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# Transient evoked otoacoustic emissions in term and pre-term neonates in the presence and absence of suction

Emisiones Otoacústicas Evocadas Transitorias en Neonatos a Término Y Prematuros en Presencia Y Ausencia de Succión  
Emissões Otoacústicas Evocadas Transientes em Neonatos a Termo e Pré-Termo na Presença e na Ausência de Sucção

## ABSTRACT

**Objective:** to verify if the sounds caused by the suction / swallowing mechanism interfere with the TEOAE in the term and pre-term newborns. **Method:** a study of 40 newborns (27 full-term and 13 preterm), evaluated with presence of TEOAE, at rest and in suction situation. **Results:** At the time of suctioning / deglutition, the frequency of suctioning / deglutition was analyzed by frequency; it was found that in 2000 Hz, a greater number of failures occurred during suction. **Conclusion:** There was no statistically significant difference between the results obtained without suction and nutritive suction in the breast.

**DESCRIPTORS:** Otoacoustic Emissions; Suction; Neonates.

## RESUMEN

**Objetivo:** Verificar el ruido causado por el mecanismo de interferir al tragar / tragar TEOAE en neonatos para termo y pre-termo. **Método:** estudio realizado con 40 recién nacidos (27 a término y 13 prematuros), con el apoyo de la presencia de TEOAE, en situación de reutilización y succión. **Resultados:** Al analizar la aparición de TEOAE, no hay tiempo para succión / deglución en comparación con el momento de succión / deglución, según la frecuencia, se encontró que en 2000 Hz hubo más fallas durante la succión. **Conclusión:** No hubo variación estadísticamente significativa entre los resultados obtenidos después de la succión y la succión nutricional, y no materna, pudiéndose realizar de dos maneras, sin perjuicio de los resultados.

**DESCRIPTORES:** Emisiones Otoacústicas; Succión; Neonatos.

## RESUMO

**Objetivo:** Verificar se os ruídos provocados pelo mecanismo de sucção/deglutição interferem nas EOAETs em neonatos a termo e pré-termo. **Método:** estudo realizado com 40 neonatos (27 nascidos a termo e 13 pré-termo), avaliados com presença de EOAETs, em repouso e em situação de sucção. **Resultados:** Analisando a ocorrência de EOAETs no momento sem sucção/deglutição em comparação com o momento sucção/deglutição, segundo a frequência, constatou-se que em 2000 Hz ocorre maior número de falhas durante a sucção. **Conclusão:** Não houve variação estatisticamente significativa entre os resultados obtidos sem sucção e em sucção nutritiva no seio materno, tal achado possibilita que o exame pode ser realizado das duas formas sem prejuízo nos resultados.

**DESCRIPTORES:** Emissões Otoacústicas; Sucção; Neonatos.

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## INTRODUCTION

The first researcher with records regarding acoustic stimulation in the external auditory canal was Kemp[1] in 1978. The responses appeared after 5 milliseconds (ms) after stimulation, where they were initially called “eco-cochlear”, later arriving at the term Otoacoustic Emissions (OAE).

In this situational setting, responses were present in individuals with normal thresholds, not in patients with sensorineural deafness. Soon, a wide field of research and diagnostic clinical investigations in human hearing began.

Evoked Otoacoustic Emissions (EOAE) have been explored for several reasons. Among them, because it represents the ability of the inner ear to create its own sound vibrations, that is, the existence of cochlear activity, since the cochlea was previously believed to be passive. Another reason was due to the technological development of Evoked Otoacoustic Emissions (EOAE), which allowed its use in the early identification of hearing impairment, Neonatal Hearing Screening (NHS), a fundamental role within the test battery. [2]

Bonfils et al. [3], in 1992 and Morlet et al.,[4] in 1993, in studies with larger populations, they found no significant differences in the levels of OAE response depending on the post-conceptual age of premature infants. Chuang et al.,[5] in 1993, when observing the changes in the response level of Transient Evoked Otoacoustic Emissions (TEOAE) according to gestational age, in a longitudinal study of only two babies, they suggested that the maturation process does not undergo changes from the 38th week onwards.

