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Auditory training in auditory processing disorders (APD)

Trening słuchowy w zaburzeniach przetwarzania słuchowego (APD)

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Summary

Auditory processing disorders (APD) are characterized by a reduction in the efficiency of auditory processing, which results in a deficit in identifying and interpreting sounds by the brain. In 2017, auditory processing disorders were awarded an individual diagnostic code. Symptoms that indicate the presence of auditory processing disorders are numerous and non-specific. The primary symptom of impaired auditory processing is difficulty understanding speech in noise. This disorder affects about 5-7% of children. Most often, the result of at least two tests included in the set is considered to be the determinant which constitutes the basis for the diagnosis of disorders.

In the diagnostic and therapeutic process of children with auditory processing disorders, the correct diagnosis is of key importance, thanks to which it will be possible to conduct an appropriate treatment. All therapeutic methods, tasks activating auditory perception and language skills should be selected reliably, individually for each participant of the therapy. The use of the so-called auditory training during corrective-compensatory and speech therapy classes in children with central auditory processing disorders should be the standard. It is the main method of treating children with central hearing impairment. Auditory training includes auditory education based on stimulating child's auditory predispositions and on developing the ability to use them in order to gain better orientation in the environment.

At present, therapists in Poland may use various types of therapeutic interactions that have a positive impact on the development of a child's hearing skills.

The aim of the work is to discuss auditory training and to present speech therapy exercises helpful in the therapeutic process of children with auditory processing disorders.

Streszczenie

Zaburzenia przetwarzania słuchowego charakteryzują się obniżeniem sprawności funkcjonowania przetwarzania słuchowego, czego następstwem jest deficyt w identyfikowaniu i interpretacji dźwięków przez mózg. W 2017 roku zaburzeniom przetwarzania słuchowego przyznano indywidualny kod diagnostyczny. Objawy, które wskazują na występowanie zaburzeń przetwarzania słuchowego, są bardzo liczne i nieswoiste. Symptom podstawowy upośledzonego przetwarzania słuchowego to trudności ze zrozumieniem mowy w hałasie. Omawiane zaburzenie dotyka około 5-7% dzieci. Najczęściej za wyznacznik stanowiący podstawę do zdiagnozowania zaburzeń uznaje się niezgodny z przyjętą normą wynik minimum dwóch testów znajdujących się w zastosowanym zestawie.

W procesie diagnostycznym i terapeutycznym dzieci z zaburzeniami przetwarzania słuchowego kluczowe znaczenie ma postawienie prawidłowego rozpoznania, dzięki któremu możliwe będzie przeprowadzenie odpowiedniej terapii. Wszystkie metody terapeutyczne, zadania aktywizujące percepcję słuchową i zdolności językowe powinny być wybrane w sposób rzetelny, indywidualnie dla każdego uczestnika terapii. Normą powinno być stosowanie tzw. treningu słuchowego podczas zajęć korekcyjno-kompensacyjnych oraz logopedycznych, przeprowadzanych u dzieci z zaburzeniami ośrodkowego przetwarzania słuchowego. Jest to główna metoda terapii dzieci z ośrodkowymi zaburzeniami słuchu. Trening słuchowy zalicza się do wychowania słuchowego opierającego się na pobudze-

niu predyspozycji słuchowych malca i na wykształceniu umiejętności ich stosowania, aby uzyskać lepszą orientację w otoczeniu.

W chwili obecnej w Polsce terapeuci mogą wykorzystywać różne rodzaje oddziaływań terapeutycznych mających pozytywny wpływ na kształtowanie umiejętności słuchowych dziecka.

Celem pracy jest omówienie treningów słuchowych i zaprezentowanie ćwiczeń logopedycznych pomocnych w procesie terapeutycznym dzieci z zaburzeniami przetwarzania słuchowego.

