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Function of the medial olivocochlear system in children with phonological disorders

Função do sistema olivococlear medial em crianças com desvio fonológico

ABSTRACT

Purpose: To verify whether children with phonological disorders present alterations in the medial olivocochlear system. **Methods:** This is a prospective cross-sectional study in which 19 normal hearing children of both genders, with ages between 4 and 7 years, were divided into two groups: 11 children without phonological disorders (control group) and eight with phonological disorders (study group). The auditory condition was verified by visual examination of the external ear canal, pure tone audiometry, and tympanometry. The study included only children with hearing thresholds below or equal to 15 dB, type A tympanometry, and presence of acoustic reflexes. To evaluate the function of the medial olivocochlear system, it was carried out the evaluation of transient evoked otoacoustic emissions (TEOAE) with and without contralateral white noise at 60 dBHL. Data were statistically analyzed. **Results:** The occurrence and average values of TEOAE suppression in right and left ears did not present differences in the frequencies of 1, 2, 3 and 4 kHz within groups. In the comparison of the mean and the occurrence of the suppressive effect of TEOAE between control and study groups, there was also no difference in the frequencies analyzed. **Conclusion:** Children with phonological disorders do not present alterations in the medial olivocochlear system, as evidenced by the occurrence of the suppressive effect of transient evoked otoacoustic emissions.

RESUMO

Objetivo: Verificar se crianças com desvio fonológico apresentam alterações do sistema olivococlear medial. **Métodos:** Trata-se de estudo prospectivo e transversal. Foram avaliadas 19 crianças normo-ouvintes, de ambos os gêneros, com idades entre 4 e 7 anos, que foram divididas em dois grupos: 11 crianças sem desvio fonológico (grupo controle) e oito com desvio fonológico (grupo estudo). A condição auditiva foi verificada por meio da inspeção visual do meato acústico externo, audiometria tonal liminar e imitanciometria. Foram incluídas em ambos os grupos somente as crianças com limiares tonais iguais ou inferiores a 15 dB, timpanometria tipo A e reflexos acústicos presentes. Para avaliar a função do sistema olivococlear medial procedeu-se à avaliação das emissões otoacústicas evocadas transientes (EOAET) com e sem aplicação de ruído branco na intensidade de 60 dBNA contralateralmente. Os dados foram analisados estatisticamente. **Resultados:** A ocorrência e a média dos valores de supressão das EOAET das orelhas direita e esquerda não apresentaram diferenças nas frequências de 1, 2, 3 e 4 kHz intragrupos estudo e controle. Na comparação da média e ocorrência do efeito supressor das emissões otoacústicas evocadas transientes entre grupo controle e grupo estudo, também não houve diferenças nas frequências analisadas. **Conclusão:** Crianças com desvio fonológico não apresentam alterações do sistema olivococlear medial, aspecto evidenciado pela ocorrência do efeito supressor das emissões otoacústicas evocadas transientes.

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INTRODUCTION

Phonological disorders are type of language disorder characterized by a difficulty in the mental organization of language sounds, in establishing the target phonological system, and in the adequacy of the received input⁽¹⁾. The processing of phonological information occurs differently than expected, and the auditory abilities are relatively rare, especially regarding the auditory feedback of one's own speech⁽²⁾.

The acquisition of the phonological system is completed around the age of five⁽³⁾. The cause of the disorder in this system is not yet defined⁽⁴⁾.

The perception of sounds is related to the learning of the articulatory pattern⁽⁵⁾. For the development of speech and language, the abilities of sound localization, memory, analysis and interpretation are extremely important. They are part of the auditory processing, defined as the ability to organize and understand sound stimuli⁽⁶⁾. Oral language difficulties may be strongly related to auditory processing disorders, because hearing is the main route of entry for language acquisition⁽⁷⁾.

The auditory system consists of afferent and efferent pathways. The efferent fibers are located from the nucleus of the superior olivary complex until the cochlea, and are named medial olivocochlear system (MOCS). The functions attributed to this tract are sound localization, auditory attention, improvement of auditory sensitivity, improvement in the detection of acoustic signals in the presence of noise, and protection against temporary or permanent damage by high acoustic levels^(8,9).

The normal functioning of the MOCS is evidenced by the suppression or reduction in the amplitude of otoacoustic emissions (OAE), in the presence of ipsilateral noise. This phenomenon occurs due to the action of medial olivocochlear tract fibers in synapses with outer hair cells. Consequently, there is a reduction in the movement of the basilar membrane^(10,11).

