


Auditory Behavior and Validation in Audiological Diagnosis and Intervention in Infants and Children with Hearing Impairment

Comportamento Auditivo e Validação no Diagnóstico Audiológico e Intervenção em Bebês e Crianças com Deficiência Auditiva

Comportamiento auditivo y validación en el diagnóstico e intervención audiológicos en bebés y niños con deficiencia auditiva

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Abstract

Introduction: Professional work with infants and young children with hearing impairment requires specific knowledge and technique regarding the prescription and adaptation of the individual sound amplification device (PSAD) and the language development process. Limitations and inaccuracies throughout the diagnostic process may compromise all subsequent procedures of the intervention process.

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Purpose: To analyze the validation of the process of audiological diagnosis and intervention in infants and children with hearing impairment based on the comparative analysis of audiological tests, auditory behavior and application of the cross-checking principle after adaptation of hearing aids. **Method:** The research subjects were 12 children aged up to 36 months, with a diagnosis of bilateral sensorineural hearing loss, selected from the availability of access to the service for the evaluation and grouped into G1 (subjects with Speech Intelligibility Index - SII 65 dB up to 35%) and G2 (subjects with Speech Intelligibility Index - SII 65 dB above 54%). **Results:** The average age of the audiological diagnosis was 4.33 months. The audiological results of all children corresponded to each other, except for two subjects from G2. **Conclusion:** The auditory behavior not only allowed the validation of the processes of diagnosis and auditory intervention of the research subjects, but also allowed the identification of behaviors that are not compatible with audibility due to the inconsistent use of hearing aids. The application of developmental monitoring instruments proved to be adequate for monitoring the development of hearing and language skills in young children.

Keywords: Hearing Loss; Hearing Aids; Auditory Perception; Language Development.

Resumo

Introdução: A atuação profissional com bebês e crianças pequenas com deficiência auditiva exige conhecimento e técnica específica no que diz respeito à prescrição e adaptação do aparelho de amplificação sonora individual (AASI) e ao processo de desenvolvimento de linguagem. Limitações e imprecisões ao longo do processo diagnóstico poderão comprometer todos os procedimentos subsequentes do processo de intervenção. **Objetivo:** Analisar a validação do processo de diagnóstico audiológico e intervenção em bebês e crianças com deficiência auditiva a partir da análise comparativa de exames audiológicos, comportamento auditivo e aplicação do princípio de verificação cruzada após adaptação de AASI. **Método:** Foram sujeitos da pesquisa 12 crianças de até 36 meses de idade, com diagnóstico de perda auditiva neurosensorial bilateral, selecionados a partir da disponibilidade de acesso ao serviço para a avaliação e agrupados em G1 (sujeitos com Índice de Inteligibilidade de Fala - SII 65 dB até 35%) e G2 (sujeitos com Índice de Inteligibilidade de Fala - SII 65 dB acima de 54%). **Resultados:** A média de idade do diagnóstico audiológico foi de 4,33 meses. Os resultados audiológicos de todas as crianças tiveram correspondência entre si, com exceção de dois sujeitos do G2. **Conclusão:** O comportamento auditivo não só permitiu a validação dos processos de diagnóstico e intervenção auditiva dos sujeitos da pesquisa, como também permitiu a identificação de comportamentos não compatíveis com a audibilidade devido ao uso inconsistente dos AASI. A aplicação dos instrumentos de acompanhamento de desenvolvimento mostrou-se adequada para o monitoramento do desenvolvimento de habilidades de audição e linguagem em crianças pequenas.

Palavras-chave: Perda Auditiva; Auxiliares de Audição; Percepção Auditiva; Desenvolvimento da Linguagem.

Resumen

Introducción: El trabajo profesional con lactantes y niños pequeños con discapacidad auditiva requiere conocimientos y técnica específicos respecto a la prescripción y adaptación del dispositivo individual de amplificación del sonido (PSAD) y el proceso de desarrollo del lenguaje. Las limitaciones e imprecisiones a lo largo del proceso de diagnóstico pueden comprometer todos los procedimientos posteriores del proceso de intervención. **Propósito:** Analizar la validación del proceso de diagnóstico e intervención audiológica en lactantes y niños con discapacidad auditiva a partir del análisis comparativo de pruebas audiológicas, conducta auditiva y aplicación del principio de cruce tras adaptación de audífonos. **Método:** Los sujetos de investigación fueron 12 niños de hasta 36 meses, con diagnóstico de hipoacusia neurosensorial bilateral, seleccionados de la disponibilidad de acceso al servicio para la evaluación y agrupados en G1 (sujetos con Índice de inteligibilidad del Habla - SII 65 dB hasta 35%) y G2 (sujetos con Índice de inteligibilidad del Habla - SII 65 dB por encima del 54%). **Resultados:** La edad promedio del diagnóstico audiológico fue de 4,33 meses. Los resultados audiológicos de todos

los niños se correspondieron entre sí, a excepción de dos sujetos del G2. **Conclusión:** La conducta auditiva no sólo permitió validar los procesos de diagnóstico e intervención auditiva de los sujetos de investigación, sino que también permitió identificar conductas no compatibles con la audibilidad debido al uso inconsistente de audífonos. La aplicación de instrumentos de seguimiento del desarrollo demostró ser adecuada para controlar el desarrollo de las habilidades auditivas y lingüísticas en niños pequeños.

Palabras clave: Hipoacusia; Audífonos; Percepción Auditiva; Desarrollo del Lenguaje.

