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Research Article

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Effects of Oromotor Exercises for Dysarthric Speech

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ABSTRACT

Background: Dysarthria is a motor speech disorder which can certainly occur with other impairments such as imprecise articulation and reduced rate of speech which leads to reduced speech intelligibility as it due to the lesion in the nervous system. Hence treatment for the same has become a major concern which falls into the remit of the speech-language pathologists. There have been various studies regarding the treatment of dysarthria to improve speech production. However, the effects of the oral motor exercises need to be determined.

Objective: The study aimed to analyse the effectiveness of Oro-Motor Exercises (OME) where percentage of intelligibility as one of the perceptual measures and acoustic based Formant Centralization Ratio (FCR) were considered as determining parameters.

Method: A total of 4 female subjects with the diagnosis of dysarthria secondary to cerebrovascular accident participated in the study. Single group pre- post therapy design was adopted. Speech samples were recorded both before and after the treatment condition. The phonemes /a/, /i/, and /u/ were analyzed perceptually and acoustically in speech samples that included narrative. Oro-motor control exercises were part of the treatment strategy to increase the oral structures' range of motion, accuracy, and speed.

Results: Pre and post treatment evaluations showed significant improvement in percentage of speech intelligibility. Also, reduced FCR in post therapeutic condition indicated of effectiveness of OME to yield speech with better intelligibility.

Conclusion: A positive correlation was seen between perceptual and acoustical measures of speech intelligibility that asserted the efficacy of oro-motor exercises in dysarthric speech.

Keywords: Dysarthria, Oro-Motor Exercises, Speech Intelligibility, Formant Centralization Ratio, Acoustic Analysis, Efficacy

Introduction

The human nervous system controls numerous intricate bodily processes. Motor speech disorder which entails nervous system dysfunction occurs as a result of illness or disease. The diagnostic label, motor speech disorders has been widely used to diagnose problems with phonation, articulation, resonation and/or prosody, which are of neuro pathologic origin [1].

Several studies have been reported in the literature regarding the management of dysarthria. The management methods include prosthetic, surgical and exercises including oro-motor exercises [2]. Several studies have targeted exercises that showed significant improvement based on multiple features such as "improving the function of the jaw, lips, and tongue"3 ,"activities preliminary to speech production", "neuro-speech therapy", "articulation subsystem exercises", improving sensory and motor functions within physiologic processes", "mechanical positioning of the patient's articulators", "oral motor phonetic drills" , "motor programming approaches", "increasing physiologic support" by following "principles of motor learning" and "motor approach" relying upon "principles of motor learning" for treatment for motor speech disorders [3-11]. According to Spencer et.al, decision regarding management of dysarthria follows three major remediation paths, which are (1) improve respiratory

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support, (2) facilitate the coordination between respiratory and phonatory aspects and (3) improve the phonatory function [12]. Previous literatures have also revealed that Lee Silverman Voice Treatment (LSVT) is effect in improving speech intelligibility in individuals with dysarthria secondary to stroke [13]. In few of the western countries, oro-motor exercises (OMEs) are included as one of the components of dysarthric management [14].

Oral motor exercises (OMEs) are often referred to as "mouth exercises," "non-speech oral motor training," and "oral motor treatment." (Brown and others, 2010) There are various ways to perform these exercises: passive (moving the tongue with a tongue depressor, massaging the jaw), active (tongue pushups, moving the tongue back and forth, sticking tongue and trying to touch chin, puckering lips, moving lower jaw from side to side, horn blowing, whistle blowing, cheek puffing), and sense stimulation (uses vibration, heat, or a cold source) [15]. There are other non-speech oral motor exercises (NSOMEs) described in the literature. This includes (a) isotonic and isometric strengthening exercises (b) relaxation exercises and (c) neurophysiological and neuro-therapeutic approaches. The strengthening exercises are carried out to boost appropriate lip, jaw and tongue postures at rest and to elevate the stability, strength, range, speed and control of the above-mentioned structures. Postural adjustments are also sometimes used as a part of larger treatment strategies to enhance the possible outcomes [16]. NSOMEs facilitates in improving the strength and endurance of oro-motor musculature thereby enhancing speech output [17-19]. According to two North American surveys, improved speech production, strengthening and increased awareness of the articulators was achieved by the use of OMEs [16].

