ORIGINAL ARTICLE

INDEX COPERNICUS INTERNATIONAL

Reference values of selected auditory temporal processing tests for Polish school children

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Article history: Received: 06.07.2018 Accepted: 03.09.2018 Published: 30.10.2018

ABSTRACT:

Introduction: Distorted processing of auditory information has a negative impact on the child's cognitive development. There are only a few studies conducted by Polish researchers determining the normative values of psychoacoustic tests in auditory processing disorders. They are inconsistent due to different methodologies and different research protocols.

Objective: The aim of the work was to determine the reference values of selected psychoacoustic tests for the population of Polish children between 7 and 12 years of age.

Material and method: The study group consisted of 213 healthy children from 7 to 12 years of age. The condition for including the child in the study was an intellectual norm, proper sound sensitivity, proper development of children's voice and speech. All children underwent two auditory temporal processing tests. The diagnostic procedure used a standardized Frequency Pattern Test (FPT) and Duration Pattern Test (DPT). The tests were carried out in accordance with the authors' recommendations, using the original versions available on the CD for 60 dB SL intensity, simultaneously for the right and left ear.

Results: The reference values for FPT and DPT tests were determined at various age ranges in children aged 7–12. It has been shown that auditory functions change with age and development of the child. Reference values including age, language, cultural and educational differences were prepared.

Conclusions: The development of reference values for individual tests for the Polish children population is a key element in the reliable diagnosis of auditory processing.

KEYWORDS: auditory temporal processing, school-age children, reference values

INTRODUCTION

Distorted auditory processing in school-aged children is still a difficult medical, educational and psychological issue [5, 14, 15, 16, 18, 19]. Distorted processing of auditory information adversely affects the child's cognitive development. A literature review shows, that works in this area in many centers in the world are very intensive and have served to establish consensus, which constitutes an attempt to organize the diagnostic protocol [1, 2, 4, 13, 22, 23]. Previous studies of Polish researchers in this field are few in number and have served to establish normative values of barely a few psychoacoustic tests [3, 6, 7, 14, 15]. Due to the growing, not only medical but also social demand in our country, works that will allow to form a unitary diagnostic model in auditory processing disorder should be extended.

PURPOSE

This work aims to determine the reference values of selected psychoacoustic tests for the population of Polish children between 7 and 12 years of age.

MATERIAL AND METHOD

The study group consisted of 213 healthy children from 7 to 12 years of age.

All children underwent laryngological-phoniatric examination as well as logopedic and psychological consultation. Criteria for inclusion in the study were: intellectual norm, proper

DOI: 10.5604/01.3001.0012.4366

sound sensitivity, proper development of children's voice and speech. All children underwent two auditory temporal processing tests. The diagnostic procedure used a standardized test to assess different tone sequences varying in frequency – Frequency Pattern Test (FPT) and a test to assess different tone sequences varying in length – Duration Pattern Test (DPT). Tests were carried out in accordance with the authors' recommendations, using the original versions available on the CD at an intensity of 60 dB SL [8, 9, 10]. Sequences in both tests were presented in binaural form. In both tests, patients were given 30 tone sequences. In the FPT test (Frequency Pattern Test) patients were given 30 sequences of three tones at a frequency of 880 and 1122 Hz. The interval between sounds in a sequence was 200 ms. The child's task was to provide the correct sequence of presented tones (e.g., low – low – high). In the DPT test (Duration Pattern Test) patients were given 30 sequences of a 1000 Hz tone with a length of 500 ms – long and 250 ms – short. The interval between successive sounds was 200 ms. The child's task was to provide the correct sequence of presented tones (e.g., low – low – high). The test result in both cases was the percentage of sequences correctly identified by the child to the total number of sequences presented. Statistical analyzes were performed using Stat Staticica 10.0 by Stat-soft. The characteristics of distribution of quantitative variables for individual age ranges are presented in tables, with average values and standard deviation.

Comparative analyzes were preceded by Shapiro-Wilk's test assessing homogeneity of variance. Depending on the results of these analyzes, student's t-test was used to assess further relationships when data showed normal distribution and Wilcoxon's rank test for pairs or Mann-Whitney U test when the test results did not show normal distribution. Comparative analyzes of the influence of individual extra-auditory parameters (e.g., age, sex) on the obtained test values were made using one-factor analysis of variance (ANOVA) and were supplemented with intragroup dependency testing. A threshold level of significance $p < 0.05$ was used for formulation of conclusions from analyzes using statistical tests, Reference values for individual age ranges were determined, as a limit value assuming the average minus two standard deviations, when data in the age group showed features of normal distribution or the fifth percentile, when the results were characterized by unilateral distribution [12].

RESULTS

The first phase of the study consisted in calculating average values, constituting the average percentage of sequences correctly identified by the child in each of the tests used (FPT, DPT) and subsequently it was assessed whether the age and sex of the child affected test values. The study group included 120 girls (56.4%) and 93 boys (43.6%). In individual age brackets, the percentage of girls ranged from 50% to just over 59%. A statistical analysis was carried out assessing the impact of sex on values of individual psychoacoustic tests. As a result of analyses conducted, no significant differences were found between FPT and DPT test values obtained in girls and boys. There were no significant differences for all age brackets (Fig. 1).

