Original Article

Artigo Original

Auditory-perceptual and acoustic analysis of voices of HIV-infected children

Análises perceptivo-auditiva e acústica das vozes de crianças infectadas pelo HIV

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Keywords

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ABSTRACT

Purpose: To compare vocal and acoustic parameters of HIV-infected children and non-HIV-infected children. **Methods:** Vocal samples were submitted to auditory-perceptual and acoustic analysis. Samples of the sustained vowel /ɛ/ and continuous speech of 74 children between 6 and incomplete 12 years old were analyzed, divided into two groups: 37 HIV-infected children (GHIV) and 37 non-HIV-infected children, the control group (CG), age and gender-matched and without previous vocal evaluation; they were all prepubescent by the Tanner Stages (MS, 2014). The children had their voices recorded and analyzed by VoxMetria 5.1, in the period between 2014 and 2015. The auditory-perceptual analysis assessed the overall degree of the vocal quality and was performed using a 100-point visual analogue scale, transformed into a 4 point numerical scale (0 = no vocal deviation and 4 = severe vocal deviation). The acoustic evaluation was based on the analysis of the vocal sample distribution in the Phonatory Deviation Diagram (PDD). The research was approved by the Ethics Committee under the number 122.746. **Results**: In the auditory-perceptual analysis, most children of both groups were evaluated as with no vocal deviation. No difference between the groups was found in the acoustic analysis using the PDD; most voice samples were within the normality area, in the quadrant 1, with a spread density distribution and a vertical shape. **Conclusion**: HIV-infected children presented similar vocal quality to children without the illness, both for the perceptual-auditory and acoustic evaluation.

Descritores

Voz
Acústica da Fala
Qualidade da Voz
Percepção Auditiva
Crianças

RESUMO

Objetivo: Comparar parâmetros vocais e acústicos de crianças infectadas e não infectadas pelo HIV (Vírus da Imunodeficiência Humana). **Método:** Amostras vocais foram submetidas às análises perceptivo-auditiva e acústica. Foram analisadas amostras da vogal sustentada /ɛ/ e da fala encadeada de 74 crianças entre seis e 12 anos incompletos, divididas em dois grupos: 37 crianças infectadas pelo HIV (GHIV) e 37 crianças não infectadas pelo HIV (Grupo Controle=GC), pareadas por idade e gênero, e sem avaliação vocal prévia; todas as crianças eram pré-púberes, pelos Critérios de Tanner (MS, 2014). As crianças tiveram suas vozes gravadas e analisadas pelo programa VoxMetria 5.1, no período de 2014 a 2015. A análise perceptivo-auditiva avaliou o grau geral da qualidade vocal e foi realizada utilizando-se a escala analógico-visual (EAV) de 100 pontos, transformada em escala numérica de 4 pontos (0- ausência de desvio e 4- desvio intenso). A avaliação acústica constou da análise da distribuição da amostra vocal no Diagrama de Desvio Fonatório (DDF). A pesquisa foi aprovada pelo Comitê de Ética em Pesquisa em Seres Humanos, sob o número 122.746. **Resultados:** Na análise perceptivo-auditiva, a maioria das crianças de ambos os grupos foi avaliada como apresentando vozes sem desvio, grau 0 na escala numérica. Na análise acústica, não houve diferença entre os grupos na distribuição das amostras no DDF, com a maioria das amostras na área de normalidade, no primeiro quadrante, com distribuição de densidade ampliada e forma vertical. **Conclusão**: Crianças infectadas pelo HIV apresentaram vozes semelhantes às de crianças sem a doença, tanto do ponto de vista auditivo quanto acústico.

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INTRODUCTION

The epidemic of the HIV/AIDS (Human Immunodeficiency Virus / Acquired Immunodeficiency Syndrome) is still one of the world's biggest public health problems[1]. Many studies regarding this disease's behavior in people of different ages have been performed due to its high mortality; especially regarding the epidemic of the HIV/AIDS in the childhood[2].

The HIV is a virus that infects cells of the immune system, especially CD4+ T lymphocytes. This virus causes the AIDS disease, which results in progressive immunodeficiency, which leads to opportunistic infections and death[3].

One of the most important consequences of the HIV is its damage to the immune system[4]. However, due to the increasing survival rates and the reduction of opportunistic infections, matters such as health promotion and guaranteeing a better quality of life for children and adolescents with HIV/AIDS have gain great importance[5].

