SPEECH BREATHING IN PATIENTS WITH ADDUCTOR SPASMODIC DYSPHONIA

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ABSTRACT

Inductive plethysmography was used to calculate respiratory measures related to volume, timing, thoracic displacement and respiratory efficiency in patients with adductor spasmodic dysphonia (ADSD) compared to controls. Results revealed significant differences between groups and across tasks. Those with ADSD had statistically higher ventilation rates, more breaths per minute, a higher degree of muscular inefficiency/breathlessness and labored breathing. Differences between tasks were attributed to a higher cognitive-linguistic demand required during conversational speech. These findings support the idea that individuals with ADSD may experience difficulties with respiration as the effects of their Botox injection dissipate.

Keywords: Adductor Spasmodic Dysphonia, Respiration, Voice, Inductive Plethysmography.

1. INTRODUCTION

The production of voice relies on the coordination and balance of the subglottal, glottal, and supraglottal systems. These systems must work together as their functions often overlap. For example, the maintenance of subglottal pressure occurs through the coordination of the muscles of the respiratory system and those within the larynx [1-3]. Unfortunately, the coordination of these three systems does not always function properly.

It has been postulated that an individual alters their respiratory behaviors in order to compensate for disordered voice production [3,4]. Individuals with voice disorders tend to produce deeper inhalations and initiate speech at different lung volumes compared to controls. These behaviors have been attributed to an attempt to "overcome respiratory difficulty, compensate for air loss at the glottal level and regulate subglottal pressure during phonation" [4, p. 648]. In addition, increased or decreased air flow rates, differing end inspiratory or expiratory lung volumes, changes in subglottal pressure and paradoxical rib cage movements have been reported [3-8].

Many of these same behaviors have been noted in patients with adductor spasmodic dysphonia (ADSD), a dystonia involving involuntary spasms of the laryngeal adductor muscles which results in excessive medial compression of the folds [9]. The result is a strained/strangled vocal quality that sounds characteristically similar to glottal fry. Previous studies have suggested that individuals with ADSD are likely to experience increased subglottal pressure with decreased airflow rates [10-14]. Yet to be studied are other parameters of breathing that may broaden our understanding of the level of compensation by the respiratory system. Therefore, this study was designed to examine parameters involving respiratory volume, timing, thoracic displacement, and efficiency in the speech of individuals with ADSD.

2. METHOD

2.1 Participants

Fifteen adults (6 males and 9 females) were recruited from the Ear, Nose and Throat (ENT) Clinic at a medical university in southwest Florida. These individuals were at the clinic for their regularly scheduled Botox injection. Individuals with a co-existing neurological or neuromotor disorder or an inadequate reading ability were excluded from this study. Fifteen age- and gender-matched individuals agreed to participate as the matched control group.

2.2 Materials

Respitrace and RespiEvents [15] were used to quantitatively measure the breathing process. Specifically, the Respitrace bands act as an inductive plethysmograph. Plethysmography is a method of determining air pressure, volume and flow by calculating changes in thoracic surface while breathing [16]. Respitrace requires the use of a vest that is wrapped around an individual's rib cage and abdomen. This vest consists of two elastic bands with embedded coiled wires. These wires calculate and quantify any thoracic movement by forming a stretchable loop around the body so that the wires change size with the rib cage and abdominal excursions. Surface displacement is measured in volts and sent to RespiEvents which then translates the volts into volume measures [16]. The result is a sinusoidal waveform that represents inhalation and exhalation. An initial calibration period of five minutes was completed for each participant. This calibration period allowed for Respitrace to track typical breathing patterns for each individual and to calibrate the equipment for experimental use.

2.3 Procedures

Participants were fitted with the Respitrace vest and were asked to complete four speaking tasks in a random order: 2 reading and 2 conversational tasks. The reading tasks involved 2 readings of the first paragraph of the *Rainbow Passage* [17], while the conversational tasks consisted of 2 conditions: a picture description task and response to an open-ended question. At the start and finish of each speaking task, the researcher pulled either the rib cage or abdominal band, which produced a notable spike within the computer waveform. All data was transferred from RespiEvents to an Excel file via an ASCII cut. These values represented breathing parameters in terms of volumes, times, derivatives, and rib cage and abdominal movements.

