LILIANNA KONOPSKA
University of Szczecin
Chair of Special Pedagogy,Institute of Pedagogy

ORCID ID: https://orcid.org/0000-0002-9289-4683

Otological and Audiological Determinants of the Well-being of Children with Desonorization*

SUMMARY

The research paper presents the results of own research on desonorization in dyslalia regarding otological and audiological conditions of the well-being of children with impaired realization of voicing of obstruent phonemes. The research material comes from 30 subjects with desonorization between 4.7 and 17.8 years of age. During research it was found, basing on specialist medical examinations, that 80% of this group of the examined children had abnormalities in the tympanic membrane regarding its color, light reflex, position and translucency. The data obtained during impedance audiometry indicated that 53% of the subjects went through exudative otitis media and/or dysfunctions of the Eustachian tube. The data obtained during pure tone audiometry indicated that 53% of the examined children suffered from bilateral or unilateral conductive hearing loss. The conducted research shows that in the case of desonorative disorders, a laryngological-audiological examination and specialist treatment are an essential prerequisite for logopedic as well as therapeutic diagnostics.

Key words: speech disorders, desonorization, tympanogram, physical hearing, conductive hearing loss, children

---

* The study was funded from science budget allocations in 2010–2013 as a research project no. N N104 084639. Project manager: Lilianna Konopska.

The presented research results were reported at the 15th National Logopedic Conference *Logopedia – tradycja i perspektywy rozwoju* [Logopedics – Traditions and Development Prospects] held in Warsaw on 29 and 30 September 2017. The title of the report was *Desonoryzacja w dyslalii – w poszukiwaniu uwarunkowań. Wyniki badań laryngologiczno-audiologicznych* (*doniesienie z własnych badań*).[Desonorization in Dyslalia – in Search of Determinants. Results of Laryngological-Audiologicla Studies (Report from own Research). Organizers: Main Executive of the Society for Language Culture, Logopedics Center of Warsaw University's Institute of Applied Polish Studies, Dept. of Logopedics and Educational Linguistics of the Maria Grzegorzewska University in Warsaw.

INTRODUCTION

The term 'desonorization' (Latin *sonorus* – sonorous, resonant) has been adopted to apply to distortions, not determined by the neutralization of voicing opposition, of sound realizations of voiced phonemes in the form of their voiceless instead of voiced realizations. The author's previous studies into desonorization in dyslalia were oriented towards analyzing and describing the observed logopedic phenomena at the articulatory, acoustic and auditory levels. The findings show inter alia that children with desonorization realize with defects not only voiced but also voiceless obstruent phonemes that make up the unmarked element of the voicing opposition, on the basis of which the marked element of the opposition is acquired in the ontogeny of the language. Furthermore, in almost all the subjects (97%), faulty realizations of voiceless obstruent phonemes co-occur with faulty realizations of sonorant phonemes (Konopska 2015). For logopedic theory and practice this means inter alia that in children with desonorization in obstruent phonemes, what should be done in the first place is to improve the sound realizations of voiceless phonemes. It is also debatable to distinguish for this type of disorder a separate type of dyslalia, i.e. 'voiceless speech' as proposed by Kania (1975) and 'desonorization dyslalia' – according to the author's earlier proposal (Konopska, Tarnowska 2005).

A continuation of the abovementioned studies on desonorization in dyslalia is the present inquiries concerning the causes of disorders in the implementation of the voicing of obstruent phonemes. The obtained data on the pre-, peri- and early postnatal determinants of the well-being[1] of children with desonorization shows that the majority of the subjects (75%) were born from high-risk pregnancy; consequently, the overwhelming portion of this group consists of high-risk group children. Furthermore, it was found that in the majority of children of this group (75%) during the pre- and/or peri- and/or early postnatal period there are single factors or groups of factors endangering their well-being, including the normal development of speech (Konopska 2017).

The purpose of the present report is to present the selected results of the author's own studies seeking to answer to the following detailed research problem: *What are the ontological and audiological determinants of the well-being of children with desonorization*?

1. Material and Methods

The collected research material comes from 30 subjects with desonorization aged between 4.7 and 17.8 years, of which 21 males (70% of the subjects) and

[1] The WHO definition of health reads: "A state of complete physical, mental and social. well-being and not merely the absence of disease or infirmity" (Domaradzki 2013).

9 females (30% of subjects). The mean age is 7 years and 6 months. The data presented in the article concern selected medical diagnoses[2] made during first visits as well as the results of specialist treatment[3]. During the otolaryngological examination the following were assessed in accordance with the binding standards:

1. the nasal cavity: nasal patency, the state of the nasal mucosa, the presence and nature of sections in the cavities of the nose, the size of the nasal conchae, and the state of the nasal septum,
2. the nasopharyngeal cavity: patency of the choanae, the size, shape and position of the pharyngeal tonsil,
3. the throat: the size of palatine tonsils, the mobility and tone of the soft palate, the respiratory and phonatory position of the palatine arches,
4. auricles and retroauricular regions,
5. the external acoustic duct and the tympanic membrane (otoscopic examination),
6 physical hearing assessed by pure tone audiometry and impedance audiometry (tympanometry).

