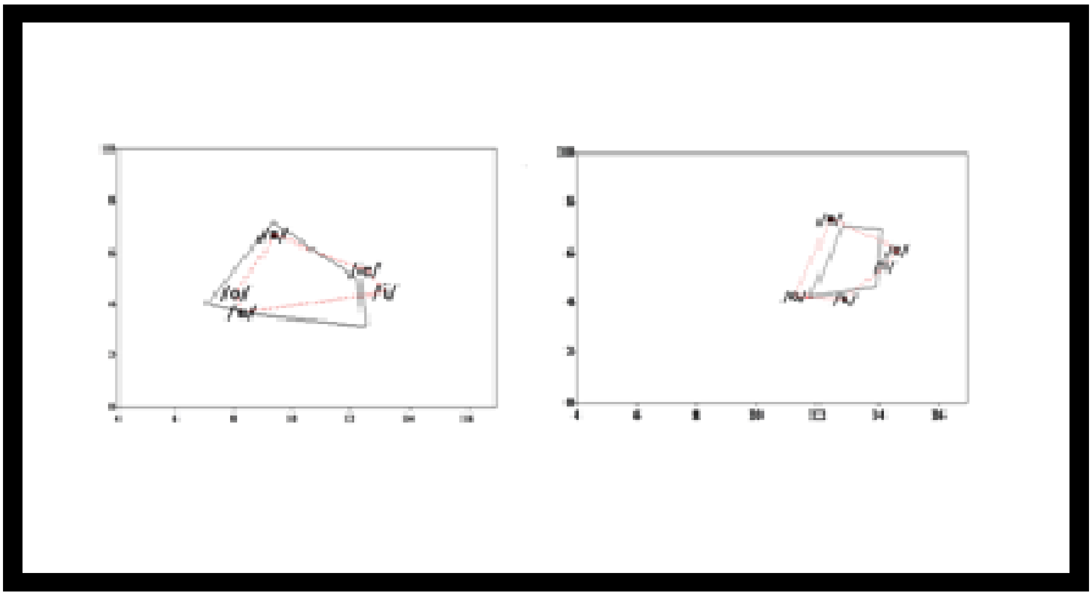

Figure 1: Depicts the results using vowel space of pre HBOT indicated by red dotted line and vowel space of post HBOT indicated by black continuous line.

As can be seen from the graph F1 for short vowels, pre and post HBOT shows no significant difference, whereas F2 shows increase in frequency post HBOT. However, the long vowels do not show a consistent pattern of increased formant frequency post HBOT sessions, for example in pre & post HBOT for vowels like |a|, |e|, |i|, |a:|, |i:| &|u:|formant frequencies are inconsistent variation and also the result showing there is a consistent pattern of variation in vowels like |o|,|u|,|e:|,|o:|. The maximum change in formant frequency is seen for the vowels like |a|, |i|, |u:|.

