Online version at http://www.minervamedica.it

Minerva Pediatrica 2018 February;70(1):20-6
DOI: 10.23736/S0026-4946.17.04355-9

ORIGINAL ARTICLE

Inter- and intra-rater reliability of nasal auscultation in daycare children

Rita SANTOS [1] *, Ana SILVA ALEXANDRINO [1, 2], David TOMÉ [3], Cristina MELO [1], António MESQUITA MONTES [1], Daniel COSTA [1], João PINTO FERREIRA [4]

[1]Department of Physiotherapy, School of Allied Health Sciences of Porto (ESTSP), Polytechnic Institute of Porto (IPP), Vila Nova de Gaia, Portugal; [2]Institute for Biomedical Sciences Abel Salazar (ICBAS), University of Porto, Porto, Portugal; [3]Department of Audiology, School of Allied Health Sciences of Porto (ESTSP), Polytechnic Institute of Porto (IPP), Vila Nova de Gaia, Portugal; [4]Department of Otorhinolaryngology, Oporto Hospital Center, Porto, Portugal

*Corresponding author: Rita Santos, Rua Camilo Castelo Branco 19, 4420-051 Gondomar, Portugal. E-mail: ritasantosft@gmail.com

ABSTRACT

BACKGROUND: The aim of this study was to assess nasal auscultation's intra- and inter-rater reliability and to analyze ear and respiratory clinical condition according to nasal auscultation.

METHODS: Cross-sectional study performed in 125 children aged up to 3 years old attending daycare centers. Nasal auscultation, tympanometry and Paediatric Respiratory Severity Score (PRSS) were applied to all children. Nasal sounds were classified by an expert panel in order to determine nasal auscultation's intra and inter- rater reliability. The classification of nasal sounds was assessed against tympanometric and PRSS values.

RESULTS: Nasal auscultation revealed substantial inter-rater (K=0.75) and intra-rater (K=0.69; K=0.61 and K=0.72) reliability. Children with a "non-obstructed" classification revealed a lower peak pressure (t=-3.599, P<0.001 in left ear; t=-2.258, P=0.026 in right ear) and a higher compliance (t=-2,728, P=0.007 in left ear; t=-3.830. P<0.001 in right ear) in both ears. There was an association between the classification of sounds and tympanogram types in both ears (X=11.437, P=0.003 in left ear; X=13.535, P=0.001 in right ear). Children with a "non-obstructed" classification had a healthier respiratory condition.

CONCLUSIONS: Nasal auscultation revealed substantial intra- and inter-rater reliability. Nasal auscultation exhibited important differences according to ear and respiratory clinical conditions. Nasal auscultation in pediatrics seems to be an original topic as well as a simple method that can be used to identify early signs of nasopharyngeal obstruction.

(*Cite this article as:* Santos R, Silva Alexandrino A, Tomé D, Melo C, Mesquita Montes A, Costa D, *et al.* Inter- and intra-rater reliability of nasal auscultation in daycare children. Minerva Pediatr 2018;70:20-6. DOI: 10.23736/S0026-4946.17.04355-9)

Key words: Nose - Auscultation - Acoustic impedance tests - Respiratory tract infections - Child.

Upper respiratory tract infections (URTI) and acute otitis media (AOM) have a high prevalence in children due to their anatomical and physiological characteristics and also to environmental and behavioral risk factors.[1-3]

Nasopharyngeal congestion generally leads to Eustachian tube dysfunction, creating negative middle ear pressure that forces mucus, nasopharyngeal secretions, and bacteria into the middle ear, spreading infection.[2-6] The clinical diagnosis of URTI depends mainly on anamnesis and physical examination. Auscultation with a stethoscope is a noninvasive method that contributes to this physical examination, but it is recurrently used to assess pulmonary condition.[1] However, often in URTI there is no lung involvement, so pulmonary auscultation shows a normal result. Thus, nasal aus-

cultation could be a relevant tool to aid in the assessment of respiratory health condition because it had a strongly support cost/effective clinical examination in children, guiding the physiotherapist intervention, such as upper tract respiratory clearance techniques. However, nasal auscultation still lacks reliability and validity studies.