Introduction

The process of language acquisition and development begins shortly after birth, when the child encounters their family and the world; in other words, it is significant that the child can establish interactions with these first interlocutors. This process, however, requires, in addition to care for the external environment, that the child presents functional anatomical integrity of the central nervous system, auditory pathways and other sensory pathways for their adequate development.¹

Considering the brain changes caused by auditory sensory deprivation and its consequences already documented in the literature, the importance of early diagnosis and intervention in childhood hearing loss as requirements for the best prognosis in the development of speech and language is also cited by several authors with the justification that the central auditory nervous system presents a critical period of maximum plasticity until six months of age.^{1,2,3,4}

Due to the importance of early intervention in infant hearing loss, the Joint Committee on Infant Hearing⁵ emphasizes that efforts should focus on determining the type, degree, and configuration of hearing loss in each ear up to three months of age, envisioning that the prescription of hearing aids (HA) can be performed accurately and reliably up to six months of age. Therefore, for places where this deadline has already been reached, the suggestion is that this entire process should occur until three months of age. This allows the child to have adequate audibility of the acoustic characteristics of speech and to develop their auditory perception, reaching complex levels of linguistic processing. Furthermore, following these principles provides better results in language skills, such as vocabulary and school learning³.

As an increasingly number of younger children reach the rehabilitation services, new challenges have arisen for the speech therapist working in the area of pediatric audiology, as, regardless of tech-

nological advances, working with young children requires greater attention from the professional in prescribing and fitting the hearing aid due to the specificities of the baby. This is due to the fact that the adjustments made to the devices are, in most cases, dependent on the auditory thresholds obtained through electrophysiological techniques, the Auditory Brainstem Evoked Responses (ABR) with specific frequencies, estimating the auditory acuity of the child, as the child does not yet have a sufficient neuropsychomotor maturation level to respond to behavioral methods, such as visual reinforcement audiometry (VRA). Therefore, limitations and inaccuracies throughout the diagnostic process can compromise all other subsequent procedures in the auditory rehabilitation process⁴.

Thinking about the need for effective communication between diagnostic and intervention teams in auditory rehabilitation services and, considering the need for precision in the proposal of the individual therapeutic plan and referrals compatible with the audiological characteristics of each child, this research seeks to bring together these two spheres of pediatric audiology, diagnosis and intervention. The analysis and application of the cross-check principle in the results of procedures used in audiological diagnosis (ABR, Transient and Distortion Product Otoacoustic Emissions, VRA and tympanometry), grouping this information in such a way that the professional can select, organize and make it compatible. Precisely the data for obtaining and determining audiological thresholds enable the beginning of the hearing aid fitting process. This precision is fundamental in the hearing aid prescription process and prognosis of the child's development.

The reliable definition of thresholds, based on electrophysiological, electroacoustic and behavioral assessments, and consolidated through the cross-check process, will support the programming of the device, the definition of the therapeutic plan and the construction of a prognosis for the development of oral language -verbal form of each

child, essential for the beginning of the intervention process. This definition contributes to counseling families, adjusting expectations, and choosing the appropriate device. It will be during the rehabilitation process that the validation of the prognosis assumed by audiological characteristics will take place, and the interference of non-audiological variables, such as consistency in the use of devices, few opportunities for verbal interaction and socio-economic factors, can be identified.

Another challenge faced by the speech therapist is the presence of complex intervening factors, such as neurological impairment and middle ear condition, which directly interfere in the process of determining thresholds in audiological diagnosis^{6,7,8}. The quantification of audibility for speech sounds and the consistency of use of the device in its relationship with audibility have been widely discussed, considering that the child's listening conditions and the great variation in the consistent use of devices end up generating variability in the results in terms development of verbal oral language, contributing to important aspects of the rehabilitation process.^{9,10}

The results obtained in this research can contribute to explaining the relevance of articulating the processes involved in audiological diagnosis, such as determining thresholds, fitting HA and establishing a prognosis based on audiological thresholds. Rehabilitation can be considered a process of continuous validation, aiming to ensure that the therapeutic plan established for the child and their family is compatible with their hearing capacity and, when they do not occur as expected, identify barriers to the development of hearing and hearing skills. language. This research emphasized the consistency of use of hearing aids as an intervening variable, as it is known that it interferes in the stages of auditory function development and, consequently, in the stages of language development, generating a confusing factor in the expectations generated by established and confirmed thresholds. in the cross-check process.

Objective

The purpose of the research was to analyze the validation of the audiological diagnosis and intervention process in babies and children with hearing loss based on the comparative analysis of audiological exams, auditory behavior, expected

and performed, and application of the principle of cross-checking after hearing aid fitting.

Materials and method

This is a descriptive, cross-sectional qualitative-quantitative research. The research project was submitted and approved by the Research Ethics Committee (CEP) under opinion number 5.589.444. All those responsible for the children who participated in the study were informed about the nature of the research and instructed to sign the Free and Informed Consent Form when agreeing with the above.

The research was carried out in a Specialized Rehabilitation Center – CER II - accredited by the Unified Health System (SUS), which offers care to children with hearing loss (or suspected hearing loss) from birth.

The selection of subjects for this research was made according to the flow of patients at the service, diagnosed with hearing impairment in the years 2020 to 2022, and the family's availability to attend scheduled return visits.

The group is made up of subjects diagnosed with sensorineural hearing loss up to 36 months of age, who attended the CER II to carry out the audiological diagnosis and the hearing aid fitting.

