

Improving speech characteristics of young adults with congenital dysarthria: An exploratory study comparing articulation training and the Beataalk method

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ABSTRACT

Introduction: This exploratory study compared the effects of two speech therapy approaches on speech characteristics of young adults with congenital dysarthria resulting from various etiologies: a) articulation training focusing on consonant articulation exercises at various levels (isolation, syllables, and words), and b) the Beataalk method, based on human beatboxing, i.e., producing various instrumental sounds in an a-cappella musical context. Both interventions were designed to increase participants' speech intelligibility.

Methods: Twelve adults with congenital dysarthria and reduced speech intelligibility participated in treatment groups for eight weeks. Six participants were assigned to the articulation training group, and six to the Beataalk group. Intelligibility of single words and continuous speech, voice measures, and oral-diadochokinesis rates were measured before and after the treatment.

Results: The results showed that the Beataalk intervention yielded a significant overall pre- to post-treatment effect. Specifically, it resulted in gains in articulatory accuracy and intelligibility for single words. Improvements were not noted following articulation training.

Conclusions: The results present initial evidence of the positive effect of the Beataalk method as an intervention tool for adults with congenital dysarthria. This relatively easy-to-learn technique shows promise, as it involves intense and repetitive production of speech sounds while controlling rhythm and breathing in an enjoyable context.

1. Introduction

Dysarthria refers to a group of neurogenic motor speech disorders that can be characterized by abnormalities in the tone, strength, steadiness, speed, range and/ or accuracy of speech production movements (Duffy, 2013). Usually, at least one speech subsystem is, but often all speech subsystems are negatively affected, i.e., respiration, phonation, resonance, articulation, and prosody. As a result, dysarthria can impair speech intelligibility and/or speech naturalness.

Many neurologic illnesses, diseases, and disorders, both congenital and acquired, can cause dysarthria (Duffy, 2013). The most common cause of dysarthria in childhood is cerebral palsy (CP; Stanley, Blair & Alberman, 2000). Most children with CP present with dysarthria, with its prevalence ranging from approximately 50% (Bax, Tydeman & Flodmark, 2006) up to 90% (Mei, Reilly, Reddihough, Mensah & Morgan, 2014). Dysarthria in childhood is associated with other congenital disorders that involve abnormal

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development in the speech-motor areas or damage to the cranial nerves that control the articulatory musculature of speech (Rudzicz, 2010), as well as with acquired etiologies such as brain tumors and traumatic brain injury (Pennington, Parker, Kelly & Miller, 2016).

Due to their neurogenic sensory-motor nature, the speech difficulties persist into adolescence and adulthood. For example, most adults with CP show moderate to severe dysarthria with symptoms in all aspects of speech, but primarily voice quality, respiration, and prosody (Schölderle, Staiger, Lampe, Strecker & Ziegler, 2016). For those individuals, articulation, respiration, and prosody have been found to be highly correlated with intelligibility and naturalness of speech. The complexity of the speech impairment and the consequences on the individuals' communication call for further dysarthria treatment designed for adolescents and adults.

The aims of speech therapy for individuals with congenital dysarthria depend on its type and severity, and on the communication needs of the individual. For example, for those with mild dysarthria, the goal of treatment may be to improve the quality and naturalness of speech while maintaining intelligibility. For individuals with severe or profound dysarthria, the goal might be to have some degree of functional verbal communication or to find non-speech-based alternatives or supplementation strategies (Enderby et al., 2010).

Guidelines for best practice recommend that speech-language pathologists (SLPs) should manage their clients with congenital dysarthria in a holistic manner, using approaches that target various subsystems of the vocal tract, for example, breathing, nasal resonance, articulation, and pitch control (e.g., Pennington et al., 2016; 2013). Indeed, the speech treatment literature describes various methods for addressing the speech difficulties of individuals with congenital dysarthria, focusing mainly on children. Such therapeutic approaches were designed to target the affected speech subsystems. For example, tasks include regulating breathing, increasing respiratory effort, slowing speech rate, exaggerating jaw movements, and/or using speech as well as non-speech exercises (Hayden & Square, 1994; Pennington et al., 2013; Yorkston, Beukelman & Bell, 1999). In most studies, treatment was associated with positive results and increased speech intelligibility (note, many of these studies focused on individuals with CP). For example, Levy and her colleagues (Levy, Chang, Ancelle & McAuliffe, 2017; 2021; Moya-Galé et al. (2021)) used a dual-focus speech treatment, Speech Intelligibility Treatment (SIT), which includes different cues to improve speech intelligibility among children with dysarthria, namely, "Speak with your big mouth" to promote clear speech and to increase articulatory excursion, and "Speak with your strong voice" to increase vocal intensity. The authors reported positive outcomes for this intervention (e.g., increases in ease of understanding or narrative intelligibility).

Pennington et al. (Pennington, Smallman & Farrier, 2006) implemented a speech breathing and speaking rate treatment to support articulatory precision in children with CP and found that these strategies improved speech intelligibility at the single word level. In another study, Pennington and her colleagues (Pennington, Miller, Robson & Steen, 2010) demonstrated that a comparable intervention focusing on controlling breath support, phonation, and speech rate increased the speech intelligibility of older children with CP (age range: 12–18 years).

Another speech therapy approach that has been offered for individuals with dysarthria is LSVT LOUD® (Lee Silverman Voice Treatment; Boliek & Fox, 2017; Fox & Boliek, 2012). This intensive voice treatment has been developed for individuals with Parkinson's disease, and it focuses on increasing vocal loudness. Implementing this approach among children with CP resulted in improvements on select aspects of vocal functioning and single word intelligibility. In a recent case-study, Moya-Galé et al. (2021) showed significant pre- to post-treatment changes for several acoustic variables in a 36-year-old female with CP and severe dysarthria following this voice-focused treatment.

Reviewing these aforementioned treatment approaches reveals a clinical focus on respiration and phonation. However, individuals with dysarthria often show articulation deficits in the form of imprecise consonants (e.g., reduced burst production, prolonged phonemes) in connected speech. Imprecision of consonant production may be related to impaired strength or coordination at the articulatory level, impairment of the respiratory subsystem and/or impaired velopharyngeal movement (Allison & Hustad, 2018). Hence, there is a clinical need for treatment methods that address improvements in consonants production, which are currently lacking.

Relatively little research has explored the effects of speech therapy for young adults with congenital dysarthria. As noted above, individuals with congenital dysarthria must cope with communicative restrictions due to speech impairments from early childhood throughout their lifetime. Clinical observations suggest that early-onset dysarthria may change its presentation with increasing age (Workinger & Kent, 1991). As noted by Schölderle and her colleagues (Schölderle et al., 2016), the speech difficulties observed already in early childhood, change their clinical appearance (severity and quality) throughout development and maturation of the speech systems, and during the transition to adulthood. Accordingly, the speech impairments do not manifest fully until adulthood. This developmental pattern stresses the need for continuing support and services related to speech difficulties for young adults with congenital dysarthria. Providing effective speech therapy for these individuals is highly important, since the reduced speech intelligibility may result in activity limitations (Dykstra, Hakel & Adams, 2007) and lessened involvement in life situations (Fauconnier et al., 2009).