Apart from dysarthric management, OMEs are also preferred as means of resolving speech sound problems by the practicing speech-language pathologists in the United States, Canada, and Great Britain [15]. As per the literature there is a lack of systematic reviews on OME's efficacy, clinicians' willingness in implementing OMEs in their practice and controversies about using OMEs among variegated population [16]. Yet, a considerable majority of survey respondents (>70% in each of these three surveys) reported that they made use of them in their practice.

Rationales have been seriously questioned on the relevance of OMEs, (e.g., the use of strengthening exercises if strength is not an underlying problem) despite their popularity and their probability in treatment efficacy (e.g., the use of strengthening exercises that seem unlikely to tax, and therefore to strengthen, targeted muscles) [17-20]. Few SLPs, believe that NSOMEs are the final option left or to be used especially for severely impaired patients alone while others stress on its appropriateness only for certain types of dysarthria [14,21,22]. Moreover, the relevance of these NSOMEs is still under debate [20]. The practice of NSOMEs has been regarded as traditional method that is thought to be handed down by word of mouth or demonstration. However, the decision on whether to use NSOMEs in the management of dysarthria or not is determined by clinician's own practice and other fellow clinicians' opinions [14]. Nonetheless, a number of critics also suggest that given their widespread use and the potential value of selected OMEs for specific purposes, vigorous investigation of OMEs is warranted [23,24].

There are various approaches that can be used to determine the efficacy of treatment of motor speech disorders. Acoustic analysis can be considered as one of the tools to identify speech intelligibility. Different studies on dysarthria have been carried out using acoustic measures. One such study reveals that the dysarthric clients have fluctuating fundamental frequency whereas some have monotone. Though monotone is a symptom of dysarthria, which might influence fundament frequency, this does not have an effect on formants, which are resonance of vocal tract. Hence the current study didn't account monotone as a variable. The results of acoustic measures revealed that, the fastest rate of dysarthric speakers was slower than the slowest rate of the normal speakers [25]. Soft phonation index (SPI) was significantly greater in dysarthric speech than in normal speech. Significant deviations were observed in pitch perturbation quotient (PPQ). i.e, slightly larger PPQ's were noticeable in dysarthric speech than in normal speech output [26].

Perceptual analysis is also used as a tool for identifying the speech disorder [20]. Apart from the subjective tests there are objective procedures as well to determine the speech inadequacy. Formant Centralization Ratio (FCR) is one among the quantitative intelligibility measure and studies explained the use of it in dysarthric speech and FCR was unfolded as a sensitive, valid and reliable acoustic metric in order to differentiate between affected and unaffected speech [21]. However, there is a paucity in utilization of FCR as a measure to analyse the treatment efficacy in person with dysarthria in Indian context. Hence the present study intended to analyse the efficacy of oromotor exercises for person with dysarthria based on perceptual and acoustic measures of intelligibility (i.e, FCR).The subjective nature of perceptual analysis may limit measurement reliability and thereby they obscure the understanding of the variables that causes a specific speech problem [20].Therefore, this necessitates the correlation between the two intelligibility measures i.e. perceptual measure and Formant Centralization Ratio (FCR) in dysarthric speech to be determined.

Null Hypothesis:

1. H_0: There is no statistically significant effect of oro-motor exercises on speech intelligibility for persons with dysarthria in perceptual and acoustical measures of speech intelligibility (FCR).
2. H_0: No statistically significant correlation between perceptual and acoustic measures (FCR) of speech intelligibility.

Method

Participants: There were 4 female subjects as participants for the study. All of them were diagnosed to have dysarthria secondary to cerebro-vascular accident and were in their spontaneous recovery period of less than 3 months post stroke. Co-occurrence of apraxia and aphasia were ruled out by experienced speech language pathologists. All the participants were right-handed, native Hindi speakers with the age ranges between 32 and 55 years. Participants reported no premorbid speech, language, or cognitive disorders. All of them had normal hearing based on informal hearing screening. Clinical reports of brain scans (computed tomography and functional magnetic resonance imaging) were used to identify the site and extent of lesion. All the participants were informed regarding the treatment and taken informed consent prior to the data collection.