Inclusion criteria

- Children up to 36 months of age;
- Diagnosed with bilateral sensorineural or mixed hearing loss at the rehabilitation center where the collection was carried out;
- Attend scheduled service returns, depending on their availability, for assessments;
- They have the hearing aids fitted in that service.

Exclusion criteria

- Children with other impairments that may make a reliable assessment of auditory behavior and/or perception of speech sounds unfeasible.

Service records were analyzed as well as available medical records to identify patients' initial data and verify the existence of possible impediments to collection, such as diagnosis of temporary conductive hearing loss, comorbidities of neurological origin, evasion of the service, losses unilateral hearing aids, among others. Therefore,

12 children and their parents were included in the study.

The research subjects were classified according to the audibility criteria proposed by Figueiredo et al.⁷, which are based on the value of the Speech Intelligibility Index (SII), of 65 dBNPS obtained with the amplification provided by the hearing aids, since this variable considers functional factors, such as speech intelligibility and audiogram configuration, rather than the degree of hearing loss. To analyze the research data, the subjects were divided into two groups based on the SII value of 65 dB, called G1 and G2. Group 1 is made up of six children with an SII value of 65 dB less than 35%; Group 2 consists of six subjects with SII 65 dB greater than or equal to 54%. The classification by Figueiredo et al.⁷ uses SII65 values lower than 35%, in the range of 36% to 55%, and the third group with a value greater than 55%. In the case of the subjects of this study, only one subject (S7) presented an SII value of 65 dB in 54%. For this reason, subjects with SII 65 dB above 54% were categorized as G2.

Regarding the procedures carried out in data collection, an audiological assessment was carried out to determine the audiological thresholds of the research participants - the procedures were carried out by the service's team of audiologists, for later collection in the medical record. The diagnostic procedures were defined according to the child's chronological age or corrected age.

According to the objective of this research, all results obtained for each child were included, even if partial, considered sufficient to determine audiological thresholds to be used in programming hearing aids. The degree of hearing loss was classified according to the recommendations of the World Health Organization - WHO¹².

Regarding the audiological diagnosis, it is worth highlighting that the results of the collected exams were classified by the service's audiologist according to tympanometry exams, measurement of acoustic reflex, transient otoacoustic emissions and by distortion product and ABR via air and bone conduction, click and frequency specific. Children over the age of six months underwent visual reinforcement audiometry and as the research method chosen, data relating to the VRA from the

date closest to the date on which the evaluation of the present study was carried out was considered.

Data collection was carried out with calibrated equipment, using the following materials: Eclipse equipment from the Interacoustics®, ILO equipment from the Otodynamics®, audiometer model AC-33 from the Interacoustics®, insertion headphones model ER-3A coupled to an ear tip disposable E-A-RLINK®, a bone vibrator model B71, a visual reinforcement box with light-up dolls and distraction toys, Interacoustics® model AT 235 H immittance meter, Hipro Interface and hearing aid fitting software provided by the company, verification equipment electroacoustic - Aurical or Axion, Desired Sensation Level (DSL_{v5})¹¹ prescriptive rule for all subjects and subjects' medical records, to collect essential information - name, age, date of diagnosis and etiology of loss, date and results of exams, date and characteristics of hearing aid fitting.

The prescriptive rule used in all hearing aid fitting carried out was the Desired Sensation Level (DSL_{v5})¹¹ to promote amplification that reaches the prescribed targets, consequent determination of the value of SII 65 dB and SII 55 dB and verification of possible behavior change in front of the sound (detection). When possible, RECD measurement was performed with the aid of a probe tube microphone and the ear mold, with the child in light sleep. In subjects in whom it was not possible to measure RECD, the measurement predicted by the equipment was used. Subsequently, the gain and output adjustments were checked in the electroacoustic verification equipment, which consists of an anechoic chamber with a 2cc coupler and the SII values of 55 dB SPL and 65 dB SPL were measured. All checks were made so that the prescribed target was reached, for the greatest benefit of the hearing aids and so that the highest SII value could be achieved.

All research subjects are users of hearing aids from the same brand and equivalent power to their needs, according to the degree of hearing loss. All children received hearing aids at the service, through the SUS agreement, at no cost to the families.

Analysis

After collecting data from medical records, all exams carried out by the subjects in the service,

from the moment of diagnosis, were analyzed and compared, to establish, or not, agreement between them.

Statistical analysis was performed using descriptive measures: mean, median, minimum, and maximum values, standard deviation, absolute and relative frequencies (percentage), in addition to graphs.

For the inferential analyzes used with the aim of confirming or refuting evidence found in the descriptive analysis, the non-parametric Mann-Whitney tests were used.

In all conclusions obtained through inferential analyses, an alpha significance level of 5% was used. The data were entered into Excel spreadsheets for adequate information storage and statistical analyzes were performed using the IBM-SPSS Statistics version 24 program.

Results

Data were collected from 12 children who were diagnosed with hearing loss and received their hearing aids at the hearing health service. The data were analyzed using descriptive and inferential statistics. Most children were male, 75% (n=9) and the average age of the children at the time of diagnosis at the service was 4.33 months (median=3; SD=3.58; range of 13 months).

To analyze the research data, the subjects were divided into two groups based on the SII 65 dB value, called G1 and G2: Group 1 is made up of six children with the SII 65 dB value less than 35%; Group 2 consists of six subjects with SII 65 dB greater than or equal to 54%. The statistical analysis of the sociodemographic and audiological characteristics of the entire sample and the two groups is presented in Table 1.