The need to identify and test effective speech rehabilitation methods for this population of young adults with congenital dysarthria has led us to consider the recently introduced *Beataalk method* (Icht, 2019). This novel approach emerged from the a-capella art of human beatboxing, referring to the production of vocal percussions and non-verbal sounds that imitate musical instruments (De Torcy et al., 2014). While beatboxing, the beatbox artist reproduces various instrumental sounds and sound effects (e.g., drum and cymbals) using the glottal and supra-glottal speech organs (vocal folds, palate, tongue, and lips) in different rhythms. Interestingly, many of the beatbox sounds are speech sounds (consonants). For example, the *kick drum* sound is very similar to the plosive [p], and the *hi-hat* corresponds to the plosive [t] or the affricative [ts]. As these consonants may be targets in speech therapy (Shriberg, 1997), the association between beatboxing and speech rehabilitation seems clear.

A careful analysis of human beatboxing reveals additional features that make it a potential method for speech therapy (De Torcy

et al., 2014; Icht, 2019), especially at the initial levels of consonant (isolation) and syllable production. First, beatboxing involves relatively intense articulatory exercises - repetition of sounds in an accented manner. These may assist to improve the incomplete closure during production of plosive consonants (Allison & Hustad, 2018). Since sequenced movements are produced in different rhythms, it may improve the timing and co-ordination of orofacial movements during speech to improve speech intelligibility (Neilson & O'Dwyer, 1981; Ward, Strauss & Leitão, 2013). Furthermore, during beatboxing, the laryngopharynx structures move in a flexible yet strong manner, with mobilization of all the facial and neck muscles (De Torcy et al., 2014; Saphthavee, Yi & Sims, 2014), and the use of the full range of airflow mechanisms (Proctor, Bresch, Byrd, Nayak & Narayanan, 2013).

Second, as beatboxing shares many features with singing (e.g., vocal techniques and coordinated strategies; De Torcy et al., 2014; Saphthavee et al., 2014), it may promote breath control and respiratory capacities (Decker & Kirk, 1988). Beatboxing involves emphasis on rhythm and tempo, thus requires increased respiratory control and respiratory muscle strength (Stegemöller, Radig, Hibbing, Wingate & Sapienza, 2017). Music, which is an integral part of the beatboxing practice, facilitates a variety of breathing patterns. Connecting the breath with vocal production may aid in increasing vocal intensity (Thorpe, Cala, Chapman & Davis, 2001).

Third, it has been hypothesized that the mechanisms involved in the production of beatbox non-voiced percussive noises most likely rely on control of the oral cavity and oropharyngeal structures. The hypopharyngeal cavity involvement (as a resonator) strengthens harmonic resonance (De Torcy et al., 2014), and the use of pharyngeal constrictors (creating a longer closed phase) increases subglottal pressure (Buescher & Sims, 2011) which may improve vocal loudness and quality. Note, although producing beatbox sounds involves intense muscular and vocal activities, it does not lead to chronic vocal pathology (e.g., vocal fold lesions; Paroni, 2014), possibly due to the reliance on voiceless mechanisms (using the pharyngeal constrictors to create a longer closed phase and increase subglottal pressure; Saphthavee et al., 2014).

Finally, beatboxing is an easy to learn activity, based mainly on imitation (Sharon & Bell, 2012). Clinical observations suggest that repeating sounds upon imitation may be easier relative to the commonly used phonetic cues which involve abstract instructions in order to be mapped onto the speaker's own vocal tract, and thus are cognitively demanding (Powell, Elbert, Miccio, Strike-Roussos & Brasseur, 1998). Indeed, beatboxing can be successfully learned even by children. The fun nature of beatboxing (Thompson, 2011) makes practicing "cool" and rewarding, enhancing motivation and engagements levels.

Considering these factors, the Beataalk method was designed, combining human beatboxing practices in a therapeutic context. The Beataalk method focuses on the acquisition of basic beatbox sounds (e.g., the *kick drum* [p], the *hi-hat open* [ts], the *snare drum* [k], the *snare meshed* [kS]). These sounds were chosen as they represent different articulation places (using different articulators) and different complexity levels (Icht & Ben-David, 2015). All are easy to demonstrate by an instructor and to imitate by a client. These target sounds are repeatedly produced in different rhythms, from simple to complex. A recent study (Icht, 2019) has found this intervention method to be effective in improving articulatory accuracy and voice in a group of adults with intellectual disabilities and reduced speech intelligibility.

The aim of the current exploratory study was to test the effectiveness of the Beataalk method for improving the speech characteristics of young adults with congenital dysarthria (of various etiologies), and to compare it to a traditional articulation training, focusing on consonant articulation exercises at several levels (isolation, syllables, and words; Powell et al., 1998). This latter approach is a functional, impairment-based intervention to encourage improvements in articulation using modeling targets, repetition of targets, and feedback on speech performance. Traditional articulation training was chosen as a comparison treatment since it is commonly used by SLPs in Israel. The clinical reality is that treatment often remains predominantly impairment-focused and relies on motor practice using meaningful words (Adi-Bensaid, Nachamani & Tubul-Lavy, 2018), while other, more holistic approaches (e.g., Pennington et al., 2016; 2013), are still less common.

In addition, articulation training may also positively affect voice measures (similar to beatboxing), mainly increase voice intensity and enhance the stability of the fundamental frequency (F0). For example, Myers and Finnegan (2015), found that increased consonant energy (e.g., over-articulation, or high level of articulatory precision, as commonly achieved in speech therapy) increases the volume of the speaking voice, and concluded that articulation treatment may be beneficial for increasing perceived vocal loudness (see also, Baken & Orlikoff, 1987).

The Beataalk method and the articulation training were both designed to address intelligibility deficits experienced by adults with congenital dysarthria, affected by imprecise consonant articulation (e.g., incomplete closure during production of plosive consonants), slow and hesitant speech, and reduced loudness. Individuals with dysarthria often produce imprecise vowels (e.g., vowel reduction), due to changes in the patterns of movements of the articulators (e.g., tongue, lips, jaw; vowel target-undershoot; for related findings in Hebrew, see: Carl & Icht, 2021). We assume that the Beataalk technique, with its focus on respiratory and phonatory control, may indirectly improve vowel production as well, and overall intelligibility. It should be noted that due to the small Hebrew vowel inventory, targeting vowel contrasts is less practical. Both interventions focused on similar target sounds (consonants of different categories), that were chosen to address the different intelligibility deficits of the participants (Ansel & Kent, 1992; Kim, Martin, Hasegawa-Johnson & Perlman, 2010). This experimental (non-randomized) matched case-control pilot study used a pragmatic design and quantitative methods to address the research questions. Twelve participants were divided into two treatment groups: six participated in an articulation training group, and the other six in a Beataalk group.

