Auditory and Vestibular Research

Psychometric Properties of the Persian Version of the Teacher's Evaluation of Auditory Performance In Auditory Processing Disorder Screening

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Highlights

- P-TEAP is a valid tool for screening APD in Persian-speaking children.
- Cut-off score of 6 yields 98.5% sensitivity, 92.1% specificity (SAB-T).
- Strong correlation of P-TEAP with SAB-T (r=0.901) and BKB tests.

Abstract

Background and Aim: Auditory Processing Disorder (APD) impairs auditory information processing specially affecting speech understanding in noise. Early screening is essential to address learning and social challenges. The Teacher's Evaluation of Auditory Performance (TEAP) is a validated teacher-based APD screening tool. This study translated TEAP into Persian (P-TEAP), evaluated its psychometric properties, and assessed correlations with the Scale of Auditory Behaviors (SAB) and Bamford-Kowal-Bench (BKB) sentence test.

Methods: The TEAP was translated trough the International Quality of Life Assessment method. Face and content validity were assessed. Teachers completed both the P-TEAP and the SAB, while parents completed the parent version of SAB, for 243 children aged 7–13 years including 93 males, who underwent hearing screening and BKB testing.

Results: All items were clear and relevant (CVR=0.92, CVI=1). Cronbach's α was 0.905 for the total scale. Test-retest reliability was excellent (ICC=0.99). Convergent validity was supported by correlations with SAB-T (r=0.901), SAB-P (r=0.716), BKB right ear (r=-0.614), and BKB left ear (r=-0.590). ROC analysis identified a cut-off score of 6 with 95.0% sensitivity and 68.3% specificity using BKB as reference, and a cut-off of 6 with 98.5% sensitivity and 92.1% specificity using SAB-T as reference.

Conclusion: The P-TEAP is a valid and reliable tool for screening APD in Persian-speaking children. Its robust psychometric properties and correlations with SAB and BKB support its use in research and clinical settings.

Keywords: Auditory processing disorder, screening, validity, reliability, children

Introduction

Auditory Processing Disorder (APD) involves deficits in central auditory processing, leading to difficulties in sound localization, auditory discrimination, and speech perception in noise, despite normal hearing thresholds [1]. Children with APD may struggle with following multi-stages, understanding rapid speech, or communicating in noisy environments [2]. The prevalence of APD among school-aged children varies widely across studies, ranging from 2% to 8%, depending on the diagnostic criteria, assessment tools, and demographic characteristics of the study populations [3]. In Iran, APD prevalence ranges from 4.5% to 11%, with boys affected nearly twice as often as girls [3, 4]. Another study in Kerman reported an 8.03% prevalence of APD in elementary school children, with higher rates observed in urban compared to suburban areas [5]. Approximately 50% of children with learning disabilities may have co-occurring APD, affecting 2–5% of school-aged children [1, 6]. Early identification is essential to reduce the adverse academic and social effects of APD. [7].

Assessing APD remains complex due to the absence of a universally accepted gold standard, a limitation acknowledged by the American Academy of Audiology (AAA) because of variability in APD profiles [8]. Diagnosis typically involves a battery of behavioral auditory tests targeting processes such as dichotic listening, temporal processing, and auditory discrimination, supplemented by case history, questionnaires, and occasionally electrophysiological measures like auditory brainstem response [9]. The American Speech-Language-Hearing Association (ASHA) and AAA advocate a multidisciplinary, test-battery approach to address the heterogeneity of symptoms and comorbidities [1, 8].

Speech-in-noise tests are critical for identifying listening difficulties associated with APD. The Bamford-Kowal-Bench (BKB) sentence test, initially developed for English-speaking children with hearing impairment or cochlear implants, evaluates speech recognition in noisy environments and has been widely adapted into various languages and groups [10]. The Persian BKB test, developed and validated with linguistically appropriate sentences and calibrated SNRs, is a useful tool for assessing speech perception in Persian-speaking children; combining questionnaires with speech-in-noise tests enables faster and more comprehensive identification of APD and related difficulties [10].