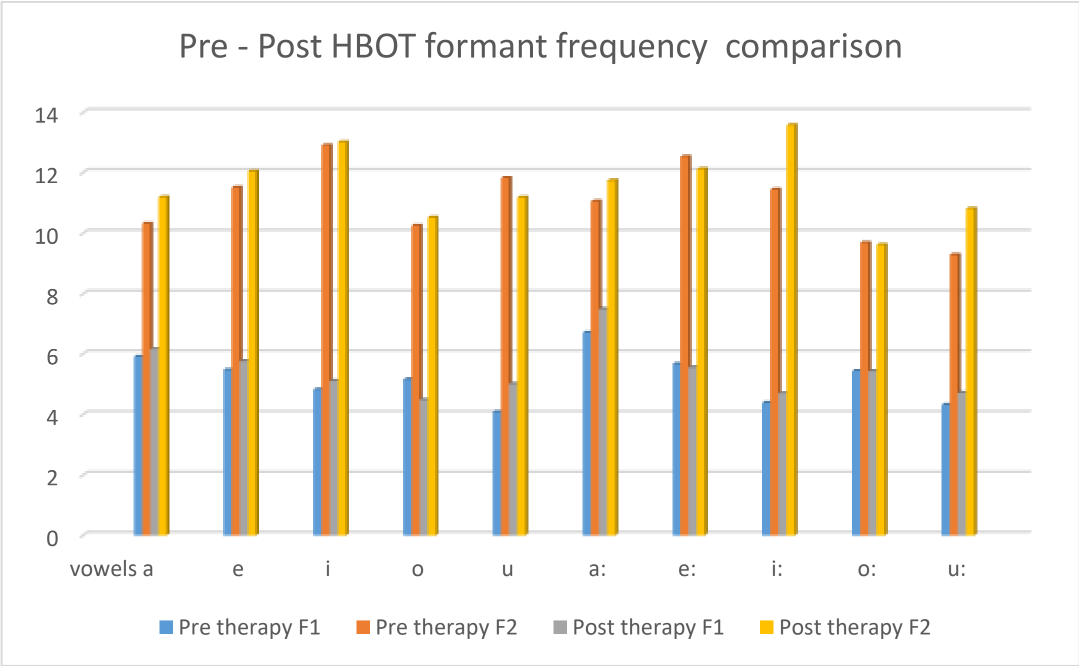

Figure 2: Shows the comparison between pre & post HPOT for F1 and F2 mean values.

The results of the present study focus on the quality and consistency of clinical outcome of the use of HBOT in children who have cerebral palsy. The results showed an increase in the vowel space area, indicating more distinctiveness in the vowel. Similar results were reported in studies conducted by Packard. M (2000), Harch. G. P., Meter. V. K., Staab. P., Gottlieb. S. (1999) who reported improvements in motor skills, attention, language and play following HBOT in children with CP. The effect of reduced vowel working space on speech intelligibility in Mandarin-speaking young adults with cerebral palsy, where they assessed the variability in speech production in 4 Mandarin-speaking children: two with cerebral palsy (CP) and two typically developing (TD) from 4 to 5 years of age. And results indicated that 1) Due to defect in speech motor control, children with CP have a smaller overall vowel space; 2) In CP group, there are more variability of formant values of each vowel and the vowel space of each vowel thus overlap more; 3) There is a trend of decrease of vowel formant values in both TD and CP; 4) Children with CP tend to spend more time in speech production because of their impaired speech-motor control, in terms of syllable per minute and intelligible syllable per minute; and 5) Slower speech rate seems to increase speech intelligibility in CP. The relationship between vowel space and intelligibility in dysarthric speech has been of interest to researchers and clinicians particularly for production of clear speech based on HBOT as a treatment means to enhance vowel contrast and thereby improve a speaker's overall speech intelligibility. Further studies are needed to verify these preliminary findings, the variability features in the production of children with CP provide important note in speech therapy.

Conclusion

The subjective impression on vowel space following the treatment showed improvement in the distinctiveness of production, thereby indicating better speech intelligibility. Overall, the results of the current study compliment the effectiveness of the HBOT on speech production. However, further research needs to be conducted in larger population to document the effect under various speech production analyses.

Limitations

- Number of subjects taken in the study were limited.
- Number of sessions between Pre and post HBOT were only 10. This may limit the effect of HBOT.
- Speech and language baseline before HBOT needs to be established for a better comparison.

Future Directions

- Effect of HBOT of other parameters of speech can be studied.
- More number of subjects with equal number of sessions needs to be studied.

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References

Ansel, B. & Kent, R. (1992). Acoustic-phonetic contrasts and intelligibility in the dysarthria associated with mixed cerebral palsy. *Journal of Speech and HearingResearch, 35*, 196-308.

Chen, L. Ni, H. Kuo,T. & Hsu, K. (2012) Acoustic variability in the speech of children. *Acoustical Society of America*

Chen, W., Chen, L., and Cheng, F. (2013). Acoustic vowel space and speech rate in Mandarin- speaking children with cerebral palsy. *Acoustical Society of America*

Fiona, P.Y. (2007)**.** Impact of breath group control on the speech of normal and individual with cerebral palsy. *University of Canterbury, 4-34.*

Collet, JP, Vanasse, M.& Marois, P. (2001). Hyperbaric oxygen for children with cerebral palsy: A randomized multicentre trial.