According to the Ministry of Health[5], the HIV/AIDS infection can affect any organ of the human body; therefore, the physical examination should be accurate and must evaluate all systems. The routine clinical evaluation includes examination of the oral cavity and oropharynx, the nervous system and the nutritional status. It is known that, pharyngeal and laryngeal infections are frequent in the HIV patients who commonly present oropharyngeal and laryngeal candidiasis; it is important to highlight that these infections may lead to hoarseness, dysphagia and laryngeal stridor. Upper airway obstruction from AIDS-related Kaposi's sarcoma can generate symptoms of stridor that may lead to the need for tracheostomy[6,7].

Until now, there is only one study[8] regarding the HIV-infected children voice; the authors investigated audiological and speech-language disorders, such as voice, language and swallowing, in children between 4 and 16 years old. Buffalo-III was used for the vocal evaluation and showed that 31.34% of the children had vocal deviations (roughness, breathiness and vocal breaks). No child presented dysarthria and there was no description of vocal abuse. Also, mild to severe hearing loss, swallowing disorders and language development delay were observed. There was a negative correlation between the duration of the HIV infection and degree severity of communication disorders. This paper concluded that children with HIV face many communication difficulties throughout their lives; therefore, they highlight the need for further studies that considers the effects of opportunistic infections and medications. The study did not compare the HIV-infected children outcomes with a control group. Dysarthria might have not been observed, once central nervous system alterations may only be evident after years of the HIV infection, not being observed at early stages. The presence of microcephaly, cognitive impairment, signs of pyramidal tract dysfunction, mood and behavioral disorders, and complications due to the use of antiretroviral therapy are common[9].

Another study aiming to create a profile of the vocal impairments in HIV-infected adults evaluated eight patients between 18 and 40 years old (seven men and one woman). Data such as medial history, vocal problems, vocal evaluation of pitch, loudness, vocal quality, maximum phonation time of the vowels "a", "i" and "u" and the s/z ratio were collected. The acoustic measures were analyzed. The authors found that 100% of the subjects had deviations in at least one vocal parameter. In addition, even in the absence of a vocal pathology, the vocal parameters were affected in HIV-infected adults. However, the authors highlight that this was a preliminary study; therefore, it was not possible to conclude if there was a correlation between vocal deviations and immunological condition[10].

Another study from the same authors and with the same HIV-infected adults analyzed their medical history, communication complaints, aspects regarding aphasia, dysarthria, articulation, fluency and subjective parameters of the voice analysis, plus standard articulation test to assess lips, tongue, mandible and soft palate, also assessing coughing, swallowing and breathing had the following outcomes: 25% HIV-infected adults presented reduction of the maximum phonation time and superior breathing; 25% had unspecified laryngeal alterations; 12.5% had alterations on speech intelligibility; 37.5% had a deviated vocal quality - 25% with roughness and 50% with soft loudness. Articulation and fluency were normal. In conclusion, it was found that HIV-infected adults might present laryngeal mobility disorders, with vocal folds paresis or paralysis due to the Central Nervous System infections, vocal complaints of a weak and breathy voice, as well as swallowing disorders[11].

In a subsequent study, these same authors studied voice disorders, dysarthria, and oral functions in 15 men between the ages of 18 and 40 years old. Oral reflex, breathing, lip, tongue, mandible, soft palate and laryngeal functions, as well as speech intelligibility and dysarthria were analyzed; 93.3% of the individuals had altered parameters, which varied from a mild to a moderate deviation. The most altered parameter was language, followed by, laryngeal functions, oral reflex, breathing, lips and lastly, speech intelligibility; no changes were observed in the mandible and the soft palate. In conclusion, they highlight the need of studies about the effects of the medication and opportunistic diseases, related to the HIV duration[12].

Lesions such as candidiasis, tuberculosis, leprosy, herpes zoster, histoplasmosis, paracoccidioidomycosis and leishmaniasis are described as secondary to opportunistic infections[1]. At some point, up to 84% of the HIV-positive patients will present signs or symptoms related to ear, nose or throat problems, which may result in a larynx and/or voice disorder[13].