The present report discusses the results of ontological examinations and the assessment of physical hearing obtained during the first visit and after treatment.

1.1. Assessment of the acoustic duct and the tympanic membrane

The basic laryngological examination conducted prior to pure tone and impedance audiometry is the examination of the auricles and retroauricular regions and otoscopic examination, which enables the assessment of the structure and patency of the external acoustic duct and the diagnosis of diseases of the external ear and middle ear. The otoscopic examination of the tympanic membrane assesses its color and light (normal or altered), position (normal, prominence, or retraction), translucency, while pneumatic otoscopy assesses mobility (normal or restricted). The normal tympanic membrane is pale-grey (pearly-grey), oval and semi-transparent. When the normal tympanic membrane is illuminated, a triangular light reflex arises in the anterior lower quadrant, which indicates its tension (Hassmann-Poznańska 2007). Changes in the position of the tympanic membrane in relation to the external acoustic duct (prominence, retraction) impact the shape and occurrence of the light cone. The inflammatorily altered tympanic membrane does not reflect light and the reflection is invisible or blurred. The

[2] During the presented studies a total of 110 diagnostic-treatment audiological-laryngological-phoniatric visits were made, in which the author took part every time. All otorhinolaryngologic, audiological and phoniatric examinations were performed by one physician – Elżbieta Teresińską, MD, PhD (Individual Specialist medical Care, Szczecin), specialist grade I in otorhinolaryngology, specialist grade II in phoniatrics and audiology, and with completed post-MA program in logopedics.

[3] The condition for conducting examinations was parental written consent, obtained in each case.

otoscopic examination enables the assessment of the condition of the middle ear, especially the tympanic cavity based on the appearance of the tympanic membrane, which, however, is only a part of the wall of the tympanic (external) cavity. Since some diseases of the tympanic cavity may occur with only slight changes within the tympanic membrane, the testing of hearing is a necessary element in each assessment of the condition of the middle ear (Chmielik 2001, Hassmann-Poznańska 2007).

1.2. Assessment of physical hearing

In the presented studies, physical hearing was assessed using the method of pure tone audiometry and impedance audiometry (tympanometry). Impedance audiometry is currently one of the most frequently utilized methods of the objective examination of hearing and finds applications in diagnosing conductive hearing disorders (by measuring pressure in the middle ear, i.e. tympanometry, and by measuring acoustic resistance). During the examination the deflections of the tympanic membrane with the changing static pressure in the acoustic duct are recorded by means of the reflected sound wave. The examination is performed separately for the right and the left ear, and it does not require the patient's cooperation. Owing to tympanometry, it is possible to precisely determine the mobility of the elements that carry sound through the middle ear, the presence of airlessness or fluid in the tympanic cavity and the patency of the Eustachian tube, while in the internal ear – stapedius reflex to administered acoustic stimuli and the phenomenon of equalization of loudness in cochlear hearing loss. Measurement of the compliance of the tympanic membrane or – depending on pressure changes in the external acoustic duct – its resistance enables plotting a tympanometric curve. In the classical typology of tympanometric curves, three principal types of tympanograms are distinguished: type A with a distinct maximum approaching 0 mm of water column, type B – with an almost flat curve without a marked maximum value, type C – with the maximum value shifted towards negative pressure. In each of the three principal tympanograms, separate forms can be distinguished: in type A – there are low (As), medium high (A), and high (Ad) tympanograms, in type B – tympanograms with a very small gradient (0 or even lower), in type C – one can distinguish tympanograms C1 with the apex situated between –100 and –199 mm of water column and C2 with the apex situated between –200 and –400 mm of water column (Pruszewicz, Obrębowski 2003). The A type tympanogram is typical of normal hearing and the normal functioning of the Eustachian tube. This type of tympanogram can also be found in pure sensorineural hearing losses because in such cases the middle ear remains intact. The As type tympanogram may result from the immobilization of the chain of auditory ossicles or the thickening of the tympanic membrane. The C type tympanogram is first of all encountered in the cases of the dysfunction of the Eustachian tube, while the B type tympanogram is observable in the cases of complete occlusion of the Eustachian tube, presence of fluid in the middle ear, or it can be caused by the residual cerumen in the auditory canal (Pruszewicz, Obrębowski 2003). In the reported studies the results of tympanometric tests were interpreted based on the Fiellau-Nikolajsen classification, in which the following curve types are adopted: A, C1, C2, B. The presence of the A type curve was interpreted as a normal result, of type C2 (pressure < – 200 daPa) or B type curve (undeterminable pressure, flat tympanogram) – as otitis media with effusion, the presence of the C1 curve (pressure between –100 and –199 daPa) – as a dysfunction of the Eustachian tube (Lous, Fiellau-Nikolajsen 1981).