Procedure: Individual consent was taken from subject before starting the study. The study followed single group pre- post therapy design. Recordings of speech samples were collected pre and post to the treatment condition. Phonation of /a/, /i/, /u/ were taken along with narration as speech samples and analysed perceptually and acoustically. Treatment plan consisted of oral-motor control exercises to improve speed, accuracy and range of movement of oral structures [21]. Exercises were focused specifically for labial musculature and tongue. Retraction, protrusion and alternate retraction and protrusion exercises were assigned for lips. For tongue, retraction, protrusion, lateral movement, elevation, depression and alternate movements such as retraction-protrusion, elevation-depression and lateral movements from side to side were considered as the set of non- speech oro- motor exercises [10]. Each exercise had to be repeated five times and the entire set of exercises were repeated three times in a day in the most comfortable position of the patient. Ten such sessions of 45 minutes each were given.

Analysis: For perceptual measures, three trained speech language pathologists were asked to rate the intelligibility of narration sample based on open set method [23]. Audio samples were presented randomly to the listeners and played it in their comfortable loudness. Acoustical evaluation was based on formants and first three formants of each vowel were measured using Praat software (Version 6.0.28) to find Formant centralization ratio (FCR) value. It is a quantitative measure of speech intelligibility [22]. Formants of cardinal vowels were measured individually and FCR was calculated based on the expression $(F_{2u}+F_{2a}+F_{1i}+F_{1u}) / (F_{2i}+F_{1a})$.

Results

Pre and post treatment speech samples were analysed perceptually and acoustically. Cronbach's alpha of inter and intra judge reliability was found to be more than 0.75 for the narrative sample for all the subjects. Mean intelligibility percentage score was 35% and 72.25% for pre and post treatment speech sample respectively in open set task. As depicted in Table 1 and Figure 1, there were variations across subjects. However, all the subjects showed noticeable difference across pre and post treatment conditions. Paired t test showed significant difference between speech intelligibility percentage of pre and post treatment conditions [t (3) = 24. 94, p<0.000]. Speech intelligibility improved significantly after three days of oro-motor exercises.

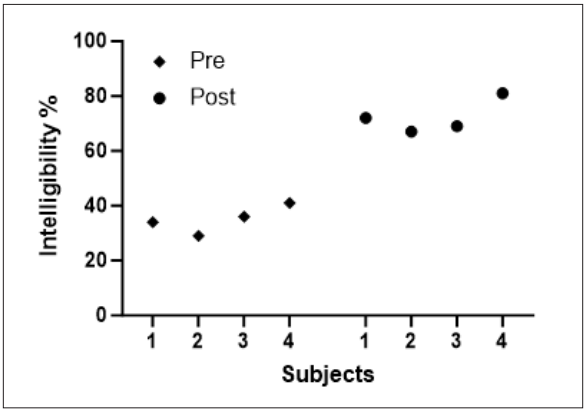

Figure 1: Scatterplot depicting intelligibility percentage in pre and post treatment conditions

Table 1: Intelligibility percentage in pre and post treatment conditions

	Intelligibility Percentage Pre-treatment condition	Intelligibility Percentage Post- treatment condition
1	34	72
2	29	67
3	36	69
4	41	81
Mean	35	72.25

FCR was calculated based on first and second formants of three corner vowels. Figure 2 explains that FCR was greater in pre-condition than post and it was common among all the subjects. Table 2 and Figure 3 shows the average formant values and FCR in both conditions. Pre-treatment condition had higher FCR indicative of poor speech intelligibility and post treatment condition showed improved speech intelligibility with least FCR. Paired t test was administered. Similar to perceptual measure, results showed that there was significantly higher FCR in pre-treatment than post treatment [t (3) = 14.66 p = 0.001]. This suggests greater intelligibility in post treatment with less than 1 FCR.