Smurzynski et al.,[6] in 1993, comparing groups of full-term and preterm neonates, they observed that the general amplitude values of the preterm group at risk for hearing loss were lower than the general amplitude values of the term group. Bassetto[7] in 1998 found differences between the level of mean TEOAE responses between neonates aged 31 to 36

weeks and neonates aged 37 to 44 weeks, with higher responses for the higher frequency bands.

In a study by Pereira et al.,[8] performed in 2007, the occurrence of TEOAEs was observed in 86,03% of full-term neonates, while in preterm infants it was present only in 79,79%. Thus, they noticed that the chance of presenting absence of TEOAEs increased as the gestational age decreased.

Although many studies report the factors that may interfere with the measurement of TEOAE, there is, however, no literature on interference in the examination of the act of sucking and swallowing in term and preterm neonates.

The examination in children during sucking / swallowing is a common clinical practice, however research shows that the results of the test during nutritional sucking (NS) may differ from those obtained in natural sleep, suggesting that breastfeeding may interfere with the auditory response. [9-17] However, clinical routine has shown that children examined while sucking have no changes in the test result.

This research is justified by the fact that sucking / swallowing during the evaluation of TEOAEs is a useful resource in clinical practice to reassure the child, since, in this situation, the child is in a comfortable position, his body movements and the stress situations become reduced, facilitating the capture of responses, which makes the exam even more dynamic. Once the ideal conditions for the measurement of TEOAEs are reached, the procedure can be used safely during the assessment of TEOAEs.

## METHOD

A quantitative, cross-sectional and intervention study was performed to obtain data at the Cardiovascular and Respiratory Physiotherapy Clinic in the city of Barbalha-CE. This study was approved by UNILEÃO's Institutional Ethics Committee (CAAE: 67487517.1.0000.5048).

The study consisted of 40 children (11 females and 29 males), born at term (27

and preterm (13). Forty right ears and 40 left ears were analyzed at one time without nutritive sucking at the mother's breast and at another time 40 right ears and 40 left ears at the second moment with nutritive sucking at the mother's breast.

The inclusion criteria in the sample of this study were: children who had TEOAEs; age between 01 to 03 months of life, at the time of the exam and who were breastfed at the breast. Exclusion criteria: behavioral change; upper airway obstruction; cry; otitis; presence of suction with hatches, presentation of positive pressure in the breastfeeding process, presentation of crackling during suction; signs of stress during sucking, such as gagging, hiccups, among others; and finally, parents or guardians do not agree with the research.

After checking the inclusion criteria and obtaining the signature of the Free and Informed Consent Term, they were evaluated in two moments and later divided into two distinct groups:

- Newborns at term;
- Preterm neonates.

Both groups were evaluated in two moments:

- At rest, without suction;
- At rest, during suction: nutritious in the chest or non-nutritious.

Each child, at the time of the exam, was in the lap of the mother or guardian, in a comfortable position, with the ear to be assessed free of any obstruction that could hinder the introduction of the probe in the external auditory canal.

There was no preference in choosing the first situation to perform the exam (non-suction or suction), respecting the children's conditions at each moment.

Anamnesis was carried out to investigate information about the family history of hearing impairment, complications during pregnancy and the child's condition, as well as other risk indicators for hearing impairment.

An inspection was also carried out

Table 1 - Occurrence of Transient Evoked Otoacoustic Emissions (TEOAEs) without and with suction, of the entire sample according to frequency (n = 40)

1500Hz			
EOAETs	Sem Sucção	Em Sucção	Valor P
Presentes	41%	38%	0,63
Ausentes	59%	62%	
2000Hz			
EOAETs	Sem Sucção	Em Sucção	Valor P
Presentes	73%	53%	0,015*
Ausentes	27%	47%	
2500Hz			
EOAETs	Sem Sucção	Em Sucção	Valor P
Presentes	88%	84%	0,65
Ausentes	12%	16%	
3000Hz			
EOAETs	Sem Sucção	Em Sucção	Valor P
Presentes	85%	83%	0,83
Ausentes	15%	17%	
3500Hz			
EOAETs	Sem Sucção	Em Sucção	Valor P
Presentes	83%	79%	0,69
Ausentes	17%	21%	
4000Hz			
EOAETs	Sem Sucção	Em Sucção	Valor P
Presentes	78%	80%	0,85
Ausentes	22%	20%	

\* Statistically significant relationship, p &lt;0.05 Chi-square test.