The relevance of assessing the medial olivocochlear complex in children with auditory processing disorder is due to the fact that this system plays an important role in hearing when there is noise⁽¹²⁾. A frequent complaint from individuals with auditory processing disorder is difficulty in speech intelligibility in noisy situations. In children, this difficulty can be manifested by behavioral alterations, and it can influence the learning process⁽¹³⁾. Individuals with auditory processing disorders have decreased or absence of otoacoustic emissions suppression, which suggests reduced inhibitory effect of the MOCS^(14,15).

Children with phonological disorders can present auditory processing deficits, and the ability to figure-ground is usually the most affected⁽¹⁶⁾. There are also reports that children with auditory processing disorders may have the suppression effect of OAEs decreased⁽¹⁷⁾.

Considering that one of the functions of the MOCS is the improvement in the perception of acoustic signals in noise, and that children with phonological disorders have alterations in figure-ground abilities, the hypothesis of this study was that children with phonological disorders could present absence of the suppressive effect of OAEs. This hypothesis is based on literature data that indicate a relationship between the ability of speech intelligibility in noise and language abilities⁽¹⁶⁾. If

this relation is confirmed, the ability of speech intelligibility in noise could be focused during the therapeutic process with children with phonological disorders, allowing improvement in the discrimination of phonemes and in language abilities.

Despite evidences that children with phonological disorders have auditory processing alterations⁽¹⁶⁻¹⁸⁾, and that children with auditory processing disorders present reduction in the suppression effect of OAEs⁽¹⁷⁾, it was not found any literature data relating phonological disorders with the condition of the MOCS. Hence, the aim of this study was to verify whether children with phonological disorders have MOCS alterations

METHODS

This research is related to the research project "Suppression effect of otoacoustic emissions", approved by the Research Ethics Committee of the Universidade Federal de Santa Maria (UFSM), under registration number 0226638. This is a prospective cross-sectional study, focused on the results of otoacoustic emission suppression in children with phonological disorders.

Participants were selected from public schools in Santa Maria (RS), Brazil, and also from the queue of the Speech-Language Pathology and Audiology Care Service (SAF), located in the same city. After being informed about the procedures that would be performed, parents signed the Free and Informed Consent Form, authorizing participation of the children in this study.

Participants were divided into two groups:

- control group (CG): 11 normal-hearing children, seven female and four male, with ages between 4 and 7 years, without phonological disorders;
- study group (SG): eight normal-hearing children, two female and six male, with ages between 4 and 7 years, with phonological disorders.

In the control group (CG), normal-hearing children who did not have any kind of phonetic and phonological disorders, language disorders, stomatognathic system disorders, and who had not been enrolled in speech-language pathology therapy were included. In the study group (SG), normal-hearing children with phonological disorders who did not present language deficits, stomatognathic system disorders and/or phonetic disorders were included.

For the definition of participants according to the criteria for inclusion and exclusion, children underwent an evaluation of the stomatognathic system through the application of the Protocol of Assessment of the Sensorial-Motor-Oral System that was used in the SAF and in the Phonological Assessment of the Children (AFC)⁽¹⁹⁾ for the identification of phonological disorders. The degree of the phonological disorder was not considered in this study group because of the reduced number of participants.

To verify the condition of hearing, the children underwent visual inspection of the external ear canal, pure tone audiometry and impedance. For visual inspection of the external ear canal, it was used the Heine mini 3000® otoscope. After that, pure tone audiometry was conducted in an acoustically treated booth, and the air-conduction thresholds were researched for the frequencies 500 Hz to 4 kHz using the Fonix® FA-12

Hearing Evaluator™ audiometer. The technique used was the descending-ascending.

The tympanometry was conducted using the Interacoustics® middle ear analyzer, model AZ-7/AZ-7R, 256 Hz tone test. Acoustic reflexes were investigated in the frequencies from 500 Hz to 4 kHz bilaterally, in contralateral and ipsilateral modes. The children who presented auditory thresholds until 15 dB, type “A” tympanogram, and presence of acoustic reflexes bilaterally were considered normal-hearing. Subjects who had any type and degree of hearing impairment were excluded from this study, and referred to the hearing care center.

Forty eight children from two public schools in Santa Maria were screened. From these, only 26 attended evaluation. From this group of children, seven were excluded due to the presence of hearing deficits.

After the speech-language pathology assessment, 19 children composed the final sample.

