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Respiratory, laryngeal and articulatory behaviors during speech and non-speech tasks in children with cerebral palsy: New evidence of function from cutting edge research methodologies

Carol A. Boliek,[1] Ignatius S. B. Nip,[2] and Cynthia M. Fox[3]

[1]Department of Speech Pathology and Audiology, University of Alberta, Edmonton, Alberta , [2]School of Speech, Language and Hearing Sciences, San Diego State University, [3] National Center for Voice and Speech, Denver, CO

Overall Objectives

To report current findings related to respiratory, laryngeal and articulatory function for speech and non-speech tasks derived from methodology to quantify chest wall kinematics, laryngeal impedance, and orofacial kinematics in children with dysarthria secondary to cerebral palsy (CP).

Study A: Developmental trajectories for speech breathing

Participants: 25 children with CP, 25 matched controls
Design: Longitudinal from birth to age 7 years
Method: Chest wall kinematics

Results:

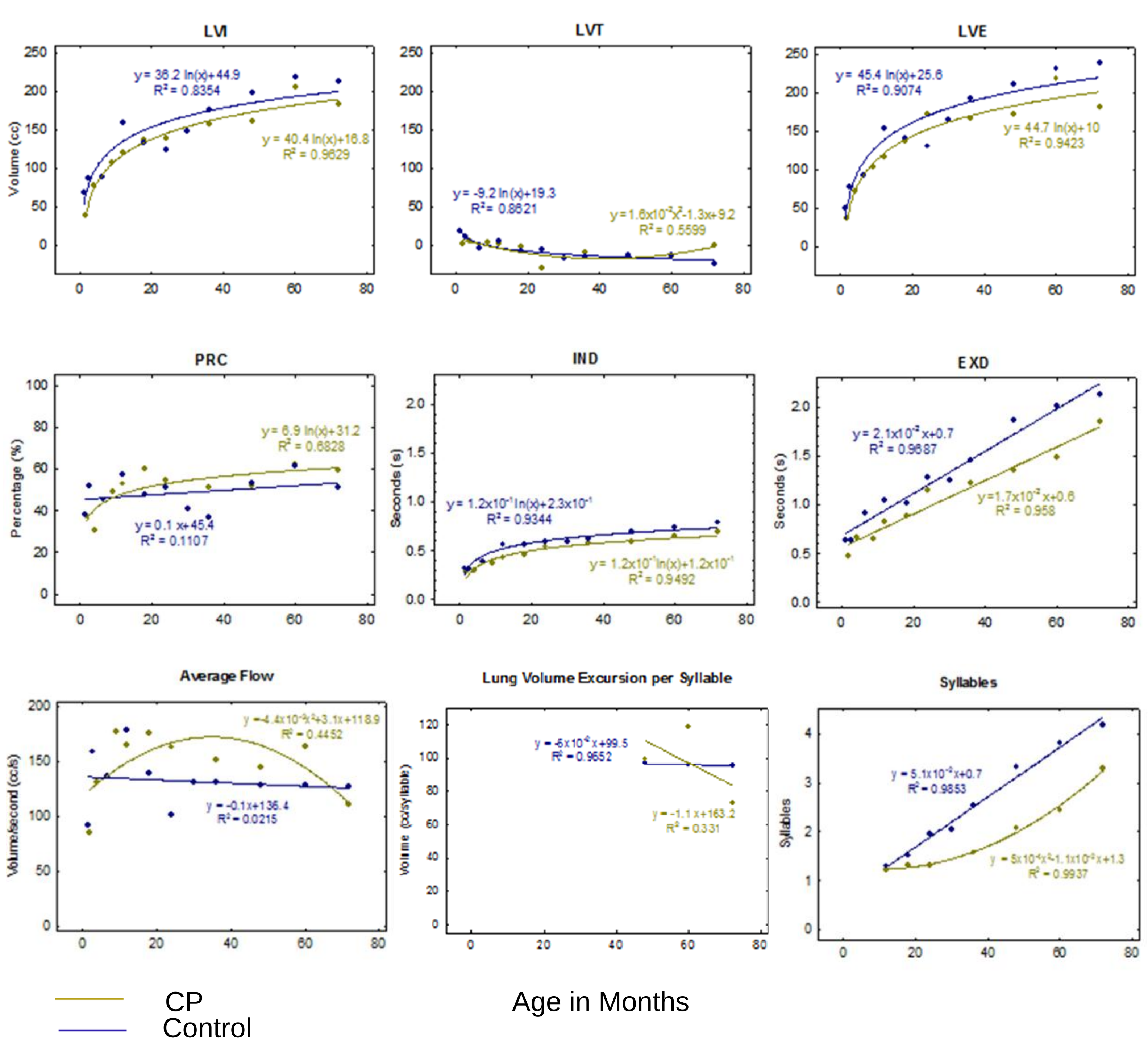


Figure 1. Developmental trajectory functions for lung volume initiation (LVI), lung volume termination (LVT), lung volume excursion (LVE), percent rib cage contribution to lung volume excursion (PRC), inspiratory duration (IND), expiratory duration (EXD), average flow, lung volume excursion per syllable, syllables per breath group.