To assess the depth and range of hearing loss, the classification was adopted based on the directions of the International Bureau for Audiophonology (BIAP). The BIAP defines the degree of hearing impairment according to Fletcher's formula on the basis of four frequencies: 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz. The point of reference is the tone audiogram curve obtained in audiometric testing according to the ISO standard, in which pure tones administered by air and bone conduction are used to determine the magnitude of hearing loss in the range of audible frequencies. Basic calculations are made based on the first three frequencies, most essential to speech reception. Expressed in dB HL, the obtained threshold values for 500 Hz, 1000 Hz and 2000 Hz are added up and divided by 3. In the cases when the difference of hearing loss in dB between 500 Hz and 2000 Hz exceeds 40 dB, Fletcher's formula is expanded to four frequencies, for which the mean is calculated for each ear. When the hearing loss for 4000 Hz is lower than for 2000 Hz, calculations allow for the loss for 4000 Hz. The data calculated for the better ear are taken into consideration. Under the BIAP guidelines, the norm is the loss up to 20 dB (Skarżyński et al. 1997).

In the qualitative scale, hearing loss is determined by "measuring the auditory threshold in individual frequencies and by defining the interrelation between the air curve and bone curve. The curve with a loss marked first of all in low tones evidences a type of conductive hearing loss, i.e. one in which the cause of hearing loss lies in the system through which acoustic energy is delivered to the receptor (from the external ear to endolymph in the internal ear). The curve with a loss marked within high frequencies shows a type of sensorineural hearing loss, in which each section of the auditory pathway, starting from the receptor. (…) A conductive hearing loss is characterized by the maintenance of the cochlear reserve, i.e. an interval between the bone curve and air curve being from 15 to 40 dB" (Pruszewicz 2003, 318–319). In quantitative terms, the classification of the International Bureau for Audiophonology distinguishes four degrees of hearing impairment: a) mild hearing loss – 21–40 dB, b) moderate hearing loss – 41–70 dB, c) severe hearing loss – 71–90 dB, d) – profound hearing loss 90 dB.

2. Results and Discussion

2.1. Results of otological examinations

The obtained results of laryngological examinations concerning the assessment of the external ear and otoscopic examinations in children with desonorization are presented in Table 1.

Table 1. Results of otorhinolaryngological examination – otological examinat

Otological examination (N=30)								
Normally developed auricles		Internal acoustic ducts		Tympanic membrane			Treatment of ears	
yes	no	wide	narrow	bilaterally normal	unilaterally abnormal	bilaterally abnormal	yes	no
29 97%	1 3%	26 87%	4 13%	6 20%	3 10%	21 70%	24 80%	6 20%

Normally developed auricles were found in 97% of the subjects while the abnormally developed auricle of the right ear was found in one person. The narrowing of external acoustic ducts was found in four persons (13%), in the other 26 subjects (87%) there were wide external acoustic ducts. The most abnormalities were reported in the tympanic membrane. Only in 6 subjects (20%) the bilaterally normal tympanic membrane was found through otoscopic examination, and in two persons in this group there were ceruminal plugs which had to be removed to perform an assessment of the tympanic membrane. In 21 subjects (70%) changes in the left and right ear were diagnosed, and in three subjects in one (10%). Altogether, in 80% of children with desonorization, in the first examination the abnormalities within the tympanic membrane were diagnosed in respect of its color and light reflex, position, and translucency. It follows from the examinations of the condition of the external auditory canal and the tympanic membrane in children with desonorization conducted during the first-time visit, that 26 children required laryngological aid, of which two children had to have the ceruminal plug removed, and treatment of ears was necessary in 24 children. Positive treatment results were achieved in almost all 24 subjects (95.8%). In the case of one child, in whom a small improvement was achieved in one ear, further treatment was recommended[4].

[4] In this child, the pharyngeal tonsil remained under observation (less effective results of conservative therapy), ultimately, however, the normal results of physical hearing were obtained, with the persistent mild dysfunction of the Eustachian tube within one ear.

2.1. Results of impedance audiometry tests

Table 2 presents the results of tympanometric tests in children with desonorization, obtained during the first medical examination and after treatment.

Table 2. Results of tympanometric tests before and after laryngological treatment

Results of tests obtained after the first laryngological examination												
Type of tympanogram								Type of tympanogram – diagnosis				
Right ear				Left ear				Type A	Type B. C1. C2 for one or both ears			
TYPE A	TYPE B	TYPE C1	TYPE C2	TYPE A	TYPE B	TYPE C1	TYPE C2	For both ears	Otitis media with effusion (OME)	Dysfunction of the Eustachian tube	OME and dysfunction of the Eustachian	Otitis
15	4	6	5	16	4	8	2	14	5	4	5	2
50%	13%	20%	17%	53%	13%	27%	6%	47%	17%	13%	17%	6%
Results of tests after laryngological treatment (data for 29 subjects)												
26	0	3	0	27	0	2	0	26	0	3	0	0
89.7%	0%	10.3%	0%	93.1	0%	6.9%	0%	89.7%	0%	10.3%	0%	0%

