Vocal Characteristics of School-Aged Children With and Without Attention Deficit Hyperactivity Disorder

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Summary

Objectives

The aim of this study was to describe the laryngeal anatomy, perceptual, acoustic, and aerodynamic vocal characteristics of school-aged children with and without Attention Deficit Hyperactivity Disorder (ADHD). The predisposition that children with ADHD have for laryngeal injuries are recurrent in nature and are more often than not overlooked as laryngitis. Previous studies have reported varied results on the prevalence rates of pediatric vocal fold nodules within the school-aged ADHD population.

Study Design

A static, two-group comparison was used in the study to investigate the clinical, perceptual, acoustic, and aerodynamic vocal characteristics of children between 7 and 9 years old with and without ADHD.

Methods

The study replicated the protocol as executed by Barona-Lleo and Fernandez (2016) with additions. The Multidimensional Voice Program and the Voice Range Profile as additions to the assessment of vocal parameters were used with which comparable dysphonia severity index scores were calculated. Once-off clinical, perceptual, acoustic, and aerodynamic voice assessments were conducted on 20 age-gender matched participants (Control group mean age [months] = 98.80, standard deviation = 10.379; ADHD group mean age [months] = 108.00, standard deviation = 10.873). It was hypothesized that children with ADHD would have more hyperfunctional vocal characteristics; leading to laryngeal injuries, than their control group peers.

Results

Forty-five percent (n = 9) of the total sample population (both groups combined) had laryngeal pathology. Similar parent reported etiological voice symptoms and vocal habits were seen across both groups. Both groups performed similarly across both perceptual and aerodynamic voice assessments. Acoustically, the control group achieved significantly higher producible pitches than the ADHD group (P = 0.028) and were found to have more dysphonic dysphonia severity index scores than their ADHD group peers (P = 0.034).

Conclusion

Prepubertal, school-aged children with or without ADHD may have similar vocal characteristics than previously thought. This is in support of the null hypothesis. The authors of the current study recommend that vocal screening in all school-aged children be carried out as an effective measure to monitor voice disorders in the pediatric population. Future research into larger sample sizes with this population with a special focus on the effect that central nervous system stimulants may have on the voice is recommended.

Key Words: Pediatric voice disorders; Attention deficit hyperactivity disorder; Vocal fold nodules; Dysphonia severity index; Multidimensional Voice Program; Voice range profile

INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is the single most common heterogeneous pediatric psychiatric disorder.[1] Internationally the prevalence of ADHD in primary school children is estimated between 5% and 8%.2, 3, 4, 5 In South Africa, a recent clinical audit at the Red Cross War Memorial Hospital reported that the prevalence rate of pediatric ADHD was 8.5%.[6]

A number of predisposing factors play a role in the high prevalence of the disorder and leave people, from low and middle income households, vulnerable to ADHD.[7] The majority of people in South Africa are classified as having a low socioeconomic status and are often at a greater risk for ADHD and its associated comorbid psychiatric illnesses.[6] Factors that play a role in the high prevalence of ADHD include decreased school enrollment, the level of parental education, parental mental health status, familial conflict and structure, being male, perinatal consumption of/exposure to toxins (especially tobacco and/or alcohol), difficulties during childbirth, brain injury as well as HIV/AIDS.6, 7

Approximately 60% of children with ADHD experience other significant comorbid impairments.8, 9, 10, 11[,45] These impairments include, among others, substantial speech-language and social communication difficulties. Such impairments may limit social interaction in subversive ways.12, 13, 14 A child may overexert their voice, also known as talkativeness, a hyperkinetic behavior common in children with ADHD.[15] "Talking too much" coupled with reduced self-monitoring of emotional reactions, communicative intent, and nonverbal cues may lead to high-pitched, rapid rates of talking at uncomfortable intensity levels which inflict phonotrauma onto laryngeal structures.12, 16[,17,46] Consequently, these phonotraumatic behaviors can be further exacerbated by excessive laryngeal and extra-laryngeal muscle tension and may lead to voice problems with or without vocal fold nodules (VFN).