INTRODUCTION

Hearing is one of the most important human senses (1). Proper hearing depends, inter alia, on proper auditory processing (2). Despite normal peripheral hearing, it may be impossible to maximize the use of information coming from sound stimuli if central functions are disturbed (3). These disorders are called Auditory Processing Disorders (APD) (4, 5), also referred to as Central Auditory Processing Disorders (CAPD) (4, 6, 7). In the recently updated version of the ICD-10 (International Statistical Classification of Diseases and Related Health Problems) (8) of 2017, CAPD has been assigned a separate, specific diagnostic code, i.e. H93.25, and was defined as a disorder characterized by a reduced efficiency of auditory processing, which results in a deficit in identifying and interpreting sounds by the brain (9, 10).

In 2018, the British Society of Audiology (BSA) presented a new definition of auditory processing disorders, according to which they are characterized by poor perception of speech sounds as well as extralinguistic sounds (9, 10).

There are many symptoms indicating APD. A key symptom of impaired central auditory processing is the inability to properly understand speech in a degraded sound environment (11). In addition, the typical symptoms reported by the patient himself and/or noticed during observation include:

- problems with localizing the sound source,
- trouble hearing when talking on the phone,
- frequent requests to repeat information,
- giving inconsistent or incorrect answers to questions,
- problems with fulfilling verbal commands,
- tendency to be easily distracted,
- learning difficulties, including reading and writing,
- difficulties in learning foreign languages (12).

It is estimated that auditory processing disorders affect approximately 5-7% of children. However, not all researchers agree on these values, as some of them report that this number is higher and reaches 10%. APD occurs twice as often in boys than in girls (11, 13).

Auditory processing disorders were first characterized over 60 years ago – the author of the earliest references to this issue was Mykelbust, whose publication on this subject appeared in the 1950s (9).

The history of formulating the definition, diagno-

sis and management of APD is not short or indisputable. Recently, the interest in APD, a health problem that has not been appreciated until recently, has increased significantly; scientists' attention was strongly drawn to a more complete diagnosis of this disorder (9).

It is currently believed that there is no approved set of diagnostic criteria for APD (9, 14). Based on the recommendations of the AAA (American Academy of Audiology), during a detailed CAP analysis (Central Auditory Processing), the specialist should take into account the processes related to:

- localization of sounds,
- differentiation of sounds,
- time analysis of the acoustic impulse (recognition of sound patterns, determining the sequence of signals presented in a short time interval, finding short pauses between sounds),
- understanding of not very expressive speech (frequency filtered, limited or demonstrated in the presence of noise), as well as with both and split-ear listening (12).

It is advisable to select the minimum number of tests necessary to ensure the best possible sensitivity and accuracy while assessing the main auditory processes (12).

In most cases, the indicator that is the basis for the diagnosis of disorders is the abnormal result of at least two tests included in the kit used. In the light of current recommendations, each diagnosis of APD should have a description of the diagnostic criterion used (9).

In the diagnosis and speech therapy of children with auditory processing disorders, it is of key importance to make an appropriate diagnosis, which will then enable appropriate therapy. Accurate targeting of the deficiency of proper hearing functions, achieved through appropriate methods, significantly improves hearing. All therapeutic methods should be selected as carefully as possible, individually for each patient. Professional help is based on the cooperation of a multidirectional team of physicians and therapists. Therapy should cover both the child and his/her parents/guardians. Such a procedure leads to the maximum improvement of the functioning of a patient in everyday life (2, 15).

Auditory training is part of auditory education based on activating the child's hearing capabilities and developing the ability to use them in order to better find

themselves in the environment. This training should be a permanent part of corrective and compensatory classes, as well as speech therapy, conducted in children with APD (16).

Auditory training takes place in various forms. The opinion that computer games have many advantages is frequently. Nevertheless, it is recommended to limit the patient's visual stimulation. The child may be offered games and aural games, using typical didactic aids, which will be easily found in educational institutions (16).

