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Research Article

Criterion Validity of Infant-Toddler Meaningful Auditory Integration Scale for Persian Children with Cochlear Implantation

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ABSTRACT

Introduction: The infant-toddler meaningful auditory integration scale (IT-MAIS) can evaluate toddlers and infants' early auditory development in aspects of detection, discrimination, and identification of sounds. The present study aims to evaluate the reliability and criterion validity of the Persian version of the IT-MAIS (IT-MAIS-P) for children with hearing loss (HL).

Materials and Methods: In this study, due to the limitations of COVID-19 and the lack of access to samples, 23 available children with HL were sampled. The cause of participants› HL was 43.5% congenital, 30.4% acquired, and 26.1% unknown. The Mean±SD of the age of these children was 21.6±6.3 months. To evaluate the predictive validity and concurrent validity, the speech intelligibility rating (SIR) and categories of auditory performance (CAP) were used, respectively. Also, to assess the inter-rater reliability, both parents of each child completed the IT-MAIS-P.

Results: A significant correlation (concurrent validity) was observed between the IT-MAIS-P and the CAP scores ($r=0.87$, $P<0.001$). Predictive validity was not confirmed by comparing it with the SIR ($P>0.05$). Also, the inter-rater reliability (kappa=0.44, $P<0.001$) of the IT-MAIS-P was confirmed.

Conclusion: The IT-MAIS-P is a valid tool to investigate the progress of auditory skills in infants, although the predictive validity was not confirmed.

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Introduction

Hearing loss (HL) is a common disorder in infants and toddlers. HL affects access to speech, which can negatively affect cognition, academic achievement, and social development [1]. In 2019, about 1.57 billion people worldwide had HL, meaning that one in five people will experience HL [2]. It is more common in infants who have one or more risk factors for HL. The prevalence of HL in low-risk infants is estimated at 0.09% to 2.3% and in high-risk infants between 0.3% and 14.1% [3]. The prevalence of HL in Iranian newborns is reported to be 1.52 per 1000 [4], and in another study, this rate is even up to 4.7 per 1000 [5]. HL may even be more prevalent in some provinces, especially due to the high level of consanguinity in Iran [3].

The severity of HL can vary from mild to profound and can be unilateral or bilateral. Negative consequences of HL increase with increasing severity of HL, bilateral involvement, and prelingual HL [6, 7]. The first three years of a baby's life is a golden time to be exposed to auditory stimuli because, at this age, the brain is more plastic to learn language, and speech skills [8]. Therefore, timely intervention and implementation of rehabilitation programs in children with HL are crucial [1]. The younger the rehabilitation intervention is, the more effective it will be [9, 10]. It is essential to have a valid ecological assessment tool to ensure the information obtained from the auditory skills assessment [11]. By ensuring the validity of the assessment tool, the ability of professionals to provide realistic assessments of hearing skills and appropriate interventions can be improved [12].

To evaluate the development of children's hearing skills, several tests exist, such as LittlEARS hearing questionnaire [13], auditory behavior in everyday life (ABEL) [14], and infant-toddler meaningful auditory integration scale (IT-MAIS). Classification of auditory performance (CAP) is also a short and widely used test that the therapist classifies the child's listening performance into 10 categories [15]. Both LittlEARS and ABEL are long tests, they target a certain age range and have more general use, but the IT-MAIS is a short and the first parent-report tool for infants under 3 years of age, which is especially useful for children with CI. Therefore, it has been translated and used in various languages [16, 17].

The IT-MAIS has been translated and used in many languages, including German, Chinese, Arabic, Polish, Italian and Persian [11, 18-20]. The content validity, test-retest reliability, internal consistency, and intraclass correlation coefficient (ICC) of the IT-MAIS in Chinese infants were 0.84, 0.92, 0.84, and 0.89, respectively [21].

The IT-MAIS can assess the prelingual auditory development of infants and toddlers [16, 17]. This is the first parent-report tool for the quantitative evaluation of auditory behaviors in different daily routine situations [22]. Since the introduction of the IT-MAIS, several studies have used this scale to determine CI outcome, CI candidacy, and hearing aid benefits [23]. This scale is a useful tool to assess various aspects of hearing development in children under 3 years of age [6, 24-26].

The IT-MAIS has been translated and used in Iran [11, 20]. The internal consistency and the content validity index of the Persian version of the IT-MAIS (IT-MAIS-P) were reported as 0.93 [20] and 0.96 [11], respectively. The IT-MAIS-P showed that the score of this scale was significantly different between hearing-impaired children and children with normal hearing [20]. Also, a significant difference was reported between the scores of the IT-MAIS-P after and before the rehabilitation program [11]. Accordingly, the IT-MAIS-P is a reliable tool for assessing Persian-speaking children with hearing impairment [11, 20].