The aims of the present study were to assess nasal auscultation's intra- and inter-rater reliability and to analyze tympanometric findings and respiratory clinical condition according to the classification of nasal sounds.

Materials and methods

Following approval (No. 13/ CEUP/2011) by the Ethics Committee of the University of Porto, six daycare centers were randomly selected from Porto. Then, the administrators of these daycare centers were contacted in order to obtain their formal consent. The formal caregivers were informed about the aims and procedures of the study and expressed their formal consent by signing the Informed Consent according to the Declaration of Helsinki.

It was performed a pilot test with four children (two healthy children and two children with rhinorrhea) in order to test methodological procedures and also to analyze spectral characteristics of their nasal sounds recurring to The Fast Fourier transform (FFT).[7] The aim of this analysis was to verify if it was possible to identify differences between obstructed nasal sounds and normal nasal sounds. It was verified that, especially in inspiratory phase, obstructed sounds had lower frequency and lower amplitude than normal nasal sounds. This suggests that the timbre of obstructed nasal sounds is similar to a low pitch (bass) sound while normal nasal sounds seem like a high pitch (treble) sound. However nasal flow spectral analyzes requires consideration of many conditions such as turbulent flow, roughness of the wall, irregular contour of the nasal cavity, collapsible segments, and other resistances as well as the use of appropriate filters that could isolate nasal sound.[8] Once it was not possible to isolate these variables without specific software, these findings were only suitable to suggest that nasal auscultation may detect differences between nasal sounds of children with rhinorrhea when compared to healthy children.

A sociodemographic questionnaire with inclusion and exclusion criteria was delivered to each of the children's caregivers at the six daycare centers. Inclusion criteria were defined as: children up to 3 years old and both genders. Exclusion criteria were defined as: preterm birth (<37 weeks' gestation); children known to have neuromuscular diseases, chronic cardiopulmonary diseases, or lower respiratory tract impairment; children who had undergone ear, nose or throat surgery; and children with obstructive ear wax or a history of grommets, as well as those who were absent on the day of evaluation or who did not complete the assessment.[9, 10] From an initial group of 182 children, 57 were excluded after the application of these criteria, and a final sample of 125 children was obtained.

All 125 children were submitted to a standard protocol consisting of otoscopy followed by tympanometry measured by an audiologist, and pulmonary/nasal auscultation performed by a respiratory physiotherapist. Children were seated on their caregiver's lap, and their head was sustained against the caregiver's chest.

For tympanometry, a handheld Impedance Audiometer MT10 (Interacoustics®, Middelfart, Denmark) was used, calibrated on November 22, 2010 according to Food and Drug Administration requirements, with a 226 Hz probe tone. The classification developed by Liden (1969) [11] and Jerger (1970) [12] was used to differentiate the three main types of tympanograms: type A (normal middle ear: compliance ≥0.2 cm^3, pressure ≥-100 daPa); type B (middle ear with fluid and/or having high impedance: compliance <0.2 cm^3 with no apparent peak pressure); and type C (negative pressure, no fluid: compliance ≥0.2 cm^3, pressure <-100 daPa).[11]

For nasal auscultation, a Littmann 3200 Electronic Stethoscope (3M Health Care®, St. Paul, MN, USA) was used. Nasal auscultation sounds were collected within a 5 cm distance between the nose and the stethoscope diaphragm in an upright position in relation to the nostrils. Each sound was recorded in a digi-

tal format for 15 seconds using the software Zargis® StethAssist™. After being recorded, the nasal sounds were transferred to a laptop computer via Bluetooth. Then, all sounds were coded and randomized using Excel Microsoft Corporation 2007® by an independent and blind investigator in regard to the study objectives. Coded nasal sounds were provided to three blind respiratory physiotherapists with at least 3 years of experience in the treatment of children's nasopharyngeal obstruction. These experts classified the nasal sounds as "obstructed" and "non-obstructed." Nasal sounds were coded and randomized again, and then provided to the same experts within an interval of 48 hours in order to analyze intra-rater reliability.