In order for the auditory training aimed at a child with APD to be effective, it should be long-term, and at the same time intense (e.g. 30 minutes, 3-4 times a week, for a period of 6 weeks), tailored to his individual abilities. Moreover, the period of the therapy depends on the chosen method, as well as on the effort put into training by the participant of therapy (7, 16, 17).

During the exercises, it is necessary to work on various sounds – on non-linguistic material (sounds of the environment, nature, etc.), and on linguistic material (sounds/phonemes, syllables, words, sentences, phrases) (16). Auditory training may either be deficit-oriented or improve the ability to compensate for existing disorders. It is advisable that the training of children with APD should not only include auditory exercises, but include games and activities supporting coordination or language skills (18).

Currently, specialists in Poland have at their disposal various variants of therapeutic interventions that favorably influence the development of a child's hearing skills. These impacts include, among others:

- the Tomatis method,
- Warnke's method (15),
- Neuroflow training (16),
- training focused on the hearing deficit (7),
- SPS-S method (Stimulation of Auditory Perception using the Skarzynski method) (19),
- interactive metronome,
- speech therapy and pedagogical aural training (15).

The aim of the study is to review auditory training used in the therapy of children with auditory processing disorders and presenting proposals for speech therapy exercises performed while working with a child with APD.

THE TOMATIS METHOD

In Poland, the Tomatis method has been used for over 20 years. Children's qualification is based on the auditory attention test, auditory lateralization and interview. When starting therapy, patients are subjected to a large number of complementary tests (functional laterality study, transformed psychological tests). The therapy itself includes sessions during which, using special headphones, the sound material is properly developed – based on Mozart's music and Gregorian chants. In addition,

the above-mentioned material is filtered and the weight of listening is gradually transferred to the right ear (1, 15).

The therapy schedule is individually prepared to enhance the child's perception of those frequency bands that are responsible for the development of communication and the ability to listen and understand. This training influences, *inter alia*, the enrichment of the vocabulary range, fluency of speech, communication skills (3).

The method consists of two phases: passive and active. During the passive phase, the patient only listens to the audio material. In the active phase, the child is stimulated with speech sounds and activated to play them (15).

The training in question is relatively intense. Professionals recommend eight to ten sessions per cycle of two hours each. These cycles should be separated with several-week breaks in order to assimilate the effects achieved by using the discussed method. The number and length of cycles depend on the nature of the problem the child is struggling with (15, 20).

One of the modifications to the Tomatis method is the Warnke method (1).

WARNKE'S METHOD

The purpose of the Warnke's method is to help children with dyslexia, learning difficulties, support them in speech therapy and in problems related to auditory processing disorders (3, 21).

In the therapy of a child carried out by this method, tasks resembling simple computer games are used, during which – when the patient can cope with them, the degree of difficulty is gradually increased (15).

The Brain-Boy Universal (BBU) is a device intended primarily for individual, daily training at home. The therapy participant, on the basis of play, trains eight functions of central hearing, visual perception and motor skills, achieving excellent results – this is the training of basic functions (21). Rehabilitated basic functions are:

1. Establishing the threshold of visual order – the patient sees one flash on the left and on the right. His task is to decide which side of the impulse came first.
2. Auditory sequence thresholding – the patient hears one click on the left and one click on the right. Its task is to answer the question from which side the signal appeared at the beginning. The degree of difficulty is constantly increasing. Children with poor results in this test show difficulty in differentiating stop-blasts (p, b, t, d, k, g), and this is reflected in problems with understanding speech.
3. Directional hearing – the patient hears one click and then decides which side it came from. Children whose results in this test are lower than the accepted norm are not able to follow

the course of activities in the vicinity of disruptive stimuli (standard range between 50 dB and 60 dB).

