Achados Vestibulares em Crianças Deficientes Auditivas

Vestibular Findings in Children with Hearing Loss

Taís Rodrigues Lisboa*, Ari Leon Jurkiewicz**, Bianca Simone Zeigelboim, Jacqueline Martins-Bassetto****, Karlin Fabianne Klagenberg****.***

* Phonoaudiologist, Master in Communication Disorder by *Universidade Tuiuti do Paraná – UTP* (Tuiuti University – Paraná).
** Clinical Doctor, PhD in Anatomy by *UNIFESP* and Professor of Post Graduation Program, Master degree in Communication Disorder by *UTP*.
*** Phonoaudiologist, PhD in Science of Human Communication Disorder by *UNIFESP* and Coordenator of Master Degree Program in Communication Disorder by *UTP*.
**** Phonoaudiologist, student of Master Degree Program in Communication Disorder by *UTP*.

Institution: *Laboratório de Otoneurologia da Universidade Tuiuti do Paraná (UTP)* (Otoneurology Laboratory of Tuiuti University - Paraná)
Sponsorship: *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – CAPES*
Mail Address: Bianca Simone Zeigelboim – Rua Gutemberg, 99 - 9º andar – Curitiba / PR – CEP: 80420-030 – Phone: (41) 3331-7807 –
E-mail: bianca.zeigelboim@utp.br
Article received on August 22, 2005, and accepted on September 20, 2005.

RESUMO

Introdução: O exame da função vestibular é um método objetivo que permite a avaliação funcional dos sistemas vestibular, visual e proprioceptivo.

Objetivo: Investigar o grau de perda auditiva, sua etiologia e a existência de comprometimento vestibular, segundo as variáveis lado e sexo, em crianças portadoras de deficiência auditiva.

Métodos: Avaliaram-se 26 crianças (11 do sexo feminino e 15 do sexo masculino) de 10 a 14 anos de idade. Realizaram-se anamnese, avaliação otorrinolaringológica, avaliação audiológica convencional básica completa seguida da vectoeletronistagmografia (VENG).

Resultados: Houve um predomínio da perda auditiva profunda bilateral, maior prevalência da meningite pós-natal e da síndrome vestibular periférica deficitária bilateral independente do sexo, etiologia e do grau de perda auditiva.

Conclusão: A alta incidência de alteração revela a importância do exame vestibular na população infantil.

Unitermos: perda auditiva, doenças vestibulares, testes de função vestibular.

SUMMARY

Introduction: The vestibular function test is an objective method that allows a functional evaluation of the vestibular, visual and proprioceptive systems.

Objective: To investigate the degree of auditory loss, its etiology and the existence of vestibular involvement, according to the variables of left or right side and sex, in children with auditory deficiency.

Methods: 26 children were evaluated (11 feminine and 15 masculine) from 10 to 14 years of age. A history, an otolaryngologic evaluation and a complete basic conventional audiologic evaluation were followed by a vectoeletronystagmography (VENG).

Results: There was a predominance of deep bilateral auditory loss and a larger prevalence of post-natal meningitis and bilateral peripheral deficient vestibular syndrome independent of sex, etiology and the degree of auditory loss.

Conclusion: The high incidence of alteration reveals the importance of the vestibular exam in the infantile population.

Keywords: hearing loss, vestibular diseases, vestibular function tests.

INTRODUCTION

Hearing impairment is researched by health and education professionals, and it covers different aspects such as: hearing anatomy and physiology, language, communication and others. Deaf people and the ones who care about deafness know how this failure affects individual's behavior (1).

Actually, hearing ability is a secondary feature. Balance maintenance is under hearing organ responsibility (2). Vestibular system detects corporal balance sensations that are important on spatial relationship between organism and environment. Thus, it is necessary that sight, proprioceptive sensitiveness and vestibular system remain in perfect integration. It does not matter what we do, we do not need to worry about keeping our balance, which is automatous (3,4).

Human balance is a complex motor activity which involves sensorial detection of body movements, the integration of motor-sensorial information in the central nervous system and the accomplishment of proper musculoskeletal responses (5). The vestibular system, through eye movements, fixes visual axis and help avoiding displacement of images on the retina (6).