Children from both groups were submitted to the assessment of Transient Evoked Otoacoustic Emissions (TEOAE) in both ears, with nonlinear click stimulus and 20-milliseconds window, in the frequencies of 1, 2, 3 and 4 kHz, and intensity of approximately 80 dB SPL. The register of the TEOAE was carried out in a quiet room with the Intelligent Hearing Systems (IHS) cochlear analyzer. TEOAE were considered present when the signal/noise rate was equal to or greater than 6 dB in at least four out of the five frequencies analyzed.

After that, the suppressive effect of TEOAE was investigated using the contralateral white noise generated by the audiometer Fonix® FA-12 Hearing Evaluator™, with TDH-39P headphones, at the intensity of 60 dB HL. The non-linear stimulus and the intensity of 80 dB NPS in the suppression of TEOAE were based on previous studies^(20,21). The calculation of TEOAE suppression was carried out by subtracting the TEOAE response level without contralateral acoustic stimulation out of the response level of TEOAE with contralateral acoustic stimulation. Positive values indicated the presence of TEOAE suppression, and negative or null values indicated the absence of the phenomenon. The suppression effect of TEOAE was analyzed by frequency bands and in *Response*.

The *Response* was calculated based on the geometric mean of all the frequency bands tested by ear, in each individual and in the different groups. It was considered presence of the sup-

pression effect of TEOAE when the average of the responses with and without contralateral stimulation was greater than or equal to 1 dB SPL.

Data were tabulated and statistically analyzed. For the analysis of the variables “presence of suppression” and “mean values of suppression by specific frequency”, the Tukey test was used. To analyze the suppressive effect of TEOAE in *Response*, first, it was tested the normality of the variable by using the Lilliefors test, which showed no normal distribution ($p < 0.05$). For that reason, to compare the suppressive effect of TEOAE in *Response* between ears and between groups, it was used the nonparametric Mann-Whitney U test for two independent samples, and the association tests Chi-square and Fisher’s Exact test. All analyzes considered the significance level of 0.05 (5%).

RESULTS

The comparison of presence and absence of TEOAE suppression effect by specific frequency bands, in both ears and in each group, showed that only two individuals in the control group had absence of suppression in all frequencies. In one of them, this absence occurred in both ears, and in the other individual, only in the right ear. All the subjects of the study group presented TEOAE suppression in all frequencies. In the comparison of the mean values of TEOAE suppression between right and left ears intragroups, there was no difference in the analyzed frequencies (Table 1).

Due to the fact that the comparison of the average of frequencies between ears did not show differences, the presence or the absence of TEOAE suppression effect of right and left ears were considered simultaneously, taking into consideration only the group to which the children belonged.

Comparing the mean TEOAE suppression values between the CG and SG, there was no difference in the frequencies (Table 2).

The intragroup analysis for the evidence of the suppression of TEOAE showed no differences between right and left ears (Tables 3 and 4).

In the analysis of the occurrence of TEOAE suppression between CG and SG, there was also no difference (Table 5).

In the comparison of TEOAE *Response* suppression betwe-

Table 1. Comparative analysis of the suppression values of TEOAE between ears

Frequency (kHz)	Control Group		p-value	Study Group		p-value
	RE Mean (dB)	LE Mean (dB)		RE Mean (dB)	LE Mean (dB)	
1	1.046	-0.603	0.4629	3.695	2.151	0.5868
2	1.191	2.455	0.8264	5.255	1.918	0.3918
3	3.515	1.811	0.5209	5.103	-0.924	0.1982
4	0.976	1.75	0.632	3.505	0.078	0.2838

Tukey test ($p < 0.05$)

Note: RE = right ear; LE = left ear

Table 2. Comparative analysis of the suppression values of TEOAE between control and study groups

Frequency (kHz)	Control Group Mean (dB)	Study Group Mean (dB)	p-value
1	0.222	2.923	0.1256
2	2.184	3.586	0.5123
3	2.663	2.089	0.8172
4	1.363	1.791	0.7910

Tukey test (p<0,05)

en right and left ears, no difference was found in CG, SG and between groups (p=0.932).

The groups were also compared regarding the presence or the absence of TEOAE suppression effect, considering presence when the *Response* was greater than or equal to 1 dB SPL. The results did not show significant association for the presence of TEOAE suppression between groups (p=0.721).