Thus, in further analyzes, the results of tests for girls and boys were treated as originating from one group. This was followed by a calculation of average test values and a 95% confidence interval of values obtained for individual tests with the division into age groups. The analysis of both tests showed a correlation between the age of the child and percentage of properly identified sequences. The percentage of sequences correctly identified by the child increased with age. It was observed that depending on the type of test, values obtained varied in different age groups (Fig. 2). Statistical analyzes were performed assessing the influence of age on the values of individual tests.

Duration Pattern Test (DPT)

Histograms for the distribution of DPT values depending on the examined child's age showed that in children aged 7 and 8 years, the most frequently observed responses ranged from 50 to 80%, with a distribution similar to normal. Older children aged 9 to 12 years showed a significant increase in the test value of over 90%. Children of this age also showed a change in the nature of the observed distribution, which was similar to unilateral distribution. The distribution of average values showed a tendency of dynamic growth between 7 and 9 years of age, and in subsequent years was characterized by moderate stabilization with a marked upward trend at the age of 12. Slight decreases in value were observed in the 10th year of life, but without statistical significance. Analyzes were performed that confirmed a statistically significant effect of age ($F = 18.76$, $p = 0.0000$) on DPT test values. Based on the analyzes performed and considering the level of significance, DPT test values were different in individual age brackets. The analysis of DPT in the 7-year-old children group and in the 8-year-old group indicated a distribution similar to normal, while values in the 9–12 age group showed unilateral distribution. The analysis did not show statistically significant differences between the DPT test values of children in 9, 10, 11 and 12 years of age. Therefore, reference values were determined for three age groups: children in the age of 7; children in the age of 8; children in the age of 9–12. Considering the characteristics for the distribution of results, the 5th percentile was used as a reference for clinical purposes, thereby minimizing the num-

ber of false positives. Tightening of criteria for determining normative values is important due to the large intraindividual dispersion, especially in younger children. The table below shows average values and standard deviation, as well as the reference value (Tab. I).

Frequency Pattern Test (DPT)

Histograms of the distribution of FPT test values depending on the examined child's age showed that in children aged 7, 8 and 9, responses in the range from 40 to 80%, with a distribution close to normal were most frequent. There were results over 80% among these children, but there were also a few results below 40%. Oder children aged 10 to 12 years showed a significant increase in the test value, above 80%. Children of this age also showed a change in the nature of the observed distribution, which was similar to unilateral distribution. Statistical analysis showed that mean values for the FPT test differed depending on child's age. The lowest values occurred in the youngest children aged 7 and were statistically significantly different from other age groups. In the group of 8-year-old and 9-year-old children, the average level of the test was comparable (70.1% and 73.7%) and was significantly different from other age groups. Children aged 10 and 11 achieved similar results (84.3% and 84.1%), which were higher than the results obtained in younger children and differed statistically significantly from the average values of the test in the group of children at 12 years of age.

Analyzes showed a statistically significant effect of age ($F = 15.3$, $p = 0.0000$) on FPT test values. Test values obtained in children aged 7 were statistically significantly lower than the test values in other age groups. There were no statistically significant differences between the mean values in the age groups of 8 and 9 years and between age groups of 10 and 11 years. Analyzes of intergroup interactions allowed to distinguish the following age brackets: children aged 7; children aged 8–9; children aged 10–11 years; children under the age of 12. Values obtained in the group of children aged 7 and in the age group of 8–9 years showed a distribution similar to normal, however, values in the group of 10–11 and 12 years were characterized by unilateral distribution. Based on the homogeneity analysis of variance for clinical purposes, the 5th percentile value was taken as the reference value. Table II presents average values, standard deviation and reference value. The lowest test values, i.e., the lowest percentage of correctly identified sequences, were observed in the group of youngest children. This group showed the largest standard deviation, which indicates quite a large diversity of the group, most probably related to the lower level of maturity of the auditory system in comparison with children from older age groups.

Tab. I. Number of tests, average values, standard deviation, reference value of DPT test broken down by age groups.

AGE BRACKET	NUMBER OF TRIALS	AVERAGE [%]	STANDARD DEVIATION	REFERENCE VALUE
7-year-old	36.0	64.8	19.7	32.5
8-year-old	24.0	78.8	15.6	52.5
9–12 years	153.0	87.7	10.9	65.0

Tab. II. Number of tests, average values, standard deviation, reference value of FPT test broken down by age groups.