Infections (meningitis and rubella), ototoxic substances (streptomycin; neomycin; gentamycin; viomycin; dihydrostreptomycin; kanamycin; vancomycin, i.e "mycin" group; chloramphenicol; salicylates, quinine and others) and congenital abnormality (hereditary or intra-uterus, such as gestational rubella) are the main causes of sensorineural hearing impairment, even though they are congenital or acquired during childhood (7-11).

Children with hypoacusis present several features and necessities: localization, cause, acquisition time, impairment grade and threshold stability (12). Vestibular hypoactivity is mentioned as a frequent finding on children with severe hypoacusis (7,9,13,14).

Vestibulometry is an objective method, noninvasive, which allows functional evaluation of the vestibular, visual and proprioceptive system, with the purpose of affirming or not the auditive and/or vestibular implications, of knowing the damaged side, if it is a peripheral, central or mixed disorder; and it also allows checking if vestibular syndrome is irritative or deficient.

Vestibulometry should be done under such events: any type of dizziness, sensorineural hearing loss, even without dizziness, and under theoretical diagnosis of syndrome of posterior cavity (brainstem and cerebellum), even without hearing loss and dizziness (17).

GUILDER and HOPKINS (7) studying deaf children through rotatory stimulus, found the labyrinthic exam results very diverse. Nevertheless, they affirmed that children with severe hypoacusis often had vestibular hypoactivity. Though, deafness in children caused by meningitis did not have vestibular reaction.

ALCOHOLADO (13) reports six out of seven cases of hearing impairment, had hypoexcitability response by a vectoeletronystagmography (VENG).

COSTEFF, KORB AND GREENGART (18) – Israel – have evaluated vestibular function in children with hearing loss and have not found any relation between vestibular and motor responses with cognitive function; yet, 13 out of 42 children who did not present any post-rotatory nystagmus complained about discomfort or dizziness after the test; four of them presented signs of paleness, sudoresis and brief difficulty when looking upwards. The 13 children had bilateral congenital deafness (of unknown etiology), probably due to recessive heredity. Though, the absence of post-rotatory nystagmus on these cases cannot be easily explained by neither lesions on fibers nor on the center of the eighth cranial nerve, and that can reasonably be due to brain damage or proximity of medial longitudinal fasciculi. This phenomenon of central reaction of vestibular stimulus can be observed when there is nystagmus absence.

The evaluation results of labyrinthic function on children with profound hearing loss show high incidence of abnormal ENG findings, not depending on the likely topographic diagnosis (peripheral, central or mixed), in all tests done (14).

GONÇALVES et al (9) have studied 42 children, aging from four to seven years old, with congenital or acquired sensorineural hearing impairment, and have found that depending on the etiology, vestibular abnormality can occur, ranging from 49% to 95%. Some causes of sensorineural hearing impairment can involve labyrinth, probably seriously affecting the inner ear, such as meningitis, traumas, hemorrhage and genetic syndromes. Some drugs such as streptomycin and aminoglycosides can affect vestibular and cochlear system. A reduction of vestibular function on caloric and rotatory tests has been recorded on hearing impairment, where horizontal semicircular canal, vestibular nucleus, oculomotor muscle are involved.

On hereditary and acquired cochleovestibular syndromes, in relation to vestibular system evaluation signs, it is observed on the static balance: instability, especially with eyes closed, tending falls or no abnormality; and on dynamic balance: ataxia especially with eyes closed, or absence of abnormalities. Positional, spontaneous and semi-spontaneous nystagmus, saccadic movements, pendular tracking and optokinetic nystagmus are usually presented without any abnormality. The lack of answers on the research of perrotatory nystagmus can become evident. Cephalic auto-rotation can appear with or without abnormalities of vestibular reflex. Caloric test made with air, when applicable, can show reduction on unilateral and bilateral vestibular responses and, the areflexia of the post-caloric nystagmus is the main finding (19).

The target of this currrent study is to investigate the hearing loss degree, its etiology and the presence of vestibular implication according to side and sex on children with hearing impairment.