Three studies investigated the vocal aspects in adults with HIV[10-12] and only one analyzed the vocal aspect of children with HIV[8]. Also, neither one of these studies compared their results with a control group, that is, a group without the HIV infection. It is known that a control group is a fundamental condition to establish whether or not the analyzed conditions are also observed in the general population or if they are indeed characteristic of the population that is being studied. In addition, to guarantee health promotion, to perform prevention strategies and to improve the health services, it is necessary to understand the vocal characteristics of the HIV-infected children considering the vocal characteristics of the general population.

Therefore, the aim of the present study was to compare the auditory-perceptual evaluation of voice and the vocal acoustic parameters of HIV-infected children and non-HIV infected children.

METHODS

This is an observational, analytical, transverse and prospective study.

The research was approved by the Ethics Committee under the protocol number: CAAE 05374712.0.0000.0096, n.º 122.746, in December 16th 2012. All guidelines of the *Comissão Nacional de Ética em Pesquisa* (CONEP) Resolution n.º 466, of December 12th 2012, were followed. The child parent and/or the legal representative were informed of the study objectives and signed an informed consent form.

The target population of this study consisted of: the study group, with HIV-infected children, with or without vocal complaints, the HIV group (HIVG), and the control group (CG) with children who seeked the Clinical Hospital Complex of the *Universidade Federal do Paraná* (CHC-UFPR) for reasons other than HIV infection. The CG presented complaints related to skin disorders, with no association with other diseases, and also included children with or without vocal complaints.

HIVG data collection was performed at the Pediatric Infectology Clinic of the CHC-UFPR, at the Medical Ambulatory Service-2 (SAM 2). The CG data collection was performed at the Pediatric Dermatology Clinic of the CHC-UFPR, also at the SAM 2.

The HIVG was formed by HIV-infected children, in follow-up at the Pediatric Infectology Clinic, including boys and girls aged between 6 and incomplete 12 years old, with or without vocal complaints. The inclusion criteria for the HIVG group were: HIV-infected children in regular follow-up (every three months); prepubertal children, according to Tanner's Stages[5]; parents or legal representatives had to agree to participate in the study and sign the informed consent form. A total of 37 children who attended to medical appointment during the data collection were included in a non-probabilistic manner.

Children who attended the Pediatric Dermatology Clinic, aged between 6 and incomplete 12 years old, who were treated for skin complaints, formed the CG. The inclusion criteria were: children who seeked for treatment at the Pediatric Dermatology Clinic for reasons other than HIV infection, with or without vocal complaints; prepubertal children, according to Tanner's Stages[5]; parents or legal representatives had to agree to participate in the study and sign the informed consent form. The CG, counted with 37 children, all age and gender-matched with the HIVG. Children from both sexes were included. As already mentioned, all children were considered prepubertal according to the Tanner Stages[5] and did not present sexual characteristics of vocal change.

The exclusion criteria, both for the HIVG and the CG, were children with: an allergic airway inflammation or respiratory tract infection at the moment of the evaluation; signs or symptoms of stomach disorders at the time of the evaluation; likely neurological disorders, visual impairment or intellectual disabilities; nonattendance for all medical appointments during the data collection.

The HIVG and the CG children underwent medical evaluation and voice recording. Also, children in the HIVG underwent the Pediatric Infectology Clinic physical evaluation, while children in the CG underwent the Pediatric Dermatology Clinic physical evaluation.

The infectious diseases physicians performed the medical evaluation of the HIVG. Data such as: identification, how the HIV was transmitted, the Centers for Disease Control and Prevention (CDC) classification system - including the current stage of the immunologic and the clinical category - and the Tanner's Stages were collected[5]. To be included in the study: girls should have nipple elevation only (Tanner's stage 1 of the breast development) and no pubic hair (Tanner's stage 1 of the pubic hair growth); boys should have no changes in the size or proportion of the testes, scrotum and penis or enlargement of scrotum and testes with little or no penis enlargement, or increase first in length then width of penis with growth of testes and scrotum (Tanner's stages 1, 2 and 3 of the genital development) and no pubic hair (Tanner's stage 1 of the pubic hair growth).

The classification system for the HIV infection is based on clinical and immunological categories proposed by the Centers for Disease Control and Prevention (CDC)[5]; a pediatric infectious disease physician preformed this phase of the research. The aim of this system is to reflect the disease stage of an infected child (having a prognostic sense) and to simplify the classification process; it is based on the categories of clinical signs and symptoms and immunologic suppression at the most critical moment of the child's life.