As suggested by Kearney et al. (2015), various outcome measures, both perceptual and instrumental, were used to document change following treatment, to increase reliability and precision of analysis. Note, as this study was a preliminary pilot trial, the number of dependent variables was relatively high to provide evidence of efficacy potential. These measures were of three therapeutic domains: a) speech intelligibility and articulatory accuracy (for single words and continuous speech), b) voice (for a sustained phonation /a/ and continuous speech), and c) oral motor abilities (oral-diadichokinesis, oral-DDK). These were measured before and after eight weeks of group treatment. Based on a previous study (Icht, 2019), we assumed that both interventions would yield

improvements in the outcome measures, yet to a larger extent for the Beataalk method relative to the articulation training, due to the intense and repetitive nature of practice, and the increased respiratory control.

2. Method

2.1. Participants

This study was conducted at the Wheels and Wings Day Center in Herzliya. In partnership with the Rehabilitation Department of the Israeli Ministry of Welfare, the Day Center provides services for over 20 adults aged 21 and over, with physical disabilities (e.g., CP, muscular dystrophy). The Center provides creative rehabilitation programs in a variety of areas: physical, occupational, and speech therapies, emotional and social support, leisure and enrichment, social opportunities, and active encouragement and facilitation of inclusion in community life. The Day Center is operated by the House of Wheels association, a nonprofit Israeli association that provides services to more than 450 participants, children and adults, in 6 centers.

The study received Institutional Review Board approval from the academic institute affiliated with the author. Inclusion was based on the level of speech impairment (from mild to severe dysarthria). The sample size of the study was determined by feasibility (a sample of convenience), given the number of participants who could be treated during a term at one daycare center, with restrictions imposed by the day center timetable (e.g., other activities, holidays. For a similar selection procedure, see: [Pennington et al., 2010](#)). The SLP of the Day Center identified 16 participants as verbal yet with speech impairments (e.g., reduced speech intelligibility, imprecise consonants, deviant voice quality). As tools for dysarthria assessment in Hebrew are lacking, dysarthria type and severity were assessed perceptually by the Day Center SLP, using informal evaluations. An oral peripheral examination was also conducted identifying abnormalities in structure or function of oral and facial structures. The parents or legal representatives of these potential participants received written information regarding the study and 12 gave their written consent.

Twelve young adults with dysarthria (age range 22–30 years; mean 24.6 years; eight men) participated (details of each participant can be found in [Table 1](#)). Nine participants had dysarthria and CP (six participants had spastic CP, two had mixed, and one had ataxic), while three participants had congenital dysarthria resulting from muscular dystrophy (with mixed dysarthria), West syndrome (undetermined dysarthria), and Pelizaeus-Merzbacher disease (mixed dysarthria). Dysarthria was rated as mild or mild-to-moderate for 5 participants, as moderate or moderate-to-severe for 6 participants, and severe for a single participant.

The speech profile of all participants was characterized by imprecise consonants, eight participants showed voice disorders (e.g., poor control of pitch, strain, or deviant voice quality), seven participants had prosody difficulties (e.g., reduced rate of speech, or prolonged intervals), and three participants had involuntary movements.

All were given oral information on the study and its goals and were invited to attend the intervention sessions. All participants gave their oral consent. The participants formed six pairs, with pair members matched for speech abilities. One member of each pair was randomly assigned to the articulation training group, and the other member was assigned to the Beataalk group. The assignment of participants ensured that the groups were similar with respect to participants' age and dysarthria severity. To confirm this, two paired samples t-tests were used, indicating no age difference ($p = .76$) and no dysarthria severity difference (dysarthria severity ratings were converted into numbers; $p = .55$).

Table 1
Participants' data.

Group	Age (years)	Gender	Etiology; Type of dysarthria; Severity	Perceptual speech characteristics
Articulation training	23	F	CP; Mixed (Spastic-dyskinetic); Moderate-severe	Involuntary movements, imprecise consonants and vowels, strained voice quality and slow speech
	22	M	West Syndrome; Undetermined; Mild-moderate	Mono-pitch, imprecise consonants
	24	M	CP; Ataxic, Mild	Imprecise consonants and vowels (mild)
	24	M	Pelizaeus-Merzbacher Disease; Spastic and Ataxic; Moderate	
	26	M	CP; Mixed, mainly spastic components; Moderate	Reduced loudness, imprecise consonants and vowels, strained voice quality
	30	M	CP; Spastic; Moderate-severe	Short phrases, voice stoppages, prolonged intervals, imprecise consonants and vowels
Beataalk	22	F	CP; Spastic; Mild	Deviant voice quality (roughness), imprecise consonants and vowels, monotone intonation
	23	F	CP; Spastic; Moderate	Imprecise consonants and vowels, deviant rate (irregular)
	30	F	CP; Mixed (Spastic-dyskinetic); Severe	Deviant voice quality (roughness), imprecise consonants and vowels, prolonged intervals, involuntary movements
	23	M	CP; Mixed (Spastic-dyskinetic); Moderate	Imprecise consonants and vowels, involuntary movements, strained voice quality
	24	M	Duchenne muscular dystrophy; Spastic and Ataxic; Mild	Mono-pitch, slow speech rate, imprecise consonants and vowels
	24	M	CP; Mixed, mainly ataxic components; Mild	Imprecise consonants and vowels, inappropriate silences

Note, to avoid a deferral of treatment from the articulation training group participants, they were invited to participate in Beataalk sessions (for eight weeks) at the conclusion of the study.

2.2. Procedures and experimental design

Setting. Ten weekly sessions were conducted: an initial pre-intervention testing session (individual), eight treatment sessions (group), and a final post-intervention testing session (individual). Each weekly therapy session was followed by two brief practice sessions. This intervention schedule was chosen as it resembles typical, conventional treatment settings in Israel, suitable for (public) workplace limitations.

All treatment sessions were undertaken in two separate comfortable rooms designed for group treatment at the Day Center. Each room was large enough to allow the participants to move around with their wheelchairs.

Treatment procedures. Both group treatments rely on the production and practice of speech sounds (consonants) at different levels, i. e., isolation, syllables, and words (note, non-speech oral motor exercises were not included in the intervention protocols, as they were found to be not specific enough to the dynamic nature of speech production to carryover to functional speech, thus less effective; McCauley, Strand, Lof, Schooling & Frymark, 2009). Each weekly session was 45 min in duration and was conducted by two experimenters, SLP students, who were trained by the author (an experienced SLP) and by a beatbox artist (Isato Beatbox, one of the developers of the Beataalk method). They were accompanied by the Day Center SLP, who knew the participants and their speech abilities, to ensure the cooperation of the participants.

(a) Articulation training sessions. This functional intervention followed the principles of the traditional motor approach, to encourage improvements in articulation. It employed various clinical methods, e.g., consonant articulation exercises (reproducing the phonemes by imitation) to elicit and stabilize sound production, training of adequate phonetic placement using placement cues, and listening training by auditory models (modeling targets; Powell et al., 1998). The target consonants (whose production was inaccurate) differed in their place and manner of articulation, articulators, and complexity levels (Ansel & Kent, 1992; Icht & Ben-David, 2015; Kim et al., 2010) and are listed in Table 2.