MATERIAL AND METHODS

This study was done at *Laboratório de Otoneurologia da Clínica de Fonoaudiologia da UTP* – Otoneurology Lab of Phonoaudiology Clinic of Tuiuti University – after parents and/or responsible people having authorized by signing a free and clear consent and approval term from Comitê de Ética Institucional (Institutional Ethics Committee).

The sample consisted of 26 children, 11 female and 15 male, aging from 10 to 14, coming from *Centro de Treinamento e Reabilitação da Audição – CENTRAU* (Hearing Training and Rehabilitation Center) – *Curitiba/PR*. Twenty of them had profound bilateral hearing loss, three had severe bilateral hearing loss and the other three had severe hearing loss at right side and profound one at the left side, according to Davis and Silverman´s classification (20).

All children had their anamnesis, ENT (ear, nose and throat) exam, basic audiological evaluation composed by conventional threshold tonal audiometry followed by threshold determinations of speech detectability in acoustic both done at *Setor de Pesquisa e Avaliação Diagnóstica da Audição, da Associação Santa Teresinha da Reabilitação Auditiva – ASTRAU* (Department of Research and Diagnostic Hearing Evaluation). It was used Interacoustics AC 40 audiometer and phones THD 39P with thresholds expressed in dB NA. Afterwards, impedance (timpanometry and acoustic reflex research) in a contralateral way was also done. For those, it was used Interacoustics AZ-26 and phones TDH 39P. To be able to interpret the results, it was used Jerger´s criteria (21).

After all those, the children were submitted to vectoeletronistagmography exam (VENG) at *Laboratório de Otoneurologia da Universidade Tuiuti do Paraná* (UTP) – (Otoneurology Laboratory of Tuiuti University). The instructions were done in a simple way so that children would not move their heads and only the eyes. Because they were deaf, cortical deprivation was done in the following way: when child hand was touched, s/he should start counting from number 1 up to the second touch, and then the last number would be reported.

In order to accomplish VENG exam, the following equipment was used: a Berg, VN 316, thermal sensitive device, having three record channels; a Neurograff, EV VEC visual stimulator; a Neurograff, NGR 05 otothermometer, with air temperature of 42^{o}C, 18^{o}C and 12^{o}C, for caloric tests, and a Ferrante adjustable height pendular swivel chair.

Ocular and labyrinthic tests to VENG were done according to PADOVAN AND PANSINI (22) and MANGABEIRA-ALBERNAZ et al. (23) criteria.

Tests without record

It was applied BRANDT AND DAROFF manuever (24), in which the child changes from sitting position to the one in which the head and body are bent to the reported side as vertigo causing. The head is bending 45^{o} in opposite direction, with nape leaned on a horizontal plan at the end of position, then, the child returns to sitting position and repeat all but now on the opposite side.

Spontaneous and semi-spontaneous nystagmi were researched with eyes opened, on frontal glance and at 30^{o} of glance deviation to right, left, up and downward.

Tests with reports

After cleaning the skin of periorbitary regions using alcohol, it was put on each child, attached with electrolytic paste, a grounding electrode and an active electrode on lateral angle of each eye and on frontal medium line, forming an isosceles triangle, which made the identification of oblique, vertical and horizontal eye movements possible.

Eye movement calibration corresponding to 10^{o} of horizontal eye movement at 10mm of amplitude on the movement of the first channel record**,** and 5mm of height on second and third channels, which was fitted according to ocular deviation of 10^{o} on vertical axis. In this step of the exam, the evaluated clinical aspect was the regularity of the diagram, what could make researches comparable.

Spontaneous (eyes open and closed) and semi-spontaneous nystagmi (eyes open) research. Occurrence, direction, inhibiting effect of eye fixation, and the value of maximum angular speed of the slow component of the nystagmus were evaluated in this record.

Pendular tracking research in order to evaluate curve occurrence and type.

Optokinetic nystagmus research at a speed of 60^{o} per second, clockwise and anti-clockwise, in horizontal position. It was evaluated the occurrence, direction and maximum angular velocity of the slow component.