For inter- and intra-rater reliability classification, the interpreting kappa values suggested by Landis *et al.* (1977) were used: <0 (no agreement); 0-0.19 (poor agreement); 0.20-0.39 (fair agreement); 0.40-0.59 (moderate agreement); 0.60-0.79 (substantial agreement), and >0.8 (almost perfect agreement).[13]

Respiratory condition of the children was assessed using the Paediatric Respiratory Severity Score adapted for the Portuguese culture. It has an internal consistency of Cronbach's alpha =0.80 and good test-retest reliability (ICC 2.1=0.91).[14] The PRSS assesses the child's respiratory clinical parameters, such as dyspnea, breathing sounds, adventitious sounds, daily expectoration, cough, nutrition, fever and rhinorrhea. Each signal/symptom is rated with 1 point (normal), 2 points (moderate) or 3 points (severe) according to the degree of severity. The final score obtained is between 8 and 24 (8 [normal index]; 9-16 [moderate index]; 17-24 [severe index]).[1, 15]

Statistical analysis

All statistical analyses were carried out using IBM® SPSS® Statistics 20 for Windows 7® with a confidence interval of 95% (significance level of α=0.05).[16]

Descriptive statistics, namely absolute and relative frequency as well as central tendency measures of mean, dispersion, standard deviation, minimum and maximum were used.[16]

For inter-rater reliability of nasal auscultation, Fleiss' kappa was used, and for intra-rater reliability, Cohen's kappa coefficient was used.

Student's *t*-test for independent sample was used for inter-group comparison ("obstructed" and "non-obstructed") between the classification of sounds and ear pressure and compliance. χ^2 Test was used for comparison between nasal auscultation and tympanogram type. Mann-Whitney U was used for inter-group comparison ("obstructed" and "non-obstructed") between classification of sounds and Paediatric Respiratory Severity Score.

Results

The final sample of this study consisted of 125 children between the ages of 3 and 36 months, with a mean age of 23.5 (±8.7) months; over half of them were male (60%). Considering the anthropometric data (percentile), most children (38.4%) were in the 50th percentile, followed by the 25th percentile (20%).

The inter-rater reliability for nasal sounds revealed a substantial agreement, with a κ=0.75, and the results of intra-rater reliability showed a substantial agreement, with a Fleiss κ coefficient of 0.69 for evaluator 1, 0.61 for evaluator 2 and 0.72 for evaluator 3.

The peak pressure of the middle ear was significantly lower in children with a "non-obstructed" classification compared to children with an "obstructed" classification (t=-3.599, P<0.001 in left ear; t=-2.258, P=0.026 in right ear) (Figure 1).

Compliance of the tympanic membrane was significantly lower in children with an "obstructed" classification compared to children with a "non-obstructed" classification (t=-2.728, P=0.007 in left ear; t=-3.830, P<0.001 in right ear) (Figure 2).

There was a significant association between the classification of nasal sounds and tympanogram types in both ears (χ^2=11.437, P=0.003 in left ear; χ^2=13.535, P=0.001 in right ear). Table I shows that children with an "obstructed" classification had more type B tympanograms (48.7% in left ear and 46.1% in right ear) and children with a "non-obstructed" classifica-

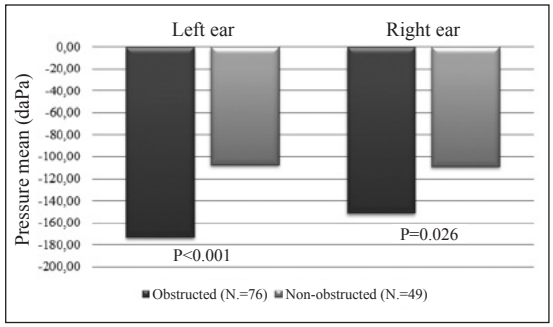

Figure 1.—Mean of middle ear pressure (daPa): "obstructed" *versus* "non-obstructed" classification of nasal sounds.