Table 1. Sociodemographic and audiological characteristics of the subjects according to the SII 65 dB classification (n=12)

Variable	Total	G1	G2	P Value
		SII65 <35	SII65 >54	
Mean Age at diagnosis (months) (SD)	4.33 (3.58)	4.83 (4.62)	3.83 (2.48)	0.935
Mean Age of hearing (months) (SD)	11.5 (5.6)	14.5 (5.54)	8.5 (3.94)	0.064
Chronological Mean Age (months) (SD)	18 (7.37)	20.83 (8.42)	15.17 (5.42)	0.199
SII 65 dB of better ear Mean (SD)	47 (24)	25 (6)	69 (11)	0.004*
SII 55 dB of better ear Mean (SD)	32 (24)	11 (4)	52 (17)	0.004*
Sex				
Female	25% (3)	16.7% (1)	33.3% (2)	
Male	75% (9)	83.3% (5)	66.7% (4)	
Degree of hearing loss				
Profound	58.3% (7)	100% (6)	16.7% (1)	
Severe	8.3% (1)	0	16.7% (1)	
Moderate	33.3% (4)	0	66.7% (4)	
Socioeconomic level				
B2	25% (3)	33.3% (2)	16.7% (1)	
C1-C2	41.7% (5)	50% (3)	33.3% (2)	
D-E	33.3% (4)	16.7% (1)	50% (3)	

*Non parametric Test Mann-Whitney. The significant difference level was 0,05.

Among the variables analyzed, SII 65 and SII 55 presented statistical relevance ($p=0.004$), which indicates the significant difference between the groups in relation to audibility. Regarding audiological diagnosis and characterization of hearing loss, all subjects who participated in the analysis had sensorineural hearing loss; 58.33% had profound hearing loss, 8.33% severe hearing loss and 33.33% moderate hearing loss in the better ear.

SII values were classified to 55 and 65 dB. G1 presents SII 55 dB with an average of 11% (minimum 7 and maximum 18%; $SD=4$) and SII 65 dB with an average of 25% (minimum 16 and maximum 34%; $SD=6$); G2 has a higher speech intelligibility index, with an average of 52% (minimum 26 and maximum 78%; $SD=17$) for SII 55 dB and 69% (minimum 54 and maximum 85%; $SD=11$) for SII 65 dB.

Regarding the groups, it can be seen in Table 1 that the average chronological age of G1 at diagnosis was 4.83 months and G2 was 3.83 months (Figure 1A); the average hearing age of G1 at the beginning of data collection was 14.5 months and G2, in turn, had a lower average hearing age, 8.5 months (Figure 1B). Although neither of the two characteristics presents a statistically significant difference and, therefore, the groups are considered equivalent in these variables, the hearing age of G2 has a certain statistical relevance ($p=0.064$), that is, the subjects of G2 have spent less time using the amplification. Regarding chronological age at the time of the first research assessment, the average age of the group was 18 months (minimum 9 and maximum 36 months; $SD=7.37$) and the difference between the groups did not show a statistically significant difference ($p=0.199$).

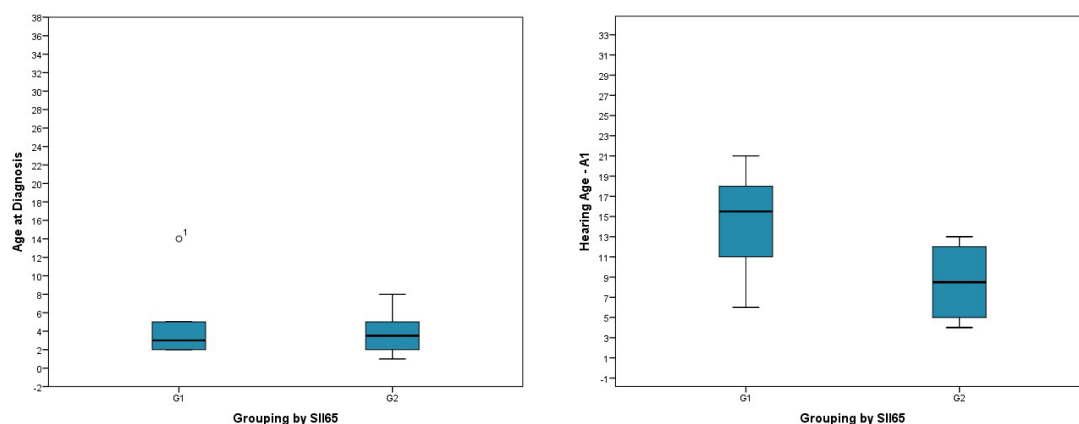


Figure 1. (A) and (B) - Chronological age (months) at the conclusion of the audiological diagnosis and hearing age (months) at the beginning of the study for G1 and G2 ($n=12$).

Figure 1(A) illustrates the greater variability in the age of diagnosis of children in G2, except for S1 belonging to G1. Figure 1(B) illustrates the difference in hearing age between the two groups, with G1 showing greater variability and G2 showing a tendency towards lower hearing age.