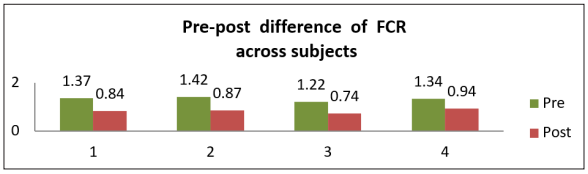

Figure 2: Pre-post difference of FCR across subjects

	Average values Pre-treatment condition	Average values Post- treatment condition
F_{1a}	480	602
F_{1i}	246	443
F_{1u}	287	330
F_{2a}	750	878
F_{2i}	1084	2275
F_{2u}	817	816
F_{CR}	1.34	0.85

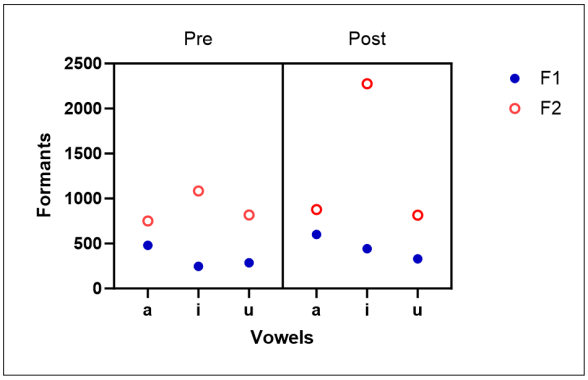

Figure 3: Scatterplot depicting average formant values and FCR in both conditions

Even though FCR is a quantitative measure of speech intelligibility based on acoustic parameters, correlation of FCR with perceptual measures needs to be evaluated. For this intention, Pearson's correlation test was administered. Based on the statistical analysis, there was a positive correlation between FCR and perceptual measures of speech intelligibility in dysarthric speech. Based on bivariant correlation coefficient, perceptual measure and FCR were moderately correlated (r = 0.503) for pre-treatment and mildly correlated for post treatment (r = 0.323).

Discussion

The present study aimed to evaluate the treatment efficacy of oro-motor exercises for dysarthric speech based on perceptual and acoustic measures of intelligibility. Results showed that speech intelligibility of all the subjects were improved after the treatment period and significant difference was noticed in terms of both perceptual and acoustical measures.

One of the positive findings of the present study is the improved speech intelligibility without any concern of naturalness. Oro motor exercises act as a direct effect on the muscle and its strength, which facilitates speech production. Speech rate control method can improve the intelligibility; however, retaining naturalness is uncertain [26].

Similar findings were reported in literature, orofacial myofunctional therapy considered to be a superior treatment method which intended to increase the strength and mobility of buccal, facial, labial, and lingual musculature. Though the study reported of progress in intelligibility for single words utterances, there was no quantitative representation of improvement explained [24]. The improved speech output post combined treatment (speech and non-speech exercises) cannot be fully attributed to NSOMEs [27]. Similarly, Park, Theodoros, Finch and Cardel (2016) also claimed a significant improvement of speech intelligibility after 'Be clear', a speech treatment method based on the principles of neuroplasticity and motor learning [25]. This treatment included intensive drilling activities which directly strengthen the orofacial muscles. However, long term effect of this particular treatment is needs to be verified quantitatively. In is to be noted that spontaneous recovery might have accelerated the improvement, which was common for all the subjects.

Based on the statistical analysis, there was a positive correlation between FCR and perceptual measures of speech intelligibility in dysarthric speech. The present study indicates that the FCR is a valid quantitative measure of speech intelligibility along with perceptual measures. There is a need of reassuring the use of FCR by finding the extent of correlation with other acoustical measures and even with physiological methods using a larger sample size in future.

Conclusion

The study was aimed to measure the intelligibility of speech pre and post treatment using FCR. A significant change in the FCR was found post treatment. The results were elicited acoustically (FCR) and it considerably showed the effect of oral motor exercises in patients with dysarthria. The intelligibility percentage was evidently altered after the oromotor exercises were carried out. The study also revealed the correlation between the perceptual and acoustical parameters measured pre and post treatment and both showed an elevation in the speech intelligibility of the dysarthric speech. Hence this study was able to suggest that FCR is a reliable measure to analyze the speech intelligibility. Use of FCR can be done to analyze speech intelligibility of other disorders such as dyspraxia, developmental apraxia of speech etc…

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The authors declare no competing interest

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