Questionnaires play a crucial role in the rapid screening and initial identification of children at risk for APD, offering insights into listening behaviors and communication challenges. These tools that completed by audiologists, teachers, or parents, guide referrals for comprehensive audiological evaluations. Widely used APD screening tools include the Children's Auditory Performance Scale (CHAPS) [11], Auditory Processing Domains Questionnaire (APDQ) [12], Scale of Auditory Behaviors (SAB) [13, 14], and Screening Instrument for Targeting Educational Risk (SIFTER) . The Teacher's Evaluation of Auditory Performance (TEAP), developed by Purdy et al. in 2002, is a teacher-based screening tool for APD, with a validated Spanish adaptation demonstrating good reliability and validity [15, 16].

The TEAP was selected for this study over other validated questionnaires due to its unique advantages. While APDQ (52 items) and CHAPPS (36 items) can be completed by parents or teachers, their time consuming may reduce response rates [17]. The SAB, primarily parent-focused with some teacher applicability, is limited to auditory issues [13, 14], and SIFTER targets hearing-impaired children in mainstream schools [18, 19]. In contrast, the TEAP, with only 10 items, is designed for teacher administration, enhancing feasibility in educational settings, and assesses both auditory and linguistic abilities in children with or without hearing aids or cochlear implants who are suspected of APD. This brevity and comprehensive scope make the TEAP an efficient and versatile tool for screening APD in diverse populations.

Given the prevalence of APD and the need for effective screening, this study aimed to translate and adapt the TEAP into Persian, evaluate its psychometric properties, and assess its convergent validity against the Persian SAB scale and BKB sentence test in children aged 7–13 years.

Methods

Study Design and Participants

This cross-sectional study followed the Consensus-based Standards for the Selection of Health Measurement Instruments (COSMIN) methodology [20]. This study included 243 children, aged 7–13 years, recruited from

primary schools in Tehran, Iran, using a convenience (or simple) sampling method. Inclusion criteria were: Passing pure-tone audiometric screening at 20 dB HL at 500, 1000, 2000, and 4000 Hz in both ears [21]; normal otoscopic findings; monolingual Persian speakers; Ethical points for children research were considered and signed parental informed consent; and appropriate behavioral cooperation during audiological evaluations. Children were not included if they had a history of any neurological or cognitive conditions, including epilepsy, brain surgery, head trauma with loss of consciousness or any history of professional music trainings, as documented in school health records or reported by parents. Additional exclusion criteria included cerumen impaction, failure in pure-tone hearing screening, incomplete assessment data, or lack of cooperation during testing. To ensure a typically developing sample, children with diagnosed developmental, cognitive, or language-related disorders—such as attention-deficit/hyperactivity disorder (ADHD), dyslexia, learning disabilities, or autism spectrum disorder— were excluded based on information obtained from parental reports, school health records, and a researcher-designed questionnaire used for history-taking. The exclusion was also confirmed by a review of the children's health documentation, ensuring that no undiagnosed conditions such as autism were present. Additionally, as all participants attended regular schools and were not enrolled in special education programs, the likelihood of undiagnosed conditions was considered very low.

Procedures

The TEAP is a teacher-reported screening tool designed to identify auditory and listening difficulties in classroom environments. It consists of two sections: Section A includes four items (A1–A4) rated on a 7-point Likert scale ranging from +1 (less difficulty than peers) to –5 (cannot function at all). The possible range is –20 to +4. Section B includes six yes/no items (B1–B6), with a possible range of 0 to 6, assessing observable auditory and language-related behaviors. The total score is calculated by summing the responses from Section A and scoring "No" responses in Section B as 1 and "Yes" as 0. The total P-TEAP score ranges from –20 to +10, with scores ≥6 indicating normal auditory performance and scores <6 suggesting potential APD. The Spanish version demonstrated good reliability (Cronbach's $\alpha = 0.82$; test-retest reliability, ICC = 0.86) [15, 16].