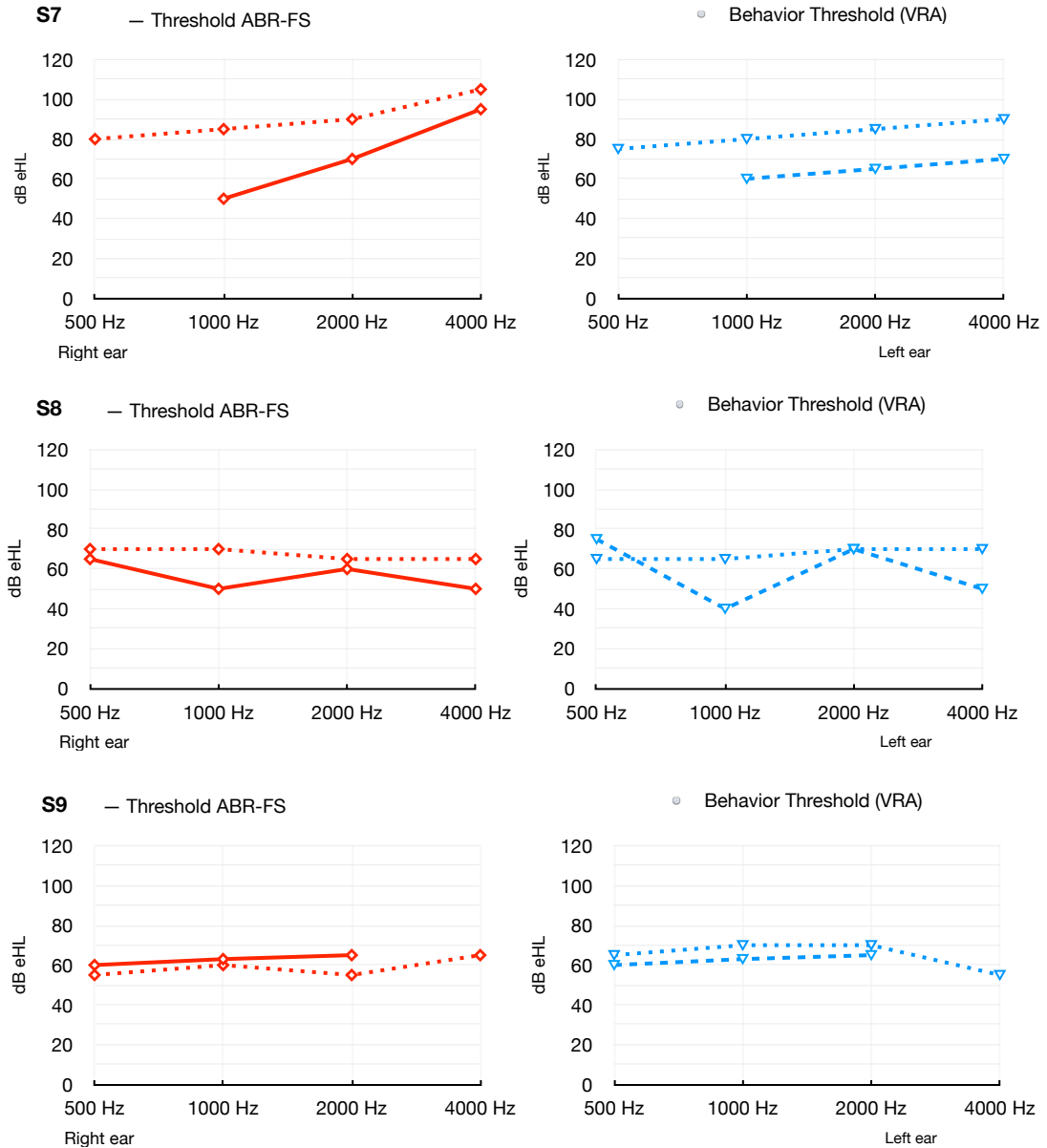
Regarding socioeconomic level, the group of subjects who participated in the study were classified as having lower socioeconomic classes, between B2 and D-E. In G1, two families are in class B2, three families in class C1-C2 and only one family in class D-E. G2 is made up of one family

in class B2, two families in class C1-C2 and three in classes D-E.

From the analysis of the audiological exams, it was possible to observe that all children had sensorineural hearing loss and absent otoacoustic emissions (OAE) (both transient and distortion product), except for one child (S10) who presented transient OAE present in low frequencies in the right ear, whose hearing loss configuration is ramped. In the tympanometry performed, only three subjects presented a type B curve (S1, S6, S7) and the others presented a type A curve.

For all G1 subjects, the ABR-FE and VRA thresholds were compared to indicate profound hearing loss, present in 100% of the group.

In G2, composed of subjects with SII 65 dB that varies from 54 to 85%, the ABR-FE (edBNA) and VRA (dBNA) thresholds are shown in Figure 2 in each ear for the six children that make up the group.



