Research Article

Screening of Auditory Processing Disorders in School-Aged Children in Tehran, Iran Using the Auditory Processing Domain Questionnaire

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Highlights

- The APD prevalence was 4.6%, with a 2.6 male-to-female ratio
- Screening of APD in normal children and comorbid disorders e.g. LD is necessary
- The parents and teachers of children in our study were not aware of APD

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ABSTRACT

Background and Aim: Early detection of auditory processing disorders (APD) is essential for preventing learning and educational problems in school-aged children. It is crucial to take into account the comorbidity with APD, as well. The goal of APD screening is to obtain the basic information about those with auditory disorders to be referred for further evaluation. This study aimed to identify the elementary school students at risk of APD in Tehran, Iran.

Methods: Participants were the parents of 536 children selected from 11 elementary schools in four districts of Tehran city. The schools in each district were selected by a random clustering method. The auditory system of students was first evaluated. The parents were then asked to complete the Persian version of the auditory processing domain questionnaire (APDQ).

Results: The prevalence of APD was 3.3% in girls and 8.3% in boys and the difference between them was statistically significant (p=0.021). The overall prevalence of APD was 4.6% based on the cut-off points of four APDQ domains, with a male-to-female ratio of 2.6.

Conclusion: It is necessary to screen APD in school-aged children to minimize learning and educational problems in them. Moreover, there is a need for developing screening methods to provide timely detection and appropriate intervention for those at risk of APD.

Keywords: Auditory processing disorder; screening; language index; attention index; auditory processing domain questionnaire

Introduction

The ability to listen, detect, perceive, and react to auditory stimuli is known as auditory processing. Listening as an active process helps with the rapid and exact analysis of these stimuli. It plays an important role in the development of linguistic skills [1]. Listening skill is crucially important for elementary students because they learn through listening in the classroom most of the time (60%) [2, 3]. Listening ability affects the quality of linguistic, reading, and writing skills in the first and second grades of elementary school [1]. Despite adequate peripheral auditory function, auditory processing disorder (APD) is a challenge to the central nervous system [4] that makes it difficult to listen to speech in a noisy environment [5]. It is a problem with auditory processing and is not related to cognitive and linguistic levels. However, difficulties with listening and speech perception in noise may have an impact on linguistic learning and practice. APD can cause problems in linguistic learning, communication, and cognitive skills, but it is not caused by these problems [6]. According to various studies, the prevalence of APD in school-aged children ranges from 2 to 20%. [2, 6-10]. Its prevalence in Iran is estimated to be about 5%, in average [11]. Other childhood diseases, such as attention deficit/hyperactivity disorder (ADHD), language disorder, learning disorder (LD), and autism spectrum disorder may demonstrate an APD-like behavior [6]. Interaction between the auditory and linguistic systems in a complex motor, attention, and cognitive network is required for speech processing. Impairment in any of these systems can be sign of APD or other neurophysiological disorders [7]. The prevalence of APD in children with LD is thought to be 30–50% [4, 5], although another study reported it as 80% [7]. Proper management and effective treatment for children with LD and other neurological disorders are based on pinpointing their specific impairments. APD-related deficiencies should be found in suspected children due to the relevance of auditory processing to language development. The interventional programs for LD children are designed based on the APD [4].

