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RESEARCH ARTICLE

Screening of auditory processing disorder in children with learning disabilities using the Persian version of the auditory processing domains questionnaire

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Abstract

Background and Aim: Auditory processing disorder (APD), as a sensory processing defect, can be comorbid with other disorders such as learning disability (LD). LD has shown a greater likelihood of comorbidity with APD. Therefore, the deficits associated with APD needs to be identified in children with LD.

Given the high likelihood of APD comorbidity in children with LD, this study aimed to screen for APD in 8−12-year-old children with LD using the Persian auditory processing domains questionnaire (APDQ-P).

Methods: In this cross-sectional study, APDQ-P was administered on 250 normal children with a mean (SD) age of 10 (1.48) years old (153 girls and 97 boys), and 110 children with LD with a mean (SD) age of 9 (1.92) years old (40 girls and 61 boys). After obtaining the cut-off point, the scores of the two groups were compared by a t-test in 5 age categories. Finally, we calculated the number of children with suspected APD using APDQ-P.

Results: There was a significant difference between the scores of LD and normal group in all subscales including auditory processing, language and attention. About 75% of LD children failed in auditory processing, 86% in attention skills, and 82% in language skills.

Conclusion: A significant proportion of children with LD were suspected of APD, which could be indicative of a high likelihood of comorbidity of APD in children with LD. More accurate identification of the degree and type of APD in these children requires central auditory diagnostic tests.

Keywords: Questionnaire; auditory processing disorder; screening; learning disability

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Introduction

Auditory processing involves the mechanisms and processes including behavioral skills such as sound localization, auditory discrimination, auditory pattern recognition, understanding temporal aspects of audition (temporal resolution, temporal masking, temporal integration, and temporal ordering), and auditory performance with competing acoustic signal [1].The auditory information processing depends on the health of the

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auditory system and the correct transmission of auditory neural impulses to the spiral, thalamic, and cortical nuclei [2]. The malfunctioning of any part of the process causes difficulties in information processing and ultimately auditory processing disorder (APD).

Auditory processing is particularly crucial in the development of language skills of reading and writing at the school age [3]. It also plays an important role in the behavioral and scientific disorder and dysfunction in children at school age [4].

According to the second statement of the American Speech-Language-Hearing Association (ASHA) in 2005, based on the evidence of impairment in the production and development of language in children suspected of APD, in addition to the previous definition, APD was defined as a defect in neural processing of auditory stimuli, which might be associated with, and not as a result of, defects in other senses [5]. Many studies have indicated the comorbidity of APD with other growth disorders. Observations suggested that some types of childhood neuropsychological disorders such as attention-deficit/hyperactivity disorder (ADHD), language disorders, learning disorders and autism spectrum disorders may lead to behaviors similar to those of APD or APD as a disorder associated with other neurophysiological disorders [6,7].

Learning disability (LD) means an impairment in one or more of the psychophysiological processes that manifests itself in the understanding and use of spoken or written language [7]. Children with reading, learning, language and attention disorders may have a poor performance in auditory processing tests [8]. The prevalence of APD in children with LD has been reported as 30%−50% [9]. Effective management and treatment of children with LD require accurate identification of existing deficits and weaknesses. Due to the probability of APD in children, the APD-associated defects in this population should be identified and diagnosed and appropriate therapeutic approaches should be adopted [10]. Given the severity and complexity of central auditory processing tests in the diagnostic phase of APD, the screening stage of this disorder is required for referral to diagnostic tests. Screening for APD is performed in two ways: a set of behavioral screening tests and screening questionnaires. The APD screening tool should be inexpensive, easy to implement and accessible. In this regard, screening for APD through a questionnaire can save time and money. Also, questionnaires can provide specific and practical information about the everyday problems of individuals. Therefore, they have a significant advantage over behavioral tests [7]. Currently, several questionnaires are used for APD screening such as Fisher's Auditory Problems Checklist (FISHER) [11], Children's Auditory Performance Scale (CHAPS) [11], Evaluation of Classroom Listening Behaviors (ECLB) [12], Scale of Auditory Behaviors (SAB) [13], Buffalo Model Questionnaire Revised (BMQ-R) [13], and Auditory Processing Domain Questionnaire (APDQ) [14]. Developed by O'Hara in 2009 at the annual conference of ASHA APDQ is a standard questionnaire with valid psychometric properties (validity and stability), which evaluates language skills and some aspects of attention in addition to auditory skills. It has 52 items that are filled in by a parent or child instructor. The items in this questionnaire were taken from a general review of previous research and consultation with and assistance of experts in this field [15] which assesses auditory skills, hearing problems, language skills, and some aspects of attention in individuals aged 7−17 years, providing a more accurate and appropriate referral of people with APD and hence having a particular advantage [14]. APDQ is the only APD screening questionnaire translated into Persian. Its validity and reliability were obtained by Cronbach α (0.9), Pearson correlation coefficient (0.88), and cumulative variance (50.3) [15].