After obtaining written permission from the original developer, the TEAP was translated into Persian (P-TEAP) using the six-stage International Quality of Life Assessment (IQOLA) method [22]. Two native Persian-speaking audiologists with healthcare backgrounds and cultural knowledge, fluent in English and experienced in translating questionnaires, performed forward translation. A third skilled bilingual translator back-translated the Persian version. The research team and the original TEAP author reviewed the equivalence of the results.

A panel of 10 audiologists with clinical and academic expertise in APD evaluated the face and content validity of the Persian version of the TEAP questionnaire. Additionally, five teachers provided qualitative feedback on the Persian version to ensure its appropriateness for the target population (face validity). For face validity, experts rated the appropriateness of each item on a 5-point scale (1 = not appropriate, 5 = highly appropriate). The Lawshe method was utilized to determine the content validity ratio (CVR) [23], and the Waltz and Basel method was used for the content validity index (CVI) [24]. For CVR, panel members rated the necessity of each item on a 3-point scale: essential (3), useful but not essential (2), or not essential (1). For CVI, experts evaluated three criteria—relevance, clarity, and simplicity—using a 4-point scale for each (1 = irrelevant/non-transparent/non-simple, 4 = highly relevant/completely transparent/quite simple). The Item-level CVI (I-CVI) was calculated as the proportion of experts rating an item as 3 or 4 for each criterion, and the Scale-level CVI (S-CVI/Ave) was computed as the average of I-CVI values across all items. A CVR value greater than 0.62 and an I-CVI or S-CVI/Ave value of 0.78 or higher were considered acceptable [24, 25]. Participants completed the valid Persian versions of the SAB, in addition to the translated version of TEAP, to assess concurrent validity. The SAB is a 12-item questionnaire designed to assess auditory behaviors commonly associated with auditory processing disorder (APD). Each item is rated on a 5-point scale from 1 (frequently) to 5 (never), with total scores ranging from 12 to 60; lower scores suggest greater auditory processing difficulties [14]. In this study, the questionnaire was completed by both teachers (SAB-T) and parents (SAB-P). A cut-off score of 46, based on the original validation, was used to identify children at risk for APD. The Persian version of the SAB has demonstrated strong psychometric properties, with Cronbach's alpha coefficients of 0.933 for SAB-T and 0.923 for SAB-P, and excellent test-retest reliability (ICC = 0.963) [13].

Audiological assessments were conducted in a quiet school setting that complied with the environmental noise level standards outlined by the American National Standards Institute (ANSI S3.1-1999 R2018) [26] and followed the procedural guidelines recommended by the ASHA [21].

To confirm the normal function of the external auditory canal, tympanic membrane (TM), and middle ear, an otoscopic examination was performed to rule out conditions such as cerumen impaction, otitis externa, TM perforation, cholesteatoma, and otitis media. Pure-tone screening followed ASHA guidelines and was performed at 500–4000 Hz at 20 dB HL in each ear; children passed if they responded to all frequencies bilaterally, and failed if any frequency was missed, indicating need for further evaluation [21].
The Persian version of the BKB sentence test was used to assess speech recognition in noise. Sentences were presented binaurally via circum-aural headphones (TSCO TH5129) connected to a calibrated ASUS Vivobook R1502ZA laptop, with output levels verified using a Brüel & Kjær analog one-third octave band sound level meter (Denmark). Sentences were presented at 50 dB SL over a four-talker babble background noise at SNRs of –3, 0, +3, and +6 dB. Testing started at –3 dB SNR, increasing stepwise until the participant correctly repeated at least two key words. The speech recognition threshold—defined as the SNR at which 50% of the key words were accurately repeated—was recorded separately for each ear. The BKB threshold of ≥3.5 dB SNR was based on the Persian validation study, which established its suitability for detecting APD-related speech-in-noise difficulties. According to experts' opinions, sentences obtained an acceptable level of content validity (CVR > 0.62). However, test-retest reliability and ICC data for the Persian version of the BKB were not reported. Only CVR data were provided as part of the reliability assessment, with CVR values indicating the relevance and appropriateness of the items in the test [10].