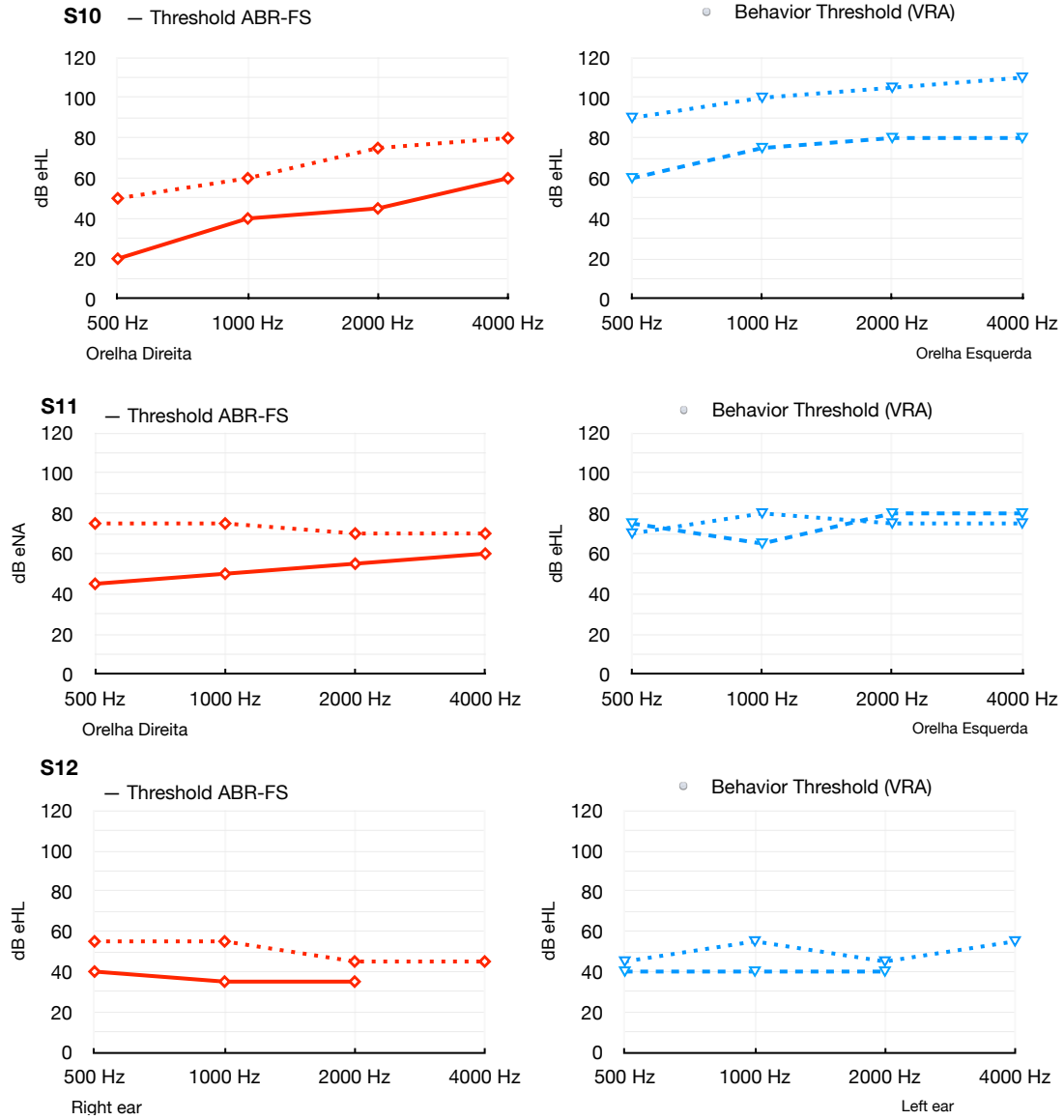


Figure 2. Graphical representation of the FE ABR and VRA thresholds of G2 subjects (n=6).

As can be seen, the thresholds of subjects S8 and S9 show similarity between the electrophysiological and behavioral tests. Subjects S11 and S12 show similarity in the left ear and a difference greater than 10 dB in at least two frequencies in the right ear. Subjects S7 and S10 present a difference of 20 to 30 dB between the exam thresholds and type B tympanometric curve, with recurrent episodes of otitis media.

Initially, the hearing aids of the research subjects were fitted and verified according to the thresholds obtained through the ABR-FE. With cognitive development and greater auditory experience, the children acquired skills to perform the VRA and, from then on, the hearing aids were

programmed and checked again, with the behavioral thresholds, even for subjects who presented differences greater than 20 dB, such as the S7, S11 and S12. The exception was S9, which, due to signs of hearing discomfort with hearing aids with VRA thresholds, remained on programming with electrophysiological thresholds.

Checking amplification is the first step in the intervention process since the audibility of speech sounds enables the child's language development.

To carry out the first evaluation with the subjects, the hearing aid amplification was verified with the DSLv5 prescriptive rule and SII values of 65 and 55 dB were obtained. The overall mean SII 65 dB was 47% (median 44%) (Table 2).

Table 2. SII 65 and 55 dB values for the groups G1 and G2 (n=12).

Variable	G1	G2
	SII65 <35	SII65 >54
SII 65 dB of better ear		
Mean	25	69
Median	26	70
Standard deviation	6	11
Minimum	17	54
Maximum	34	85
SII 55 dB of better ear		
Mean	11	52
Median	11	52
Standard deviation	4	17
Minimum	7	26
Maximum	18	78

Figure 3A shows the SII 65 dB value of the best ear for G1 and G2 ($p=0.004$) and Figure 3B shows the SII 55 dB value of the best ear for G1 and G2 ($p=0.004$).

Figures 3(A) and 3(B) demonstrate the statistically significant difference between the two groups in the two SII intensities, but with greater variation in SII 55 dB in relation to G2.

Periodically, the children undergo assessment of their hearing skills and on the same day as the

subjects' assessment, the hearing aids were checked and the average number of hours of amplification use was analyzed (Table 3).

According to Table 3, the number of hours of hearing aid use in the better ear averaged 3.56 hours/day (median=2.15 h/day). At this initial moment, G1 had an average usage of 3.78 hours and G2 was 3.33 hours, with no statistically significant difference. ($p=0.423$).