As shown by the presented data, only in 14 subjects (47%) the A type tympanogram for both ears, whereas in 16 subjects (53%) the objective examination by impedance audiometry showed abnormalities. The most frequent type of tympanogram in children with desonorization is type C1, which indicates a dysfunction of the Eustachian tube (23% – the result calculated for 60 ears), and then type B (13% – the result calculated 60 ears) and C2 (12% – the result calculated for 60 ears) – both types (B, C2) indicate otitis media with effusion. The prevalent diagnosis in the studied group, therefore, is otitis media with effusion (with Eustachian tube dysfunction or without), which was diagnosed in one third of the children with desonorization (in ten subjects). The dysfunction of the Eustachian tube was diagnosed in four subjects (13%), and otitis in two subjects (6%). In each case it was necessary to start specialist treatment (Table 3).

2.2. The results of pure tone audiometry

The results of audiological tests obtained during pure tone audiometry are as follows: in the first audiological test in the studied group, conductive hearing loss was found in 16 subjects (53.3%) and normal physical hearing was found in 14 subjects (46.7%). In terms of the level of hearing loss, mild conductive hearing loss was diagnosed in 15 children (50% of the subjects), and moderate (i.e. medium level) hearing loss was found in one child (3.3% of the subjects). Bilateral conductive hearing loss was diagnosed in 6 children (20% of the subjects), and unilateral loss was found in the right ear (in 5 children) or in the left ear (in 5 children) – a total of 10 children (in 33.4% of the subjects). In the group in question, unilateral hearing loss occurs therefore more often than the abnormalities affecting both ears. Table 4 presents data concerning the mean values of the auditory threshold for the right and the left ear calculated based on Fletcher's formula for frequencies of 500 Hz, 1000 Hz and 2000 Hz in the group with normal and abnormal physical hearing.

Tab. 3. Pure tone audiometry – mean values of auditory threshold in the right and the left ear in the group with normal and abnormal physical hearing

Right ear – mean values of auditory threshold in dB HL for frequencies of 500, 1000 Hz and 2000 Hz										
Physical hearing	N=30	Average loss in dB HL	95% confidence intervals (CI)		Median	Limit values		Standard deviation (±SD)	Standard error (SE)	p- value
			(–95%	+95%)		min.	max.			
normal	14	14.76	12.84	16.68	15.00	8.33	20.00	3.32	0.89	0.0006
abnormal	16	23.96	19.49	28.43	22.50	10.00	45.00	8.39	2.10	
Left ear – mean values of auditory threshold in dB HL for frequencies of 500 Hz, 1000 Hz and 2000 Hz										
Physical hearing	N=30	Average loss in dB HL	95% confidence intervals (CI)		Median	Limit values		Standard deviation (±SD)	Standard error (SE)	p-value
			(–95%	+95%)		min.	max			
normal	14	13.21	10.61	15.81	14.17	5.00	18.33	4.50	1.20	0.0004
abnormal	16	22.19	18.58	25.79	21.67	13.33	43.33	6.77	1.69	

As shown by the data presented in Table 3, in the group of 16 children with conductive hearing loss (uni- or bilateral) the maximum values of hearing loss in the right ear are 45 dB, and minimum values – 10 dB, the average hearing loss being 24 dB. In the group of children with normal physical hearing, minimum and maximum values range from 8 to 20 dB, whereas the mean values of the auditory threshold for the right ear are 15 dB, which corresponds to the normal hearing level. In the case of the left ear, in the group with hearing loss the mean maximum values of hearing loss in the left ear are 43 dB, the minimum values being 13 dB, while the average hearing loss is 22 dB. In the group of 14 children with the auditory norm, the minimum and maximum values range from 5 to 18 dB, while the mean values of the auditory threshold for the left ear are 13 dB, which corresponds to the normal hearing level.

After laryngological treatment, the results of audiological examinations considerably improved – 89% of children obtained the correct result of the physical hearing examination. It should however be added that in the case of three children with mild conductive hearing loss, there was no improvement in one child with left-ear hearing loss (in the objective BERA test the correct morphology of the record and normal temporal parameters were obtained while for the left ear the auditory threshold remains at 30 dB), one child (with hearing loss in the left ear at 25 dB) did not attend the follow-up examination, (thus remaining in statistics as a child with hearing loss because it was impossible to verify the state of physical hearing), whereas in the case of the third child (with bilateral hearing loss at 25 dB for the right ear and 22 dB for the left ear), who was still under treatment when the tests were conducted, the follow-up examination - carried out much later after the completion of the program - showed normal physical hearing.

Tables 4 and 5 feature detailed data concerning the mean values of the auditory threshold in the right ear and the left ear for all frequencies, obtained by pure tone audiometry, in 30 subjects with desonorization before and after laryngological treatment.