In test evaluation, the vital factor to be considered is test validity [27]. In the preparation and assessment of the validity of a test, after confirming the content validity, the determination of criterion validity is the second most crucial [28]. Criterion validity shows how consistent and related the scores obtained from one test are with the scores obtained from another test called the criterion. Criterion validity is determined through two methods, predictive validity and concurrent validity [28]. When a test is used to predict future behavior, predictive validity must be calculated. To calculate the predictive validity, the test is performed on the subjects, after the required time, the scores of the criterion test are collected and the correlation between these two scores is calculated to obtain the predictive validity. If a time limit exists to perform and calculate predictive validity, concurrent validity can be used. To calculate the concurrent validity of a new test, if a valid test exists in that field, both tests are performed on the same sample group, and if a high correlation is observed, the new test is confirmed [27, 28]. Considering that the content validity of the IT-MAIS-P has been confirmed in previous studies [11, 20], to increase the confidence in the appropriateness of this test in measuring the hearing skills of infants with HL. This study was conducted to evaluate the types of criterion validity as well as the inter-rater reliability of the IT-MAIS-P for Persian-speaking children with hearing loss.

Materials and Methods

Study subjects

All participants in this study included severe or profound HL children who were referred to the cochlear implant center of Rasoul Akram Hospital in 2020. The inclusion criteria included severe or profound HL in both ears, pre-lingual HL, no multi-disability, use of hearing aid or CI, at least 6 months after hearing aid, and age group under 3 years. Sampling was purposeful and accessible. Sampling lasted three months, and finally, due to COVID-19 restrictions, 23 children met the inclusion criteria. Twenty-three children with HL (16 boys/7 girls) aged between 10 and 36 months (Mean±SD 21.6±6.3 months) were enrolled in the study. The cause of participants' HL was 43.5% congenital, 30.4% acquired, and 26.1% unknown. All participants used CI. The age of CI of the participants was from 8 to 29 months (Mean±SD 13.9±5.1 months). The education of the parents of the infants participating in this research was as follows, 10 mothers' education was below a diploma, 7 had a diploma, and 6 had education higher than a diploma, and 8 fathers were below a diploma, 10 had a diploma, and 5 had education higher than a diploma.

Study tools

The IT-MAIS

Items included in the IT-MAIS are intended to measure 3 underlying principles: vocalization, alerting to sounds, and deriving meaning from them [11]. The questionnaire included 10 items; 2 items associated with vocalization behaviors, 4 items associated with alerting to sounds, and 4 items associated with deriving meaning from sounds. According to the degree of observation of each behavior, the score of each item ranges from 0 to 4 (never=0, rarely=1, sometimes=2, most of the time=3, and always=4). Therefore, the maximum IT-MAIS score is 40 [20]. In this study, the IT-MAIS-P translated by Geravand et al. was used [11]. For the IT-MAIS-P, the content validity ratio for all items was >0.79, the content validity index was >0.96, and Cronbach's α was 0.74 [11].

CAP

The categories of auditory performance (CAP) have ten categories of performance arranged in ascending order of difficulty [15]. In this scale, the child's assessment is based on observations made of his/her auditory function in everyday situations, such as home, clinic, kindergarten, or school, by parents, educators, or therapists. There is also no age limit. Children's awareness of environmental sounds, identifying environmental sounds, response to speech sounds, and distinguishing speech sounds, phrases, and conversations without lip-reading are examined in this scale. Scoring on this scale is based on the examiner's judgment. Each child's rehabilitation therapist measured auditory performance [15]. In this study, the CAP was used to evaluate the concurrent validity of the IT-MAIS-P.

Speech intelligibility rating (SIR)

Speech intelligibility rating (SIR) was used to investigate predictive validity. The speech intelligibility rating (SIR) is a universal measure of speech intelligibility in real-life situations. The therapist classifies the child's spontaneous speech intelligibility into five categories (1 to 5) by the SIR [29]. The speech therapist (last author) scores on this scale. The speech therapist uses this scale to rank their speech intelligibility after listening to a short section of the subjects' connected speech. A child who cannot communicate verbally and probably gestures is at the lowest level, level 1, and a child whose verbal clarity is such that everyone understands what he or she is saying is at level 10 [30].