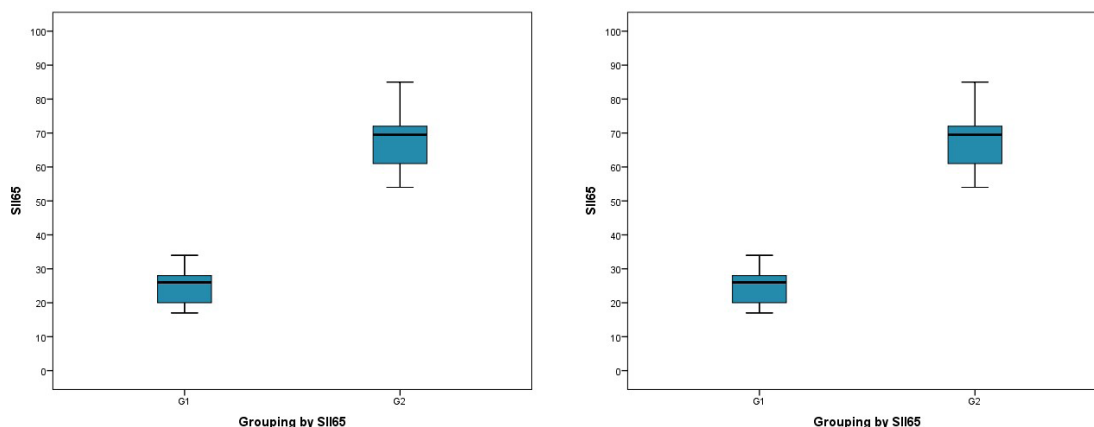


Figure 3. (A) and (B) – SII 65 and 55 dB Values of the best ear for G1 and G2 (n=12).

Table 3. Results of the instruments applied in the first evaluation with the subjects grouped according to the SII 65 dB classification (n=12).

Variable	Total	G1	G2	P Value
		SII65 <35	SII65 >54	
Mean chronological age(months) (SD)	18 (7.37)	20.83 (8.42)	15.17 (5.42)	0.199
Number of hours of use of HA	3.56	3.78	3.33	0.423

*Non parametric Test Mann-Whitney. The significant difference level was 0,05.

Discussion

The study included 12 subjects with chronological ages at the beginning of the research ranging from nine to 36 months of age, diagnosed with hearing loss in a Specialized Rehabilitation Center (CER) – II in the city of São Paulo, whose families accepted to be part of the study and have their data collected.

The average age at which the audiological diagnosis was completed at the service was 4.33 months; lower average than that found in the literature^{13,14,15,16}. It is believed that, due to the fact that it is a reference service in pediatric audiology for low-income families, the distance from home, in addition to factors such as absences due to bad weather, illness in babies, delays due to public transport, end up causing greater time to complete the diagnostic process. In an article carried out at the same rehabilitation institution, Galvão et al.¹⁷ identified that, of a group of 24 children referred after a failed Universal Newborn Hearing Screening, 50% of them completed the audiological diagnosis

process before three months of age, which differs from what was found in the group of this research.

Hearing loss can impair various aspects of a child's life, including their academic, social, psychological, and behavioral well-being, and it can also limit access to higher education¹⁸. Due to these implications, the literature recommends early diagnosis and intervention in cases of pediatric hearing loss⁵. In a literature review, Lieu et al.¹⁹ shed light on some factors that can predict better outcomes from early intervention: maternal education level, average daily use of hearing aids, early intervention, greater audibility, and non-verbal intelligence.

All the subjects in the study were diagnosed with sensorineural hearing loss. However, unlike the study by Kuschke et al.¹⁶, where the subjects were mostly diagnosed with moderate hearing loss, the majority of the children in the present study had profound hearing loss (58.33%), followed by moderate (33.33%) and severe (8.33%) degrees, likely due to different etiologies, which were not studied in this research.

Regarding the diagnosis of hearing loss, the study aimed to validate the process of audiologic assessment and intervention by applying the principle of cross-check in the analyzed subjects, considering both audibility for speech sounds and consistency of device use.

Since 1976, Jerger and Hayes¹⁹ have discussed the importance of implementing the principle of cross-verification in clinical practice, meaning that the results obtained in one test should be verified by another independent test measurement to avoid potential errors in the diagnostic process for children suspected of having hearing loss. This approach ensures that all tests lead to the same diagnosis, thus increasing the reliability of the obtained diagnosis.

In the present research, data from all tests conducted in the diagnostic process were cross-referenced: specific frequency and click-ABR, transient otoacoustic emissions and distortion product otoacoustic emissions, visual reinforcement audiometry, tympanometry, and acoustic reflex measures. Additionally, Norrix²⁰ describes in his article the need to consider, in the cross-check process, reports from family members and individuals close to the baby and child about their daily auditory performance and behavior. These data, combined with the assessment and clinical observation of auditory skills conducted by the speech therapist, constitute the functional measure of verification and validation of the audiologic thresholds, compared to measures of electrophysiological, electroacoustic, and behavioral tests. All subjects in the study had their final assessment data consistent with the type and degree of hearing loss obtained from the initial ABR, except for S9.

S9 allowed to highlight the relevance of the principle of cross-verification. Similar to the study by Ringger et al.²¹, the child's auditory behavior led to the perception that the audiologic cross-check did not confirm. This clinical case presented several inconsistencies in its diagnostic and intervention process. The child was fitted with hearing aids at four months of age, with thresholds obtained through specific frequency ABR, diagnosed with moderate sensorineural hearing loss at two months of age. Fitted with the DSLv5 prescriptive rule, which promotes greater audibility for the pediatric population²² meeting the proposed targets, the patient exhibited behavioral responses incompatible with their diagnosis, showing clear signs of auditory discomfort during clinical evaluation. Faced

with the identified contradictions, it was necessary to revisit the diagnosis¹⁹⁻²⁰⁻²¹⁻²³. After conducting a new ABR and VRA, the thresholds were confirmed.