DISCUSSION

Some studies have evidenced significant auditory processing deficits in children with phonological disorders. The results indicate alterations in the abilities of speech comprehension and perception of its components^(11,15-16,19). In addition, children with auditory processing disorders have decreased suppression effect of otoacoustic emissions⁽¹⁸⁾.

In the view of the lack of studies regarding the effect of TEOAE suppression in children with phonological disorders, our results are compared, whenever possible, with similar studies. In the lack of such researches, they are related to studies on auditory processing disorders, which are present in children with phonological disorders.

In this study, it was found that children with and without phonological disorders present TEOAE suppression. The suppressive effect of the presence of OAEs shows normal efferent auditory pathways, which are mediated by the activity of the MOCS⁽²²⁾.

Table 3. Occurrence of the suppression effect of the TEOAE according to ear and frequency in the control group

Frequência (kHz)	Right ear				Left ear				p-value
	Present		Absent		Present		Absent		
	%	n	%	n	%	n	%	n	
1	53.85	7	44.44	4	46.15	6	55.56	5	0.6646
2	50.00	7	50.00	4	50.00	7	50.00	4	1.000
3	53.33	8	42.86	3	46.67	7	57.14	4	0.6471
4	46.15	6	55.56	5	53.85	7	44.44	4	0.6648

Tukey test (p<0.05)

Table 4. Occurrence of the suppression effect of the TEOAE according to ear and frequency in the study group

Frequência (kHz)	Right ear				Left ear				p-value
	Present		Absent		Present		Absent		
	%	n	%	n	%	n	%	n	
1	50.00	6	50.00	2	50.00	6	50.00	2	1.000
2	54.55	6	40.00	2	45.45	5	60.00	3	0.5896
3	54.55	7	40.00	2	45.45	5	60.00	3	0.5896
4	58.33	7	25.00	1	41.67	4	75.00	4	0.2482

Tukey test (p<0.05)

Table 5. Occurrence of the suppression effect of the TEOAE according to frequency in the study group and in the control group

Frequency (kHz)	Control Group		Study Group		p-value
	Present (%)	Absent (%)	Present (%)	Absent (%)	
1	40.91	59.09	25.00	75.00	0.374
2	36.36	63.64	31.25	68.75	0.7429
3	31.82	68.18	31.25	68.75	0.9703
4	40.91	59.09	25.00	75.00	0.3074

Tukey test (p<0.05)

The results also showed that children with and without phonological disorders did not differ in the occurrence and the average of TEOAE suppression effect, both when considering the specific frequency response or in *Response*. These results agree with a study where no correlation was observed between MOCS and the ability of speech intelligibility in noise⁽²³⁾, and another research⁽²⁰⁾ where no alterations were found in tests of figure-ground abilities in children with phonological disorders.

The ability of figure-ground or speech recognition in noise and auditory attention are functions assigned to the MOCS⁽²⁴⁻²⁶⁾. According to some researches^(16,17), children with phonological disorders have difficulty with auditory attention and figure-ground tests. In contrast to our results, some studies have reported that children with language development deficits present evidence of auditory processing and TEOAE suppression effect alterations, suggesting deficits in this system⁽²⁷⁾.

No difference was observed in the comparison of the averages and the occurrence of suppressive effect of TEOAE between right and left ears within groups. These results disagree with a study⁽¹⁸⁾ in which there was an advantage of the right ear in the group of children without auditory processing disorder, and the left ear in the group of children with auditory processing disorder. The right ear advantage in the left ear is interpreted as a reflex of left-hemisphere dominance for speech and language processing, suggesting that the efferent activity of the MOCS may be lateralized⁽²⁷⁾.

In this study, the SG presented higher suppression effect of TEOAE when compared to the CG. This finding disagrees with studies that indicate that children with auditory processing disorders have a decreased level or absence of suppression of otoacoustic emissions^(14-15,18). Moreover, other findings assume that the figure-ground ability is directly related to the MOCS reflex, that is, the higher this ability, the greater the suppression of OAE^(28,29). The figure-ground ability is the one that seems to be more affected in subjects with phonological disorders, which disagrees with previous findings⁽¹⁶⁾.

The results of this study may have been influenced by the small sample size. For this reason, we suggest further studies involving a larger number of participants.

CONCLUSION

Children with and without phonological disorders present TEOAE suppression, both in the analysis by specific frequency and in *Response*. These results suggest that children with phonological disorders have no alterations in the MOCS, an aspect evidenced by the occurrence of the suppressive effect of TEOAE. Therefore, the suppression of TEOAE is not able to differentiate children with and without phonological disorders.

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