Pre and post-rotatory nystagmus research stimulating lateral semicircular, anterior and posterior ducts, was applied to a pendular rotatory test in order to stimulate lateral semicircular, anterior and posterior ducts. In order to stimulate those ducts, the head of the child was bent 30^{o} to front direction. Next, head was bent 60^{o} back and 45^{o} to right, and then 60^{o} back, 45^{o} to left, respectively to soothe anterior and posterior semicircular (vertical) ducts. It was observed the occurrence, direction and frequencies to clockwise and anti-clockwise rotation and nystagmus direction preponderancy calculation.

Pre and post-caloric nystagmus research done with children in sitting position in a way that the head and body were bent 60^{o} backward, in order to have a proper stimulation of the lateral semicircular ducts. The time spent on each ear for air irrigation at 42^{o}C, 20^{o}C and 10^{o}C was 80s for each of the temperatures and the responses were recorded with eyes closed and then opened in order to evaluate EIFO (inhibiting effect of eye fixation). In this evaluation, it was observed direction, accurate values of VACL (maximum angular velocity of the slow component) and the calculation of nystagmus direction preponderancy and labyrinthic predominance of post caloric nystagmus relations.

RESULTS

We have not found any alteration on the research of positional, spontaneous and semi-spontaneous nystagmus without record, eye movement calibration, spontaneous and semi-spontaneous nystagmus with record, pendular tracking, optokinetic, pre and post rotatory nystagmus.

The caloric test analysis, in relation to sex, degree and hearing loss etiology are displayed in Tables 1, 2 and 3.

In Table 4, we can observe the frequencies of vestibular syndromes. It is possible to notice that one child (3.8%) presented normal vestibular exam and 25 children (96.1%) presented alterations on peripheral vestibular system.

In Table 5, we can observe the distribution of hearing loss etiologies in relation to peripheral vestibular syndromes; and in Table 6, results of the vestibular exam in relation to hearing loss degree.

DISCUSSION

The ear is a very sensitive system, especially in children who are more inclined to pre, peri and post-natal disease, resulting in severe and profound sensorineural hearing loss.

All patients, no matter what age or sex, with sensorineural hearing loss diagnosis, should undergo a vestibular exam, even if they do not have any symptom of vertigo and other type of dizziness (17)

Results of the research referring to positional, spontaneous and semi-spontaneous nystagmi without record, eye movement calibration, spontaneous and semi-spontaneous nystagmi with record, pendular tracking, optokinetic, pre and post rotatory nystagmi were normal. Such results agree with the authors (19) who studied hereditary and acquired cochleovestibular syndromes. Those authors observed the absence of responses on pre-rotatory nystagmus test and that the cephalic self-rotation can present itself with or without abnormality of vestibulocochlear reflex, a sort of text not applied in this current research.

Opposed to this study, post-rotatory nystagmus was not present in all children with bilateral congenital deafness of unknown etiology and of a possible recessive heredity (18). To such authors, the absence of post-rotatory nystagmus cannot be easily explained by lesions neither of the center nor of the fibers of vestibulocochlear nerve, but by the cerebral damage or by medial longitudinal fasciculi.

Making a relation of hearing loss degree to women, nine of the cases (34.6%) presented bilateral profound hearing loss, one case (3.8%) bilateral severe hearing loss and one case (3.8%) of severe hearing loss to right side and profound to left side. On men, 11 of the cases (42.3%) presented bilateral profound hearing loss, two cases (7.7%) did severe hearing loss to right side and profound to left one. It was recorded an amount of 76.9% of bilateral profound hearing loss, 11.5% of bilateral severe hearing loss and 11.5% of severe hearing loss to right side and profound to left one. In the researched literature, the authors do not refer sex or hearing loss type.

In relation to sensorineural hearing loss etiology, the following diseases were correlated: post-natal meningitis in seven cases (26.9%), heredity in three cases (11.5%), gestational rubella in two cases (7.7%) and ototoxity in one case (3.8%) were related to bilateral profound hearing loss, in a total of 13 cases (50.0%) and in seven cases (26.9%) etiology was unknown. Bilateral severe sensorineural hearing loss occurred in one case of jaundice (3.8%) and two cases (7.7%) with unknown etiology. As for severe sensorineural hearing loss at right side and profound at left one, the responsible diseases were: two cases of post-natal meningitis (7.7%) one case of gestational rubella (3.8%), summing up three cases (11.5%).