In view of the high likelihood of APD comorbidity in children with LD, the aim of this study was to screen for APD in 8−12-year-old children with LD using Persian version of APDQ (APDQ-P). As no official study reported the cut-off point of the APDQ-P, we first calculated its cut-off point, and then, addressed the main objective of the study, that is, screening for APD in children with LD compared to normal children.

Methods

In this cross-sectional study, we employed the APDQ-P which had valid psychometric properties (validity and stability) [15] to collect the data. After obtaining the informed consent of the participants and the Ethics Committee Approval Code (IR.IUMS.REC.1394. 9211301206), the APDQ-P was distributed among 620 parents of normal children and 150 parents of children with learning disabilities. The consent forms for participation were provided to the parents.

Finally, 263 questionnaires from parents of normal children and 101 questionnaires from parents of children with LD were collected. Subjects in the normal group had the inclusion criteria determined by interviewing their parents including the age of 8−12 years for both male and female children, no history of neurological disorders, good general health, no history of speech therapy and occupational therapy courses, and parents' education level of high school (diploma and above), Also their auditory abilities were measured by the audiometric test and the cases with normal hearing thresholds entered the study. In the case group, all the subjects were selected from learning disability schools in any kind of LD, who were referred by a psychiatrist’s discretion and were under treatment with the inclusion criteria of the age of 8−12 years old for both males and females, any kind of LD, no other neurological comorbidities such as ADHD/ autism spectrum disorder, parents' education level of high school diploma and above. There were 61 (60.4%) boys in the LD group and 97 (36.9%) in the normal group. The mean age and standard deviation was 9 ± 0.99 years in the LD group and 10.2 ± 1.48 years in the normal group.

$$\text{Questionnaire scorin} = \frac{[Scores\ of\ each\ subscale]}{Total\ number\ of\ each\ subscale \times 4} \times 100$$

Each item in each subscale is scored 4 for always, 3 for often, 2 for sometimes, and 0 for rarely.

In the first step, using the scores of normal and LD groups, the cut-off point values were obtained SPSS 16 and the receiver operating characteristic (ROC) curve were established to determine the rejection and acceptance values.

We used several statistical tests to assess the difference in the scores of the two study groups. The Kolmogorov-Smirnov showed that all the values related to the variables recorded in this study groups were normally distributed. T-test was run to analyze the data. The t-test was used to examine the differences between the mean scores of the each subscale of questionnaires including auditory processing (AP), targeted auditory processing (TAP), language (LA), and attention (AT) in the two groups. In the next step, the number of cases who failed in this screening questionnaire was calculated.

After this step, since there was a one-year difference between the average ages of two groups, the effect of age must be checked. Changes of APDQ-P scores in terms of age were calculated as the last step. In other words, the difference between LD and normal groups was investigated again in 5 age categories including 8, 9, 10, 11, 12 years old. For this aim, the number of LD and normal cases for each year was 20 and since the data was normally distributed, t-test was used run to analyze the data.

Results

The cut-off point values were obtained for each subscale with a sensitivity and specificity of above 70% (76% for AP, 80% for TAP, 78% for LA, 61% for AT). The ROC curve obtained for the Persian version of APDQ questionnaire is presented in Fig. 1, and the sensitivity and specificity values of each subscale are presented in Table 1.