2.4 Measured breathing parameters

For the purposes of the present study, fourteen breathing parameters were analyzed and compared across groups and tasks. Specifically, three volume measures were analyzed: inspiratory and expiratory volume (ViVol & VeVol, respectively) and minute ventilation (Vent) or how much air is inhaled and exhaled in a minute. Six timing measures were recorded: breaths per minute (Br/M), inspiratory time (Ti), expiratory time (Te), total breath time (Tt), a fractional inspiratory time (Ti/Tt) and the time to reach peak expiratory flow (PefTTe). Two measures that related specifically to thoracic displacement were analyzed: the percentage of rib cage contribution (%RC) and a labored breathing index (LBI). And finally, three measures of respiratory efficiency were recorded: a rapid shallow breathing index (F/Vt), peak inspiratory flow (PifVt) and a measure of respiratory muscular efficiency and breathlessness (VePif). The values obtained during each task were averaged then combined to get an average for the reading tasks and an average for the conversation tasks for each participant.

2.5 Reliability

The data obtained from four participants (two from each group) were randomly selected to determine the intra-judge reliability. Because each participant engaged in four speaking tasks, the data from 16 speaking tasks were re-analyzed. In total, these four participants contributed a total of 148 breaths. During reliability testing, 146 breaths matched correctly for 98.6% accuracy in measurement.

3. RESULTS

MANOVAs were performed for each of the 14 breathing parameters included in this study. Many significant differences were found when comparing across group, task, and gender. A main effect according to group was found in four parameters: minute ventilation (expressed in arbitrary milliliters, Aml) [$F(1,26) = 5.519$, $p = .027$, $\eta^2 = .175$], breaths per minute [$F(1,26) = 4.769$, $p = .038$, $\eta^2 = .155$], muscular efficiency and breathlessness [$F(1,26) = 11.88$, $p = .002$, $\eta^2 = .314$], and labored breathing index [$F(1,26) = 7.716$, $p = .01$, $\eta^2 = .229$] [see Figs. 1-4]. The ADSD group was found to ventilate more liters of air per minute and take more breaths per minute than the control group, regardless of speaking task. This group performed the speaking tasks with a higher index of labored breathing and respiratory inefficiency and breathlessness.

Figure 1. Mean minute ventilation rate compared across participant groups.

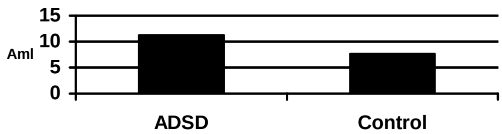


Figure 2. Average breaths per minute compared across groups.

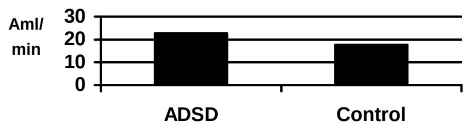


Figure 3. Differences in respiratory muscular efficiency and breathlessness by speaker gender.

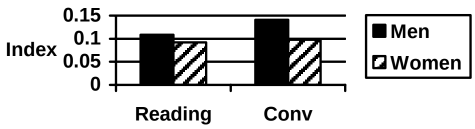
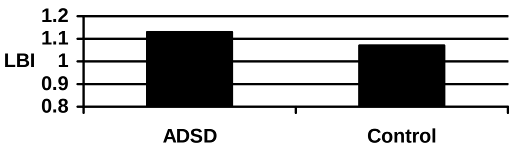


Figure 4. Differences in the LBI across groups.



Main effects according to speaking task were found in expiratory volume [$F(1,26) = 5.499$, $p = .027$, $\eta^2 = .175$], inspiratory time [$F(1,26) = 5.809$, $p = .023$, $\eta^2 = .183$], time to reach peak expiratory flow [$F(1,26) = 5.599$, $p = .026$, $\eta^2 = .177$] and % rib cage contribution [$F(1,26) = 18.329$, $p = .001$, $\eta^2 = .413$] [see Figs. 5-8]. Both groups had longer inspiratory times, larger expiratory volumes and took longer to reach peak expiratory flow during conversational tasks. Also during conversation, the rib cage contributed less to the tidal volume than during reading tasks.