In the total of all etiologies which are responsible for the types of sensorineural hearing loss, we can notice post-natal meningitis in nine cases (34.6%), heredity in three (11.5%), gestational rubella in three (11.5%), jaundice in one case (3.8%), ototoxity in one case (3.8%) and in nine other cases (34.6%) the responsible disease was unknown.

This high incidence of unknown causes (34.6%) is probably due to lower social, cultural, economic level of the families as a consequence of the difficulty in obtaining medical resources.

The authors of the studied literature do not mention the frequency of the hearing loss types or the incidence of possible causes of these hearing impairments. They deal with it in general terms. Any grade of hearing loss in a child reduces the accurate understanding of a spoken message or learning (2).

Congenital abnormalities of unknown etiology, referred as hearing disfunction causes are mentioned and they point out the recessive trait on children with bilateral congenital deafness and with absence of post-rotatory nystagmus (8,18).

Different authors besides emphasing genetic syndromes in general as causes of hearing deficts, they also correlate hemorrhages, traumas and miningitis as causes of those losses.

In this current study, the incidence of hearing loss caused by gestational rubella was bilateral profound in two cases (7.7%) and in one case (3.8%) was severe at the right side and profound at the left one, in agreement with the authors who say that gestational rubella is responsible for bilateral sensorineural hearing loss from severe type to profound one (11). These authors also say that acute meningitis and rubella are responsible for 10% of sensorineural hearing deficits from severe to profound type. The importance of rubella as a congenital deafness cause is pointed out by DEWEESE AND SAUNDERS (8).

There are reports on presence of ototoxic substances as responsible causes for sensorineural hearing deficits (8,9,11), which occurred in one case (3.8%) of bilateral profound hearing loss in this study. Streptomycin and aminoglycosides are refered as responsible drugs for serious sensorineural hearing loss in high and irreversible frequencies, and acetylsalicylic acid as responsible for light and moderate sensorineural hearing loss, though reversible (11).

From 26 cases analyzed, 15 were male and 11 female. It was found the following data in relation to the analysis of caloric test: among women, one case (3.8%) of normoreflexia, one case (3.8%) of directional predominance of asymmetrical nystagmus, one case (3.8%) of unilateral hyporreflexia and eight cases (30.8%) of bilateral hyporreflexia. Among men, it was found three cases (11.5%) of unilateral hyporreflexia and 12 cases (46.1%) of bilateral hyporreflexia (Table 1).

Thus, 38.4% of the female cases and 57.7% of the male cases presented alterations on caloric test with predominance of bilateral hyporreflexia (76.9%), followed by unilateral hyporreflexia (15.3%), not depending on sex, which was not correlated by the studied authors. These results agree with the authors (7,9,13,19) who found a reduction of vestibular function on caloric tests in children with hypoacusis, not counting the etiology. Besides reduction of unilateral and bilateral vestibular responses on caloric tests, there is also arreflexia of post-caloric nystagmus on cochleovestibular syndromes (19).

The caloric test analysis in relation to hearing loss grades and to etiology shows one case (3.8%) of normoreflexia, where hearing loss was severe at the right side and profound at the left one, caused by gestational rubella; one case (3.8%) of unilateral hyporreflexia, (15.3%) with bilateral severe hearing loss of unknown cause and three cases (11.5%) of bilateral profound hearing loss, in what one case was of hereditary cause and two of unknown etiology. Bilateral hyporreflexia (76.9%) was found in two cases (7.7%) of bilateral severe hearing loss, one caused by post-natal jaundice and the other was of unknown etiology. From 16 cases (61.6%) of bilateral profound hearing loss, 7 of them of meningitis, two were hereditary, two gestational rubella and five cases were unknown; two cases (7.7%) of severe hearing loss at the right side and profound at the left by post-natal meningitis. The directional predominance of asymmetric nystagmus was recorded in one case (3.85%) where hearing loss was bilateral profound of ototoxic etiology.

In this record, the cases of severe hearing loss (Table 2) and all post-natal meningitis cases (Table 3) show a vestibular hyporreflexia at caloric test, the former agreeing and the latter disagreeing with authors who noticed vestibular arreflexy in cases of meningitis (7).