Only a few studies have reported on the prevalence of VFN in the pediatric population in general.18, 19, 20 Much variance in the incidence of VFN in school-aged children has been reported in previous research.[18] The majority of other studies investigated children with pathological voice characteristics. In 2008, authors reported that 82.4% (n = 257) of children aged between 8 and 14 years presented with significant structural changes to their vocal folds.[20] Although previously reported incidence rates were as low as 1% and as high as almost 23.4%, authors recommend that 6%–9% should be considered more realistic.[18] In a Turkish study, the reported prevalence of VFN in school-aged children was found to be 16.9%.[18] In contrast, 82% of children previously diagnosed with dysphonia aged between 8 and 14 years of age presented with significant structural changes to their vocal folds.[20] Not until recently did research direct itself to investigating the related factors that may either cause or contribute to hyperfunctional vocal habits that may manifest in laryngeal pathology.

Only five recent studies, albeit with small sample sizes, have explored the relationship between hyperfunctional vocal habits in children and the presence of ADHD.10, 12[,]15, 16[,21] It has been reported that children with ADHD presented with increased loudness were more hoarse and breathy than their control peers.[15] As a result, early identification and assessment of vocal characteristics in children with ADHD is necessary.12, 15[,49] Phonotraumatic behaviors may lead to concentrated swelling or submucosal bleeding; changing the size, weight, the range of motion and elasticity of the vocal folds, or the subsequent emergence of functional voice disorders.[15] Conversely, inattentive and or hyperactive/impulsive behaviors most commonly associated with ADHD were higher in children with VFN.12, 21 It was recommended that future research should include laryngoscopic evaluation in this population to investigate the presence of organic laryngeal pathologies.12, 15[,21] Authors postulated that ADHD may be an associated risk factor in the development of hyperfunctional voice disorders that may manifest in VFN.[21] Moreover, the parental report results from the Conners' Parent Rating Scale-Revised: Short Form indicated that children with VFN presented with more hyperactive and oppositional behaviors than their control group peers.[16] Recently, another study reported that over 90% of children with ADHD presented with hyperf-unctional vocal behaviors. Seventy-eight percent of these children with ADHD (n = 25) had clinically significant changes to the anatomy of their vocal folds, most commonly VFN.[10] Bearing in mind that due to its chronicity, ADHD often persists into adulthood and coupled with the increased risk of having comorbid conditions, any effort to ameliorate or reduce the effect of subsequent disorders or difficulties of ADHD should be made efficiently and effectively.6, 22

Higher disease/disorder prevalence rates are proportional to increased primary health-related costs.[23] The annual cost per child with ADHD in the United States can reach over $17 000 (R250 000) per annum.[20] The medical treatment and educational support required due to ADHD's chronicity and comorbidity may be a lifelong expense.[22] If ADHD-related laryngeal injuries are identified in children, effective management necessitates medical and speech-language intervention.19, 24 This inflates the costs incurred by their families. The reality remains that, for people from low- and middle-income countries and low socioeconomic status and other related risk factors that predispose them to ADHD, they simply cannot afford or access such services.[6]

The predisposition that children with ADHD have for laryngeal injuries is recurrent in nature and is more often than not overlooked as laryngitis.10, 15 Voice therapy remains the primary preventative treatment measure to date for children with laryngeal injuries.25, 26[,47] Previous studies have reported variability in the prevalence rates of VFN in school-aged children with ADHD and thus merit further investigation.10, 12[,]15, 16[,]18, 21 As a result, the following research question is posed: What are the vocal characteristics of school-aged children with ADHD?

METHOD

Aim

The aim of the study was to describe the laryngeal anatomy, perceptual, acoustic, and aerodynamic vocal characteristics of school-aged children with and without ADHD. It was hypothesized that children with ADHD would have more hyperfunctional vocal characteristics; leading to laryngeal injuries, than their control group peers.

Research design

A static, two-group comparison was used in the study to investigate the clinical, perceptual, acoustic, and aerodynamic vocal characteristics of children between 7 and 9 years old with and without ADHD.

Ethical clearance was obtained through the Faculty of Humanities Research Ethics Committee at the University of Pretoria on February 2017 (Ref: *GW20170116HS*).