HBO-CP Research Group. 357(9256): 582-86.

Denhoff, E. (1976). Medical Aspects. In W. M. Cruickshank (Ed.), *Cerebral palsy: A developmental disability* (3rd ed., pp. 29 - 71). New York: Syracuse University Press.

Fiona, P. (2007). Impact of Breath group control on the speech of normal and individual with cerebral palsy. *University of Canterbury.*

Fitch, W. (1997) Vocal tract length and formant frequency dispersion correlate with body size in rhesus macaques. *J. Acoustic. Soc. Am., Vol. 102, No. 2,*

Harch, P. Meter. Staab, P. & Gottlieb, S. (1999). Hyperbaric oxygen therapy for cerebral palsy and static encephalopathy of childhood. *www.uddan.org*.

Harch, P. Meter. Staab, P. Gottlie, S. (2013). Hyperbaric oxygen therapy for cerebral palsy and static encephalopathy of childhood. www.uddan.com.

Hardy, P. Collet, JP. Goldberg, J. et al. (2002) Neuropsychological effects of hyperbaric oxygen therapy in cerebral palsy. *Journal of Developmental Medicine & Child Neurology. -44:436– 446*.

Kim H, Hasegawa-Johnson M, Perlman A. Vowel contrast and speech intelligibility in dysarthria. Folia Phoniatr Logop. 2011;63(4):187-94. doi: 10.1159/000318881.

Hustad, K. (2006) Estimating the intelligibility of speakers with dysarthria. *217-228 Doi; 10.1159/000091735*

Hustad, K. C., Auker, J., Natale, N., & Carlson, R. (2003). Improving Intelligibility of Speakers with Profound Dysarthria and Cerebral Palsy. *Augmentative and Alternative Communication, 19(3),* 187-198.

Hustad, K., Schueler, B., Schultz, L. and DuHadway· (2012). Intelligibility of 4 year old children with and without cerebral palsy.*US National Library of Medicine National Institutes of Health DOI:10.1044/1092-4388(2011/11-0083)*

Kent, R. D., Netsell, R., & Abbs, J. H. (1978). Articulatory abnormalities in athetoid cerebral palsy. *Journal of Speech and Hearing Disorders, 43,353-373.*

Kent, R. D., Weismer, G., Kent, J. F., Vorperian, H. K., & Duffy, J. R. (1999). Acoustic studies of dysarthric speech: methods, progress, and potential. *Journal of Communication Disorders, 32*(3), 141-180, 183-146; 181-143, 187-149.

Kent RD., Weismer G., Kent JF., Vorperian HK., Duffy JR. Acoustic studies of dysarthric speech: methods, progress, and potential. J Commun Disord. 1999 May-Jun;32(3):141-80, 183-6; quiz 181-3, 187-9. doi: 10.1016/s0021-9924(99)00004-0. PMID: 10382143.

Kim, H. Johnson, & Perlman, A. (2011) Vowel Contrast and Speech Intelligibility in Dysarthria**.** *DOI: 10.1159/000318881*.

Lacey, D., Stolfi, A. & Pilati, L *(2012)* Effects of hyperbaric oxygen on motor function in children with cerebral palsy. *Ann Neurol.; 72(5): 695-703.*

Lansford, K., & Liss, J. (2014). Vowel Acoustics in Dysarthria: Speech Disorder Diagnosis and Classification. *Journal of Speech, Language, and Hearing Research • Vol. 57 • 57–67*

Levitt, S. (1995). *Treatment of cerebral palsy and motor delay, (2nd Ed.). Oxford: Blackwell.*

Lindblom, B. (1990). Models of phonetic variation and selection. *Phonetic Experimental*

Research, 11, pp. 101–118.