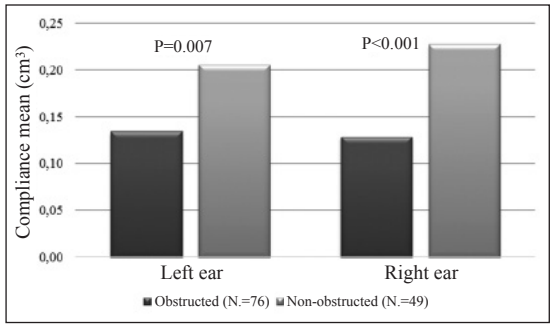

Figure 2.—Mean of middle ear compliance (cm³): "obstructed" *versus* "non-obstructed" classification of nasal sounds.

tion had more type A tympanograms (59.2% in both ears).

According to the results of the Paediatric Respiratory Severity Score, children with a "non-obstructed" classification had a significantly lower PRSS compared to children with an "obstructed" classification (U=1483.5; P=0.042), meaning that children with a "non-obstructed" classification had a healthier respiratory condition than children with an "obstructed" classification (Table II).

Discussion

This study revealed substantial intra- and inter-rater agreement of nasal auscultation, and classification of nasal sounds showed important differences according to tympanometric findings and respiratory clinical condition in children up to three years old.

There is a lack of research about the reliability of nasal auscultation and only a few studies about pulmonary auscultation. Aweida [17] and Brooks [18] used recorded and in vivo lung sounds, and both reported a fair inter-rater reliability (κ=0.22 and κ=0.33, respectively). Pulmonary auscultation, in children it is considered to be a less precise assessment than in adults.[19, 20] Elphink (2004) [19] found that the reliability of stethoscope examination of respiratory sounds in infants was poor to moderate. In our study, we found substantial inter-rater reliability (Fleiss κ coefficient of 0.749) and good intra-rater reliability for nasal auscultation. The substantial agreement of measure-

TABLE I.—*Association between classification of nasal sounds and tympanogram types of left and right ear.*

	Tympanogram type			Total N. (%)	χ^2	P value
	A N. (%)	B N. (%)	C N. (%)			
Classification of nasal sounds (right ear)					13.535	0.001
Obstructed	20 (26.3)	35 (46.1)	21 (27.6)	76 (100)		
Non-obstructed	29 (59.2)	12 (24.5)	8 (16.3)	49 (100)		
Classification of nasal sounds (left ear)					11.437	0.003
Obstructed	23 (30.2)	37 (48.7)	16 (21.1)	76 (100)		
Non-obstructed	29 (59.2)	11 (21.4)	9 (18.4)	49 (100)		

TABLE II.—*Median of Paediatric Respiratory Severity Score: "obstructed"* versus *"non-obstructed" classification of nasal sounds.*

	Median	Minimum	Maximum	U	P value
Obstructed (N.=76)	9.5	8	13	1483.500	0.042
Non-obstructed (N.=49)	9.0	8	13		

ments between examiners and within 48 h by the same examiner shows consistency in nasal auscultation assessment, but these results cannot predict the accuracy of experts' classification. Therefore, it was crucial to assess these findings against a measure of the middle ear, such as tympanometry, due to the relation between nasal obstruction and Eustachian tube dysfunction.[4-6, 10, 21, 22]

The present study revealed an important relationship between experts' classifications of nasal sounds and peak pressure as well as compliance of the middle ear.