4. Tone differentiation – the patient hears two sounds of unequal pitch, and then he should specify the order in which they appeared.
5. Synchronous tapping of the rhythm – the patient hears a regular pattern of sounds (clicks), which alternate from the right and left side. The child's task is to press the buttons simultaneously to the rhythm of clicks. The negligible coordination of the work of the cerebral hemispheres is the reason for the poor results achieved in the above sample.
6. Reaction time with selection – on the left and on the right, the patient hears two sounds of unequal pitch, and his task is to press the button on the side of the lower stimulus as quickly as possible.
7. Frequency pattern recognition – the patient hears three sounds, one of which differs from the others in pitch. The therapy participant has to indicate which stimulus was different.
8. Tone length recognition – the patient hears three tones: two of the same length and one longer. The child's task is to identify which sound differed in length.

All the above tests are performed by the child using headphones (3).

The aim of the training performed with the use of the described method is to automate the processing of auditory, visual and motor impulses (3).

NEUROFLOW METHOD

Another active method is the Neuroflow auditory training – the first in Poland interactive training of higher auditory functions used in APD therapy, as well as in children at risk from the age of 4. This training improves the efficiency of the child's communication and learning processes. It requires attention from the little one in order to be able to best answer the assigned tasks. The level of difficulty of the tasks is adapted to the abilities of the participant and it changes adaptively. This means that when a child answers correctly, the system makes his task difficult, and if incorrectly – the task facilitates (22, 23).

Auditory training is composed of modules corresponding to the needs of any selected type of clinical APD. The program, fit to several developmental stages, from preschool to adolescence, has a varied verbal material selected according to different age groups, including stories, poems, puzzles, the content of which includes appropriate language and stylistic aids. The training includes exercises in speech understanding in the presence of various jamming stimuli, from pleasant – such as birds singing, the sound of the sea, through neutral – discussions, to unpleasant for the ear, annoying, such as the sound of an electric toothbrush. After listening to a story, fairy tale or poem, the

next step is for the child to answer questions about the text he has just heard. This motivates the participant of therapy to listen carefully, even vigilantly, and to remember the content. The questions check understanding of the piece listened to, mindfulness and short-term memory (23, 24).

Neuroflow training is carried out in the child's place of leaving under parental supervision. It is divided into three parts that last approximately 8 weeks. Before each part of the training, a diagnosis is made, on the basis of which an individual Neuroflow exercise plan is created. Training sessions are held 3 times a week, each session lasts approximately 20-25 minutes. Full training takes about 24 weeks (22).

Young patients suffering from auditory processing disorders can also benefit from training focused on the auditory deficit (7).

TRAINING FOCUSED ON THE HEARING DEFICIT

The premise of training is to directly influence a specific auditory function. Therapy transforms the basic auditory mechanisms that determine cognitive processes, such as speech understanding, learning and memory (7).

During the therapy, certain auditory tasks are trained and the auditory system is simultaneously stimulated. This leads to favorable neuroplastic changes in the brain. Improving a specific auditory function has a positive effect on the improvement of the quality of life (7, 16).

In order for the auditory training intended for young patients with central hearing impairment to be effective, it should be long-term and intensive – at least 1 hour a day, 5 days a week, over a period of several weeks is required. Such training should take into account the individual capabilities of the therapy participant. It is important that the therapy does not only concern passive listening to sounds, but also takes into account tasks that enable the active participation of a few-year-old (7, 16).

In each case, a thorough diagnosis of auditory functions should be performed prior to training (7).

SPS-S METHOD (STIMULATION OF AUDITORY PERCEPTION USING THE SKARZYNSKI METHOD)

The concept of the creators of SPS-S therapy is mainly influencing the sense of hearing, and then the synergy between auditory-visual, auditory-motor and auditory-visual-motor (19).

Training in a group of no more than 4 subjects takes place in three series. Each of them lasts 5 days, roughly 3 hours a day. The participants of the therapy are stimulated with processed stimuli that reach them through a specially designed tool via air and bone conduction. The applied sound transformation is based, inter alia, on reducing the intensity of the stimulus in the left earpiece. Both the developed

schemes relating to sounds and the way of their administration train auditory attention, stimulate the functioning of the middle ear and perceptual-motor processes (19).