Data Analysis

To assess the content validity, the CVI indices from the Waltz and Basel methods and the CVR from the Lawshe method were utilized [23, 24].
The area under the curve (AUC) was calculated using receiver operating characteristic (ROC) analysis to evaluate the predictive validity of the total P-TEAP score for identifying children at risk for APD. In the absence of a gold standard for APD diagnosis, two surrogate references were used: the Persian BKB test (risk defined as ≥3.5 dB SNR in either ear) and the teacher-completed Persian SAB (SAB-T), with scores ≤46 indicating APD risk..
Internal consistency was assessed using Cronbach's alpha for Section A, which includes Likert-scale items [27], and the Kuder-Richardson Formula 20 (KR-20) for Section B, which consists of dichotomous (yes/no) items [28]. This distinction ensures that the appropriate reliability coefficient is applied based on the measurement scale of each section. Internal consistency is considered acceptable if the estimate is 0.70 or higher [27, 28]. The reliability of a test was assessed using the intra-class correlation coefficients (ICC). This assessment involved asking ۴۸ teachers to complete a questionnaire twice, two weeks apart. Convergent validity was established by calculating the correlation between the TEAP, SAB, and BKB scores. The Pearson correlation coefficient assessed the convergent validity between the TEAP, SAB, and BKB scores. The data were analyzed using SPSS software version 25, with the significance level at 0.05.
This study received ethical approval from the University of Social Welfare and Rehabilitation Sciences (USWR) with reference number IR.USWR.REC.1403.140. Written informed consent was obtained from all participants.

Results

Participant characteristics

Of 257 screened children, 243 met inclusion criteria (93 males, 38.1%; 150 females, 61.9%; mean age = 8.8 ± 1.6 years).Fourteen children were excluded due to not meeting one or more eligibility criteria. APD risk was identified in 41 children (16.9%) based on BKB thresholds ≥3.5 dB SNR and in 38 children (15.6%) based on SAB-T scores ≤46. All participants passed audiometric screening and had normal otoscopic findings; audiological and questionnaire results are summarized in Table 1.

Translation

Content and face validity

Face validity scores ranged from 4.3 to 4.6, with a mean of 4.44, indicating high acceptability of the questionnaire's wording and appearance. The mean CVR was 0.92, with values ranging from 0.8 to 1.0, demonstrating that all items were deemed essential for assessing auditory behavior. For content validity, I-CVI

values for relevance were 1.0 across all items, reflecting perfect expert agreement. I-CVI values for clarity and simplicity ranged from 0.8 to 1.0, with S-CVI/Ave values of 1.0 for relevance, 0.96 for clarity, and 0.93 for simplicity.

Receiver operating characteristic curves

Based on the Persian BKB sentence test as a reference, the AUC for the total P-TEAP score was 0.843 (95% CI, 0.758–0.928), indicating good discriminatory ability (Figure 1-A). Based on the teacher-completed Persian SAB (SAB-T) as a reference, the AUC for the P-TEAP total score was 0.954 (95% CI, 0.900–1.000), indicating excellent discriminatory power (Figure 1-B). The optimal cut-off point, determined using the Youden index and the closest point to (0,1), was 6, yielding a a sensitivity of 98.5% and a specificity of 92.1% based on SAB-T.

Internal consistency

Internal consistency for Section A (Q1–Q4), which includes Likert-type items rated on a 7-point scale, was assessed using Cronbach's alpha. The resulting coefficient was 0.952, indicating excellent internal reliability. Internal consistency for Section B (Q5–Q10), comprised of dichotomous (yes/no) items, was assessed using the Kuder-Richardson Formula 20 (KR-20), which yielded a value of 0.832, indicating good reliability. The total scale (Q1–Q10) had a Cronbach's alpha of 0.905, which is considered excellent. Corrected item-total correlations ranged from 0.450 to 0.936, all exceeding the acceptable cut-off point of 0.30.