Table 2 - Occurrence of Transient Evoked Otoacoustic Emissions (TEOAE) without and with suction, according to the frequency and divided between preterm and term. (n = 40)

1500Hz						
EOAETs	A Termo Sem Sucção	A Termo Em Sucção	Valor P	Pré-Termo Sem Sucção	Pré-Termo Em Sucção	Valor p
Presentes	39%	35%	0,55	46%	42%	0,57
Ausentes	61%	65%		54%	58%	

with the purpose of verifying the existence of impediment to the testing of TEOAEs, such as vernix, secretions, epithelial desquamation and cerumen partially or totally obstructing the external auditory canal, using the Welch Allyn 240 A otoscope.

The analysis of TEOAEs was performed in a quiet place, TEOAEs were measured at the frequencies of 1500, 2000, 2500, 3000, 3500 and 4000 Hz. The duration of the sound stimulus was approximately 64 seconds. TEOAEs were considered present when there was a response to at least three frequencies between 1500 to 4000Hz. The results were printed and attached to the patient's protocol with the Interacoustics Otoread Clinical device.

The main variables analyzed were: variation of amplitude, noise, and signal/noise ratio of TEOAEs, presence or absence of TEOAEs and whether there was suction at the time of analysis.

Student's t test was applied for independent samples, comparing the ears. To compare the frequencies of presence/absence, the "chi-square" test was adopted for independence between two attributes. The critical level of significance adopted was 5% probability.

## RESULTS

The analysis of presence / absence of TEOAEs by frequency evaluated, in situations of suction and non-suction of the sample is shown in Table 1.

The occurrence of TEOAEs were not significantly altered at the moment of suction, the variation did not exceed 5%. However, at the frequency of 2000Hz, there was an increase in the number of absence of TEOAEs, which does not significantly affect the overall result of the analysis, nor the practical exam, given that to change the exam result there would have to be an absence in at least 4 frequencies .

The analysis of presence/absence of TEOAEs by frequency assessed, in situations of suction and non-suction and divided by non-prematurity or prematurity is shown in Table 2.

2000Hz						
EOAETs	A Termo Sem Sucção	A Termo Em Sucção	Valor P	Pré-Termo Sem Sucção	Pré-Termo Em Sucção	Valor p
Presentes	70%	50%		77%	73%	
Ausentes	30%	50%		23%	27%	
			0,0039*			0,51
2500Hz						
EOAETs	A Termo Sem Sucção	A Termo Em Sucção	Valor P	Pré-Termo Sem Sucção	Pré-Termo Em Sucção	Valor p
Presentes	89%	88%		85%	73%	
Ausentes	11%	12%		15%	27%	
			0,82			0,03*
3000Hz						
EOAETs	A Termo Sem Sucção	A Termo Em Sucção	Valor P	Pré-Termo Sem Sucção	Pré-Termo Em Sucção	Valor p
Presentes	83%	85%		88%	77%	
Ausentes	17%	15%		12%	23%	
			0,7			0,04*
3500HZ						
EOAETs	A Termo Sem Sucção	A Termo Em Sucção	Valor P	Pré-Termo Sem Sucção	Pré-Termo Em Sucção	Valor p
Presentes	81%	78%		81%	80%	
Ausentes	19%	22%		19%	20%	
			0,6			0,86
4000HZ						
EOAETs	A Termo Sem Sucção	A Termo Em Sucção	Valor P	Pré-Termo Sem Sucção	Pré-Termo Em Sucção	Valor p
Presentes	74%	80%		85%	81%	
Ausentes	26%	20%		15%	19%	
			0,31			0,45

\* Statistically significant relationship,  $p < 0.05$  Chi-square test.