Using the cut-off point values obtained in this study, 74% of children with LD were rejected at the APD screening stage. Additionally, 86% of the children with LD in the attention subscale and 84% in the language subscale were rejected in the screening stage and were suspected of having the disorder. On the other hand, in the normal group, 9% of the children in the auditory processing subscale, 9% in the language subscale, and 19% in the attention subscale obtained a score of lower than the cut-off point. Also, the pass-fail percentage is presented in Table 2 in more detailed. The scores of the normal and LD groups in each subscale are presented in Table 3. The t-test

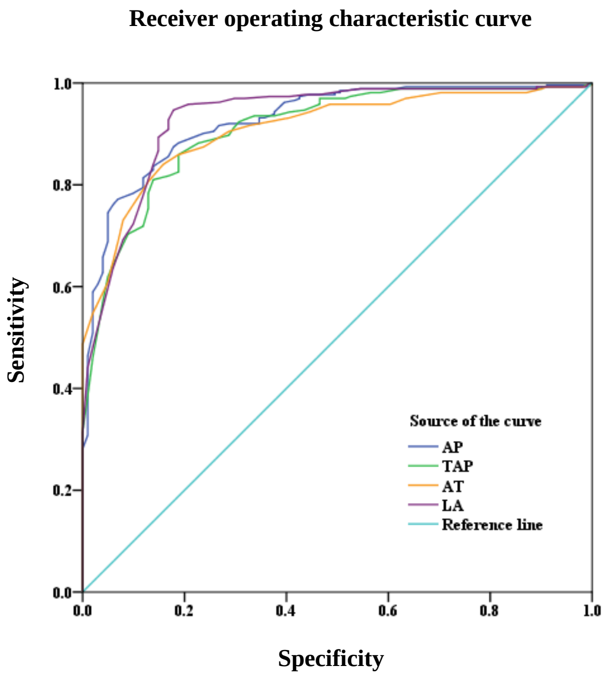

Fig. 1. Receiver operating characteristic curve for the Persian version of auditory processing domain questionnaire. AP; auditory processing, TAP; targeted auditory processing, AT; attention, LA; language.

results showed the significant difference between normal and LD children in all ages ($p < 0.05$).
The result of subscales scores belonged to each age groups including 8, 9, 10, 11, and 12 years old was mentioned in Table 3. There were significant difference between LD and normal groups of each age category (Tables 4 to 8).

Discussion

In the present study, first, the cut-off point of the Persian version of APDQ was employed to identify those suspected of APD, which is reported in Table 1. According to the results, the cut-off point of the Persian version of APDQ (76% for AP, 80% for TAP, 78% for LA, 61% for AT) had a significant sensitivity and specificity of over 70%. In the study by the developer of APDQ, the cut-off point in each subscale had a sensitivity of 75% and specificity of 89%, which is consistent with the results of the present study [14].
The results of t-test showed that there were significant differences between the normal children and children with LD in terms of different APDQ subscales scores. According to the results, the score of children with LD in each subscale including auditory processing, language, and attention was significantly lower than those of the normal children. This can be indicative of poor auditory processing performance in children with LD (74%), which is in line with the previous research. It would be worth mentioning that the high percentage of the failed LD cases could be due to, firstly, including students of any learning disability disorder. For instance, the reading disability can decrease the number of the failed cases. Secondly, it is the result of screening step and possibility of suspected cases of APD in LD group, it does not mean final diagnosis.
Several studies have shown comorbidity of APD in children with other neurological disorders. In a study by O'Hara and Melings the developer of APDQ, the questionnaire was used for a normal group and a group with LD, ADHD and APD [14]. There was a significant difference in the mean of each subscale between the normal group and the group with other disorders, such that the

Table 1. Cut-off point for the Persian version of auditory processing domain questionnaire

Subscales	Cut-off point (%)	Sensitivity (%)	Specificity (%)
Auditory processing	76.20	88	82
Targeted auditory processing	80.92	81	83
Language	78.40	89	85
Attention	61.25	80	87