Pearson correlation coefficients indicated strong inter-scale associations within the P-TEAP: between Section A and the total score ($r = 0.988$, $p < 0.001$), Section B and the total score ($r = 0.914$, $p < 0.001$), and between Sections A and B ($r = 0.840$, $p < 0.001$). These results suggest high internal coherence among the subscales.

Test-retest reliability

The ICC was 0.99 (95% CI: 0.97–1.0), indicating excellent test-retest reliability.

Convergent validity

Convergent validity was supported by correlations with SAB-T ($r = 0.901$, $p < 0.001$), SAB-P ($r = 0.716$, $p < 0.001$), BKB right ear ($r = -0.614$, $p < 0.001$), left ear ($r = -0.590$, $p < 0.001$). The negative correlations with BKB scores are expected, as lower SNR thresholds indicate better performance. These findings provide evidence of convergent validity, as they demonstrate moderate and strong correlations with related constructs.

Discussion

Auditory processing disorder (APD) in children adversely affects cognitive, linguistic, academic, social, and emotional functioning and, without early identification, can compromise long-term educational outcome [1,7]. Universal screening may reduce these effects by enabling early detection; therefore, a valid and reliable Persian screening tool is essential. The adapted Persian TEAP provides a practical instrument for identifying children at risk of APD.

This study developed and psychometrically evaluated the Persian TEAP (P-TEAP) in 7–13-year-old schoolchildren in Tehran, Iran. The P-TEAP demonstrated strong content validity (acceptable CVR and CVI), excellent diagnostic accuracy on ROC analysis, acceptable internal consistency and test–retest reliability, and good convergent validity with SAB and BKB, supporting its use as a valid and reliable APD screening tool.

Unlike the Spanish validation, which focused on reliability (Cronbach's $\alpha = 0.82$, ICC = 0.86) and construct validity without reporting CVR or CVI, our study employed quantitative indices (CVR and CVI) to systematically assess item quality, addressing a methodological gap in the Spanish study where such metrics were not reported [16]. This structured approach enhances the P-TEAP's applicability in educational and clinical settings across Iran.

The ROC analysis provided further evidence of the clinical utility of the P-TEAP questionnaire for identifying children at risk of APD, but the absence of a universal accepted gold standard for APD necessitated the use of surrogate references (BKB, SAB-T), which may limit the generalizability of ROC findings.

The cut-off score of 6 was selected based on Youden's Index to balance sensitivity and specificity and was consistent with the original TEAP threshold [15, 16]. The stability of this cut-off across both reference measures supports the robustness of the original criterion and indicates that the P-TEAP effectively reflects teacher-

observed auditory behaviors, supporting its ecological validity. Overall, the total P-TEAP score appears to be a valid screening measure for identifying children at risk for APD, particularly in comparison with SAB-T.

The P-TEAP demonstrated excellent internal consistency, with Cronbach's alpha of 0.952 for Section A, KR-20 of 0.832 for Section B, and an overall alpha of 0.905, exceeding accepted reliability standards ($\alpha > 0.70$) ($\alpha > 0.70$) [27, 28] and surpassing values reported in the Spanish validation study ($\alpha = 0.82$) [16]. This comparative strength suggests that the P-TEAP may offer greater measurement precision and homogeneity in capturing teacher-reported auditory performance indicators among children suspected of having APD [16]. Also, internal consistency of the P-TEAP is strongly supported by significant correlations observed between Section A and Section B ($r = 0.840$), as well as between both sections and the total score ($r = 0.988$ for Section A, $r = 0.914$ for Section B). These high correlation values highlight the strong structural coherence of the instrument, suggesting that the subscales are well-aligned and effectively contribute to the overall construct being measured. This coherence is essential for ensuring that the P-TEAP accurately reflects children's auditory processing abilities across different test dimensions. However, the original Spanish study does not report specific correlation values between Section A and Section B of the P-TEAP [16].