Participants

Convenience sampling was employed to obtain a sample of 24 children who agreed to participate in this study. However, the results of only 20 participants could be included in the study due to poor tolerance of the videostroboscopic examination. Remaining participants were categorized into two groups, aged between 7 and 9 years old. The ADHD group comprised of 10 children with ADHD and the control group had 10 children with no history of ADHD. This was confirmed by the outcome of the Vanderbilt ADHD Diagnostic Parent Rating Scale and no reported academic difficulties. The groups had a similar age and gender distribution. Participants were required to be aged between 7 and 9 years old in order to control for the pubertal-vocal differences in fundamental frequencies (F_0) found across conversational speech.27, 28, 29, 30, 31 The ADHD diagnosis of the ADHD group participants had to be made by a pediatric neurologist according to either the Diagnostic and Statistical Manual of Mental Disorders (DSM)-IV-TR or DSM-V ADHD criteria. ADHD group participants had to be actively taking their prescribed medication. Participants were excluded if they presented with any chronic medical condition as well as intellectual developmental, neurological, and/or sensory disabilities. A qualified ear, nose and throat (ENT) specialist conducted a thorough physical examination on all participants.

Voice assessment protocol

Permission was obtained from school authorities and parents, or guardians from all participants. All 20 children (14 boys and 6 girls) with and without ADHD underwent a once-off, free clinical, perceptual, acoustic, and aerodynamic voice assessment.

The clinical examination

For reliable comparability measures, all participants had to undergo the clinical assessment. The clinical examination was conducted by a qualified ENT specialist. In order to detect or differentially diagnose for the presence of upper respiratory illnesses and voice disorders, a videostroboscopic examination of the anatomy and functioning of the upper airways was conducted. A RLS 9100B strobe unit by KayElemetrics Corp was used. Depending on each participant's tolerance, either a rigid or flexible scope was used; namely an ENT VNL 1170K or an ENT SN 9108 scope. The assessment consisted of a physical examination of each participant as well as minimally invasive direct video laryngoscopy to examine the larynx and vocal folds (VFs). The clinical assessment took a total of 15 minutes. To obtain consensus across diagnoses, another qualified ENT specialist reassessed the stroboscopic examination recordings of 25% of participants. The ENT was not aware of the age, gender, or the ADHD status of any participant reassessed. Diagnosis was made based on normal vocal fold, edema, or the presence of vocal fold nodules. Interrater reliability has been determined and interpretations have been deemed reliable as 100% consensus was obtained between the physicians.

The perceptual, acoustic, and aerodynamic voice assessment

The complete voice assessment was conducted by the researcher at the Voice Laboratory at the University of Pretoria. A comprehensive case history questionnaire was given to all the participants' parents, which included a checklist of hyperfunctional vocal characteristics (Table 1) to best describe their child's voices. To ensure the reliability of the absence of an ADHD diagnosis among control group participants, parents were asked to complete the Vanderbilt ADHD Diagnostic Parent Rating Scale.[53] Parents of all participants were asked to complete the validated and reliable[50], 23-item pediatric Voice Handicap Index (pVHI); assessing the impact of dysphonia on a pediatric population.[32] A cutoff point of seven or less was considered asymptomatic.[33]

TABLE 1. Summary of the Parental Responses of the Vocal Etiological Symptoms Checklist of Participants (n = 20)

Variable	Basic themes	ADHD group (n = 10)	Control group (n = 10)	Total (n = 20)
Pitch quality	*Normal*	6	6	12
	Too high	2	1	3
	Too low	2	3	5
Volume perception	*Normal*	4	6	10
	Too loud	3	0	3
	Too soft	3	4	7
Overall vocal quality *(can report more than one)*	*Normal*	5	6	11
	Monotonous	3	0	3
	Control issues	0	3	3
	Nasal	1	1	2
	Hoarse/Harsh	1	2	3
	Breathy	2	1	3
Breathing as a factor to voice problem	*Yes*	2	1	3
	No/Not applicable	8	9	17
Child awareness of voice problem	*Yes*	2	2	4
	No/Not applicable	8	8	16
The effect their voice has on their everyday life	*None*	9	9	18
	Significant	0	1	1
	Moderate	1	0	1

The widely accepted and validated GRBASI four-point scale[34] was employed during the perceptual assessment of participants' voices using a spontaneous speech sample. Picture-based speech sample stimuli were used to control for the reading ability of all participants. Consensus of the GRBASI results obtained by the researcher was achieved by means of a panel of qualified speech language pathologists with experience in voice therapy. The diagnosis of ADHD of each participant's recordings was unknown to the panel members.