According to the CDC, if the child has already been classified, the infant cannot be reclassified to a less severe category, even though, the clinical and immunological stages improve. Thus, all children were classified according to the clinical signs and symptoms of the disease (CDC classification system) as with: no or mild signs/symptoms; moderate signs/symptoms and severe signs/symptoms. Regarding the immunologic categories they were classified as with: no evidence of suppression; evidence of moderate suppression and severe suppression. The children clinical and immunologic conditions were also evaluated at the moment of the speech language pathologist evaluation. Therefore, children had two classifications, one on their most critical moment in life and another at the moment of this research data collection.

The medical evaluation of the CG was performed by the pediatric dermatologist physician and followed the same steps of the HIVG, expect to issues regarding HIV infection, that were replace with information regarding skin disorders.

The vocal evaluation was the same for both groups. Each child was asked to produce the sustained vowel / Ɛ /, at a confortable loudness and pitch; following, each child was asked to count from 1 to 20, also at confortable loudness and pitch. If the children presented any difficulties to understand the task or had performed it in a loudness and pitch very different from the one used in spontaneous speech, the task was once again explained and a new recording was made.

The recordings were performed on a silent room using the VoxMetria® software (CTS *Informática*, version 4.5h), installed on an ACER® ultrabook computer, and a Plantronics audio DSP 400 microphone - ultimate headset unidirectional - coupled to the computer. Next, the vocal recordings were stored on a CD and three-speech language pathologist with at least five years of vocal evaluation experience performed the perceptual-auditory analysis. The judges evaluated the voices in a quiet room using a headphone; they could listen to each recording how many times they wanted to conclude the analysis.

The reliability was evaluated by repeating 20% of the 74 voice samples both of the sustained vowel and the continuous speech. Therefore, there were a total of 88 voice samples for the continuous speech and 88 for the sustained vowel, thus, 176 samples. The intra-rater reliability considered the evaluation of each judge for the sustained vowel /ɛ/. The inter-rater reliability compared the 74 voice samples of the sustained vowel and the continuous speech between the three judges; inter-rater reliability was poor, therefore, only the answers of the judge 1, with an excellent Cohen's Kappa Coefficient (0.83), were considered.

The perceptual-auditory analysis for the sustained vowel and the continuous speech used a Visual Analog Scale (VAS) with 100 points. This scale was later adapted to a 4 point numerical scale, were 0 = no vocal deviation and 4 = severe vocal deviation[14].

The acoustic analysis was performed by the Phonatory Deviation Diagram (PDD), available on the VoxMetria® Software, using the sustained vowel. The program's graph interpretation was performed by one of the authors who was blind to the recording conditions and groups; another judge also analyzed 10% of the program's graphs, the classifications were compared and no divergences were found.

The graph interpretation of the PDD[15] considers four parameters:

- Normality: central point of the PDD located at the normality area, at the left lower quadrant;
- Density: refers to the concentration of the points inside one square or distributed in more than one of the squares of the graph, classified as concentrated or spread;
- Shape: refers to the points distribution on the PDD graph; it was evaluated using a computer ruler to measure the distance between the X and Y coordinates - if the distance was greater for the coordinate X, the shape would be classified as horizontal; if the distance was greater for the coordinate Y, the shape would be classified as vertical; if the distance was the same for both coordinates the shape would be classified as circular;
- Location in the four diagram quadrants was classified as: left lower (quadrant 1); right lower (quadrant 2); right upper (quadrant 3) and left upper (quadrant 4).

All data were submitted to statistical analysis. The Intra-class Correlation Coefficient (ICC) was used to analyze the continuous variables (mean and standard deviation) of the intra and inter-rater reliability. The Cohen's Kappa Coefficient was used for the analysis of the categorical variables (absolute value and percentage). The Fisher's Exact Test and the Chi-Square Test estimated the difference between the categorical variables, which were expressed in absolute value (N) and percentage (%). A minimum level of significance of 5% was considered for all analysis. The studied sample had a 95% minimum power analysis for the results of both groups with 37 participants each.

RESULTS

The CDC classification system showed that most HIVG children had clinical categories with moderate or severe signs/symptoms at the most critical moment of their life's and also moderate or severe suppression for the immunologic categories. While at the moment of the voice recording, the current evaluation, most children presented no or mild signs/symptoms and no evidence of suppression (Table 1).