Table 2. The numbers of cases passed and failed in normal and learning disability groups according to the Persian version of auditory processing domain questionnaire

		Learning disability		Normal	
Subscales	**Cut-off point**	**Number**	**Percent**	**Number**	**Percent**
Auditory processing					
	Lower than 76.2	64	74	23	9
	Upper than 76.2	24	26	233	91
Targeted auditory processing					
	Lower than 80.9	75	82	44	17
	Upper than 80.9	17	18	212	83
Language					
	Lower than 87.4	77	84	23	9
	Upper than 78.4	15	16	233	91
Attention					
	Lower than 61.2	79	86	48	19
	Upper than 61.2	13	14	208	81

scores of the group with LD, ADHD, and APD were significantly lower than those of the normal group, which agrees with our findings according to the author (developer), the results indicated poor auditory processing skills in children with neurological disorders such as LD and

Table 3. Mean (standard deviation) scores of the Persian version of auditory processing disorder questionnaire in normal and learning disability groups in 5 age categories

Group	n	Age (year)	Mean (SD) score			
			Auditory processing	**Targeted auditory processing**	**Language**	**Attention**
LD	23	**8**	61.12 (23.71)	61.38 (24.60)	55.47 (24.85)	39.86 (20.12)
	21	**9**	54.08 (18.47)	55.70 (19.31)	49.24 (16.62)	38.33 (13.11)
	21	**10**	60.44 (19.20)	61.91 (19.69)	54.18 (24.99)	42.50 (15.81)
	22	**11**	68.17 (13.04)	70.85 (13.52)	61.71 (14.45)	51.73 (9.37)
	23	**12**	56.35 (8.47)	58.88 (8.28)	56.25 (14.04)	47.19 (9.39)
	110	**Total**	60.41 (19.81)	61.68 (20.53)	55.14 (21.57)	42.47 (16.56)
Normal	56	**8**	86.96 (16.94)	87.26 (16.91)	86.72 (17.89)	73.68 (15.15)
	37	**9**	88.16 (14.58)	87.97 (14.94)	90.62 (15.20)	70.04 (15.32)
	44	**10**	89.18 (11.27)	88.04 (15.33)	89.98 (15.46)	69.43 (19.54)
	57	**11**	91.17 (8.38)	91.33 (8.23)	93.48 (7.16)	73.18 (14.71)
	56	**12**	92.69 (6.74)	92.82 (7.13)	93.92 (7.17)	78.24 (10.40)
	250	**Total**	89.81 (11.56)	89.55 (12.84)	91.42 (12.89)	72.20 (15.94)

Table 4. The result of t-test for score differences in 8 years old normal and learning disability groups

	Mean (SD) score		
Subscales	**Normal (n = 20)**	**LD (n = 20)**	**p**
Auditory processing	83.50 (22.74)	62.98 (20.86)	0.005
Targeted auditory processing	83.75 (22.74)	64.94 (21.75)	0.011
Language	83.18 (23.53)	62.04 (23.98)	0.008
Attention	70.75 (19.73)	39.63 (19.97)	<0.001

LD; learning disability

ADHD [14]. Also, several studies (16 to 21) have shown comorbidity of APD in children with LD through central tests. In a study by King et al [16], the likelihood of the comorbidity of APD dyslexia disorder was investigated. They reported that almost half of the people with dyslexia showed poor APD results. According to the author, considering the high comorbidity rate of these two disorders, the assessment of auditory processing in children with dyslexia should be taken into consideration, confirmed by the findings of the present study [16]. In a study in 2006, they examined the prevalence of APD in children with non-verbal learning disabilities. A test battery of central auditory, learning, and memory tests were performed demonstrating that 61% of children with learning disabilities had weaknesses in central tests [17]. In another study in 2010, differences in the behavioral profiles of 19 children with dyslexia and 25 children with APD were investigated. They employed auditory processing and language tests, level of literacy, evaluation of non-verbal intelligence, as well as Children's Auditory Performance Scale (CHAPPS) and Children's Communication Checklist-second edition (CCC-2) questionnaires [18]. According to the statistical results, the two groups showed similar performance in the test results. These results show similarities in behavioral profiles between children with APD and children with dyslexia, which is a learning disability. In one study, the results of central auditory assessments in children with LD showed a weakness in the central auditory system. In this study, there was a significant improvement in auditory performance of these children following a central auditory training. The results also indicated the comorbidity of APD in children with learning disabilities [19]. In another study, the ability to control auditory disturbances in