Over time, as children were able to provide consistent responses in visual reinforcement audiometry, the obtained thresholds were used for hearing aid adjustments. The exception was S9, who, due to showing signs of auditory discomfort with the hearing aids at VRA thresholds, remained with the programming based on electrophysiological thresholds.

All children in the study were fitted with hearing aids shortly after diagnosis, on average less than two months after the diagnosis, following the recommendation of JCIH⁵, as the literature demonstrates that early intervention in infants identified with hearing loss yields better results in various linguistic abilities compared to children diagnosed later^{1,3,4,5,6,18,22,24}. Electrophysiological thresholds were initially used as the children did not show sufficient development for behavioral assessment⁶.

Through the programming and verification of the hearing aids, the SII measure of 65 dB was obtained and used to classify the research subjects into groups characterized by the speech intelligibility index⁷. Thus, subjects in G1 had a significantly smaller dynamic range of hearing than G2, making it impossible to achieve audibility for all levels of speech input, even considering the strongest speech signal level (75 dB)²⁶.

All families were accompanied at the time of hearing aid fitting. Guidance was provided verbally, in periodic speech therapy sessions, with the aim of ensuring that the family had a good understanding of the importance of using amplification at all times when the child is awake.

Smith et al.²⁷ reinforce the concept of "eyes open, ears on," aiming to demonstrate to families of children with hearing loss the importance of consistent hearing aid use in order to reap the benefits. Subjects in our study exhibited an average daily hearing aid usage below what would be expected for their age⁷. At the time of the initial assessment, G1 showed an average of 3.78 hours, and G2 showed 3.33 hours. In Walker et al.'s study¹³, children closer in age to those in our study (6 months to 2 years old) had an average hearing aid usage of 4.36 hours, while the two to four-year-old age group had an average of 7.5 hours, both higher than what was found in our sample. In other words, the older the chronological age, the higher

the average hearing aid usage. According to the literature, some possible reasons why parents may not keep the hearing aids on their children for the entire time they are awake include fear of losing or damaging the devices, concern about harming their children, difficulty in keeping the devices on their ears, belief that their children do not need the devices, and difficulty in establishing a routine²⁸. To help families better understand how to keep the devices on for longer periods, the literature suggests that for parents of younger children, professionals should request a record of every time the child removed the hearing aids and the reasons why, so that solutions to these issues can be sought together with the family²⁷.

In Booyen et al.'s study²⁹, the average use of hearing technology was 9.4 hours. However, the subjects in the study were children up to 11 years old, who are awake for longer periods, and therefore a higher average daily usage is expected at that age. The authors identified that higher degrees of hearing loss predicted a higher average daily use of hearing aids, as was the case with our sample, although without statistical significance. Moderate hearing loss resulted in 65 minutes less daily usage, and mild loss in 178 minutes less, when compared to severe and profound losses. Families with higher adherence to appointments and a preference for auditory-communication were predictive of greater hearing aid use. Predictive of higher hearing aid usage were families with greater adherence to appointments, a preference for auditory-oral communication, older chronological age, and children capable of independently handling their devices, unlike the subjects in the current study. Recent research has introduced the concept of auditory dosage^{9,10}, which sought to create an algorithm that related the average hours per day and audibility through the SII - Speech Intelligibility Index with and without the device, a proposal that contributes to the inconsistent use of devices in children with mild to moderate hearing loss. In the researched group, calculating the dosage would likely explain the consistent device usage in the early stages of rehabilitation. Adherence to device use in group G1 - children with SII 65 dB less than 35% (Median = 2.85 hrs/day) was greater than in group G2 - children with SII 65dB greater than 54% (Median 1.55 hrs/day), likely explained by reactions to speech sounds even without the device.

In the second assessment of G2, after guidance, the median increased to 3.9 hrs/day.

Kuschke et al.¹⁶ identified that lower average daily usage of the devices was associated with low family income, which is consistent with the sample in the present study, given that the most commonly found class among participating families was Class C. The low socioeconomic status in the subjects studied may be explained by the fact that the research was conducted in a CER II (Rehabilitation and Educational Center for Deaf Individuals) affiliated with the public healthcare system (SUS), and consequently, dependent on the public healthcare network.

The team responsible for auditory health must always be attentive to the development of children with hearing loss, especially concerning language development, conducting periodic audiometric assessments, as well as observing auditory behavior in therapy situations, listening to and providing guidance to families about the importance of using hearing aids, and verifying whether these families are receiving the necessary support for maintenance and consistent usage of the devices. The auditory health team should always be attentive to the development of children with hearing loss, particularly regarding language development, conducting periodic audiometric assessments, as well as observing auditory behavior in therapy situations, listening to and offering guidance to families about the importance of using hearing aids, and verifying whether these families are having their basic needs for food and security met²⁷⁻³⁰. Close monitoring of children with hearing loss allows for the monitoring of potential changes in auditory thresholds, which consequently lead to changes in sound amplification³⁰.

Conclusion

Through the validation of the audiologic diagnostic and intervention process for babies and children with hearing impairment from 0 to 3 years old, it is possible to highlight the need for constant observation of auditory behavior, combined with the use of appropriate tools for monitoring the early years of development in children with hearing loss who do not yet have the ability, due to their age and cognitive development, to undergo formal tests for speech and language perception.

The cross-check process throughout the validation process indicates consistency in all cases of children with profound hearing loss in Group 1. In Group 2, due to the greater variability in the characteristics of the children, this process triggered the need for a new audiologic assessment, differential diagnosis of intervening factors, and consequently, the specificities of guidance to the families.

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