Although middle ear pressure was negative in both ears, children classified with "non-obstructed" nasal sounds revealed fewer negative values than those classified as "obstructed," in agreement with Moody *et al.*,[22] who found that there is often an association between negative pressure of the middle ear and nasopharyngeal obstruction. Also, Tomé *et al.*[23] found a significant association between lower pressure values and rhinorrhea presence as well as Palmu.[24]

Once it is well established that rhinorrhea presence is related to lower pressure values of the middle ear this could mean that blinded experts in this study were able to detect early signs of nasopharyngeal obstruction.

A decrease in ear compliance increases Eustachian tube dysfunction, reducing ventilation and drainage of middle ear contents, and thus increasing the risk of acute otitis media.[10] In this study, children with a "non-obstructed" classification had a significantly higher compliance mean compared to children classified as "obstructed". This reinforces the hypothesis that nasal auscultation may provide useful quantitative information about nasopharyngeal obstruction.

Our study also found a significant association between experts' classifications of nasal sounds and tympanogram type, suggesting that "non-obstructed" nasal classification was related to type A tympanogram and "obstructed" classification to type B tympanogram. A higher frequency of type B tympanograms in "obstructed" children suggests lower pressure and mobility of the tympanic membrane, possibly due to the presence of fluid in the middle ear in these children. In fact, Revai [12] reported that 75% to 88% of URTIs were associated with at least one abnormal tympanograms, and type B tympanograms during an episode of URTI were most commonly found in children from 6 to 11 months of age, while older children (>24 months) tend to have type C tympanograms, confirming the prevalence of type B tympanograms observed in the present study with a mean age of 23 months.

In this study, we also found an association between nasal auscultation and respiratory health condition. "Non-obstructed" sounds were linked to children who had a lower Paediatric Respiratory Severity Score, meaning better respiratory condition. "Obstructed" sounds were linked to children with poorer respiratory condition, reinforcing the hypothesis that blinded experts in this study not only were consistent in their classification but also this classification was related to the health condition of the children.

Limitations of the study

The major limitation of this study is the absence of an adequate gold standard test that assesses nasal obstruction in children under 3 years old at a community set. There are several methods that could be used as gold standard measures to assess the validity of nasal auscultation, such as acoustic rhinometry, rhinomanometry and peak nasal inspiratory flow, as they are efficient in evaluating the presence of nasopharyngeal obstruction.[21, 25] However, they include several important limitations: acoustic rhinometry and rhinomanometry are sophisticated and expensive, and they are used only in laboratory settings and thus unavailable for community care. Peak nasal inspiratory flow could be used in community practice, as it is an inexpensive and portable device, but it requires the patient's cooperation so it cannot be used in infants.[21, 25, 26] It could be used another methods such as nasopharyngolaryngoscopy or nasal endoscopy in order to make the inspection of nasal cavities, possible also in children. It provides the detection of ob-

structive structural factors, such as adenoid hypertrophy, septal deviation, choanal atresia and polyps, however it is an invasive procedure in spite of its accuracy.[27-29]

Another limitation of this study was the use of a 226 Hz probe tone instead of high-frequency probe. In fact, the majority of studies support the use of 1000 Hz probe tones particularly in children under 3 months because it is easier to interpret and more reliable than 226-Hz tympanometry. However, the final sample of this study consisted of children between the ages of 3 and 36 months. At this age several authors considered that a 226 Hz probe tone has a sufficient accuracy concerning the tympanometric assessment of middle ear.[30-32]

These methods can be expanded to include a spectral analysis of obstructed and non-obstructed nasal sounds of children using appropriate software. Also it could be relevant to investigate the role of nasal resistances in children with obstructive sleep apnea with the use of polysomnography.[33]

Conclusions

Nasal auscultation revealed substantial intra- and inter-rater reliability. The classification of nasal sounds showed important differences according to tympanometric findings and respiratory clinical condition.