Berg and Pallasch (25) report that in one case of sudden deafness, the initial exam showed vestibular arreflexia to caloric stimuli and three months later a slight reduction on caloric stimulus reaction was reported.

In this study, 96.1% of the patients presented alterations on caloric test, not counting hearing loss grade. One case of gestational rubella presented normoreflexia vestibular, despite of severe hearing loss at the right side and profound at the left one (Table 2 and 3).

The results of this research agree with Lavinsky (14) when mentioning that the incidence of abnormal ENG findings is high on deaf people of severe and profound grades, not depending on the diagnosis even if it is topographic, peripheral, central or mixed.

The vestibular exam was normal in one case (3.8%), one case (3.8%) of irritative peripheral vestibular syndrome, four cases (15.3%) of unilateral deficient peripheral vestibular syndrome and 20 cases (76.9%) of bilateral deficient peripheral vestibular syndrome (table 4). This study show that in 26 patients with severe and profound hearing loss, 25 of them (96.1%) presented peripheral vestibular syndrome and one case (3.8%) the vestibular exam was normal. This shows, therefore, a greater incidence of bilateral deficient peripheral vestibular syndrome.

In the correlation between peripheral vestibular syndromes and their respective etiologies, nine cases of post-natal meningitis (34.6%) were bilateral deficient peripheral vestibular syndrome; on the three heredity cases, one of them (3.8%) was unilateral deficient peripheral vestibular syndrome and two cases were (7.7%) bilateral deficient peripheral vestibular syndrome. On the three cases of gestational rubella, one case (3.8%) was normorreflexia and two (7.7%) presented bilateral deficient peripheral vestibular syndrome. In one jaundice case (3.8%) it was found bilateral deficient peripheral vestibular syndrome and one case (3.8%) of irritative peripheral vestibular syndrome to ototoxic etiology. In the nine cases (34.6%) of unknow etiology, unilateral deficient peripheral vestibular syndrome occurred in three patients (11.5%) and bilateral deficient peripheral vestibular syndrome in six of them (23.1%), according to Table 5.

In the correlation between peripheral vestibular syndromes and hearing loss grades, unilateral deficient peripheral vestibular syndrome occurred in three cases (11.5%) of bilateral profound loss, in one case (3.8%) of bilateral severe loss, in a total of four cases (15.3%). Bilateral deficient peripheral vestibular syndrome was present in 16 cases (61.5%) of bilateral profound loss, in two cases (7.7%) of bilateral severe loss, in two cases (7.7%) of severe loss at the right side and profound at the left side, in a total of 20 cases (76.9%). An irritative peripheral vestibular syndrome occurred in one case (3.8%) of bilateral profound loss. The exam was normal in one case (3.8%) of severe hearing loss at the right side and profound at the left side (Table 6).

We conclude that there is a prevalence of bilateral deficient peripheral vestibular syndrome, no matter the sex, etiology and hearing loss grade.

CONCLUSION

1. There was a predominance of bilateral profound hearing loss, followed by bilateral severe hearing loss and severe at the right side and profound at the left one, no matter the sex of patients.
2. The post-natal meningitis prevailed as responsible for causing hearing loss.
3. There was a predominance of peripheral vestibular syndromes, not depending on sex and type of hearing loss and its etiology.
4. There was a predominance of bilateral deficient peripheral vestibular syndrome, not depending on sex, etiology and hearing loss grade.

BIBLIOGRAPHY

1. Sebastián G. Audiologia prática. 3º ed. Rio de Janeiro; Enelivros: 1986. p. 27-32.

2. Northern JL, Downs MP. Audição em crianças. 3º ed. São Paulo; Manole:1989. p. 25-54.

3. Guyton ACH, John E. Tratado de fisiologia médica. 8º ed. Rio de Janeiro; Guanabara Koogan: 1992. p. 531-43.

4. Ganança MM, Caovilla HH, Munhoz MSL, Ganança FF. Tonturas na criança e no adolescente. RBM-ORL, 1995, 2(4):217-42.

5. Gontijo APB, Araújo AR, Chaves FS, Pedrosa FM. Aspectos neurológicos e biomecânicos do equilíbrio para fundamentar a prática clínica: Revisão bibliográfica. Temas sobre desenvolvimento, 1997, 6(33): 2-11.