The purpose of APD screening is to obtain main information about the listening abilities so that the main criteria for central auditory processing diagnostic tests can be determined [6]. A consensus conference held by Jerger and Musiek at the Callier Center in Dallas on the diagnosis of APD in school-aged children reported the need for development and psychometric evaluation of questionnaires for APD screening in children by or without behavioral tests [6]. Questionnaires have advantages over other methods for identifying people at risk of APD because of their ease of use and being time-saving. Children's home inventory for listening difficulties (CHILD), children's auditory performance scale (CHAPS), evaluation of classroom listening behavior (ECLB), the scale of auditory behaviors (SAB), The auditory processing domain questionnaire (APDQ), listening inventory for education (LIFE), Fisher's auditory problem checklist, and the Buffalo model questionnaire (BMQ) are some of relevant questionnaires with acceptable psychometric properties [6, 7]. Fisher's auditory problem checklist includes behavioral items such as not paying attention to the instruction, the necessity to repeat the instruction, and inability to attend to auditory stimuli linked to a competing auditory signal. The CHAPS assesses auditory function in a variety of environments, including quiet, noisy, and competitive. The ECLB is used to detect listening problems of children in the classroom, but it has not been tested in patients with central APD. The SAB is a questionnaire filled by parents or teachers of children aged 4–6 years [6, 7]. The revised BMQ assesses the decoding, integration, organization, memory, and performance in noise and is suitable for both screening and monitoring of listening skills through therapy [7]. The APDQ assesses auditory processing abilities as well as listening challenges related to attention and linguistic abilities. It is filled by parents or teachers of students aged 7–17 years adapted from Conners et al. [12], Belliss and Ferre [13], Wilson [14], ASHA [15] and designed by O'Hara and Mealings [2]. This questionnaire can be used as a screening tool for LD, ADHD, and APD in children. Screening for APD without addressing cognitive, linguistic, and attention problems is not reliable due to the behavioral overlap of these problems. The APDQ estimates some aspects of attention and language skills and provides a more precise diagnosis of suspected APD children [2]. It was suggested for APD screening by the American Speech-Language-Hearing Association in 2010. The Persian APDQ is also a reliable and valid tool. It can be used to classify functional and behavioral features for designing interventional programs and parental consultation. It is also useful for determining treatment outcomes and following up [11].

Due to similarities between APD and other neurological diseases such as LD and ADHD, it is important to consider attention and linguistic ability [2]. Recently, the translation, localization, and psychometric evaluation of APDQ in Persian have been conducted [11]. This study aimed to use the Persian APDQ to identify elementary school students at risk of APD in Tehran, the capital of Iran with about 10 million populations. Since APD influence learning and education, finding a tool for prompt

identification, correct diagnosis, and having efficient early intervention can be beneficial in determining the number of school-aged children at risk of APD.

Methods

This descriptive-analytical study with a cross-sectional design was conducted on elementary school students aged 7–12 years in city of Tehran, Iran in the academic year 2018–2019. According to Iran's Ministry of Education, there were 520000 elementary school students in Tehran in 2017. Using a cluster randomized sampling method, 330 students were selected from girls' and boys' schools located in districts 3 (north), 4 (east), 6 (center), 11 (south) of Tehran. We were unable to obtain data from the schools in western Tehran due to their lack of cooperation. To avoid possible sample drop, the sampling size was set at a higher value than the initial sample size (n=304) calculated using the following formula: $n=Z^2P(1-P)/\Delta^2$ where $\Delta=KP$, $0<K<1$, $K=0.5$, and $p=0.05$. Finally, we had 536 students (larger sample) fortunately. All of samples were right-handed (According to the Edinburgh handedness inventory score) and Persian with a normal hearing. Audiometry and tympanometry were carried out if they had no medical record. The purpose of the study was first explained to their parents and they then signed an informed consent form.

The APDQ was used to collect data completed by the parents of students at the schools selected randomly. They were asked to answer each question based on the following scale: Always, Often, Sometimes, or Never. Permissions had obtained from the school principals. At each school, the classrooms had also been randomly selected. A quiet room with the fewest visual or auditory distractions was selected for hearing assessment. The external auditory canal and tympanic membrane were examined using otoscopy, and both ears were assessed using a handheld tympanometer (Tymp, Rexton, Denmark) and an audiometer (SA78B, Pejvak Ava, Iran). Each student was evaluated separately. An intensity level of 20 dB at 500–4000 Hz was set as normal in audiometry and type A tympanometry (–50<TPP (dapa)<+50, 0.3<Ytm (mmho)<1.6). The parents were then asked to fill the questionnaires completely. The questionnaire had 4 domains including auditory processing (AP, 31 items), attention control (AC, 10 items), language (11 items), and targeted auditory processing (TAP, 19 items). The cut-off points were 76.2, 61.3, 78.4, and 80.9% for each domain, respectively. A total score lower than the cut-off point indicates poor conditions at the assessed domain. The total number of items was divided by the sum of scores multiplied by 0.04 to obtain the score for each domain.