Majority consensus was reached through independent scoring in a quiet room, of all 20 samples in free-field, in one session. Fifty percent of the samples were repeated for validity purposes. After independent scoring of the samples, results were compared and discussed.

The maximum phonation time (MPT) of all participants was taken using the steady state vowel /a/ [48] after maximum inspiration and the best time over three repetitions were recorded. MPT was considered normal when greater than or equal to 7.98 seconds.[35]

Thereafter, an s/z ratio was calculated by producing the voiceless /s/ and voiced /z/ on maximal inspiratory effort for as long as possible. The best of three attempts was recorded.

Aerodynamic assessment reveals information regarding phonatory efficiency[36] was carried out using a Contec DATASpiro digital spirometer (SASPRSP10W). The aerodynamic parameter investigated was Forced Vital Capacity (FVC). FVC measures were analyzed using the digital spirometer and recorder through a software program. Theoretical models suggested that a predicted FVC of 1,4 - 1,6L (girls) and 1,4 – 1,8L (boys) was to be considered as normal for children aged 7–9 years old.[37]

Multidimensional Voice Program (MDVP) analysis and the Voice Range Profile (VRP) of the Computerized Speech Lab (MODEL 4105B; KayPENTAX) was conducted on all the participants in a sound-proof room. Data were processed, recorded, and stored on a Mecer Prelude Intel Pentium Dual Core desktop computer. Acoustic analysis of the voice was executed using a microphone set at a fixed off-axis position of 45° and 10 cm away from the mouth. The MDVP was used to evaluate the jitter (*jitt %)*, shimmer (*shim %)*, fundamental frequency variation (vF_0), and noise-to-harmonics ratio (NHR) of each participant. The VRP is a depiction of one's minimum and maximum volume and pitch capacities across one's vocal range.

A dysphonia severity index (DSI), a multiparametric tool, was employed to generate an objective vocal quality score based on acoustic results. A score was then generated using the MPT (seconds), highest frequency (Hz), lowest intensity (dB), and jitter (%). Although paediatric normative data is not yet available for the DSI, the index was used in a descriptive manner. Adult norms indicate that a DSI of >0 as normal and a DSI of <0 to −5 as either mild, moderately or severely dysphonic. Likewise, for our study population, a DSI of >0 was classified as normal and <0 to −2 was considered as dysphonic. These norms were used as a guideline .”[38]

The perceptual, acoustic, and aerodynamic voice assessment lasted 25–30 minutes. The duration of the entire protocol was 45–60 minutes.

Data analysis

Descriptive statistics were employed through the use of Statistic Package Social Sciences (SPSS) v 23 (Chicago, IL). Due to the small sample sizes of the ADHD and control groups, the interpretations of results are to be regarded as descriptive and not conclusive. The Kolmogorov-Smirnov test was run on each variable to determine the normality of the distribution.[39] A Levene's test was employed to evaluate whether the data set had equal or unequal variances.[39] An independent *t* test was conducted where the normality assumption was met, in order to detect for significant differences between the groups’ acoustic means (Jitter %, Shimmer %, F_0, NHR, Highest dB, Lowest dB, F-Hi, and F-Lo).[39] Where the normality assumption was not met, the Mann-Whitney test, the nonparametric equivalent of the independent *t* test, was executed.[39] Cross-tabulations were conducted, by means of a Pearson Chi-square test in order to investigate any significant correlations between the perceptual, acoustic and respiration assessment results and the clinical findings.[39] A significance level of <0.05 was considered as significant for all analyses.

RESULTS

The ADHD and control group were similar in terms of age ($P = 0.069$) and gender distribution. In this study, both groups comprised of seven males and three females. In the ADHD group, only six of the ten participants were on prescribed medication; namely Ritalin, Concerta, or Strattera.

According to the case history questionnaire, six parental reports of children with ADHD reported experiencing at least three or more etiological vocal symptoms. Four parents of children within the control group also reported vocal symptoms that indicated hyperfunction. Overall, half of the total population sample reported hyperfunctional vocal symptoms (n = 10) (Table 1).