The first series of therapy is the passive part, during which patients only listen to the modified sound material. The next two series are active parts that interweave passive parts of training with tasks that stimulate auditory-visual, auditory-motor and auditory-visual-motor synergy. The activities and the sound material are adapted to the individual needs, problems and, obviously, the age of each patient (19).

INTERACTIVE METRONOME

The interactive metronome is a computer version of the classical musical metronome. Its task is to synchronize the movements of the arms and legs with the rhythm heard in the headphones. In addition, stimulation is used with the use of special gloves and sensory mats. A program using the above method is developed for 15 hours in series of three sessions over seven days. The exact number of sessions and their duration are adjusted to the possibilities and needs of the therapy participant. To conduct therapy, it is necessary to use a specialized, licensed audio or audio-video set. During training, you can also verify the quality and precision of the task, i.e. the time difference between the given rhythm and the movement performed by the participant. This allows for the development of motor planning, spatial and temporal analysis of rhythmic structures, as well as sequence memory (extremely important for the development of language functions) during therapy (3, 15).

LOGOPEDIC AND PEDAGOGICAL AUDITORY TRAINING

In the field of auditory training aimed at shaping phonemic and prosodic hearing, and developing speech understanding in noise, four stages are usually distinguished:

- detection of background sounds (sound detection),
- differentiation of sounds (discrimination),
- identifying (recognizing) different sounds, distinguishing:
 - sound intensity,
 - sound pitch,
 - sound length,
 - order of sounds,
 - distorted sounds,
 - sounds in the presence of a jamming impulse,
- speech understanding:
 - shaping phonological abilities – syllable and phonetic analysis and synthesis of words, listening and determining the number of words in a sentence, attention control, auditory concentration (e.g. by listening to audiobooks, recorded stories, dialogues, talking to the child about the content),

- shaping linguistic abilities – developing the vocabulary by means of, for example, creating words in the range of various categories, the ability to build sentences of various types, using correct grammatical forms of words in such a way that they enter into the right relationships in a sentence, and at the same time accurately convey the intended content,
- shaping verbal and conceptual thinking, tasks with the use of picture stories, read stories, sorting objects based on specific features and assigning names to them (16).

DISCUSSION

Over the years, many authors have undertaken the task of explaining exactly what central auditory processes are (25). Lasky and Katz believe that auditory processing concerns the use of and manipulation of sound stimuli through the central nervous system (26). On the other hand, Katz define central auditory processing as serial and parallel processing in the central auditory system responsible for auditory attention, detection and identification of acoustic signals, as well as remembering and reproducing auditory information (27). On the other hand, ASHA (American Speech Language Hearing Association) described auditory processing as “perceptual (nerve) processing of sound information in the central nervous system and neurobiological activity, which underlies the formation of auditory electrophysiological potentials” (28).

The number of children suffering from auditory processing disorders is not clear. Some researchers believe it is between 5 and 7%. Others disagree on the above values. They believe that it is higher and reaches even 10% (13).

BSA and ASHA report that the effectiveness of auditory training based on electronically modulated, modified (among them filtered) sounds has not been confirmed. The article does not describe, inter alia, Berard’s method due to the fact that its effectiveness has not been proven (16).

The number of auditory training sessions available is large. So far, however, no universal method has been developed that would effectively help every child (15).

The literature on the subject often emphasizes the advantages of auditory training in the form of computer games. Nevertheless, it is advisable to reduce the visual stimulation of the child, offering instead games and auditory games that use classical teaching aids, which are available to a large part of educational institutions (16).

CONCLUSIONS

An important feature of the therapy of auditory processing disorders is an individual approach to each patient and the selection of appropriate exercises and therapeutic methods taking into account the child’s difficulties and the stage of its

development. The presented review of therapeutic methods shows that currently therapists in Poland have a wide selection of auditory training, thanks

to which it will be possible to effectively improve the disturbed functions and alleviate the symptoms associated with APD.

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