Clinical and Acoustic Vocal Profile in Children With Attention Deficit Hyperactivity Disorder

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Summary: Purpose. The objective of this study was to evaluate the presence of etiologic factors, symptoms, and vocal acoustic alterations related to vocal hyperfunction in children with attention deficit hyperactivity disorder (ADHD).

Method. In 23 children with ADHD and 28 control children, vocal acoustic exploration was performed to analyze the F_0, jitter %, and voice turbulence index for the sustained vowels /a/ and /i/ and the average tone and intensity and tonal modulation in tests of continuous speech. The children's parents completed a specific questionnaire aimed at detecting etiologic factors and vocal symptoms.

Results. Children with ADHD displayed more vocal symptoms (hoarseness, neck strain, and shortness of breath while talking) and more etiologic factors (they shouted more, spoke louder and faster, and became angry more easily) than did children in the Control group. Likewise, children in the ADHD group exhibited a greater % jitter and a lower average intensity in the continuous speech tests.

Conclusions. These results indicate that children with ADHD display greater vocal hyperfunction as compared with children in the Control group and suggest a higher risk of developing dysphonia. The results of this study could be useful for designing vocal programs focusing on vocal education and hygiene to prevent and decrease vocal risks and on promoting vocal health in children with ADHD.

Key Words: Attention deficit hyperactivity disorder–Voice disorder–Acoustic voice analysis.

INTRODUCTION

Attention deficit hyperactivity disorder (ADHD) is the most common childhood psychiatric disorder.[1] According to the *Diagnostic and Statistical Manual of Mental Disorders* (Fourth Edition, Text Revision) (*DSM-IV-TR*) of the American Psychiatric Association ADHD is a chronic neurobiologic disorder of multifactorial origin, characterized by an impaired ability to regulate activity (hyperactivity), inhibit behavior (impulsiveness), and maintain attention to a task (inattention). It is estimated that between 3% and 7% of school-aged children have ADHD.[2] In Spain, the prevalence is 4.57% in children aged between 6 and 11 years.[3] Boys exhibit ADHD more often than do girls,[4] with the boy/girl ratio varying from 5/1 to 3/1 during childhood.[5]

The chronicity of the disorder implies a major public health problem because there are other associated illnesses. The comorbidity of ADHD is well known. The repercussions in the child's familial, social, and academic context require considerable assistance and educational care and entail a substantial economic cost.[6]

From a psychiatric point of view, it is estimated that 60% of children with ADHD have other impairments. Between 20% and 25% children display anxiety, 20% have behavioral disorders and 15–25% have mood disorders.[7] Regarding language, speech delays are observed in 35%, learning disorders in 20–30%, and expressive language disorders in 10–54%. Pragmatic language disorders are of special interest because they further limit the social interactions of these children. Children with ADHD are known to have difficulties in understanding communicative intent and the nonverbal indicators of their interlocutors (eg, changes in intonation and voice volume). They often poorly measure their own emotional behavior during conversations.[8,9] It has been reported that this communicative conflict has important socioemotional implications[10] and could add to other vocally abusive behaviors, such as high-pitched talking or shouting to obtain attention.

The hyperkinetic voice use can produce excessive laryngeal and extralaryngeal muscle tension during voice emission, which can trigger vocal hyperfunction.[11–13]

Vocal hyperfunction has been defined as "conditions of abuse and/or misuse of the vocal mechanisms due to excessive and/or imbalanced muscular forces."[14] It has an estimated prevalence of 10–40% of cases of vocal dysfunction[15] and is often associated with psychological and personality factors.[16] It has been observed that children with ADHD are very likely to exhibit characteristics of vocal hyperfunction, including talkativeness.[17] Early detection and control of abusive vocal behaviors is of great clinical interest because it prevents vocal hyperfunction and phonotrauma, which have been associated with laryngeal injuries such as edema, nodules, and polyps.[18,19]

Current literature primarily includes studies dealing with learning and psychiatric alterations among children with ADHD. Few publications have focused on the vocal characteristics and voice disorders that these children may exhibit. Therefore, the objective of the present study was to evaluate the vocal characteristics of children with ADHD for detection of vocal hyperfunction and, in particular, vocal etiologic factors that may generate vocal symptoms and acoustic changes in voice. The results could be useful for designing vocal programs focusing on vocal education and hygiene to prevent and decrease vocal risks and on promoting vocal health.

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METHODS

Subjects

The study examined 51 children, 35 boys and 16 girls, aged 6–15 years. The children were classified into two groups: an ADHD group and a Control group.

The ADHD group consisted of 23 cases (20 boys and 3 girls) with an average age of 10.48 years (range: 6–14 years). Within the ADHD group, two cases had hyperactivity (8.70%), two cases had attention deficit (8.70%), and 19 cases were diagnosed with the combined type (82.60%). The Control group included 28 cases (15 boys and 13 girls) with an average age of 10.11 years (range: 7–15 years).