Articulation training was conducted at the isolation, syllable, and word levels (focusing mainly on both latter levels). Word-level practice included different positions of target consonants in mono- and bi-syllabic familiar words). Practice was done using different activities, e.g., board games, puzzle games, solving crossword puzzles, and role playing. Each session consisted of 15 min of repetition of the sounds, syllables, and words of the previous sessions, 20 min of learning and practicing new sounds in various contexts, and 10 min of group practicing.

(b) Beataalk sessions. The treatment involved the acquisition and practice of five basic beatbox sounds (targets), comparable to the target consonants of the articulation training group (see Table 2 for a detailed description). In the treatment sessions, these target sounds were repetitively produced in an intensive and accented manner, in different rhythms, from simple (e.g., repeating a certain single sound, [p]) to complex (e.g., repeatedly producing two or three sounds, [p-ts p-ts] or [k-k-kS k-k-kS]). A practice example is available at: <https://www.youtube.com/watch?v=HkmZkAciyaM&t=8s>. Modeling and feedback were provided by the experimenters. The structure of the sessions was similar to that of the articulation training intervention. Each session consisted of 15 min of repetition of the sounds and rhythms of the previous sessions (each participant separately, and then all together in a “band”), 20 min of learning and practicing new sounds and rhythms (separately and together), and 10 min of group practicing using a familiar song.

Practice sessions. Following each treatment session, two weekly practice sessions were conducted (on Day 4 and Day 6 following the treatment session), in which each participant practiced the target sounds for 3–5 min individually, with the Day Center SLP and/or a staff member. The articulation training participants practiced using printed A4 pages with the colored pictures of the target words introduced in the most recent treatment session. For the Beataalk participants, practice was achieved using a short video clip (about 30 s). The participants watched it using their cellphone or an iPad, and then repeated the rhythms.

2.3. Speech material and tools

For pre- and post-intervention assessments, participants were recorded producing various speech materials (detailed next). These assessments took place one week prior to and one week following the intervention program. The recordings were made while the participants were seated next to the experimenter in a quiet room, using a high-quality digital recorder (Panasonic; RRXS350) which has a noise cancelling feature, using a built-in stereo microphone. The audio signals were processed by a standard low-pass filter, and the PCM / 1411 kbps (Stereo; LPCM) mode was used. Acoustic signals were recorded at a sampling rate of 44.1 kHz. SPL was calibrated with a reference signal consisting of a 300-Hz sine wave with an intensity of 80 dB SPL (A) that was generated and recorded on a

Table 2
Description of the intervention target sounds.

Target sound effect	Beataalk method (Standard beatbox notation description)	Articulation training (IPA description)
The kick drum	[p] or [b]	[p]
The hi-hat closed	[t]	[t]
The hi-hat open	[ts]	[ts:]
The snare drum	[k]	[kx:]
The snare meshed	[ksh]	[kf:]

sample digital audio file. The level of the reference signal was monitored using the same sound level meter (for a similar procedure, see: Ben-David & Icht, 2016). The recorder was held about 8 cm from the speaker's mouth and was slightly tilted toward the speaker (following Icht & Ben-David, 2018a), close enough to allow for quality sound recording.

(a) *Sustained phonation.* Participants were instructed to hold the vowel /a/ as long as they possibly could, at their normal speaking voices, after taking a maximal inhalation. The examiner demonstrated the task once.

(b) *Single words.* We used a common Hebrew articulation and naming test (Pictures for Examining Articulation and Naming of Hebrew-speaking Children in Israel; Rosin & Yakir, 2000). The test includes 32 pictures of familiar objects, mono- to four-syllabic words. All 22 consonants appear in initial-, medial-, and final-positions, and all 5 vowels are also fully represented. Participants were required to name the pictures. In case a participant failed to name the picture (or provided an incorrect response, less than 8%), the experimenter named it and asked the participant to repeat the word. Transcription of the verbal output of each participant was performed by two experimenters, trained SLP students, blinded to the participant group assignment and condition (pre- or post-treatment). Each experimenter coded the participants' responses separately. In the few cases when the two did not reach an agreement (less than 5%), they consulted with the author to reach a decision.

(c) *Continuous speech.* We used a familiar picture, a line drawing depicting a simple beach scene. Each participant was instructed to give an oral description of everything that they could see happening in the picture. The experimenter encouraged the participants using simple questions ("What do you see here?").

(d) *Oral-Diadochokinetic (DDK) rate.* This task was performed twice, once using a non-word (the trisyllabic sequence "pataka", a widely used sequence, for which normative data for adults are available in Hebrew; Icht & Ben-David, 2014) and once using a real word (the word "bodeket", the female rendition of the noun examiner or the verb inspecting in Hebrew; Icht & Ben-David, 2015). Prior to the recordings, the experimenter explained and demonstrated the (real- or non-word repetition) task, and the participants were given a single practice trial. Then, the participants were instructed to repeat the tri-syllabic stimulus, as fast and accurate as possible, stating: "Now, please repeat this word [or non-word] once again, as quickly as possible, without making a mistake, until I signal you to stop", for 10 s, using a count-by-time method (see, Icht & Ben-David, 2014). All participants successfully completed both tasks. The order of tasks was counterbalanced across participants.

2.4. Dependent measures and analysis

As noted above, to document reliably and accurately pre- to post-treatment change, various outcome measures were used (Kearney et al., 2015). For example, following Pennington et al. (Pennington et al., 2006), measures of change in speech breathing (Maximum Phonation Time and maximum duration of sustained /s/) and articulation (Percentage of Consonant Correct) were gauged. Changes were assessed in three speech domains: a) speech intelligibility and articulatory accuracy, b) voice, and c) oral-motor abilities.

(a) *Articulatory accuracy and speech intelligibility.* These were measured at two speech levels: single words and continuous speech. We used the following transcription-based measures: (1) The Proportion of Whole-Word Correctness (PWC,%; Ingram, 2002) – This measure determines what proportion of the individual's words were produced correctly out of the entire produced vocabulary (from the articulation and naming test), and (2) Percentage of Consonant Correct (PCC,%; Shriberg & Kwiatkowski, 1982) – A segmentally based measure that represents the percentage of correct consonants in a given sample (the total number of consonants judged correct divided by the total number of intended consonants in the articulation and naming test). It is acknowledged that transcription-based measures are very common in the literature (Kearney et al., 2015) providing a relatively objective estimation of client's intelligibility (Mei et al., 2014). To calculate PWC and PCC, four trained SLP students (blinded to the participant group assignment and status) separately analyzed the transcriptions of the articulation and naming test (to ensure inter-rater reliability) and counted correct consonants and words. If a disagreement between the research assistants was identified (less than 5 percent of the recordings), the author reached a decision.