Tab. 4. Pure tone audiometry – mean values of the auditory threshold in the right ear for all frequencies in children with desonorization before and after treatment (in dB HL)

Right ear – mean values of the auditory threshold in dB HL for all frequencies before and after treatment											
Frequency (Hz)	Physical hearing*	N	Mean (dB HL)	95% credibility intervals (CI)		Median	Limit values		±SD dB	SE dB	p-value
				(–95%	+95%)		min.	max.			
250 Hz	A. normal	14	17.14	13.80	20.49	17.50	10.00	25.00	5.79	1.55	0.0064
	B. abnormal	16	25.31	20.60	30.03	22.50	15.00	40.00	8.84	2.21	
	Group A after	11	14.55	11.75	17.34	15.00	10.00	20.00	4.16	1.25	0.6470
	Group B after	16	15.31	13.04	17.59	15.00	5.00	20.00	4.27	1.07	
500 Hz	A. normal	14	16.07	13.76	18.39	15.00	10.00	25.00	4.01	1.07	0.0041
	B. abnormal	16	24.06	19.37	28.75	20.00	10.00	45.00	8.80	2.20	
	Group A after	11	14.09	11.57	16.61	15.00	10.00	20.00	3.75	1.13	0.4508
	Group B after	16	15.31	13.04	17.59	15.00	5.00	20.00	4.27	1.07	

Tab. 4.

1000 Hz	A. normal	14	14.29	12.06	16.51	15.00	5.00	20.00	3.85	1.03	0.0010
	B. abnormal	16	25.94	19.92	31.95	25.00	10.00	60.00	11.29	2.82	
	Group A after	11	14.09	12.07	16.12	15.00	10.00	20.00	3.02	0.91	0.9872
	Group B after	16	14.06	11.27	16.85	15.00	5.00	25.00	5.23	1.31	
2000 Hz	A. normal	14	13.93	11.61	16.24	15.00	5.00	20.00	4.01	1.07	0.0017
	B. abnormal	16	21.88	17.76	25.99	20.00	10.00	35.00	7.72	1.93	
	Group A after	11	13.64	10.25	17.03	15.00	5.00	20.00	5.05	1.52	0.9602
	Group B after	16	13.75	10.45	17.05	10.00	5.00	30.00	6.19	1.55	
4000 Hz	A. normal	14	13.21	9.89	16.54	15.00	5.00	25.00	5.75	1.54	0.0065
	B. abnormal	16	22.81	16.98	28.65	20.00	10.00	45.00	10.95	2.74	
	Group A after	11	12.27	9.96	14.58	15.00	5.00	15.00	3.44	1.04	0.8045
	Group B after	16	11.88	9.52	14.23	10.00	0.00	20.00	4.43	1.11	
8000 Hz	A. normal	13	15.00	11.51	18.49	15.00	5.00	30.00	5.77	1.60	0.0011
	B. abnormal	14	26.79	20.94	32.63	25.00	15.00	50.00	10.12	2.70	
	Group A after	11	13.18	9.73	16.63	15.00	5.00	25.00	5.13	1.55	0.1060
	Group B after	15	18.00	13.34	22.66	20.00	5.00	40.00	8.41	2.17	

*A. normal, B. abnormal – data before treatment. Group A after, Group B after – data after treatment

In the group of children with normal physical hearing the minimum values of all the frequencies assessed by pure tone audiometry are in the range of 5–10 dB, while the maximum values range from 20 to 30 dB. The data show that in the group with normal hearing there are also children with hearing deficit in single frequencies. The mean values of the auditory threshold for individual frequencies (after being rounded off to unity) in the group with the auditory norm are: for frequencies 250 Hz – 17 dB, 500 Hz – 16 dB, 1000 Hz – 14 dB, 2000 Hz – 14 dB, 4000 Hz – 13 dB, 8000 Hz – 15 dB and are significantly lower than in the group with hearing loss. In the group of children with hearing loss the minimum values of the frequencies from 250 Hz to 8000 Hz, assessed by pure tone audiometry, range from 10–15 dB, while the maximum values are in the range of 20–60 dB. The mean values of hearing loss for individual frequencies (after being rounded off to unity) in the group with hearing loss (bilateral or unilateral) are: for frequencies 250 Hz – 25 dB, 500 Hz – 24 dB, 1000 Hz – 26 dB, 2000 Hz – 22 dB, 4000 Hz – 23 dB, 8000 Hz – 27 dB (Table 4.). The obtained results of audiological examinations for the right ear before and after laryngological treatment in the group of children with abnormal physical hearing are presented in Figure 1.