Test–retest reliability was excellent (ICC = 0.99), exceeding that of the Spanish adaptation (ICC = 0.86) [16], and indicating high temporal stability. Such high reproducibility reinforces the robustness of the instrument in reliably capturing auditory performance behaviors in children, even when administered on separate occasions.

Convergent validity was demonstrated through strong correlations between the TEAP and the SAB-T ($r = 0.901$), and moderate correlations with the SAB-P ($r = 0.716$), supporting the tool's ability to reflect real-world listening difficulties reported by teachers and parents. Furthermore, significant negative correlations with BKB speech-in-noise test scores (right ear: $r = –0.614$, left ear: $r = –0.590$) underscore the TEAP's sensitivity to auditory performance in adverse listening conditions [10]. Unlike the Spanish study, which relied exclusively on comparisons between the TEAP, Auditory Behavior in Everyday Life (ABEL), and basic audiometry results, the inclusion of independent behavioral questionnaires and a speech-in-noise test in the present study provides stronger evidence for the P-TEAP as a valid screening tool for auditory processing difficulties beyond peripheral hearing loss [16].

In the present study, the main focus was on screening for APD in children, which is conceptually and clinically distinct from hearing loss/hypoacusis. This contrasts with the Spanish study, which primarily focused on hearing loss and did not include any evaluation of APD. The standard assessment tool used in the Spanish study was pure-tone audiometry, which is suitable for detecting peripheral hearing impairment but does not evaluate APD. The methodological difference by using BKB and SAB, provides a significant advantage in our study over the Spanish research [16], as the combination of behavioral and report-based tools offers a more comprehensive picture of the children's auditory performance. It is important to note that, due to the lack of alternative versions of the TEAP in other languages, our study had to rely heavily on the original Spanish version of the TEAP for comparative purposes. While this comparison provided valuable insight into the instrument's psychometric properties, the absence of similar studies or versions in other languages necessitated a more detailed focus on the Spanish study, particularly in evaluating the tool's reliability and validity. This methodological choice was made to ensure that the P-TEAP could be appropriately validated and adapted for the Persian-speaking population.

Participants were not systematically screened for psychiatric or neurological conditions, and assessment relied on health records and parent interviews without formal psychological evaluations, which may have influenced auditory processing performance. Additionally, the sample included only typically developing children with normal hearing, limiting generalizability to children with hearing loss or those using hearing devices. The lack of a gold standard for APD diagnosis and reliance on surrogate references (BKB and SAB-T), potential teacher response bias, and sampling restricted to urban schools in Tehran are further limitations. Future studies should include larger and more diverse samples, clinically diagnosed APD populations, and varied sociocultural and geographic contexts within Iran..

Conclusion

The Persian TEAP (P-TEAP) demonstrated strong psychometric properties and appears to be a valid and reliable screening tool for APD in children aged 7–13 years. High content validity, excellent internal consistency, test–retest reliability, and strong correlations with SAB and BKB support its clinical and educational utility. A cut-off score of 6, supported by ROC analysis, provides a practical threshold for identifying children at risk for APD. The P-TEAP is therefore recommended for routine APD screening in educational settings and for monitoring

changes following intervention. Further research is needed to confirm its diagnostic accuracy in clinically diagnosed APD populations and across diverse regions of Iran.

Ethical considerations

In this study, the research team has considered and applied ethical guidelines. The Ethics Committee of the University of Social Welfare and Rehabilitation Science approved this study method (Ethical Code: IR.USWR.REC.1403.140).

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Authors' contributions

NR: Study design, acquisition of data, statistical analysis, interpretation of results, and drafting the manuscript. MJ: Study design, supervision, statistical analysis, interpretation of results and critical revision of the manuscript. EB: Statistical analysis and critical revision of the manuscript. AAE: Study design and critical revision of the manuscript. AR: Acquisition of data, drafting the manuscript, and critical revision of the manuscript. All authors approved the final manuscript.