Interestingly, seven (mean = 8.3; standard deviation [SD] = 11.08) of the total sample population were found to have abnormal pVHI scores. Similar parent-reported pVHI scores of participants, indicating hyperfunction, were found among both groups (Control [n = 4]: mean = 9.2, SD = 4.3; ADHD [n = 3]: mean = 7.4, SD = 13.6; $P = 0.328$).

TABLE 2. Frequency Distribution of GRBASI Scores (n = 20)

GRBASI	Condition	Normal *(score = 0)*	Slight *(score = 1)*	Moderate *(score = 2)*	*P* value*
G	ADHD (n = 10)	7	1	2	0.684
	Control (n = 10)	5	4	1	
	Total (n = 20)	12	5	3	
R	ADHD (n = 10)	7	2	1	0.971
	Control (n = 10)	7	2	1	
	Total (n = 20)	14	4	2	
B	ADHD (n = 10)	3	5	2	0.143
	Control (n = 10)	5	3	2	
	Total (n = 20)	8	8	4	
A	ADHD (n = 10)	8	2	0	0.529
	Control (n = 10)	8	2	0	
	Total (n = 20)	16	4	0	
S	ADHD (n = 10)	8	2	0	0.684
	Control (n = 10)	8	1	1	
	Total (n = 20)	16	3	1	
I	ADHD (n = 10)	9	1	0	0.739
	Control (n = 10)	9	0	1	
	Total (n = 20)	18	1	1	

*Significance level: $P < 0.05$.

TABLE 3. Comparison of the Aerodynamic and Acoustic Assessment Results between Children With and Without ADHD

Acoustic parameter	Group	Mean	SD	*P* value
MPT (s)	ADHD (n = 10)	15.2	5.8	0.500
	Control (n = 10)	13.5	5.3	
	Overall (n = 20)	14.4	5.5	
VC (mL)	ADHD (n = 10)	1746.0	439.0	0.091
	Control (n = 10)	1403.0	420.3	
	Overall (n = 20)	1574.5	453.8	
PQ (mL/s)	ADHD (n = 10)	129.6	57.6	0.583
	Control (n = 10)	116.0	50.9	
	Overall (n = 20)	122.7	53.4	
Jitter (%)	ADHD(n = 10)	1.3	0.5	0.514
	Control (n = 10)	1.5	1.0	
	Overall (n = 20)	1.4	0.8	
Shimmer (%)	ADHD (n = 10)	4.6	2.0	0.705
	Control (n = 10)	5.0	2.2	
	Overall (n = 20)	4.8	2.0	
Fundamental frequency variation (%)	ADHD (n = 10)	2.0	0.6	0.530
	Control (n = 10)	1.8	0.8	
	Overall (n = 20)	1.9	0.7	
NHR (dB)	ADHD(n = 10)	0.1	0.02	0.877
	Control (n = 10)	0.1	0.02	
	Overall (n = 20)	0.1	0.0	
s/z	ADHD(n = 10)	0.8	0.02	0.968
	Control (n = 10)	0.8	0.02	
	Overall (n = 20)	0.8	0.2	
Highest dB (dB)	ADHD(n = 10)	97.9	7.5	0.819
	Control (n = 10)	99.8	4.2	
	Overall (n = 20)	98.9	6.0	
Lowest dB (dB)	ADHD(n = 10)	68.1	6.4	0.089
	Control (n = 10)	74.6	9.5	
	Overall (n = 20)	71.4	8.5	
F-high (Hz)	ADHD(n = 10)	718.4	191.2	0.290
	Control (n = 10)	630.2	169.7	
	Overall (n = 20)	674.3	181.7	
F-low (Hz)	ADHD (n = 10)	110.8	52.6	0.028*
	Control (n = 10)	170.1	58.5	
	Overall (n = 20)	140.5	62.1	
DSI	ADHD (n= 10)	0.4	4.5	0.034*
	Control (n = 10)	−3.2	2.3	
	Overall (n = 20)	−1.4	3.9	

Abbreviations: SD, standard deviation; MPT, maximum phonation time; VC, vital capacity, PQ, phonation quotient, NHR, noise-to-harmonics ratio; DSI, dysphonia severity index.

⁎Significance level: $P < 0.05$.