The correlation between the situation of non-suction and suction in the chest, for term neonates using the variables analyzed, is shown in Table 3.

The correlation between the situation of non-suction and suction in the chest, for preterm neonates using the variables analyzed, is shown in Table 4.

## DISCUSSION

There are advantages to using OAEs as a clinical test, among them are the simple, non-invasive and fast way to capture OAE in the external auditory canal, the latter explains why they are useful in screening cochlear function in neonates.

Analyzing the occurrence of TEOAEs in the moment without suction/swallowing in comparison with the moment suction/swallowing, according to the frequency, it was found that in 2000 Hz there was a greater number of failures during suction. Almeida et al., [16] carrying out a similar study in 2004, they realized that bands 1 and 2 (low frequencies) were the most affected during breastfeeding, and that as the frequencies increased, the damage decreased. Such findings are in agreement with those observed in other studies. [9-18]

Comparing the groups of term neonates with the group of preterm neonates, the occurrence of TEOAEs in the moment without suction/swallowing in comparison with the moment of sucking/swallowing, according to the frequency, it was noted that in 2000 Hz there is a greater number of failures during suction in the group of full-term neonates corroborating the first finding. However, in the group of preterm neonates, it was noted that at 2500 Hz and 3000 Hz, more failures occur during suction.

Kei et al., [19] observed that the newborn in suction or noisy breathing was responsible for the failure in the TEOAE tests in 11,27% of the evaluations. The lower frequencies, during breastfeeding, are the most impaired in the assessment, and the higher the frequencies, the less influence they have on the assessment.

Table 3 - Analysis of Transient Evoked Otoacoustic Emissions (TEOAE) in term neonates, according to frequency, without and with suction in the chest.

Orelha	Variáveis	Média sem sucção de neonatos a termo (Desvio Padrão)	Média durante a sucção de neonatos a termo (Desvio Padrão)	Valor de p
Direita	1500HZ			
	Amplitude	6,59 (4,07)	8,22 (3,72)	0,13
	Ruído	3,29 (4,91)	4,77 (4,26)	0,24
	Relação S/R	3,18(3,88)	3,33 (3,74)	0,88
Esquerda	Amplitude	8,18 (5,74)	7,88 (7,17)	0,87
	Ruído	6,22 (6,16)	7,22 (5,93)	0,5
	Relação S/R	2,7 (4,23)	1,11 (4,73)	0,2
2000Hz	Amplitude	3,71 (3,62)	3,29 (3,57)	0,7

Direita	Ruído	-3,44 (5,15)	-1,92 (4,78)	0,26
	Relação S/R	6,96 (5,34)	5,11 (5,06)	0,19
	Amplitude	3,37 (3,80)	3,66 (4,16)	0,80
Esquerda	Ruído	-2,85 (4,61)	-1,25 (5,79)	0,27
	Relação S/R	5,66 (4,42)	5,37 (5,10)	0,82
2500Hz				
	Amplitude	-1,18 (4,02)	-1,25 (4,10)	0,95
Direita	Ruído	-11,29 (3,77)	-9,77 (3,49)	0,13
	Relação S/R	10,07 (4,49)	5,11 (3,45)	0,0005*
	Amplitude	-0,88 (5,22)	-0,11 (5,15)	0,59
Esquerda	Ruído	-9,74 (7,04)	-9,5 (4,79)	0,93
	Relação S/R	9,11 (4,85)	8,71 (4,23)	0,75
3000Hz				
	Amplitude	-2,25 (5,59)	-3,5 (5,70)	0,44
Direita	Ruído	-13,81 (2,98)	-13,74 (3,20)	0,94
	Relação S/R	10,67 (6,26)	10,29 (6,19)	0,83
	Amplitude	-3,85 (4,70)	-2,92 (4,08)	0,45
Esquerda	Ruído	-12,29 (7,50)	-11,18 (9,36)	0,63
	Relação S/R	8,37 (5,79)	10,45 (3,63)	0,12
3500Hz				
	Amplitude	-1,14 (5,88)	-1,03 (6,07)	0,95
Direita	Ruído	-10,55 (3,60)	-10,25 (3,66)	0,77
	Relação S/R	8,81 (6,67)	9,18 (5,66)	0,83
	Amplitude	-2,03 (6,50)	-2,29 (5,96)	0,88
Esquerda	Ruído	-9,7 (7,01)	-10,77 (4,81)	0,53
	Relação S/R	7,85 (5,47)	9,37 (8,11)	0,43
4000Hz				
	Amplitude	-0,88 (6,74)	-0,85 (6,54)	0,98
Direita	Ruído	-9 (4,90)	-7,74 (5,41)	0,38
	Relação S/R	8,37 (6,02)	7,66 (5,54)	0,66
	Amplitude	-1,66 (5,82)	-1,12 (5,80)	0,73
Esquerda	Ruído	-7,85 (5,86)	-7,41 (6,33)	0,79
	Relação S/R	7,18 (4,96)	7,37 (4,63)	0,89