Another measure was (3) Intelligibility score – Five experienced SLPs (all had 8 or more years of experience working as SLPs), blinded to the study goals and participant status listened to the recordings of the continuous speech and were asked to rate speech intelligibility on a 5-point Likert scale (following the procedure of Lousada, Jesus, Hall & Joffe, 2014). The following instructions were provided: "Select the number that best corresponds to the participant's speech using this rating scale ("1 – impossible to understand; completely unintelligible"; "2- very difficult to understand"; "3 – difficult to understand"; "4 – easy to understand"; "5 – very easy to understand; completely intelligible")".

(b) *Voice measures.* Many adults with CP demonstrate reduced voice quality and impaired respiration (Schölderle et al., 2016), features that have been found to be correlated with speech intelligibility and naturalness. The Beataalk method may be suitable for addressing such difficulties, as it may promote breath control and respiratory capacities (Decker & Kirk, 1988; Stegemöller et al., 2017), and may strengthen harmonic resonance (De Torcy et al., 2014). These skills may positively affect vocal loudness and quality (Buescher & Sims, 2011). Hence, in the current study, several voice measures were gauged and analyzed using Praat software (Boersma & Weenink, 2017): (1) Vocal loudness (sound pressure level, dB), (2) Harmonic-Noise Ratio (HNR, the ratio of the acoustic energy of the harmonic components to that of the noise, dB), (3) Vocal shimmer - a measure for the amplitude instability of vocal cord vibration (%), (4) Vocal jitter - a measure of the frequency instability of vocal cord vibration (%), and (5) Maximum Phonation Time (MPT) - the longest period during which a patient can sustain phonation of a vowel sound (/a/, sec). These were measured from sustained phonation (the vowel /a/). We also gauged the maximum duration of sustained /s/ (in sec).

Additionally, two experienced SLPs separately listened to the recordings of the continuous speech and perceptually rated the participants voice using two subscales of the GRBAS scale (from 0 – normal, to 3 - severely impaired; Hirano, 1981): (1) overall grade (G subscale, degree of voice abnormality), and (2) vocal strain (S subscale, excessively tense and high-pitched).

(c) *Oral-DDK*. Oral diadochokinesis (oral-DDK) tasks involve rapid repetition of alternating syllables. Oral motor performance, as reflected in oral-DDK rates, was found to be correlated with the degree of speech impairment in patients with speech disorders associated with a neurogenic disease or damage (dysarthria and apraxia of speech; Ziegler, 2002). Since oral-DDK rates relate to dimensions of overall speech performance in dysarthria (Wang, Kent, Duffy & Thomas, 2009), in the current study, real word and non-word oral-DDK rates (syllables/sec) were assessed.

Oral-DDK rate was calculated by multiplying the total number of trisyllables (“pataka” or “bodeket”) produced by each participant in 10 s, by 0.3. In the case that a trisyllable was only partially completed by the time 10 s elapsed, it was excluded. Counting was performed manually from the digital recordings and using Praat visual output, separately by two trained SLP students. When the two did not agree on a specific sample (less than 5%), it was recounted by an experienced SLP.

2.5. Statistical analyses

As a first step, pre- and post-treatment values and scores were calculated for each of the tested measures and means and SDs were gauged for the two treatment groups. To assess and compare the overall treatment effect, compensating for the different measures and scales, raw scores were converted to z-scores using the means and SDs from the entire sample. Standardized scores were generated for both groups by averaging z-scores within each measure. To reduce the number of comparisons, all z-scores were equally weighted and combined into a composite treatment index (for a related procedure, see: Bensafi et al., 2003; Gelstein et al., 2011; Wyart et al., 2007). This was justified considering significant positive correlations which have been found between the variables measured. Specifically, positive correlations were observed between PWC and PCC (Kim et al., 2018), between various voice measures (Yang et al., 2014), and between oral-DDK rates (Icht & Ben-David, 2021).

This procedure allowed us to perform a mixed-model repeated-measures analysis of variance (ANOVA), with the composite treatment index as the dependent variable, time point (pre- or post-treatment) as a within-participant variable, and group as a between-participant variable (for a comparable analysis, see: Tallal et al., 1996), followed by t-tests.

Finally, separate analyses were conducted for each measure using Wilcoxon Signed-Rank Tests (using a 0.05 probability level). This

Table 3

Results. Pre- and post- treatment values and scores (means, SDs, and ranges) in the various measures, for the two treatment groups. *P* values (based on Wilcoxon Signed-Rank Tests) are also listed.

Therapeutic Domain	Measure, Speech material	Articulation training Pre-treatment, Mean (SD) [Range]	Post-treatment, Mean (SD) [Range]	<i>p</i> value	Beatalc Pre-treatment, Mean (SD) [Range]	Post- treatment, Mean (SD) [Range]	<i>p</i> value
Articulatory accuracy, speech intelligibility	PWC (%), Single words	21.33 (7.09) [14–32]	23.16 (7.52) [13–32]	0.13 [§]	25.16 (8.03) [11–32]	27.33 (5.92) [17–32]	0.03
	PCC (%), Single words	71 (4.81) [65–77]	74.16 (7.62) [62–83]	0.07	75.83 (11.16) [60–86]	78 (9.51) [63–86]	0.03
	Intelligibility score (1–5), Continuous speech	3.36 (1.06) [2.2–4.4]	2.82 (1.51) [1–4.4]	0.91	3.83 (0.89) [2.5–5]	3.96 (0.62) [3.25–5]	0.29
Voice	Loudness (dB), Sustained phonation /a/	81.71 (8.68) [71.24–92.14]	82.73 (7.34) [74.5–93.1]	0.22	77.72 (3.64) [73.68–81.38]	80.23 (6.41) [71.66–87.14]	0.15
	HNR (dB), Sustained phonation /a/	17.71 (5.55) [11.05–27.17]	16.75 (5.85) [11.25–25.9]	0.65	15.93 (4.86) [7.14–20.38]	16.39 (4.48) [8.18–21.56]	0.28
	Shimmer (%), Sustained phonation /a/	5.78 (3.10) [2.42–10.94]	7.91 (5.71) [1.77–15.22]	0.89	7.97 (4.64) [4.84–17.26]	6.61 (4.55) [2.64–15.01]	0.08
	Jitter (%), Sustained phonation /a/	0.54 (0.31) [0.23–1.09]	0.74 (0.50) [0.25–1.85]	0.89	1.22 (1.42) [0.43–4.08]	1.08 (1.32) [0.29–3.69]	0.22
	MPT (Sec), Sustained phonation /a/	4.54 (2.09) [0.67–6.04]	3.44 (1.12) [1.6–4.68]	0.95	6.65 (2.76) [3.61–10.31]	9.03 (5.47) [4.35–19.62]	0.03
	Duration of sustained /s/ (Sec), Sustained /s/	4.57 (4.36) [1.15–13.13]	4.77 (5.85) [0.62–16.4]	0.5	5.46 (2.34) [1.26–8.51]	7.42 (6.05) [2–20.46]	0.34
	Voice quality (G score) [#] , Continuous speech	1.66 (0.87) [1–3]	1.5 (0.83) [0–3]	0.86	0.83 (0.81) [0–2]	0.58 (0.80) [0–2]	0.91
	Vocal strain (S score) [#] , Continuous speech	1.66 (1.03) [0–3]	1.33 (1.03) [0–3]	0.25 [§]	1 (1.14) [0–3]	1.16 (1.03) [0–3]	0.29
	Rate (Syl/Sec), Non-word	3.02 (1.76) [0.85–4.8]	2.85 (1.83) [0.9–5.4]	0.5	4.29 (1.68) [2.1–7.1]	4.41 (1.26) [2.83–5.8]	0.42
	Rate (Syl/Sec), Real word	3.03 (1.47) [1.3–4.8]	2.65 (1.81) [1.2–5.1]	0.78	3.87 (2.01) [1.96–7.26]	4.35 (1.82) [2.45–6.63]	0.15

Abbreviations: PWC = The Proportion of Whole-Word Correctness; PCC = Percentage of Consonant Correct; HNR = Harmonics-Noise Ratio; MPT = Maximum Phonation Time.