Thus, nasal auscultation in pediatrics seems to be an original topic as well as a simple method that can be used to identify early signs of nasopharyngeal obstruction. This may be clinically important in order to assist the assessment of upper respiratory tract condition and to evaluate the impact of nasal physiotherapy clearance techniques.

References

1. Postiaux G. Fisioterapia respiratória pediátrica: o tratamento guiado por ausculta pulmonar. Artmed, Porto Alegre; 2004.
2. Bluestone C, Klein J. Physiology, pathopysiology and pathogenesis. In: Decker B, editor. Otitis Media in Infants and Children; 2007 [Internet]. Available from: https://societyformiddleeardisease.org/Content/OtitisMediaInInfantsAndChildren/ch03.pdf [cited 2017, Sep 26].
3. Roberts F. Paediatric specifics. In: Harden B, Cross J, Broad M, Quint M, Ritson P, Thomas S, editors. Respiratory Physiotherapy: An On-Call Survival Guide. Philadelphia: Elsevier; 2009.
4. Heikkinen T, Chonmaitree T. Importance of Respiratory Viruses in Acute Otitis Media. Clin Microbiol Rev 2003;16:230-41.
5. Revai K, Dobbs LA, Nair S, Patel JA, Grady JJ, Chonmaitree T, *et al.* Incidence of Acute Otitis Media and Sinusitis Complicating Upper Respiratory Tract Infection: The Effect of Age. Pediatrics 2007;199:e1408-e141.
6. Chonmaitree T, Revai K, Grady JJ, Clos A, Patel JA, Nair S, *et al.* Viral upper respiratory tract infection and otitis media complication in young children. Clin Infect Dis 2008;46:815-23.
7. Seren E. The effect of an adhesive external nasal dilator strip on the inspiratory nasal airflow. Am J Rhinol Allergy 2010;24:e29-e31.
8. Tahamiler R, Canakcioglu S. Evaluation of nasal obstruction with Odiosoft-Rhino in nasal septal deviation. J Otolaryngol Head Neck Surg 2008;37:285-91.
9. Palmu A, Syrjanen R, Kilpi T, Pursiainen H, Puhakka H, Rahko T, *et al.* Negative pressure tympanograms in children less than 2 years of age—different bacterial findings in otitis media by tympanometric results. Int J Pediatr Otorhinolaryngol 2001;61:61-9.
10. Revai K, Patel JA, Grady JJ, Chonmaitree T. Tympanometric Findings in Young Children During Upper Respiratory Tract Infections With and Without Acute Otitis Media. Pediatr Infect Dis J 2008;27:292-5.
11. Liden G. The scope and application of current audiometric tests. J Laryngol Otol 1969;83:507-20.
12. Jerger JF. Clinical experience with impedence audiometry. Arch Otolaryngol 1970;92:311-24.
13. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33:159-74.
14. Alexandrino AM, Santos RI, Melo MC, Bastos JM, Postiaux G. Subjective and objective parameters in paediatric respiratory conditions: cultural adaptation to Portuguese population. Fisioter Mov 2017;30:49-58.
15. Postiaux G, Bafico J, Masengu R, Lahaye JM. Paramètres anamnestiques et cliniques utiles au suivi et à l'achèvement de la toilette bronchopulmonaire du nourrisson et de l'enfant. Ann Kinésithér 1991;18 :117-24.
16. Maroco J. Análise Estatística Com Utilização SPSS. Lisbon: Edições Sílabo; 2007.
17. Aweida D, Kelsey CJ. Accuracy and reliability of physical therapists in auscultating tape- recorded lung sounds. Physiotherapy Canada 1990;42:279-82.
18. Brooks D, Thomas J. Interrater Reliability of Auscultation of Breath Sounds Among Physical Therapists. Phys Ther 1995;75:1082-8.
19. Elphick HE, Lancaster GA, Solis A, Majumdar A, Gupta R, Smyth RL. Validity and reliability of acoustic analysis of respiratory sounds in infants. Arch Dis Child 2004;89:1059-63.
20. Gould A. Cardiopulmonary Evaluation of the Infant, Toddler, Child, and Adolescent. Pediatric Physical Therapy 1991;3:9-13.
21. Spronsen E, Ingels KJAO, Jansen AH, Graamans K, Fokkens WJ. Evidence-based recommendations regarding the differential diagnosis and assessment of nasal congestion: using the new GRADE system. Allergy 2008;63:820-33.
22. Moody SA, Alper CM, Doyle WJ. Daily tympanometry in children during the cold season: association of otitis media with upper respiratory tract infections. Int J Pediatr Otorhinolaryngol 1998;45:143-50.
23. Tomé D, Alexandrino A, Santos R, de Melo MC, Costa DA, Ferreira JP. Characterization of middle-ear condi-