AGE BRACKET	NUMBER OF TRIALS	AVERAGE [%]	STANDARD DEVIATION	REFERENCE VALUE
7-year-old	36	55.6	19.9	15.8
8–9 years	65	72.4	16.6	39.2
10–11 years	74	84.2	10.6	63.0
12 year-old	38	92.4	7.6	77.1

DISCUSSION

The age criterion is a very important element in determining the auditory profile in children. Numerous literature data and own experience show that as the child grows and develops, auditory processes mature and progress [2, 4, 5, 7, 10, 11, 17, 21]. In audiological diagnostics this means increasing the number of sequences correctly identified by the child in selected psychoacoustic tests [2, 10, 11, 17]. The average values of time-conversion tests such as DPT, FPT show a fairly large variation, which is mainly related to the research methodology [8, 9, 20, 21]. This applies to the research protocol itself, the assessment made for one ear or both ears but also for cultural or educational differences. Unfortunately, normative values are also determined in various ways [1, 7, 14, 22]. According to ASHA, in the recognition of processing disorders the test value below the average minus two standard deviations is considered, while in the case of irregularities in only one test, the value of this test should be below the average minus three standard deviations. Therefore, there are a number of factors that have a significant impact on the normative values of tests carried out in children in different countries and different parts of the world. Therefore, as an environment, we should strive to develop Polish reference values for tests from all auditory test groups recommended by ASHA [1, 22]. This study helped to determine reference values in a binaural test on the basis of the 5th percentile value. Reference values indicated the lowest values of correctly identified sequences in each of the researched tests in the control group, assuming specificity of the test at a level of 95% below which the result obtained for each test was defined as incorrect. Our previous studies showed no effect of sex on the value of tests, which is consistent with

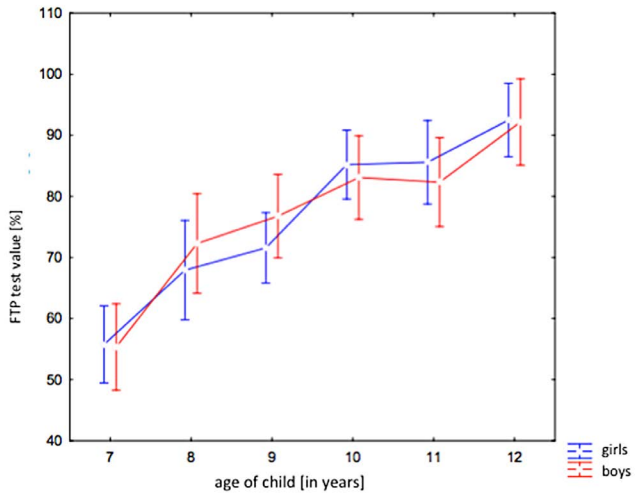

Fig. 1. Distribution of values for FPT test depending on gender.

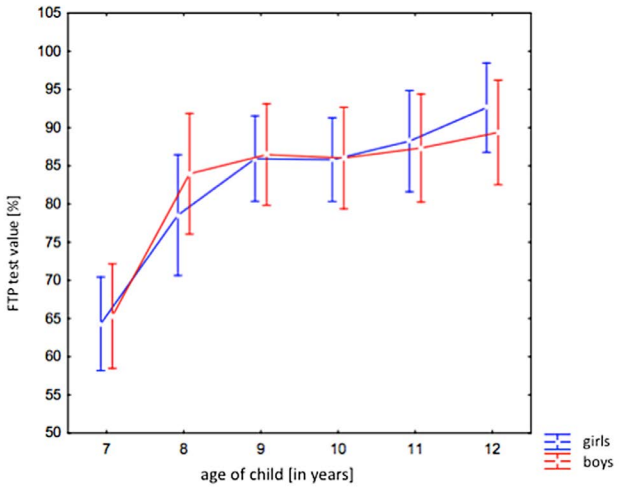

Fig. 2. Distribution of values for DPT test depending on gender.

the observations of other authors [3, 7, 17, 20]. Based on the analysis of the distribution of values in each of the tests used in the study, a very interesting phenomenon was observed in the research group, which consisted in a clear decrease in the values obtained in each test for a group of 10-year-olds. These values were close to those obtained by 7-year-old children. While the low values obtained in tests in 7-year-old children can be explained by the lowest, in comparison to other children, maturity of the auditory path related to age and the moment of beginning education at school, causing an increase in requirements in relation the hearing organ, insofar sudden lowering of these values for 10-year-old children requires reflection. It seems that the fall in value in 10-year-old children in the research group may be closely related to educational conditions. Integrated education covering the first three grades of primary school has a completely different substantive construction and other pedagogical goals and expectations. After this period, at the age of 10, children begin subject-oriented education and perhaps experiences increased demands imposed on them, as well as requirements for specialized sensory organs, especially sight and hearing, explain the reduction in test values in the group of healthy children.

CONCLUSIONS

Hearing functions change with a child's age and development; therefore, age norms should be applied in clinical practice. The child's gender does not affect the value of psychoacoustic tests. Assessment of reference values in psychoacoustic tests must consider linguistic, cultural and educational differences. Development of reference values for individual tests in our country will constitute a key element in the diagnosis of auditory processing processes in the population of Polish children.

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Word count: 2680 Tables: 2 Figures: 2 References: 23

Access the article online: DOI: 10.5604/01.3001.0012.4366 Table of content: https://otolaryngologypl.com/issue/11771

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Competing interests: The authors declare that they have no competing interests.

Cite this article as: Włodarczyk E., Szkiełkowska A., Piłka A.: Reference values of selected auditory temporal processing tests for Polish school children; Otolaryngol Pol 2018; 72 (6): 30-35; DOI: 10.5604/01.3001.0012.4667