Figure 5. Mean expiratory volume averaged across speaking task.

Figure 6. Average inspiratory time compared across speaking tasks.

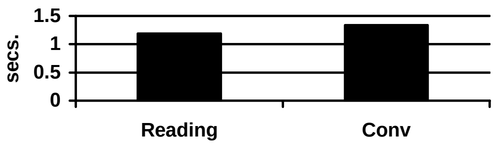


Figure 7. Percent of expiratory time used to reach peak expiratory flow compared across speaking tasks.

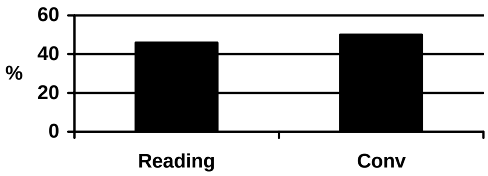
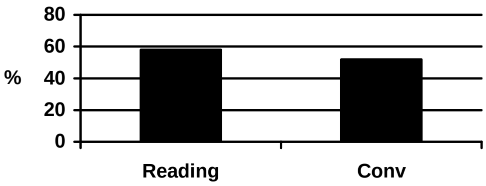


Figure 8. Percentage of rib cage contribution across speaking tasks.



Additionally, several interactions were found to be significant. An interaction between speaking task and group was found to be statistically significant in inspiratory volume [$F(1,26) = 4.212$, $p = .05$, $\eta^2 = .139$] and in peak inspiratory flow [$F(1,26) = 3.746$, $p = .001$, $\eta^2 = .126$]. Those in the control group inhaled significantly less air in conversation than the ADSD group or both groups in conversation. In addition, the ADSD group increased their respiratory drive in reading tasks when compared to the control group in reading or both groups in conversational tasks. Also, an interaction was found between task and gender in fractional inspiratory time [$F(1,26) = 7.442$, $p = .011$, $\eta^2 = .223$] and muscular efficiency and breathlessness [$F(1,26) = 6.681$, $p = .016$, $\eta^2 = .204$]. Men demonstrated a greater fractional inspiratory time with a greater muscular efficiency in conversation versus in reading or when compared to women in both tasks. Overall, these results indicate that individuals with ADSD evidenced more difficulties with breathing efficiency than the control group. In addition, reading proved to be a less taxing task for the participants, but also required more rib cage involvement.

4. DISCUSSION

The results of the present study indicate that those with ADSD exhibit disordered breathing when compared to controls. The objective data obtained for this study can be linked to the patient's reports of a higher degree of effort needed during speaking. This effort becomes more apparent as the effects of Botox treatment dissipate.

Individuals with ADSD utilized higher ventilation rates in both speaking tasks when compared to controls. This finding would suggest that individuals with ADSD used more air while speaking, however they did not differ from controls in their average inspiratory volumes. In general, patients with ADSD increased ventilation rates to overcome glottal resistance and lead to a decrease in the number of syllables per second (controls = 230.5 and ADSD group = 189.5 syllables per minute). The higher ventilation rate also suggests that the individuals with ADSD replenished their air supply more frequently in order to initiate speech.

When considering speaking task effects, a higher volume of exhaled air (VeVol) and longer inspiratory times (Ti) were found in conversational tasks. Also during these tasks, the rib cage contributed less to the tidal volume (%RC) and participants took longer to reach peak expiratory flow (PefTTe). These differences supported the previous research that suggested that respiratory patterns were altered when engaged in different speaking tasks [8, 16]. These speaking task differences were attributable to the demands of cognitive-linguistic planning. In these studies, longer speaking tasks, without grammatical indicators for when to replenish air supply, resulted in deviant respiratory patterns.

These present results suggest that deviations in respiratory parameters coexist with laryngeal spasm in patients with ADSD. In addition, these effects may be exacerbated when the cognitive-linguistic load of speaking is increased.

5. REFERENCES

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