Liu, H. M., Tsao, F. M., & Kuhl, P. K. (2005). The effect of reduced vowel working space on speech intelligibility in Mandarin-speaking young adults with cerebral palsy. *Journal of the Acoustical Society of America, 117(6), 3879-3889.*

MacDonagh, M. & Morgan, D. (2007) Systematic review of hyperbaric oxygen therapy for cerebral palsy: the state of evidence. *Developmental Medicine & Child Neurology , 49: 942–947*

MacDonagh, M. Carson & Ash (2003). *Hyperbaric Oxygen Therapy for Brain Injury Cerebral palsy & Stroke.* Retrieved from *http://www,ahrq.gov*

Maoris, P, Vanasse M. Hyperbaric oxygen therapy and cerebral palsy. *Dev Med Child Neurol.*2003; 45:646– 648.

Mukherjee, A (2013) Hyperbaric therapy –Based Multimode Therapy for children with CP. Retrieved from www.Udaan .org

Peterson,G. & Barney, H. (1952).Control methods used in a study of the vowels. *The journal of the acoustical society of America, Vol. 24, No. 2, 175-184.*

Rockswold, S., Rockswold, G., Vargo, J. Effects of hyperbaric oxygenation therapy on cerebral metabolism and intracranial pressure in severely brain injured patients. *J Neurosurg.2001; 94:403– 411.*

Rothman, J. G. (1978). Effects of respiratory exercises on the vital capacity and forced volume in children with cerebral palsy. *Physical Therapy*, 5*8*, 421-425. *Retrieved from www.UDAAN.org.*

Sahni, T. Hukku., Jain, M. & Prasad, P. (2004) Recent advances in hyperbaric oxygen therapy *MEDICINE UPDATE, Volume 14, The Association of Physicians of India.*

Spencer, K. A., Yorkston, K. M. & Duffy, J. R. (2003). Behavioral management of respiratory/phonatory dysfunction from dysarthria: a flowchart for guidance in clinical decision making. *Journal of Medical Speech-Language Pathology, 11(2), xxxix-lxi.*

Stanley, F. J. (1997). Prenatal determinants of motor disorders. *Acta Paediatrica, 422, 92-102.*

Stanley, F., Blair, E. & Alberman, E. (2000). *Cerebral palsies: epidemiology and casual pathways*. London: Mac Keith Press.

Stockwell, K. (2015) Acoustic analysis of speech produced by Children with CP.

Neubauer, R, & James, P. (1994) Cerebral oxygenation and the recoverable brain. Neurol Res.; 20

Neubauer, R, & James, P. (1994) Cerebral oxygenation and the recoverable brain. Neurol Res.; 20 Suppl 1: S33-6.1: S33-6.

Tjaden, K., Rivera, D., Wilding, G., & Turner, G. S. (2005). Characteristics of the lax vowel space in dysarthria. *Journal of Speech Language and Hearing Research,48(3), 554-566.*

Tsao, Y-C., Weismer, G., & Iqbal K. (2006). The effect of intertalker speech rate variation on acoustic vowel space. *Journal of the Acoustical Society of America, 119*(2), 1074-1082.

Turner, G. S., Tjaden, K., & Weismer Wang, Y., Kent, R. D., Duffy, J. R., & Thomas, J.E. (2005). Dysarthria in traumatic brain injury: A breath group and into national Analysis. *Folia PhoniatricaLogopaedica,57, 59 - 89.*

Wolfe, W. G. (1950). A comprehensive evaluation of fifty cases of cerebral palsy. *Journal of Speech and Hearing Disorders, 15*, 234-251.

Yorkston, K. M., Beukelman, D. R., & Bell, K. R. (1988). *Clinical management of* dysarthric *talkers.* Austin, Texas: Pro-Ed.

Yorkston, K., Beukelman, D., Strand, E., & Bell, K. (1999). *Management of Motor Speech Disorders in Children and Adults.* Austin, Texas: Pro-Ed.

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