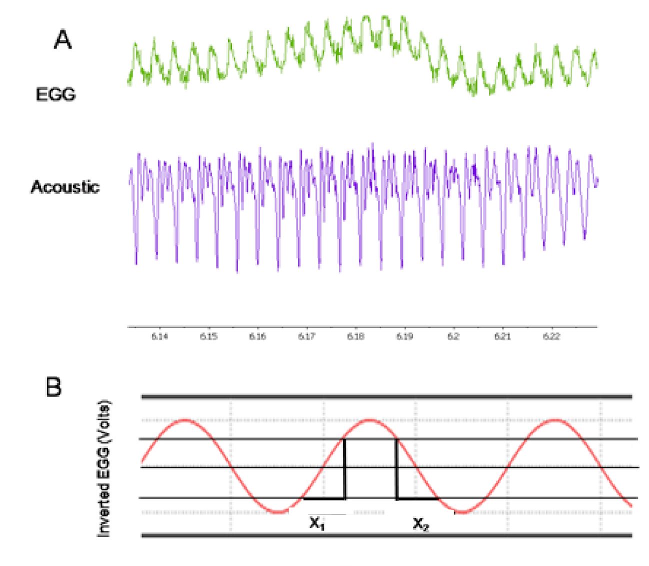
Conclusions:

- When positioned optimally, infants and children with CP exhibit similar developmental trajectories for lung volume initiation, termination and excursion when vocalizing and speaking as their control counterparts.
- Developmental trajectories for rib cage contribution, expiratory duration, average flow per breath group, lung volume expenditure per syllable and number of syllables produced per breath group differed between groups indicating that children with CP use a different chest wall configuration and laryngeal control for speaking.

Study B: Laryngeal function for speech produced at different loudness levels

Participants: 5 children with CP, 5 matched controls
Ages 8 to 12 years
Method: Electroglottograph (laryngeal impedance)
Tasks: Conversational, 2X's, 4X's, .5X's conversational loudness for the phrase, "I sell a sapapple again"
Measure: Speech quotient

Figure 2. Acoustic signal and resulting EGG signal in typical child speaker, during production of the "ah" vowel (A). Signal is not rectified. Simulated signal and speech quotient measurement (X_1/X_2) (B).



Results:

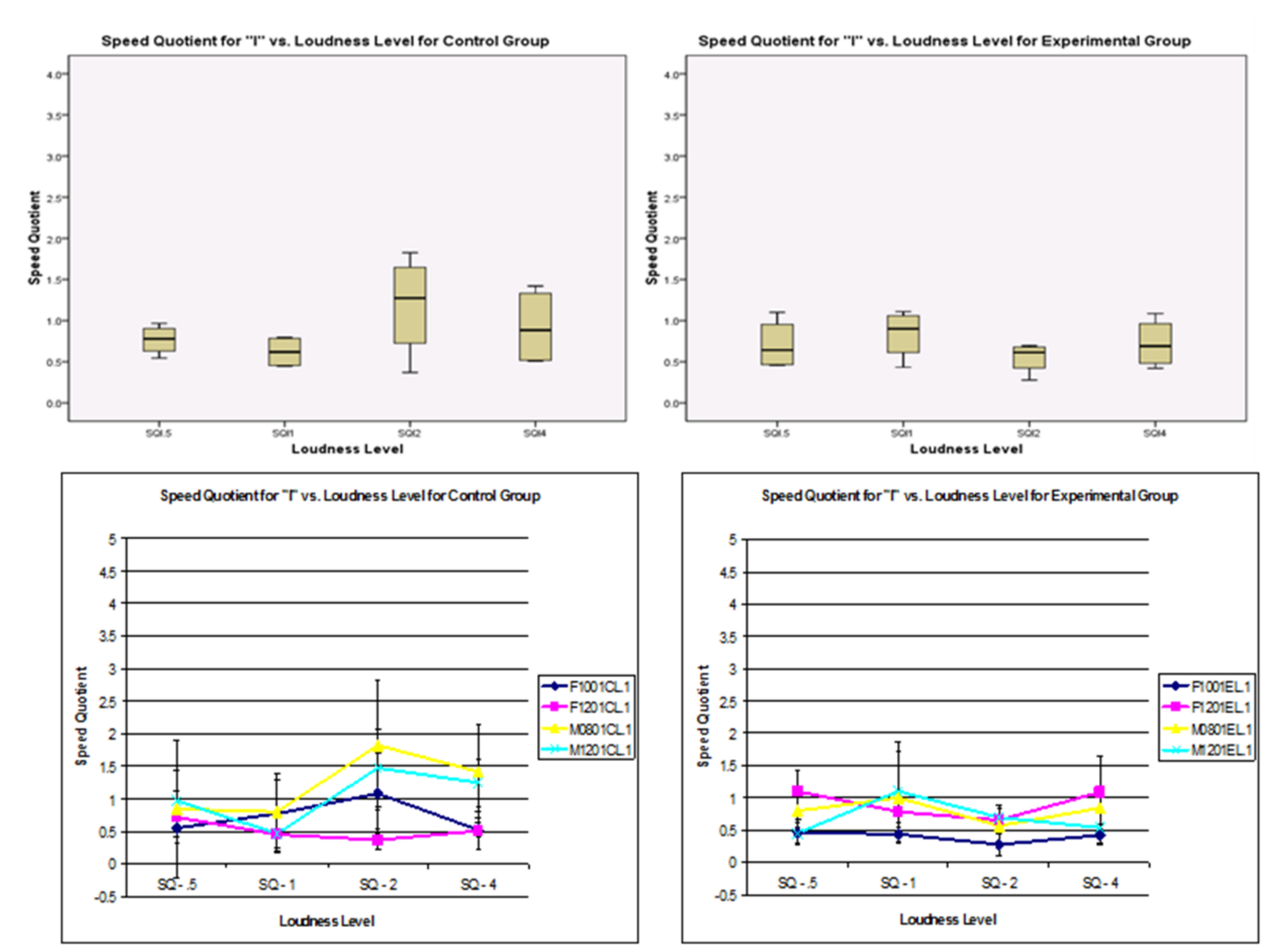


Figure 3. Group and individual data for SQ (the time taken for impedance to rise from 20% to 80% divided by the time taken for it to decrease from 80% to 20%) for the vowel in "I" produced during the sentence task. Four panels represent group and individual data. Data from the control group (typically developing children) are shown in the two panels on the left and data for the experimental group (children with CP) are shown in the two panels on the right. In all four panels, speed quotient is depicted on the y-axis. In all four panels the loudness condition (SQ.5 = .5X Loud, SQ1 = Normal Loudness, SQ2 = 2X Normal Loudness, and SQ4 = 4X Normal Loudness) is depicted on the x-axis. The top two panels represent box and whisker plots, indicating the median, upper and lower quartiles and inner fences for each group. The bottom two panels show the average and standard deviation SQ values for individual participants. These yoked pairs are displayed in the same color.

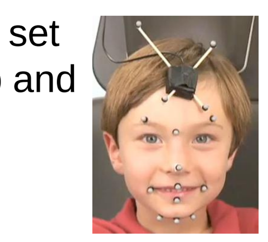
Conclusions:

- Control children increased the "closed phase" of the vocal folds (i.e., a higher speed quotient) when producing speech greater loudness levels.
- Children with CP did not appear to make a vocal fold adjustment (i.e., similar speed quotient across loudness tasks) when producing speech at louder or softer levels.

Study C: Articulatory kinematic correlates of speaking rate in three different speaking tasks

Participants: 4 speakers with CP, 38 age-matched controls
Method: Optical motion capture (Motion Analysis, Ltd.)
Tasks: Diadochokinetic task ("buh"), syllable ("uhba"), sentence ("Buy Bobby a puppy")
Measure: Speaking rate (syll/s), speed (mm/s), range of movement (mm), duration (s)

Figure 4. Marker set used to record lip and jaw movements



Results:

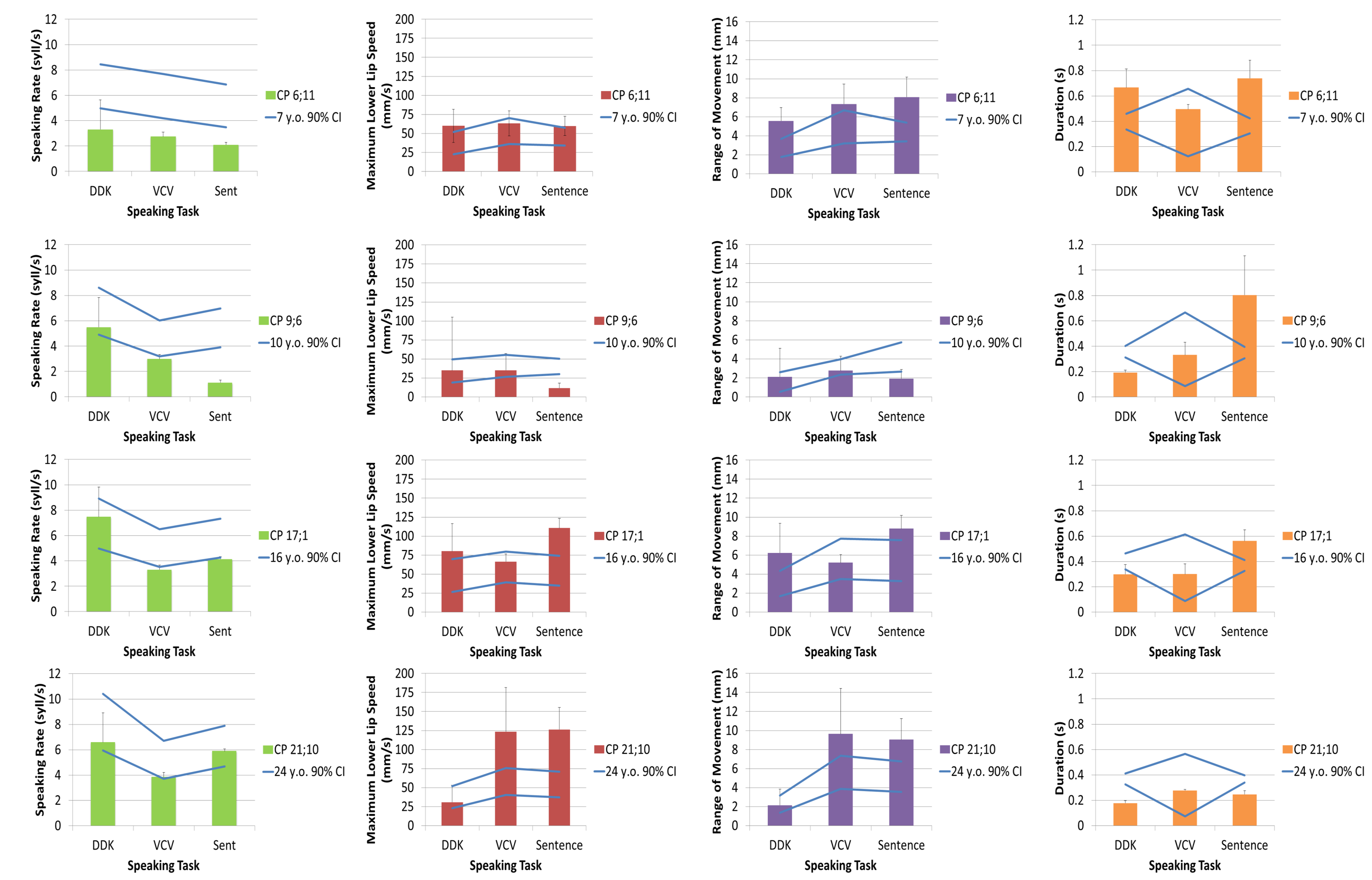


Figure 5 Speaking rate, maximum speed, range of movement, and duration of lower lip closing and opening for DDK, syllable (VCV), and sentence tasks. The bars represent the performance of the speakers with CP. The blue lines mark the upper and lower bounds of the 90% confidence interval of their age-matched peers. Each row represents one of the speakers with CP.

Conclusions:

- Speakers with CP have slower speaking rates than their typically-developing peers but similar maximum speeds of their age-matched peers
- Range of movement of speakers with CP generally increased with linguistic task demands, similar to typically-developing peers and corresponds with reduction in speaking rate.
- This may be due to the higher ranges of movement that speakers with CP have, potentially reflecting inefficient force control

Acknowledgements

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