Children from both groups presented normal vocal quality (Table 2). No differences were found on the outcomes of the PDD, most voices were within the normality area and most voices presented a spread density, a vertical shape and were located at the quadrant 1 (Table 3).

Table 1. Distribution of the HIVG regarding pediatric and laboratory assessment, according to the CDC classification system and at the current evaluation moment

Pediatric and Laboratory Assessment	Category	CDC Classification System (n=37)		Current Evaluation (n=37)	
		N	%	N	%
Signs/symptoms clinical categories	No or Mild	12	32.4	35	94.6
	Moderate	14	37.8	1	2.7
	Severe	11	29.7	1	2.7
Immunologic categories	No evidence of suppression	11	29.7	37	100.0
	Moderate suppression	14	37.8	0	0.0
	Severe suppression	12	32.4	0	0.0

Caption: CDC - *Centers for Disease Control and Prevention*

Table 2. Perceptual-auditory analysis of the vocal evaluation using a numerical scale

Vocal Deviation Overall Degree	HIVG (n=37)		CG (n=37)		p-value
	N	%	N	%	
Sustained Vowel					
Degree 0	30	81.0	33	89.1	0.51
Degree 1	7	18.9	4	10.8	
Continuous Speech					
Degree 0	31	83.8	36	97.3	0.10
Degree 1	6	16.2	1	2.7	

Statistical analysis: Fisher's Exact Test ($p<0.05$)

Table 3. Outcomes of the acoustic analysis: Phonatory Deviation Diagram

Phonatory Deviation Diagram		HIVG		CG		p-value
		N	%	N	%	
Classification	Normal	23	62.1	26	70.2%	0.62[a]
	Deviated	14	37.84	11	29.73%	
Density	Concentrated	1	2.7	3	8.1%	0.61[a]
	Spread	36	97.2	34	91.8%	
Shape	Horizontal	5	13.5	8	21.6%	0.57[b]
	Vertical	26	70.2	22	59.4%	
	Circular	6	16.2	7	18.9%	
Quadrant	Left lower	26	70.2	29	78.3%	(*)
	Right lower	6	16.2	6	16.2%	
	Right upper	3	8.1	1	2.7%	
	Left upper	2	5.4	1	2.7%	

Statistical analysis: Fisher's Exact Test[a] and Qui-square[b], ($p<0.05$). Descriptive analysis due to the small sample size in each group (*)

DISCUSSION

Voice is one of the natural characteristics that differs children from adults; vocal disorders affect both adults and children. Some factors that may trigger vocal problems in children are chronic diseases, such as the HIV infection and AIDS. Thus, it is important to understand the vocal characteristics of children with such disease, who need a constant follow-up and special treatment.

When it comes to HIV-infected children, it is very important to understand their clinical and immunological condition at the moment of the evaluation and also at their most critical moment in life, usually when the disease is diagnosed. Therefore, it is possible to compare these data with those of other studies and then analyze the clinical moment of the assess population.

Regarding the clinical and immunologic categories of the HIVG children, the CDC classification system showed that most of them had moderate or severe signs/symptoms at the most critical moment of their life's, and evidence of moderate or severe suppression. Mainly, these data show that most of these children have suffered severe clinical conditions associated to the HIV infection. On the other hand, during the data collection of this study, almost all the children had no or mild signs/symptoms and no evidence of suppression. Hence, most of the children were with the HIV under control, with no negative effects on the larynx or neurological impairment.

In the CHC-UFPR, where this research took place, HIV children are followed-up with pediatric infectious disease physician every three months. In addition to the routine evaluation, children are also followed-up by the pediatric team, which includes neurological and dermatological evaluations, and, if necessary, otorhinolaryngologist, pneumologist, cardiologist, psychologist and social worker evaluations.

Although considered to be subjective, the vocal perceptual-auditory evaluation is the basis of the vocal clinic and, when it is combined with vocal self-assessment, it becomes the standard procedure for the speech language pathologist vocal evaluation[16].