The sample of children with ADHD was obtained from the Association of Children with Attention Deficit and Hyperactivity of the cities of A Coruña and Vigo (Galicia). The Control sample was obtained from two schools located in the cities mentioned above. Participation in the study was voluntary and agreement and informed consent were obtained from parents in all cases.

The participants in the ADHD group had been previously diagnosed by a specialist according to the *DSM-IV-TR* criteria.[2] Participants were required to have an age of 5–15 years and no medical problems related to brain injury, hearing, autism, or mental disability.

The study was approved by the Ethics Committee for Research of the University of Coruña (code CE41/2012).

Materials and procedure

Symptom assessment and etiologic variables. A specific questionnaire was designed for the parents to specify symptoms and etiologic variables that they had observed in their children. The questionnaire had a total of nine items and five answer options for each question based on the frequency of occurrence (0 = never, 1 = almost never, 2 = sometimes, 3 = frequently, and 4 = always). The vocal symptoms listed were "Tension in the neck while talking," "Hoarseness," and "Breathlessness while talking." These were selected for being easily visible by parents.

The selected etiologic variables were five behaviors associated with vocal risk: "Loudness," which reflected excessively strong intensity while talking; "Shouting," which reflected the frequency of shouting; "Speed," which established whether the child talk too rapidly; "Amount," to evaluate the talkativeness; and "Respecting others' turn to talk." To these etiologic variables, we added the variable "Easily becomes angry while talking," as this behavior could act as a trigger for the selected etiologic variables.

Acoustic analysis

Because the age range in our sample included adolescent and age affects some variables acoustic analysis, we subdivided our Control samples and those of the ADHD into subgroups of children younger than 12 years (from 6 to 11 years and 11 months) and those older than 12 years (from 12 to 15 years).

With this, we established four subgroups for acoustic analysis: younger than 12 years Controls (10 boys and 10 girls), older than 12 years Controls (5 boys and 3 girls), younger than 12 years ADHD (13 boys and 2 girls), and older than 12 years ADHD (7 boys and 1 girl).

The voices of all the participants were recorded with a digital audio recorder (model KENWOOD, MGR-A7-B; Kenwood Electronics, France SA, France) with its microphone placed 20 cm from the participant's mouth at a 45° angle. The recordings were always performed by the same equipment, in the same room, and with minimal background noise. These were stored directly in a computer, as digital files, for subsequent analysis with acoustic programs.

Tests were performed using the sustained vowels /a/ and /i/ and continuous speech, following the phonetic targets of the Consensus Auditory-Perceptual Evaluation of Voice developed by the American Speech-Language-Hearing Association in 2003.[20] The vowels were emitted in the children's in a comfortable and habitual way for 3 seconds, after deep inhaling. The procedure was repeated three times, and the average value of these recordings was used. Both the beginning and end of the vowel uttering were discarded to avoid the instability produced by onset and offset of phonation.

To examine continuous speech, the children were asked to read six sentences, each having specific phonetic characteristics and involving different laryngeal and articulator behaviors. They were asked to tell the story "Little Red Riding Hood" for 20 seconds, with bullet points provided as visual support to avoid pauses that could alter the narrative rhythm. The designed sentences were all the vowels found in Spanish (sentence 1), voiced velar fricative /ɣ/ in syllable-initial position (sentence 2); voiced phonemes /g, r, m, n, b, l, j/ (sentence 3); voiceless velar stop /k/ (sentence 4); voiced bilabial nasal phoneme /m/ (sentence 5), and voiceless bilabial stop /p/ (sentence 6).

The sustained vowels were subsequently analyzed with the *Multi-Dimensional Voice Program* (*MDVP*; model 5105, Version 2.4) and the continuous speech samples were analyzed with *Real-Time Pitch Program* (model 5121, Version 2.4), both from the software *Multi-Speech* (model 3700) by Kay Elemetrics, Lincoln Park, NJ. A sampling rate of 44 100 kHz was used in both programs.

The acoustic parameters average fundamental frequency (F_0, Hz), jitter percentage (% jitter), and voice turbulence index (VTI) were analyzed with *MDVP*. Average tone, average intensity, and tonal modulation were analyzed with *Real-Time Pitch Program*. The obtained data were recorded in a database created for this purpose for subsequent statistical analysis. The results were summarized in tables, and the averages are presented with their respective standard deviations. The necessary comparisons were performed using the appropriate statistical tests (listed in the "Results" section) with the statistical software suite *SPSS*, Version 15 (SPSS, Chicago, IL). A statistical significance level of $P < 0.05$ was considered.

RESULTS

Higher frequency of vocal symptoms in the ADHD group compared with the control group

Table 1 shows the number of ADHD and control cases according to the frequency of symptoms reported on the questionnaire.