6. Kileny P. Avaliação da função vestibular. In: Katz J. Tratado de audiologia clínica. 3º ed. Rio de Janeiro; Manole:1989. p. 592-614.

7. Guilder RP, Hopkins LA. Auditory function studies in an unselected group of pupils at the Clarke school for the deaf. Laryngoscope, 1936, 46:190-7.

8. Deweese DD, Saunders, WH. Textbook of otorrinolaryngology. 6ºed. St. Louis; Mosby Company:1982. p.279-95.

9. Gonçalves VMG, Piovesana AMSG, Moura-Ribeiro MVL. Avaliação do equilíbrio estático numa população de crianças deficientes auditivas. Arq. Neuropsiquiatr., 1993, 51(3):346-51.

10. Russo ICP, Santos TMM. Prática da audiologia clínica. 4º ed. São Paulo; Cortez: 1993. p.191-212.

11. Bess FH, Humes LE. Fundamentos de audiologia. 2ª ed. Porto Alegre; Artmed: 1998. p.155-95.

12. Bevillacqua MC, Formigoni GMP. Princípios básicos para a habilitação e a reabilitação da criança deficiente auditiva. In: Bevillacqua MC, Formigoni GMP. *Audiologia educacional: Uma opção terapêutica para a criança deficiente auditiva.* 2ª ed. Carapicuiba: Pró-Fono – Departamento editorial: 1998. p.11-9.

13. Alcoholado LA. Exploración vestibular pendular y eletronistagmografia em lãs hipoacusias de percepción. Acta Otorinolaryngol Iber Am., 1970, 21(6):589-622.

14. Lavinsky L. Estudo da função labiríntica em crianças com hipoacusia severa e profunda. Rev. HCPA, 1990, 10(1):14-26.

15. Caldas N, Caldas Neto S, Sih T. Otologia e audiologia em pediatria. 1º ed. Rio de Janeiro: Revinter: 1999. p.277-87.

16. Ganança MM, Vieira RM, Caovilla HH. Princípios de otoneurologia. São Paulo: Atheneu, v.1 – Série Distúrbios da Comunicação Humana: 1999.

17. Ganança MM, Mangabeira-Albernaz PL. Guia prático: Labirintologia. 1ºed. São Paulo: Editamed; 1976.

18. Costeff H, Korb M, Greengart H. Vestibular function of hearing-impaired children. Develop. Med. Child Neurol., 1988, 30(4): 552-3.

19. Garcia da Silva ML, Lei Munhoz MS, Ganança MM, Caovilla HH, Ganança FF. Sintomas cocleovestibulares hereditários e adquiridos. In: Ganança MM, Lei Munhoz MS, Caovilla HH, Garcia da Silva ML. *Quadros clínicos otoneurológicos mais comuns.*1º ed. São Paulo: Atheneu: 2000. p. 187-97.

20. Davis H, Silverman RS. Hearing and deafness.3ª ed. New York: Holt, Rinehart & Wilson: 1970. p. 253-79.

21. Jerger J. Clinical experience with impedance audiometry. Arch Otolaryngol., 1970, 92:311-24.

22. Padovan I, Pansini M. New possibilities of analysis in electronystagmography. Acta Otolaryngol., 1972,73:121-5.

23. Mangabeira-Albernaz PL, Ganança MM, Pontes PAL. Modelo operacional do aparelho vestibular. In: Mangabeira-Albernaz PL, Ganança MM. *Vertigem*. 2.ed. São Paulo: Ed. Moderna; 1976. p. 29-36.

24. Brandt T, Daroff RB. Physical therapy for benign paroxysmal positioning vertigo. Arch Otolaryngol Head Neck Surg., 1980,106: 484-5.

25. Berg M, Pallasch H. Sudden deafness and vertigo in children and juveniles. Adv Oto-Rhino-Laryngol., 1981, 27: 70-82.

Table 1. Analysis of caloric test in relation to sex.