Legend: S / R ratio: signal / noise ratio. \* Statistically significant relationship, p < 0.05 Student t test.

Table 4 - Analysis of Transient Evoked Otoacoustic Emissions (TEOAE) in preterm neonates, according to frequency, without and with suction in the chest.

Orelha	Variáveis	Média sem sucção de neonatos pré-termo (Desvio Padrão)	Média durante a sucção de neonatos pré-termo (Desvio Padrão)	Valor de p
1500HZ	Amplitude	7,93 (5,91)	9 (5,11)	0,63

When we analyzed the noise variable, we noticed that in all frequencies there were no statistically significant differences as to the intensity during the evaluation of TEOAE when it was in suction in both the left ear and the right ear in newborns born at term (Table 3). In this same group, however, at 2500Hz there was significant interference in the signal/noise ratio, which was lower in the right ear, during suction. In the group of preterm infants, it was noticed that the signal/noise ratio during suction/swallowing, despite remaining very close to the value obtained at the moment without suction, decreased in most frequencies and in both ears.

Analyzing this same variable, Almeida et al., [16] noticed a high number of altered tests during breastfeeding, both for the signal/noise ratio and reproducibility, suggesting that there is a loss in the quality of the tests performed in this condition. This frequency range of 2500-3000Hz is likely to be a high sensitivity range of the test in which small interferences generate relevant changes in the results.

In other studies [19-24] a greater amplitude of TEOAE response was also reported in the right ear, in addition it was perceived that they were more relevant in the female gender. Thus, the findings of this study coincide with the literature for the analyzed variables.

Other authors, despite not having researched TEOAE during breastfeeding, also reported that noise contaminates the TEOAE response, in addition to impairing the signal/noise ratio and reproducibility, making responses diminished for lower frequencies. [9-17]

When measuring the swallowing sound in the external auditory canal and in the cricopharynx with a microphone, it was observed that the sound was concentrated between 400 and 600 Hz with a peak at 1384 Hz, in studies on the concentration of acoustic energy during swallowing. [25,26] This fact cannot be observed in our findings, since the frequencies analyzed in our research were from 1500Hz and up to 4000Hz.