tion of Oporto daycare children up-to 3 years-old: A cross sectional study. Int J Pediatr Otorhinolaryngol 2014;78:2132-5.
24. Palmu A, Puhakka H, Huhtala H, Takala AK, Kilpi T. Normative values for tympanometry in 7- and 24-month-old children. Audiology 2001;40:178-84.
25. Corey JP, Yilmaz AS. Assessment of nasal function. In: Snow JB, Wackym PA, Ballenger JJ. Ballenger's Otorhinolaryngology: Head and Neck Surgery. Hamilton, ON: BC Decker; 2009.
26. Nathan RA, Eccles R, Howarth P, Steinsvåg SK, Togias A. Objective monitoring of nasal patency and nasal physiology in rhinitis. J Allergy Clin Immunol 2005;115:442-59.
27. Torretta S, Marchisio P, Cappadona M, Baggi E, Pignataro L. Nasopharyngeal fiberendoscopy in children: A diagnostic challenge in current clinical practice: How we do it. Int J Pediatr Otorhinolaryngol 2013;77:747-51.
28. Pagella F, Pusateri A, Chu F, Cairello F, Benazzo M, Matti E, *et al.* Adenoid assessment in paediatric patients: the role of flexible nasal endoscopy. Int J Immunopathol Pharmacol 2011;24:49-54.
29. Kubba H, Bingham BJ. Endoscopy in the assessment of children with nasal obstruction. J Laryngol Otol 2001;115:380-4.
30. Alaerts J, Luts H, Wouters J. Evaluation of middle ear function in young children: clinical guidelines for the use of 226-and 1,000-Hz tympanometry. Otol Neurotol 2007;28:727-32.
31. Garcia MV, Azevedo MFD, Testa JR. Accoustic immitance measures in infants with 226 and 1000 hz probes: correlation with otoacoustic emissions and otoscopy examination. Revista Brasileira de Otorrinolaringologia 2009;75:80-9.
32. Prieve BA, Calandruccio L, Fitzgerald T, Mazevski A, Georgantas LM. Changes in transient-evoked otoacoustic emission levels with negative tympanometric peak pressure in infants and toddlers. Ear Hear 2008;29:533-42.
33. Rizzi M, Onorato J, Andreoli A, Colombo S, Pecis M, Marchisio P, *et al.* Nasal resistances are useful in identifying children with severe obstructive sleep apnea before polysomnography. Int J Pediatr Otorhinolaryngol 2002;65:7-13.

Conflicts of interest.—The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Congresses.—The paper was already present in 2nd International Conference on Respiratory Physiotherapy March 21-23, 2013.

Acknowledgements.—Thanks to all participants, children, caregivers and educators. Thanks to Dr. Andreia Noites and Dr. Carlos Crasto from the Department of Physical Therapy. Thanks to Dr. Paula Lopes and Dr. Natália Oliveira from the Department of Audiology.

Article first published online: September 11, 2015. - Manuscript accepted: August 14, 2015. - Manuscript revised: August 4, 2015. - Manuscript received: June 2, 2015.