[#] Perceptual evaluation by means of the GRBAS scale (0 to 3); [§] Exact Wilcoxon Signed-Rank Test.

non-parametric test is commonly used to compare two related (or matched) samples to assess whether their population mean ranks differ (similar to the paired t -test), when the distribution of the difference between the two samples' means cannot be assumed to be normally distributed.

3. Results

3.1. Descriptive analysis

A summary of the results (raw data) is provided in Table 3. Listed are the pre- and post-treatment values and scores (means, SD s, and ranges) in the various measures, for the two treatment groups, as well as the p -values. Reviewing table 3 suggests a trend for increase in performance in most measures (12 out of 13) for the Beataalk group, while for the articulation training group such trend only appears in 6 out of 13 measures.

3.2. Evaluating the overall effect of treatment using a Z-score analysis

To compare the overall intervention effects of the Beataalk method and the articulation training, analysis based on the standardized measurements (z-scores) of each measure (across the two time points, pre- and post-treatment) was conducted.

Since a range of measures and variables were gauged, each with different scores or units on different scales, interpretation of these measurements requires conversion of all raw scores (individual pre- and post-treatment scores in each measure) by standardizing the distribution for comparison. Thus, averaged z-scores (pre- and post-treatment, across all variables) were calculated for each participant, and were equally weighted and combined into a composite treatment index to be used in the statistical analyses (to reduce multiple comparisons). Z-scores were calculated by subtracting the raw score from the mean score of the sample and dividing that by the sample's standard deviation. Standardized z-scores are approximately normally distributed with mean = 0 and standard deviation (SD) = 1. Thus, the z-score transformation improves the power of the analysis (given the limited number of participants, 12, and the large variance in a clinical population), and allows for calculation of parametric tests. Specifically, an ANOVA was used, testing a single dependent variable (i.e., the composite treatment index), to assess the overall treatment effect (for a comparable analysis, see Broomfield & Dodd, 2011; Tallal et al., 1996).

As a first step, we confirmed that there was no difference between the groups in the pre-treatment scores, $t(10) = 0.691$, $p = .505$. Next, a mixed-model repeated-measures ANOVA was conducted, with time point (pre- or post-treatment) as a within-participant variable, and group (articulation training or Beataalk) as a between-participant variable. There was no significant main effect for group, $F(1,10) = 1.21$, $p = .297$, $\eta_p^2 = 0.108$, or for time, $F(1,10) = 2.572$, $p = .14$, $\eta_p^2 = 0.205$. Importantly, the analysis showed a significant interaction of time point and group, $F(1,10) = 6.097$, $p = .033$, $\eta_p^2 = 0.379$, indicating a difference in the effect of treatment between both groups. Planned comparisons showed that this interaction can be attributed to a significant improvement following the Beataalk intervention, $t(5) = 4.207$, $p = .008$, $\eta_p^2 = 0.783$. However, no such improvement was found following the articulation training, $t(5) = 0.546$, $p = .609$. A visual depiction of these results (individual as well as group level standardized scores) is presented in Fig. 1.

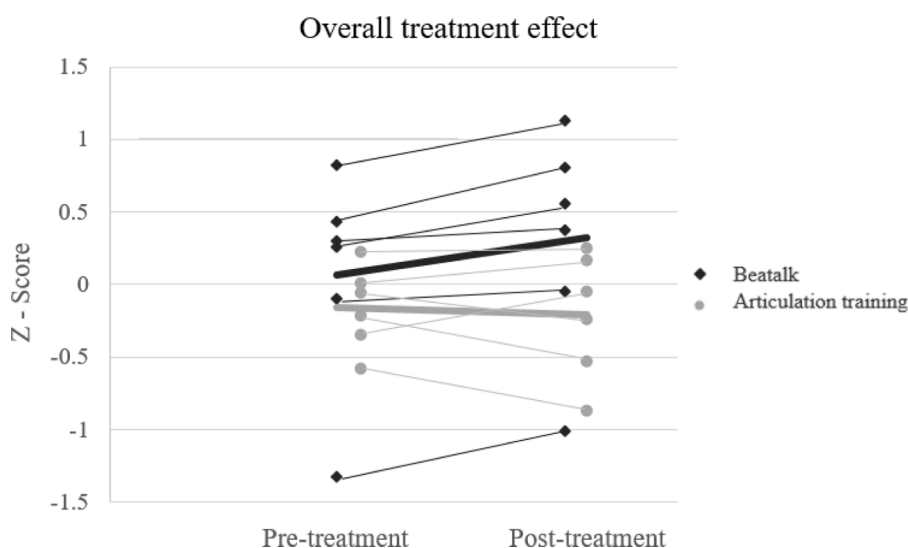


Fig. 1. Overall treatment effect (individual Z-scores): Pre- to post- treatment scores for the Beataalk and the articulation training participants. The thin lines represent individual participant; the thick lines represent group means. .

3.3. Improvements in articulatory accuracy measures

Since the primary goal of both interventions was to improve articulatory accuracy, separate analyses were conducted for the PWC and PCC measures, using Wilcoxon Signed-Rank Tests. Numerically, improvements in PWC scores were comparable in magnitude for both groups (Articulation training: from 21 to 23%; Beataalk: from 25 to 27%); yet only for the Beataalk group the improvement was statistically significant ($p = .03$). Similar trend was noted for the PCC scores, as numerically both groups showed equivalent increases (Articulation training: from 71 to 74%; Beataalk: from 75 to 78%), yet this difference was statistically significant only for the Beataalk participants ($p = .03$). A visual illustration of the data (individual as well as group level data) is presented in Fig. 2.

3.4. Voice and oral-DDK measures

For the Beataalk group, a significant improvement was noted for MPT, with an increase of about 2.3 s in the duration of sustained phonation ($p = .03$, using Wilcoxon Signed-Rank Test). Changes in other measures were non-significant, possibly due to the small sample size, and the heterogeneity that characterizes this population. For the articulation training group, no significant effects were noted (see Table 3).