Caloric Test	Female	Male	Total
Bilateral Hyporreflexia	8 (30.8%)	12 (46.1%)	20 (76.9%)
Unilateral Hyporreflexia	1 (3.8%)	3 (11.5%)	4 (15.3%)
Normorreflexia	1 (3.8%)	-	1 (3.8%)
Directional Predomiance of asymmetric nystagmus	1 (3.8%)	-	1 (3.8%)
Total	11 (42.3%)	15 (57.7%)	26 (100%)

Table 2. Analysis of calorci test in relation to hearing loss grade.

Caloric Test	HEARING LOSS GRADE Bilateral Severe	Bilateral Profound	Severe at right and profound at left	Total
Bilateral Hyporreflexia	2 (7.7%)	16 (61.5%)	2 (7.7%)	20 (76.9%)
Unilateral Hyporreflexia	1 (3.8%)	3 (11.5%)	-	4 (15.3%)
Normorreflexia	-	-	1 (3.8%)	1 (3.8%)
Directional Predomiance of asymmetric nystagmus	-	1 (3.8%)	-	1 (3.8%)
Total	3 (11.5%)	20 (76.9%)	3 (11.5%)	26 (100%)

Table 3. Analysis of Caloric Test in relation to hearing loss etiology

Hearing loss etiology	CALORIC TEST Hyporreflexia bilateral	Hyporreflexia unilateral	Normorreflexia	Directional Predomianance of asymmetric nystagmus	Total
Unknown	6 (23.1%)	3 (11.5%)	-	-	9 (34.6%)
Post-Natal Meningitis	9 (34.6%)	-	-	-	9 (34.6%)
Hereditarity	2 (7.7%)	1 (3.8%)	-	-	3 (11.5%)
Gestational Rubella	2 (7.7%)	-	1 (3.8%)	-	3 (11.5%)
Jaundice	-	-	-	1 (3.8%)	
Ototoxity	-	-	-	1 (3.8%)	1 (3.8%)
Total	20 (76.9%)	4 (15.3%)	1 (3.8%)	1 (3.8%)	26(100%)

Table 4. Frequencies of peripheral vestibular syndromes.

Vestibular Exam	number of cases	%
Normal Irritative Peripheral Vestibular Syndrome	11	3,83,8
Unilateral deficient peripheral vestibular syndrome	4	15.3
Bilateral deficient peripheral vestibular syndrome	20	76.9
Total	26	100

Table 5. Hearing loss etiology in relation to peripheral vestibular syndrome.

Etiology	Normal	PERIPHERAL VESTIBULAR SYNDROMES UDPVS	BDPVS	IPVS	Total
Unknown	-	3 (11.5%)	6 (23.1%)	-	9 (34.6%)
Post-Natal Meningitis	-	-	9 (34.6%)	-	9 (34.6%)
Hereditarity	-	1 (3.8%)	2 (7.7%)	-	3 (11.5%)
Gestational Rubella	1 (3.8%)	-	2 (7.7%)	-	3 (11.5%)
Jaundice	-	-	1 (3.8%)	-	1 (3.8%)
Ototoxity	-	-	-	1 (3.8%)	1 (3.8%)
Total	1 (3.8%)	4 (15.3%)	20 (76.9%)	1 (3.8%)	26 (100%)

Subtitle: UDPVS = Unilateral deficient peripheral vestibular syndrome; BDPVS= Bilateral deficient peripheral vestibular syndrome; IPVS= Irritative peripheral vestibular syndrome.

Table 6. Analysis of vestibular syndromes in relation to hearing loss grade.

	PERIPHERAL VESTIBULAR SYNDROMES				
Hearing Loss	Normal	UDPVS	BDPVS	IPVS	Total
Bilateral Profound	-	3 (11.5%)	16(61.5%)	1(3.8%)	20 (76.9%)
Bilateral Severe	-	1 (3.8%)	2 (7.7%)	-	3 (11.5%)
Severe at right and profound at left	1 (3.8%)	-	2 (7.7%)	-	3 (11.5%)
Total	1 (3.8%)	4 (15.3%)	20 (76.9%)	1 (3.8%)	26 (100%)

Subtitle: UDPVS = Unilateral deficient peripheral vestibular syndrome; BDPVS= Bilateral deficient peripheral vestibular syndrome; IPVS= Irritative peripheral vestibular syndrome.