The outcomes of the perceptual-auditory analysis, which evaluated the overall vocal quality, found no differences in the vocal quality between HIV-infected and non-HIV-infected children – 18.9% for the HIVG and 10.8% for the CG; both groups presented more voices with no deviation. There is only one study that evaluated the voices of HIV-infected children[8]; the authors found altered vocal parameters in the perceptual-auditory analysis for 21 of the 67 children (31.3%). Of these children with deviated vocal quality, 10 (14.9%) presented hoarseness; 8 (11.9%), harshness, and 3 (4.47%), breathiness. The authors did not describe the CDC classification system or the immunologic and clinical categories at the moment of the vocal evaluation. These results[8] differ from those found in the present study. It is worth mentioning that, at the time of this study evaluation, 94.59% of the children were not or mildly symptomatic and 100% had no evidence of suppression. This condition may have directly influenced these different outcomes.

Two preliminary studies[10,11], which evaluated the same eight HIV-infected adults, found deviated parameters regarding the perceptual-auditory analysis (pitch, loudness and vocal quality) and the acoustic parameters (maximum phonation time and

acoustic measurements - F_0, jitter, shimmer)[10]. In addition, the presence of aphasia and dysarthria were also observed[11]. Another study, which counted with 15 HIV-infected men, found dysarthria in 93.3% of them[12]. These three studies with HIV-infected adults and this one study with HIV-infected children[8] were develop in India and they did not present data related to the CDC classification system neither the immunologic and clinical categories at the moment of the vocal evaluation; in others word, the studies did not consider the stage of the disease.

The incidence of dysphonia in the Brazilian population, from 6 to 10 years old, is 37.14%[17]; others countries show numbers from 6% to 30%[18-20]. The present study found lower incidence of dysphonia then what was previously reported for the Brazilian population (HIVG = 18.9% and CG = 10.8%). Considering the data of another study - that found an incidence of childhood dysphonia between 4.4% and 30.3%[18] - both groups, HIVG and CG, were within the expected percentage of childhood dysphonia. Therefore, it is possible to say that HIV-infected children have similar vocal characteristics to non-HIV-infected children and that they are within the vocal deviation range observed in the general population.

The perceptual-auditory and the acoustic analysis are the main tools for the vocal evaluation, as well as important clinical instruments that complement each other[21]. The PDD has been frequently used in the clinical practice in order to provide a reliable description of the vocal quality; the program demonstrates a graph that shows the vocal quality distribution towards its proposed normality area[22]. Thus, the present study, in addition to the perceptual-auditory evaluation, included the PDD as a complementary analysis of the children vocal quality.

Regarding the PDD classification, both groups were within the normal range - which concurs with the perceptual-auditory analysis - and both presented a spread density. Previous studies, with adults, have demonstrated concentrated density at post-therapy moment and a greater concentration of the points in voices with no or mild deviations[22,23]. The spread density observed in the present research may be a reflection of the children irregular vocal quality due to the immature vocal ligament.

Also, both groups presented a vertical shape, which is less usual for adults with no vocal deviation[15-23], although, it was observed on vocally healthy children. Probably, children present a voice with more hoarseness due to their glottic configuration and irregularities of vocal parameters, such as jitter and shimmer.

Most voices were located at the quadrant 1, left lower; it is know that voices that are less deviated are closer to the quadrant 1[22,23], therefore, the voices of the children from this study, that were considered normal by the perceptual–auditory evaluation, also showed normal acoustic parameters.

A study found that the PDD is able to differentiate the predominant vocal quality through the quadrants distribution in children voices[24]. Plus, the authors found that healthy voices were located both inside and outside the normality area, with concentrated or spread density, that were distributed in the left lower and right lower quadrants, with an horizontal shape[24]; different from what the present study found, a more vertical shape. Thus, the authors concluded that the PDD was able to differentiate the predominant vocal quality but was not able to differentiate children healthy and deviated voices[24].

In this study, the voices were mostly normal, once they were located at the quadrant 1, the normality area; no great discrepancy with the literature was observed[24]. There were no differences between both groups and most of the samples were within the normality area of the PDD.

The acoustic analysis performed by the PDD was in agreement with the perceptual-auditory analysis with no differences between the HIVG and the CG.

CONCLUSION

HIV-infected children who had have moderate or severe signs/symptoms and evidence of moderate or severe suppression, currently with no or mild signs/ symptoms and no evidence of suppression, presented voices that were similar to voices of children without the disease, both for the perceptual-auditory analysis and the acoustic parameters.

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Author contributions

ECP was responsible for the data collection and analysis and the writing of the manuscript; GM and KCAS were responsible for data analyses and writing of the manuscript; MB and COR were the advisors and responsible for the data analysis and final revision of the manuscript.