4. Discussion

In the presence of congenital or developmental dysarthria, all vocal tract subsystems can be implicated, resulting in poor control over respiration, phonation, resonance, articulation and/or prosody. Although controlled studies of intervention for individuals with congenital dysarthria have not been extensive, the literature supports the potential effectiveness of speech therapy for these individuals (Pennington et al., 2016).

The present exploratory study compared the effect of two speech therapy intervention programs, articulation training and the Beataalk method on various aspects of speech production of young adults with congenital dysarthria of different etiologies. Specifically, we assessed speech intelligibility and articulatory accuracy, voice measures in different speech samples, and oral-DDK rates. The results indicated that the Beataalk method induced positive significant overall improvement in speech characteristics, mainly, changes in articulatory accuracy for single words. Following the articulation training there was no appreciable improvement.

Beatboxing mainly involves articulation exercises (intense repetition of plosive consonants), yet it also promotes other aspects of speech production, such as respiration, resonance, and rate. Hence, the intervention may be more global, and different levels of speech production can be targeted in combination. These findings echo the increases in speech intelligibility of individuals with dysarthria reported following speech therapy using a speech systems approach (Pennington et al., 2016), which also targets various components of the vocal tract. In contrast, the traditional articulation training is more impairment-focused, and other speech subsystems are not addressed. Although the findings are preliminary in nature, and improvements were documented primarily on a single-word level, they look promising and may prompt further investigation. Next, we will explain these results and discuss their implications.

4.1. Articulatory accuracy and speech intelligibility

The difference between the pre- and post-treatment PWC scores was numerically similar for both groups, yet the improvement was statistically significant only for the Beataalk group. This may be attributed to the fact that in the Beataalk group five out of six participants showed improvements, while only three out of six participants showed higher post-treatment PWC scores in the articulation training group. A similar trend was observed for the PCC measure, with a numerically comparable difference between pre- and post-treatment values for both groups, which was found to be statistically significant only for the Beataalk group (with five out of six participant showing improvements, relative to four out of six in the articulation training group).

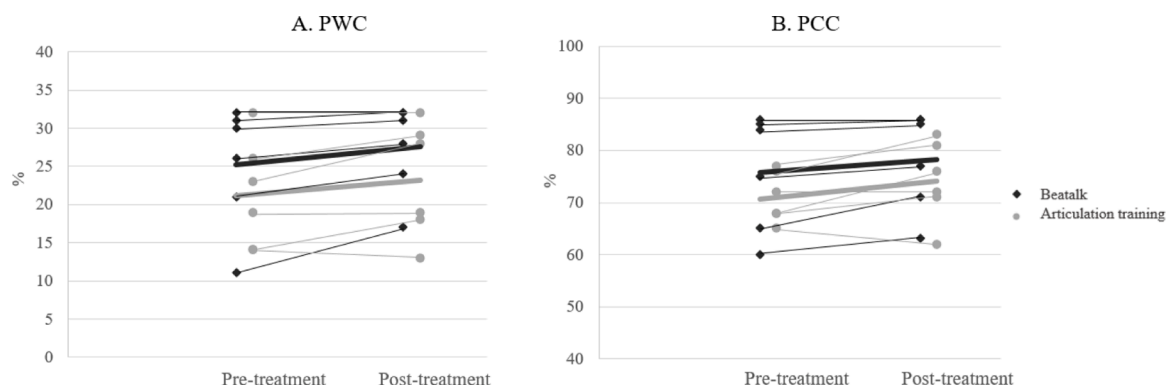


Fig. 2. A visual illustration of the pre- to post-treatment PWC and PCC scores (individual as well as group level data) for the Beataalk and the articulation training participants. The thin lines represent individual participant; the thick lines represent group means. .

The significant improvements in PWC and PCC for the Beataalk participants indicate that on a single-word level more words and more consonants were produced in a correct manner following treatment. Since the main goal of the intervention was to improve articulatory accuracy, these initial results may be encouraging. The Beataalk method is based on vocally producing and practicing beatbox sounds, which is quite similar to intensive consonant production. For example, to produce the kick drum sound, which is parallel to the plosive [p], a strong lip seal is required. Since the sound is made when air is forced through the lips, a tight lip closure enhances the quality of the sound (Patil, Greer, Blaylock & Narayanan, 2017). We assume that the Beataalk practice, i.e., repeatedly and intensively producing such sounds, ultimately results in improvement in speech production on the word-level. That is, along the intervention period, the participants improved their ability to produce the beatbox sounds, thus they also improved their ability to produce the corresponding speech sounds within familiar words.

In addition, the various beatbox sounds were practiced in different combinations. Each target sound was produced in different positions (initial, medial, and final) within various sound sequences, with different adjacent sounds (e.g., [p-ts] vs. [k-p]). This yielded a practice which shares many features with speech production (e.g., different word length, locations, co-articulation; Icht & Ben-David, 2018a) increasing word-level production accuracy.

Although participants could employ the Beataalk strategies in single words, they did not generalize these skills to continuous speech. Indeed, for the Beataalk participants intelligibility scores increased from pre- to post-treatment, yet non-significantly. That is, an overall improvement in speech intelligibility was not documented. Possibly, as this intervention was relatively brief (8 weeks) and focused on the initial levels of consonant production (isolation, syllables), carryover and benefits to continuous speech intelligibility were limited. Having a longer treatment period may allow participants to build up to more practice in conversational speech, increasing their intelligibility in continuous speech (for a comparable trend, see: Pennington et al., 2006).

4.2. Voice measures

Voice instrumental analyses showed a significant improvement for the MPT measure following the Beataalk intervention. This may be of special importance since the ability to maximally sustain a vowel after having taken a maximal inspiration is considered an objective measure of laryngeal function (Maslan, Leng, Rees, Blalock & Butler, 2011) and of the efficiency of the respiratory mechanism during phonation (Neiman & Edeson, 1981). Non-significant improvements were noted in other voice measures following the Beataalk intervention, namely increased vocal loudness, higher HNR, smaller shimmer and jitter values, and longer duration of sustained /s/. In addition, the subjective measure of overall voice abnormality (G subscale of the GRBAS) was smaller. As much variability existed between the participants, most improvements were non-significant, but the fact that positive trends were found for nearly all measures is noteworthy.

The abovementioned vocal improvements may be related to the Beataalk practice, which involves the use of the full range of airflow mechanisms (Proctor et al., 2013). Beatboxing necessitate breath control and increased respiratory capacities (Sapthavee et al., 2014). For example, Patil et al. (2017) documented the use of extra pulmonic pressure to achieve certain sound quality characteristics. The involvement of the hypopharyngeal cavity promotes harmonic resonance (De Torcy et al., 2014), and the use of the pharyngeal constrictors increases subglottal pressure (Buescher & Sims, 2011). Together, such vocal techniques lead to improved vocal loudness and quality.

Many adults with dysarthria show voice symptoms (e.g., reduced voice quality, impaired voice stability), which may adversely affect speech naturalness. Voice impairments may cause irritation or impatience among communication partners even when speech intelligibility is relatively intact (Schölderle et al., 2016). Thus, it is important to address voice symptoms in treatment (Miller et al., 2013). The current encouraging results warrant further evaluation of the Beataalk method in improving voice characteristics.