Table 5. The result of t-test for score differences in 9 years old normal and learning disability groups

	Mean (SD) score		
Subscales	**Normal (n = 20)**	**LD (n = 20)**	**p**
Auditory processing	86.61 (10.53)	61.50 (22.06)	<0.001
Targeted auditory processing	86.25 (11.51)	55.87 (18.74)	<0.001
Language	86.00 (16.20)	52.09 (16.36)	<0.001
Attention	70.62 (11.72)	39.97 (11.77)	<0.001

LD; learning disability

Table 6. The result of t-test for score differences in 10 years old normal and learning disability groups

	Mean (SD) score		
Subscales	**Normal (n = 20)**	**LD (n = 20)**	**p**
Auditory processing	84.04 (9.94)	62.22 (20.30)	<0.001
Targeted auditory processing	83.87 (11.44)	60.42 (20.29)	<0.001
Language	85.53 (9.05)	54.34 (24.33)	<0.001
Attention	67.82 (18.78)	42.48 (15.39)	<0.001

LD; learning disability

normal children and children with LD was examined. According to the results, children with LD had difficulty in controlling unwanted and unrelated auditory disturbances, which indicated a weakness in auditory processing skills in this population [20]. Another study which investigated the processing in children with LD showed that children with learning disabilities had a significant weakness in auditory processing examination tests compared to the normal group [21] this study supports their findings.

As the results of the present study and previous studies suggest, children with LD can have difficulty in auditory skills. In fact, from a more comprehensive perspective, auditory processing depends on parallel and network interaction throughout the cortical and subcortical regions. Although some of the brain regions are considered as single-sensory regions (auditory brainstem, auditory cortex), it is now argued that neurophysiological responses and neuronal activity in some of these areas change by non-auditory input, too. Auditory processing is a complex process, and interactions between the brain regions significantly affect the comorbidity of APD with other disorders such as ADHD and LD [22]. As a secondary result of auditory problems in children with APD, language disorders, disorders in reading and dictation, lack of attention and restlessness might occur.

Conclusion

Based on the findings, the Persian version of the auditory processing domains questionnaire (APDQ-P) revealed that 7.2% of normal children and 74.2% of children with learning disability (LD) failed in the auditory processing disorder (APD) screening stage, which shows a significant difference. In order to accurately determine the type and extent of APD, central auditory tests are

Table 7. The result of t-test for score differences in 11 years old normal and learning disability groups

	Mean (SD) score		
Subscales	**Normal (n = 20)**	**LD (n = 20)**	**p**
Auditory processing	92.50 (8.41)	64.34 (9.67)	<0.001
Targeted auditory processing	92.50 (8.16)	66.86 (10.30)	<0.001
Language	89.68 (9.68)	59.36 (11.03)	<0.001
Attention	76.63 (13.55)	51.12 (7.68)	<0.001

LD; learning disability

Table 8. The result of t-test for score differences in 12 years old normal and learning disability groups

	Mean (SD) score		
Subscales	**Normal (n = 20)**	**LD (n = 20)**	**p**
Auditory processing	91.94 (6.46)	55.32 (7.86)	<0.001
Targeted auditory processing	91.78 (7.20)	57.96 (7.70)	<0.001
Language	93.86 (6.26)	55.79 (12.30)	<0.001
Attention	75.75 (11.06)	46.88 (9.55)	<0.001

LD; learning disability

necessary. Effective treatment and management of children with LD require accurate identification of existing deficits. According to the results of studies, APD can be a common disorder in this group of children. Therefore, screening and comprehensive assessment of auditory processing skill in children with learning disabilities will be effective in their rehabilitation program.

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Conflict of interest
The authors declared no conflicts of interest.

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