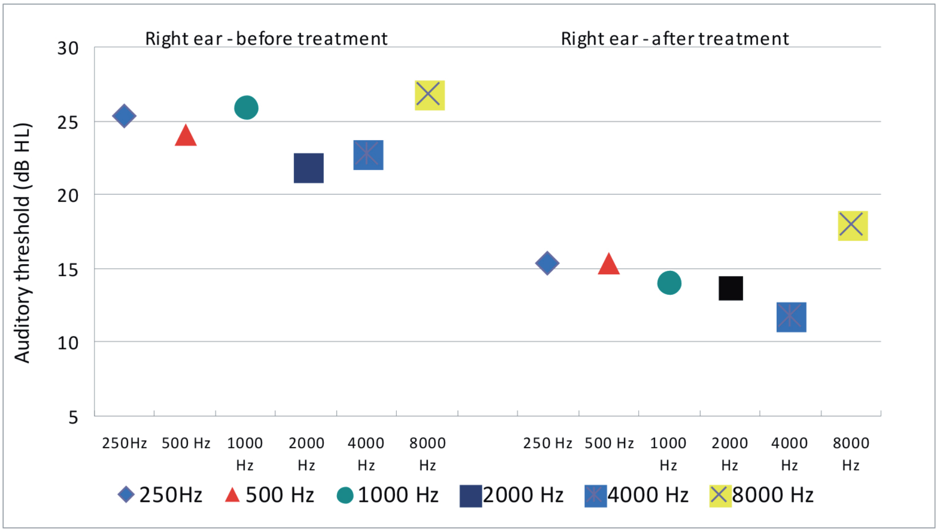

Fig. 1. The right ear – mean values of the auditory threshold for all frequencies in the hearing loss group before and after treatment

With regard to the left ear in the group of children with the auditory norm the minimum value of all the frequencies assessed by pure tone audiometry is 5 dB, the maximum values being in the 20–25 dB range. These data, as in the case of the right ear, show that in children with normal hearing there are deficits in single frequencies. The mean values of the auditory threshold (after being rounded off to unity) for individual frequencies in the group with the auditory norm are: for frequencies 250 Hz – 15 dB, 500 Hz – 15 dB, 1000 Hz – 13 dB, 2000 Hz – 12 dB, 4000 Hz – 14 dB, 8000 Hz – 11 dB and are significantly lower than in the hearing loss group. In the group of children with hearing loss the minimum values of the frequencies, assessed by pure tone audiometry, from 250 Hz to 8000 Hz are contained in the range of 5–15 dB, the maximum values ranging from 20 to 45 dB. The mean values of hearing loss for individual frequencies (after being rounded off to unity) in the hearing loss group are: for frequencies 250 Hz – 24 dB, 500 Hz – 26 dB, 1000 Hz – 23 dB, 2000 Hz – 18 dB, 4000 Hz – 19 dB, 8000 Hz – 19 dB (Table 5.).

Table 5. Pure tone audiometry – mean values of the auditory threshold in the left ear for all frequencies in children with desonorization before and after treatment (in dB HL)

Left ear – mean values of the auditory threshold in dB HL for all frequencies before and after treatment											
Frequency (Hz)	Physical hearing	N	Mean (dB HL)	95% Credibility intervals (CI)		Median	Limit values		±SD dB	SE dB	p- value
				(–95%	+95%)		min.	max.			
250 Hz	A. normal	14	15.00	12.00	18.00	15.00	5.00	20.00	5.19	1.39	0.0004
	B. abnormal	16	23.75	20.31	27.19	22.50	15.00	40.00	6.45	1.61	
	Group A after	11	13.18	10.08	16.29	15.00	5.00	20.00	4.62	1.39	0.5051
	Group B after	16	14.38	12.02	16.73	15.00	5.00	20.00	4.43	1.11	
500 Hz	A. normal	14	14.64	10.98	18.31	15.00	5.00	25.00	6.34	1.70	0.0002
	B. abnormal	16	25.63	21.75	29.50	25.00	15.00	45.00	7.27	1.82	
	Group A after	11	10.91	7.97	13.84	10.00	5.00	20.00	4.37	1.32	0.1046
	Group B after	16	15.31	11.13	19.49	15.00	0.00	30.00	7.85	1.96	
1000 Hz	A. normal	14	13.21	9.89	16.54	12.50	5.00	25.00	5.75	1.54	0.0008
	B. abnormal	16	22.50	18.49	26.51	20.00	15.00	45.00	7.53	1.88	
	Group A after	11	9.09	6.57	11.61	10.00	5.00	15.00	3.75	1.13	0.0503
	Group B after	16	14.06	10.14	17.98	10.00	5.00	30.00	7.35	1.84	
2000 Hz	A. normal	14	11.79	9.10	14.47	10.00	5.00	20.00	4.64	1.24	0.0088
	B. abnormal	16	18.44	14.34	22.53	17.50	10.00	40.00	7.69	1.92	
	Group A after	11	10.91	8.39	13.43	10.00	5.00	15.00	3.75	1.13	0.3759
	Group B after	16	13.13	9.13	17.12	10.00	5.00	30.00	7.50	1.88	
4000 Hz	A. normal	14	13.57	9.74	17.40	12.50	5.00	25.00	6.63	1.77	0.0798
	B. abnormal	16	18.75	14.14	23.36	20.00	5.00	40.00	8.66	2.17	
	Group A after	11	10.45	8.10	12.81	10.00	5.00	15.00	3.50	1.06	0.2578
	Group B after	16	13.13	9.37	16.88	12.50	5.00	25.00	7.04	1.76	
8000 Hz	A. normal	13	11.15	7.42	14.89	10.00	5.00	25.00	6.18	1.71	0.0118
	B. abnormal	15	19.33	14.22	24.45	15.00	5.00	35.00	9.23	2.38	
	Group A after	11	9.55	7.19	11.90	10.00	5.00	15.00	3.50	1.06	0.5987
	Group B after	15	11.00	6.30	15.70	10.00	0.00	30.00	8.49	2.19	