Conflict of interest

The authors declared no conflict of interest

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Table 1- Means (SD) for Audiological Tests and Questionnaires for All Participants.

	TEAP-total (n=243)	TEAP-A (n=243)	TEAP-B (n=243)	BKB-Right (n=243)	BKB-left (n=243)	SAB-T (n=243)	SAB-P (n=91)
Mean (SD)	8.13 (٤,٤٦)	2.68 (٣,٣٥)	5.45 (١,٢٦)	-0.63 (٣,٠٧)	-0.49 (٣,١٦)	54.88 (9.47)	52.29 (6.95)

Abbreviations: SD = Standard Deviation; TEAP = Teacher's Evaluation of Auditory Performance; TEAP-A =first section or section A of TEAP; TEAP-B = second section or section B of TEAP; BKB = Bamford-Kowal-Bench; SAB = Scale of Auditory Behaviors; SAB-T and SAB-P, completed by teachers and parents, respectively; n = number of participants.

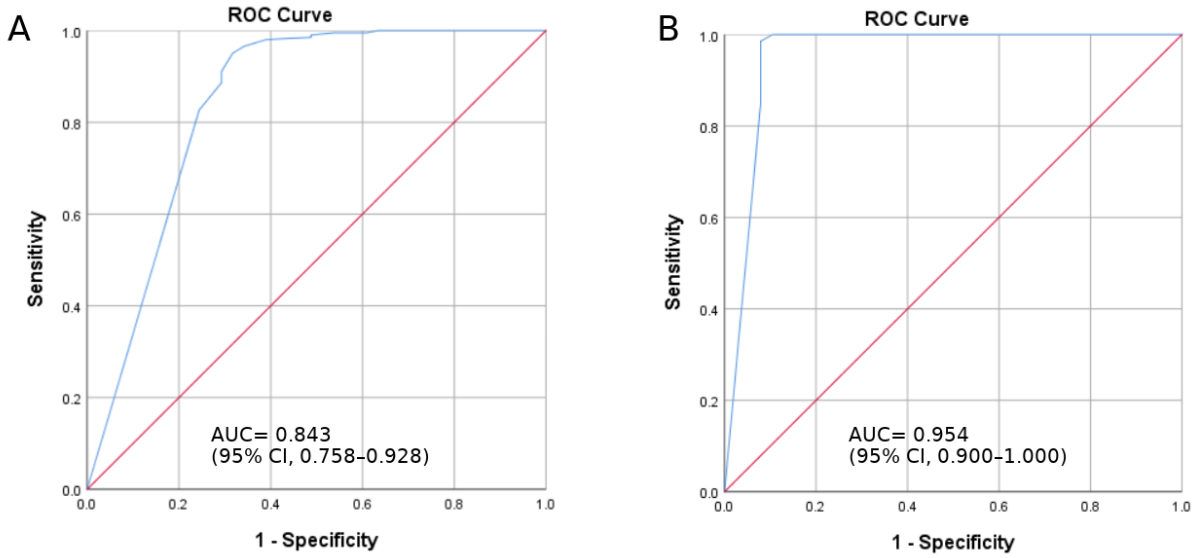

Figure 1- A: Receiver operating characteristics (ROC) curve of P-TEAP total score for detecting APD using Persian BKB sentence test as reference. **B:** Receiver operating characteristics (ROC) curve of the P-TEAP total score for detecting APD using teacher-completed Persian SAB (SAB-T) as reference.

Figure 1 Legend. A: Receiver operating characteristics (ROC) curve of P-TEAP total score for detecting APD using Persian BKB sentence test as reference. B: Receiver operating characteristics (ROC) curve of the P-TEAP total score for detecting APD using teacher-completed Persian SAB (SAB-T) as reference.