4.3. Oral-DDK rates

The oral-DDK tasks involve maximally rapid syllable repetition and are commonly used to assess the efficiency of speech motor control (Duffy, 2013). As they require maximum articulatory performance, these tasks are considered as a highly sensitive measure of motor speech impairments (e.g., dysarthria; Kent, Kent & Rosenbek, 1987). Of the various subgroups of the oral-DDK tasks, the sequential motion rates (SMRs) were used in the current study, requiring the participants to rapidly and accurately repeat two syllable sequences, a non-word sequence (/pataka/), and a real word (/bodeket/; Icht & Ben-David, 2018b).

The results indicated non-significant improvements for both tasks, non-word as well as real word repetition following the Beataalk intervention. Oral-DDK rates can measure the severity and presence of neurological impairments, with slower rates associated with disorders of the central nervous system or peripheral sensory motor functions (Wang et al., 2009). The post-treatment faster oral-DDK rates for the Beataalk participants may be related to the nature of the practice, which involves rapid repetitions of the different beatbox sound while quickly connecting them. Presumably, this requires finely tuned temporal control (De Torcy et al., 2014), that may be transferred to the oral-DDK tasks.

4.4. Limitations and future directions

Some limitations of the current pilot study should be mentioned. First, this study was carried out with a small sample of participants. Indeed, most studies of speech treatment in dysarthria have been restricted to relatively small sample sizes (for a review, see Table 1 in Pennington et al., 2016). Hence, the current study is limited in its ability to draw general conclusions. In addition, the sample was relatively heterogeneous (e.g., in terms of dysarthria etiology and severity, comorbidity, etc.). Second, as this study was a pilot

trial, the number of dependent variables was relatively high, providing preliminary evidence of intervention efficacy, and information to design future studies. Specifically, the transcription-based measures (PWC, PCC) were chosen according to recommendations in the literature (e.g., [Kearney et al., 2015](#)). However, they have some constraints. For example, PCC was originally designed to assess severity rather than measure change subsequent to intervention. In addition, the original calculation of PCC requires measuring all consonants in all word positions. Treatment targeted at select consonants may not significantly alter PCC scores. The fact that multiple comparisons for related variables were conducted, and the lack of significant findings for some of the tested measures may not be a substantial limitation at this preliminary stage. However, these findings must be verified in further studies. Future studies may also assess ease of understanding judged by naïve listeners as a global measure of speech intelligibility and compare it to other transcription-based measures.

It is also important to note that both intervention programs focused on a limited number of target consonants, mainly due to the relatively brief intervention period (8 weeks). The literature indicates that consonants with high complexity (e.g., sounds later acquired) are more commonly misarticulated by adults with dysarthria ([Kim et al., 2010](#)) and that they more frequently misarticulate fricatives and affricates than speech sounds in other categories ([Platt, Andrews & Howie, 1980](#)). Future studies may expand the variety of treatment targets and may also evaluate the impact of beatboxing on the production of prosody, a partially preserved skill of adults with CP and dysarthria ([Patel, 2002; 2004](#)).

Another limitation concerns the intervention schedule. The current schedule was chosen to resemble conventional treatment settings in Israel; hence it was relatively less intensive. However, the frequency, intensity, and duration of service delivery may have an impact on treatment outcomes ([ASHA, 2020](#)). On the one hand, there are some evidence that intensive speech therapy improves speech intelligibility for individuals with CP ([National Institute for Health & Care Excellence, 2019](#)). On the other hand, the relationship between intensity and outcome is not always linear, and more is not always better (e.g., intensive therapy was found to be associated with higher drop-out rates; [Baker, 2012](#)). Possibly, longer intervention period and a more intensive treatment program may result in larger and broader improvements (e.g., in continuous speech intelligibility). Future studies may assess the benefits of longer and intensive treatment schedule, as well as its long-term effects (in a follow-up session), to understand generalization and the possible impact of treatment on communication function.

Additional future recommendations include evaluating motivation and engagement levels. Indeed, assessing change following treatment not only at the impairment level but also from a broader social perspective may add valuable clinical information ([Kearney et al., 2015](#)). Since motivation and engagement are key factors influencing rehabilitation outcomes, these may also be gauged.

The positive outcomes of the Beataalk intervention on a number of measures, along its abovementioned benefits, may guide future intervention studies with other populations (e.g., teenagers and adults with mild intellectual disability; individuals with speech disorders due to cranio-facial defects such as cleft palate).

4.5. Conclusions

The need for effective therapeutic tools that can be successfully implemented in speech therapy for adults with congenital dysarthria (and possibly other populations) has led us to consider the use of beatbox sounds and rhythms. In recent years, the beatboxing art form has gained considerable popularity ([Thompson, 2011](#)), and it continues to develop, with many new techniques and sounds. The current initial results suggest that this unique vocal style, which involves creating music with the speech organs, may be intended for entertainment, but can also be used as a therapeutic tool within the context of speech rehabilitation, mainly at the early levels of isolation and syllable production. As the Beataalk method addresses various aspects of speech production, such as breathing and respiratory control, articulatory accuracy, and production rate, it improves different speech characteristics relative to an articulation training approach. These findings are in accord with the pertinent literature, suggesting that a focus on control of respiration, phonation and speech rate are associated with improved intelligibility for individuals with CP ([Miller et al., 2013; Pennington et al., 2013](#)).

Besides these speech-related benefits, the Beataalk method has other advantages. First, practicing beatbox can be done anytime, anywhere (e.g., classroom-based, home-based, pull-out, etc.), thus improving generalization ([Cirrin & Penner, 1995](#)). Second, practice can be achieved through peer interaction in informal everyday settings, allowing for the emotional and social benefits of group music making ([Hagen & Bryant, 2003](#)). Third, the Beataalk method is cross-linguistic and cross-cultural in nature, as the beatbox sounds can be found in the sound systems of many languages ([Proctor et al., 2013](#)). Hence, beatbox practice may be appropriate for speakers of many languages, an advantage in multicultural and multilingual societies. Finally, it may reduce available staff resources and budgets, since learning to beatbox does not necessitate any professional musical education (but it can be easily achieved via media, e.g., YouTube clips), and practicing can be done by non-professional providers (e.g., briefly trained volunteers). In addition, the required equipment is minimal, and practicing can be performed in a group.

Taken together, the overall supportive nature of the current initial findings suggests that the Beataalk technique may be a promising tool in improving articulatory accuracy for adults with congenital dysarthria. These findings are encouraging, as comparable gains have been found in a group of adults with intellectual disability and speech problems ([Icht, 2019](#)), suggesting that the Beataalk method can be a useful addition to SLPs' toolbox.

CRedit authorship contribution statement

MI designed the study, collected the data, analyzed the raw data, interpreted the data, wrote, and revised the manuscript.

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Conflict of Interest Statement

The Author declares that there is no conflict of interest.

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