After analyzing the clinical examinations of the laryngeal anatomy of all participants, it was found that 9 out of the total 20 participants had some anatomical change to their vocal folds. Both groups were found to laryngeal pathology; namely edema (ADHD n = 2; Control n = 1), bilateral prenodules (ADHD n = 3) and bilateral VFN (Control n = 3). More interestingly, 35% (n = 7) of the same participants who were found to have a laryngeal pathology also had abnormal pVHI scores (*P* = 0.002) and DSI scores indicative of possible dysphonia (*P* = 0.020). A significant difference was also seen between the pVHI and DSI scores (*P* = 0.035) over the total sample population. This may indicate that the pVHI may have been more accurate in detecting vocal concerns prior to the perceptual, acoustic, and aerodynamic assessment of the participants' voices. When evaluating the scores of the GRBASI (Table 2), similar results were seen in both groups across the six categories of perceptual voice quality.

The acoustic assessment results (Table 3) revealed that there was a significant difference between the two groups in terms of the overall DSI score (*P* = 0.034) and the F-low (*P* = 0.028) of participants. In both instances, the control group had more dysphonic DSI scores and achieved lower F-low results than ADHD group peers. The ADHD group achieved lower means in jitter and shimmer and a higher variation in their fundamental frequencies than control group peers. Although not statistically significant (*P* = 0.091), the ADHD group participants had a higher VC (mean = 1746 mL; SD = 439) than control group participants (mean = 1403 mL; SD = 420.3). This was in alignment with the higher MPT scores (*P* = 0.500) in the ADHD group participants (mean = 15.2 s; SD = 5.8) when compared to control group peers (mean = 13.5 s; SD = 5.3). Almost identical mean values were found in the NHR and s/z ratio scores for both groups (ADHD mean = 13.5 s; SD = 5.8; control mean= 15.2 s; SD = 5.3; *P* = 0.877).

DISCUSSION

Thirty percent (n = 6) of the total sample population were found to have VFN. Similar prevalence rates of VFN have been reported in large cohort studies conducted in a general school-age population where the prevalence ranged between 15% and 35%.18, 40 In contrast, in an early retrospective review of almost 18,000 pediatric cases, only 4% (n = 731) of patients were classified with a laryngeal pathology of which 17.5% (n = 128) were predominantly VFN.[41] In the current study VFN diagnosis in male participants outnumbered that in females by an even larger 5:1 ratio. Similar findings were reported where males outnumbered females in prevalence of VFN diagnosis by a 2:1 ratio.[18] Acoustically, the overall means of the jitter (1.4%, SD = 0.8), shimmer (4.8%, SD = 2.0), fundamental frequency variation (1.9%, SD = 0, 7), NHR (0.1 dB, SD = 0.0), F-high (674.3 Hz, SD = 181.7), and F-low (140.5 Hz, SD = 62.1) in the current study were similar to the findings reported by Campisi et al.[52] Interestingly, in the current study the F-low in the ADHD group was significantly lower than among controls (*P* = 0.028). Variations in previous findings may be due to differences in research methodology used, that is sampling strategies, small sample sizes, and the voice criteria used to determine dysphonia.[18]

Previous findings reported that children with ADHD were at risk for developing voice disorders as almost half of the participants with ADHD were breathier, louder, and hoarser than control peers.12, 15 In the current study, 40% of the total sample population, that is children with and without ADHD, were identified with the same hyperfunctional voice symptoms. Acoustically, there was no significant difference between the jitter (*P* = 0.514) or the speaking volumes of either groups which is in contrast to previous findings.10, 12,15, 42 The current study demonstrated that there were equal rates in the incidence of VFN among control and ADHD group participants. Previous authors showed that more than 90% (n = 30) of children with ADHD had anatomical changes to their vocal folds and that 78% (n = 25) of these changes were classified as VFN.[10] They recommended voice assessment, by relevant medical professionals and speech therapists, as part of the holistic management of children with ADHD due to the possibility that ADHD may be a risk factor in pediatric dysphonia. The authors of the current study support these recommendations, due to the fact that school-aged children with or without ADHD were found to have similar vocal characteristics with equal propensity towards incurring laryngeal injuries.