Direita	Ruído	7,92 (7,94)	5 (7,12)	0,44
	Relação S/R	2,69 (5,05)	3,92 (4,97)	0,49
	Amplitude	8 (3,13)	9,15 (4,11)	0,44
Esquerda	Ruído	3 (6,31)	5,61 (6,21)	0,3
	Relação S/R	4,92 (5,54)	3,38 (4,87)	0,46
2000Hz				
	Amplitude	3,61 (4,14)	4,07 (4,20)	0,8
Direita	Ruído	-2,77 (5,73)	-1,23 (5,65)	0,5
	Relação S/R	6,46 (3,71)	5,46 (4,07)	0,52
	Amplitude	5,23 (4,24)	4,92 (4,42)	0,86
Esquerda	Ruído	-3,61 (5,96)	-1,85 (4,35)	0,4
	Relação S/R	8,84 (6,03)	6,85 (6,76)	0,45
2500Hz				
	Amplitude	-2,6 (4,30)	-2,3 (4,14)	0,86
Direita	Ruído	-9,62 (7,45)	-9,46 (6,40)	0,96
	Relação S/R	8,38 (3,22)	7,07 (5,28)	0,45
	Amplitude	-1,23 (4,10)	-2,07 (5,52)	0,67
Esquerda	Ruído	-11,31 (5,66)	-10,69 (5,07)	0,78
	Relação S/R	9,92 (5,53)	8,38 (6,51)	0,53
3000Hz				
	Amplitude	-2,46 (3,91)	-3,77 (3,87)	0,42
Direita	Ruído	-12,23 (7,69)	-11 (9,01)	0,71
	Relação S/R	10,15 (4,32)	8,92 (5,18)	0,53
	Amplitude	-2,15 (6,16)	-2,39 (6,09)	0,93
Esquerda	Ruído	-11,85 (10,16)	-11,38 (8,87)	0,91
	Relação S/R	12,53 (6,98)	11,38 (6,19)	0,67
3500Hz				
	Amplitude	-1 (6,99)	-1,2 (7,82)	0,93
Direita	Ruído	-10,92 (8,75)	-11,23 (4,93)	0,92
	Relação S/R	11,53 (6,54)	10,15 (6,96)	0,61
	Amplitude	-0,15 (6,59)	-1,0 (7,17)	0,76
Esquerda	Ruído	10,23 (6,70)	-11,07 (3,68)	0,72
	Relação S/R	11,23 (5,15)	10,23 (6,04)	0,66
4000Hz				
	Amplitude	-1,84 (6,99)	-1,61 (7,82)	0,94
Direita	Ruído	-10,38 (8,75)	-9,69 (4,93)	0,7
	Relação S/R	8,53 (6,54)	7,85 (6,96)	0,77
	Amplitude	-1 (6,59)	-2 (7,17)	0,6
Esquerda	Ruído	-9,38 (6,69)	-9,39 (3,68)	0,99
	Relação S/R	7,76 (5,15)	6,46 (6,04)	0,31

Legend: S / R ratio: signal / noise ratio. \* Statistically significant relationship,  $p < 0.05$  Student t test.

In another study, Gorga et al., [27] observed that the DPOAE response levels were higher at 1500 and 2000 Hz, compared to 3000 and 4000 Hz. However, as frequencies increased, noise levels decreased and resulted in a more favorable signal/noise ratio at 3000 and 4000 Hz. Thus, with the exception of body activity and the crying of neonates, the state had little influence on the results of DPOAE.

The environment in which the examination is performed did not influence the measurement of DPOAE, suggesting that the primary source of noise is internal to the newborn (breathing, movement, etc.). Thus, it suggests that the noisy sounds have an internal origin of the newborn.

The difficulty in recording DPOAE at lower frequencies is due to the fact that the primary source of noise is the newborn's breathing and movements, whose frequency spectrum is manifested mainly in low sounds. [28]

For this reason, when measuring otoacoustic emissions, noise is always present, but it is perceived more intensely in the region of frequencies close to 1500 Hz, and it can rarely come from the environment or more frequently from physiological activities, such as suction or swallowing, from the same patient. [29]

## STUDY LIMITATIONS

The study uses the standardized frequency parameters of the measuring device (1500 - 4000 Hz), it is possible that other devices with other standards, that is, that presented frequencies below 1500Hz or above 4000Hz, have different results from the one presented in this study.

In the anamnesis, it was searched for risk indicators for hearing loss, however few neonates had any indicator present. Thus, it is possible that analyzing a single and larger sample of neonates with risk indicators present, some significant finding or interference is not found in the present study.

## CONCLUSION

The study evaluated whether the sounds produced during sucking or swallowing interfered with TEOAE in neonates at term and preterm. We found that the observed

changes showed no difference in the higher frequencies and did not show a statistically significant difference in the low frequencies to generate changes in the final exam results and, consequently, in the diagnosis.

Thus, the TEOAE assessment can be

performed on neonates during suction, since the minimum criteria to validate the exam are reached and the changes produced with this strategy do not affect the responses to the point of showing false/positive results. ■

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