For data analysis, descriptive statistics (frequency, mean, and standard deviation), correlation test, Mann Whitney U test, independent t-test (to determine the effect of demographic factors such as gender on the total and domain scores) and ANOVA (to assess the difference between age groups) were used.

Results

A total of 720 questionnaires were distributed among selected schools. Of these, the data of 536 completed questionnaires were used in the study. Most of students were girls (n=391, 72.9%) from 11 schools in four districts. The lowest percentage of students (14.4%) were at grades 1 and 5, while the majority of them were at grades 2 and 4 (18.7%). The mean age of girls was 9.17±1.75 years old, while for boys it was 9.78±1.65 years. The mean scores in three domains of AP, TAP, and Language were not significantly different in terms of gender, school grade, and district ($p>0.05$). The mean score of the AC domain was not significantly different in terms of school grades or district ($p>0.05$), but it was significant in terms of gender ($p=0.002$) where the boys'

Table 1. Mean (standard deviation) scores of all four domains of the Persian version of the auditory processing domain questionnaire by gender (n=536; Tehran, 2019)

Domain	Mean (SD)		p	Observed power
	Male	Female		
AP	84.24 (17.15)	86.48 (15.24)	0.145	0.308
TAP	86.08 (15.05)	88.25 (12.77)	0.097	0.383
LAN	87.31 (15.35)	89.46 (13.41)	0.114	0.353
ATT	76.43 (21.21)	81.98 (17.55)	0.002	0.860

AP; auditory processing, TAP; targeted auditory processing, LAN; language, ATT; attention

Table 2. The relative frequency of auditory processing disorder based on gender (n=536; Tehran, 2019)

Domain	Participants who failed (n, %)	Female (n, %)	Male (n, %)	p	Observed power
Auditory processing	102 (19.0)	67 (65.7)	35 (34.3)	0.067	0.304
Targeted auditory processing	110 (20.5)	76 (69.1)	34 (30.9)	0.307	0.118
Language	87 (16.2)	58 (66.7)	29 (33.3)	0.150	0.197
Attention	76 (14.2)	45 (59.2)	31 (40.8)	0.005	0.684
Auditory processing and targeted auditory processing	93 (17.4)	62 (66.7)	31 (33.3)	0.157	0.214
Auditory processing and language	36 (6.7)	22 (61.1)	14 (38.9)	0.119	0.250
Auditory processing and Attention	35 (6.5)	21 (60.0)	14 (40.0)	0.079	0.290
Targeted auditory processing and language	35 (6.5)	20 (57.1)	15 (42.9)	0.047	0.419
Targeted auditory processing and attention	33 (6.2)	19 (57.6)	14 (42.4)	0.045	0.379
Language and attention	54 (10.1)	33 (61.1)	21 (38.9)	0.051	0.379
Auditory processing, targeted auditory processing, and language	34 (6.3)	20 (58.8)	14 (41.2)	0.071	0.333
Auditory processing, targeted auditory processing, and attention	33 (6.2)	19 (57.6)	14 (42.4)	0.045	0.379
Auditory processing, language, and attention	26 (4.8)	14 (53.8)	12 (46.2)	0.039	0.444
Targeted auditory processing, attention, and language	25 (4.6)	13 (52.0)	12 (48.0)	0.021	0.503
Auditory processing, targeted auditory processing, attention, and language	25 (4.6)	13 (52.0)	12 (48.0)	0.021	0.503

score was less than that of girls (Table 1). Based on the scores of four domains, 13 girls (3.3%) were at risk of APD and 8.3% of boys were referred for further evaluation. There was a statistically significant difference between boys and girls (p=0.021). Table 2 shows the results of those who had scores lower than the cutoff point

Table 3. The relative frequency of auditory processing disorder according to district and grade (n=536; Tehran, 2019)