*A. normal. B. abnormal – data before treatment. Group A after Group B after – data after treatment

The obtained results of audiological examinations for the left ear before and after laryngological treatment in the group of children with abnormal physical hearing are presented in Figure 2.

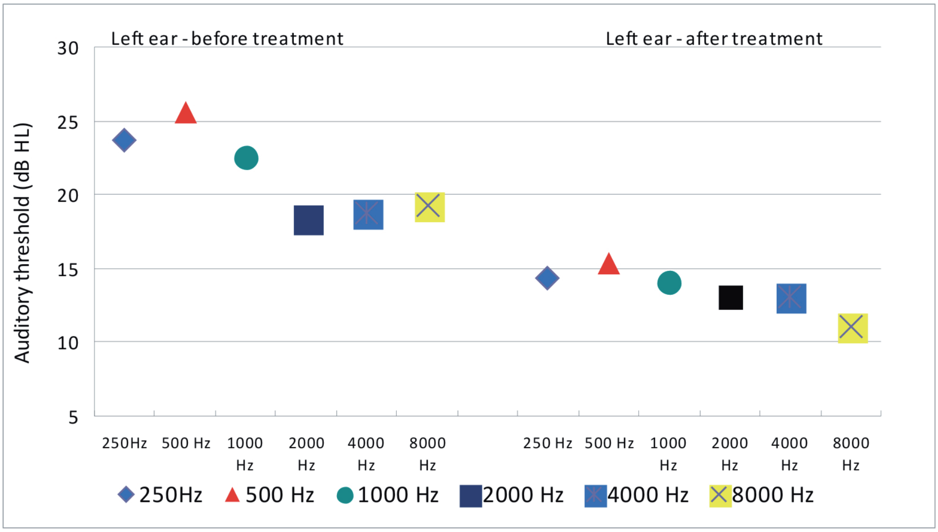

Fig. 2. The left ear – mean values of the auditory threshold for all frequencies in the hearing loss group before and after treatment

As shown by the data presented in Tables 5 and 6 the treatment applied in children with desonorization had a beneficial effect also on the quality of hearing in the children who had previously been diagnosed as patients without hearing defects. These data explicitly show that after treatment the obtained results of the examinations of physical hearing in both groups are similar. Moreover, in the group with normal physical hearing, the auditory threshold of from 5 dB to 20 dB for the left ear was reported for all frequencies, and the same values of the auditory threshold for the right ear, ranging from 250 Hz to 4000 Hz. Therefore, hearing deficits in single frequencies which were diagnosed during the first visit to the doctor and before starting specialist treatment were equalized to the normal state.

3. Recapitulation and Conclusions

The conducted ontological and audiological examinations show that in the group in question of children with desonorization there are predominantly abnormalities within the tympanic membrane, inflammatory conditions of the middle ear and/or dysfunctions of the Eustachian tube, and subsequently – conductive hearing loss[5]. These results were surprising to almost all parents because they perceived their children as functionally hearing. Otitis media with effusion (OME) is one of the frequently diagnosed inflammatory diseases of the mucous membrane in the middle ear in children, its essence being the presence of fluid in the air spaces of the middle ear, which consequently leads to conductive hearing loss. The most important of the listed OME risk factors include the dysfunction of the Eustachian tube (of anatomical or functional origin) and recurrent airways infections, in particular – acute otitis media (AOM) (then OME occurs as an initial or subsequent stage of AOM (more frequently in boys than in girls) and according to epidemiological studies, this disorder was diagnosed in 50% of cases in children aged 5–7. Otitis media with effusion affects mainly children with frequent infections of the upper respiratory tract, allergy, or hypertrophy of the lymphatic tissue of Waldeyer's ring (Chmielik 2001, Zielnik-Jurkiewicz 2004).

Otitis media with effusion (with subsequent conductive hearing loss) is termed as a treacherous condition because an ear with effusion does not hurt. The disease can last for months, develop slowly and may remain undiagnosed for a long time. Consequently, it may escape parents' attention, especially when unilateral hearing disorders occur. It may also happen that when OME occurs as a consequence of acute otitis media, whose course is a rule short-lasting (the pain in the ear accompanying AOM usually appears at night and last about one day in most cases), parents may ignore the painful conditions reported by children in such cases (the ear does not hurt the next day so it does not need to be examined). Medical literature lists the symptoms that should arouse parental caution and suspicion of OME like developmental delays of speech, learning difficulties, loud listening to music, loud TV watching, the need to repeat orders several times, inferior motor coordination or coordination disorders (Chmielik 2001, Gromek, Krzeski 2010, Obrębowski, Obrębowska 2009).