In the current study the ADHD group achieved significantly lower pitch levels (110.8 Hz) than their control group peers (170.1 Hz; *P* = 0.028). This may be due to the fact that central nervous system (CNS) stimulants may indirectly and as a secondary effect lower the F_0 in the voices of children with ADHD to counteract the hyperfunctional vocal behaviors that may cause voice problems.43, 44 However, not much research has been conducted in investigating the effect of CNS stimulants on voice production, much less in children.43, 44 Therefore future research should explore the effect of medication on the vocal characteristics of children with ADHD.

Both the ADHD and control group presented with similar outcomes in the aerodynamic, the acoustic, and the parent-reported etiological voice symptoms and vocal habits of their children. It was apparent to the authors that the pVHI, although lengthier than the parental vocal etiological symptoms checklist, was somewhat easier to understand and rate without prior orientation to, education and training in good voice production. However, of the nine participants identified with laryngeal changes, only four participants' pVHI scores were abnormal, with or without ADHD. Laryngeal pathology diagnoses were seen in participants whose parents rated on the checklist to have been more talkative, loud, harsh manner of talking and having high pitched voices. Taking into consideration that 45% of the sample population (n = 9) were diagnosed with a laryngeal pathology, it is cumbersome that parent-proxy reports (the vocal etiological symptom checklist or pVHI) failed to identify these children prior to their clinical examination. Previous authors argue that parent-proxy questionnaires may under detect dysphonia in children, even when guiding instructions are provided, and is most often associated with insufficient knowledge or training regarding good vocal hygiene and use.[12,47,51] This discrepancy highlights the importance of using multidimensional methods in pediatric voice assessments, advocating the need for greater awareness creation regarding good voice habits, and supporting parents of children at risk for developing childhood voice disorders.[47] Additionally, the need for the support of parents in understanding healthy voice production prior to rating their children's voices will aid in more accurately screening children before subjecting them to full voice assessment.

Limitations and recommendations

The largest limitation of the current study is our small sample size. Strict study criteria, access to the specified population, recruitment of participants that matched study criteria, consent and availability of parents and participants were factors that determined our sample size. Although the current study did have a small sample size, the current study is time and cost efficient for future research to expand to larger sample sizes.

Furthermore, the possible secondary effect, that CNS stimulants used in treating pediatric ADHD has on voice production and use, justifies for further research into this population. In our study, participants differed in terms of the type of medication, dosage, duration on the type of medication, as well as adherence and attitudes toward the treatment plan. To ensure that representative vocal differences, or lack thereof, are detected, future research utilizing larger sample populations is recommended. As a precaution, stricter control should be employed with regard to medication type, dosage, and duration.

Moreover, voice production is highly sophisticated, thus a, wide array of parameters were required in order to detect changes at each level of voice production. Measurements investigated in the current study, as part of a replicated voice protocol from recent research, are based on internationally accepted standards in the assessment of voice.[10]

Additionally, as a whole the results are valuable particularly in a population where normative values are scarce; consequently adding to a growing body of research. It is recommended that the MDVP, VRP, and spirometry be used to assess vocal characteristics in this population for the holistic value the data sets play as well as their time and cost efficiency. Further research is recommended into larger populations so as to establish pediatric norms for the DSI, as it quantifies the degree of severity of dysphonia and is useful as a means of tracking progress when speech therapy is employed as an adjunct therapy.

Finally, the results of this study support previous findings in which the pVHI should be included in the screening of pediatric voice problems as it was more likely to detect dysphonia in participants identified with laryngeal changes in the current study. In addition, parent education and training in normal voice production should be given prior to scoring parent-proxy questionnaires or voice-related quality of life scales. This may curb the effect that was seen in the underdetection of voice-related problems in children from parent-proxy reports used as a means of voice screening.

CONCLUSION

In conclusion, the current study confirmed that despite a small sample size, a significant amount of school-age children were prone to developing voice problems whether or not they may have ADHD. This is in support of the null hypothesis. This study highlights the importance of screening all school-aged children to ensure early detection of possible voice problems and to intervene when necessary. Furthermore, efforts to increase parental awareness of the importance of good vocal habits are evident. Further research is warranted within a larger sample size of this population, with a new direction in investigating the effect of the pharmacological management of ADHD on the pediatric voice.

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