		Total number	APD (n, %)	Other (n, %)	p	Observed power
District	3	112	8 (7.1)	104 (92.9)	0.193	0.293
	4	98	6 (6.1)	92 (93.9)		
	6	169	8 (4.7)	161 (95.3)		
	11	157	3 (1.9)	154 (98.1)		
Grade	1st	77	4 (5.2)	73 (94.8)	0.970	0.052
	2nd	100	6 (6.0)	94 (94.0)		
	3rd	87	3 (3.4)	84 (96.6)		
	4th	100	4 (4.0)	96 (96.0)		
	5th	77	3 (3.9)	74 (96.1)		
	6th	87	5 (5.7)	82 (94.3)		

APD; auditory processing disorder

at each domain. The APD prevalence was 4.6%, with a 2.6 male-to-female ratio. The AC domain revealed the impairment of 76 students (14.2%). Compared to girls, boys had more difficulties in AC (p=0.005). From grade 1 to 6, the APDQ scores of students improved; however, there were no significant difference based on school grade (p=0.97) and district (p=0.19) (Table 3).

Discussion

The present study showed that, among 536 elementary school students in Tehran, 3.3% of girls and 8.3% of boys were at risk of APD. The difference between boys and girls was statistically significant (p<0.05). The prevalence of APD was reported 4.6% with a male-to-female ratio of 2.6. The APD screening provides necessary information for experts in audiology to determine criteria for diagnostic central auditory processing tests. Nowadays, the diagnosis and treatment of APD, particularly in children has become a research priority in audiology throughout the world. Therefore, screening and identifying people at risk of APD are valuable [6]. The APDQ is a time-saving tool to screen a higher number of school students. It is more feasible considering the schools' administrative capabilities. Overall, APDQ has two advantages for screening and identifying at-risk school-aged children; by using four subscales, it can reduce the false-negative results and detect all affected children even those with comorbidities such as LD, ADHD, autism spectrum, and other neurological disorders. APD prevalence in LD is estimated to be 30–50% [4, 12]. In our previous study on LD children in Tehran, the risk of APD occurrence was 74.2% [16].

The exact prevalence of APD in the world is unknown, but it varies from 2 to 20% (2, 6–10). One study in the UK and the USA reported a prevalence of 3–5% in school-aged children by using behavioral diagnostic tests [17]. Geffner reported a prevalence of 12% using behavioral tests, while Katz found a prevalence of 20% using the BMQ [7, 10]. Ebadi et al. reported an APD prevalence of 5% in Arak, Iran by using the Persian version of Minimal Auditory Processing Assessment tool [18]. Therefore, there is an agreement between the results of Chermak and Musiek [17], Geffner [10], Ebadi, et al. [18] and the results of our study. It is known that the result of behavioral screening tests is more accurate with less error in comparison with the questionnaires. However, since the APDQ includes language and attention domains and considers comorbid diseases, its result was similar to the results of behavioral tests [18]. The APDQ was also used in another study on the school-aged normal children and with LD in Tehran which reported that the prevalence of APD was 7.2% [16]. The discrepancy may be due to the use of larger sample size and more precise sampling method in our study.

Overall, an APD screening program is required for school-aged children in Iran and need to be supported by the Ministry of Education. The parents and teachers of children in our study were not aware of APD. Hence, audiologists need to increase their awareness through knowledge sharing. Further diagnostic studies using a follow-up phase for at-risk students is recommended.

Conclusion

The prevalence of auditory processing disorders (APD) among school-aged children in Tehran is 4.6 %. Since APD is a common disorder and almost 60% of learning at primary schools is done through listening, early detection of children at risk of APD and comorbidities by precise tests and their subsequent referral for intervention are needed. It may prevent educational and learning problems at schools in the future.

Ethical Considerations

Compliance with ethical guidelines

This study obtained its ethical approval from the Ethics Committee of Iran University of Medical Sciences (Approval ID: IR.IUMS.REC. 1396-01-32-30717).

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Authors' contributions

FJ: Study design, data collection, interpretation and writing the manuscript; AP: Writing the manuscript; SJ: Study design and analysis of the data; MO: Analysis of the results.

Conflict of interest

The authors declare that there is no conflict of interest.

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