It should be emphasized at this point that in the process of treating children with desonorization, it was necessary to see laryngologists several times, and to change the way of treatment, adjust it to the current state of the child's health (e.g. a disease in progress), to provide allergological consultations and implement allergological treatment because in patients with a positive allergological history, lower stability of the obtained results of laryngological treatment was observed. A positive symptom that was most frequently reported by parents was the regression of snoring during sleep, sleeping with the closed mouth, more frequent breathing at rest through the nose, and lower incidence of diseases of the upper airways. The results of the author's own studies on disorders in the realization of

[5] A more broader discussion of the results of the examinations is outside the scope of this study. For more on the subject see Konopska L. *Desonoryzacja w dyslalii – w poszukiwaniu uwarunkowań zaburzenia* (forthcoming).

voicing with regard to the otological and audiological determinants of the well-being of children with desonorization permit the conclusion that:

1. The majority of the children with desonorization (80%) require specialist medical care because of abnormalities within the tympanic membrane concerning its color, light reflex, position and translucency.
2. More than half (53%) of the children with desonorization require treatment of inflammatory conditions of the ears and the Eustachian tube as well as subsequent conductive hearing loss.
3. In the case of desonorization disorders, a necessary condition for logopedic diagnostic-therapeutic management is laryngological-audiological examination and specialist treatment.

BIBLIOGRAPHY

Chmielik M. (ed.), 2001, *Otorynolaryngologia dziecięca*, PZWL, Warszawa.

Domaradzki J., 2013, *O definicjach zdrowia i choroby*, "Folia Medica Lodziensia", 40,1, 5–29.

Gromek I., Krzeski A., 2010, *Zastosowanie glikokortykosteroidów donosowych w leczeniu przerostu migdałka gardłowego oraz wysiękowego zapalenia ucha środkowego u dzieci*, "Magazyn Otorynolaryngologiczny", IX, 1, 7–29.

Hassmann-Poznańska E., 2007, *Technika badania otoskopowego i zasady interpretacji wyniku*, "Medycyna Praktyczna Pediatria", 2007/06.

Kania J., 1975, *Fonetyczna i logopedyczna charakterystyka mowy bezdźwięcznej*, [w]: *Wybrane zagadnienia z defektologii*, t. III, (ed.) T. Gałkowski, Akademia Teologii Katolickiej, Warszawa, 200–226.

Konopska L., 2015, *Desonoryzacja w dyslalii. Analiza artykulacyjna, akustyczna i audytywna*, Wydawnictwo Naukowe Uniwersytetu Szczecińskiego, Szczecin, 2015.

Konopska L., 2017, *Pre-, peri- i wczesne postnatalne uwarunkowania dobrostanu dzieci z desonoryzacją*, "Logopedia", t. 46, Polskie Towarzystwo Logopedyczne, Lublin, 17–36.

Konopska L., Tarnowska Cz., 2005, *Dyslalia desonoryzacyjno-fonacyjna, czyli o tzw. mowie bezdźwięcznej – inaczej*, [in]: Młynarska M., Smereka T. (eds.), *Logopedia. Teoria i praktyka*, Agencja Wydawnicza a linea, Wrocław, 307–315.

Lous J., Fiellau-Nikolajsen M., 1981, *Epidemiology of middle ear effusion and tubal dysfunction. A one-year prospective study comprising monthly tympanometry in 387 nonselected 7-year-old children*, "Int J Pediatr Otorhinolaryngol", 3, 303–317.

Obrębowski A., Obrębowska Z., 2009, *Wpływ przewlekłego wysiękowego zapalenia ucha środkowego na rozwój mowy u dzieci,* "Otorynolaryngologia" 8 (4), 159–162.

Pruszewicz A. (ed.), 2003, *Audiologia kliniczna. Zarys. Wydanie III poprawione i rozszerzone*, Wydawnictwa Akademii Medycznej im. K. Marcinkowskiego w Poznaniu, Poznań.

Pruszewicz A., Obrębowski A., 2003, *Audiometria impedancyjna*, [in]: *Audiologia kliniczna. Zarys*. Wydanie III poprawione i rozszerzone, (ed.) A. Pruszewicz, Wydawnictwa Akademii Medycznej im. K. Marcinkowskiego w Poznaniu, Poznań.

Skarżyński H., Mueller-Malesińska M., Wojnarowska W., 1997, *Klasyfikacje zaburzeń słuchu*, "Audiofolonolgia", t. X, 49–60.

Zielnik-Jurkiewicz B., 2004, *Zmiany immunologiczne w wysiękowym zapaleniu ucha środkowego*, "Terapia", no. 4 (150), 44–47.