Study procedure

In this study, the experts (first and last authors) of the Cochlear Implant Center of Rasoul Akram Hospital first explained the necessity of the IT-MAIS-P and how to respond individually to parents. This questionnaire was then given to the parents. While completing the questionnaire, potential parents' questions were answered by experts. To assess the inter-rater reliability, both parents of each child completed the IT-MAIS-P, and the correlation between their scores was calculated. Inter-rater reliability in this study was the degree of agreement among independent observers (parents of each baby) rating the same phenomenon (baby's listening skills). The speech therapist assessed all children with the CAP and SIR scales. The obtained scores were used to evaluate the criterion validity (predictive and concurrent validity) of the IT-MAIS-P.

Statistical analysis

SPSS software, version 22, was used for data analysis. Mean±SD, frequency, and percentage were used to analyze descriptive statistics. Shapiro-Wilk statistic was used to evaluate the normality of the distribution of variables. Pearson correlation was used to evaluate concurrent and predictive validity. To evaluate the inter-rater

reliability, for each child, both the father and the mother completed the IT-MAIS-P, and the correlation between the father's score and the mother's score was calculated through the Kappa coefficient.

Results

Descriptive results

Twenty-three infants with HL (16 boys/7 girls) aged between 10 and 36 months (Mean±SD 21.6±6.3 months) were enrolled in the study. The cause of participants' HL was 43.5% congenital, 30.4% acquired, and 26.1% unknown. All participants used CI. The age of CI was from 8 to 29 months (Mean±SD 13.9±5.1 months). The education of the infants' parents was as follows: The education of 10 mothers was below a diploma, 7 had a diploma, and education of 6 mothers was higher than a diploma, and the education of 8 fathers was below a diploma, 10 had a diploma, and the education of 5 fathers was higher than a diploma.

Table 1 presents the scores of the participants in the CAP, SIR, and IT-MAIS-P. As you can see in this table, the babies who scored higher in the IT-MAIS-P usually showed higher scores in CAP, but the SIR scores did not follow the expected pattern.

Concurrent validity

In determining concurrent validity, the Pearson correlation coefficient test showed a significant correlation between the IT-MAIS-P and the CAP scores in the evaluated samples ($r=0.877$, $P<0.001$). Then, to further confirm the concurrent validity results, a linear regression test was used using the Enter method. The regression results confirmed the direct correlation between MAIS-IT and CAP scores and showed that MAIS-IT can explain about 76% of CAP variances ($F=69.76$, $df=1$, $P<0.001$). Finally, concurrent validity was confirmed. Table 2 presents the results.

Predictive validity

In determining the predictive validity, the Pearson correlation coefficient test showed that the correlation between the IT-MAIS-P and the SIR scores in the evaluated samples was not significant ($r=0.311$, $P>0.05$). Then, to further confirm the validity results of the predictor, a linear regression test was used using the Enter method. The regression results confirmed a weak direct correlation between MAIS-IT and SIR scores but showed that MAIS-IT did not explain the variance of SIR. The $P>0.05$ and this means that with the change in SIR, MAIS-IT does not change significantly. As a result, the predictive validity was not confirmed ($F=2.25$, $df=1$, $P=0.148$). Finally, predictive validity was not confirmed. In other words, a change in MAIS-IT scores cannot significantly change SIR scores. Therefore, strengthening the auditory skills of infants with CI does not necessarily guarantee the strengthening of their speaking skills. Table 3 presents the results.

Inter-rater reliability

To evaluate the inter-rater reliability, the correlation between the father's score and the mother's score for each child was calculated via the Kappa coefficient. The kappa coefficient is a numerical measure between -1 to +1, the closer it is to +1, indicates the existence of a proportional and direct agreement. Measures close to -1 indicate the presence of inverse agreement and values close to zero indicate disagreement. In this study, the kappa coefficient was 0.446. This value indicates the existence of an average agreement between mother's and father's scores. This level of agreement was significant at a significance level of <0.001 (Table 4). As a result, the inter-rater reliability of the IT-MAIS-P was confirmed.

Discussion

A valid instrument is required to investigate the auditory skills of children younger than three years, especially to assess children with hearing loss and monitor their progress. The present study focused on the IT-MAIS-P, a parental self-reporting tool developed as a complementary measure of hearing in children with HL [21]. In previous studies, the IT-MAIS was translated into Persian based on the IQOLA translation protocol. Investigating the content validity ratio (CVR) with the participation of 10 experts and using Lawshe's method indicated that all the IT-MAIS-P items have a good content validity ratio (CVR>0.79). Furthermore, the CVI was obtained using the Waltz and Basel method for each item of the questionnaire based on the three criteria of "relevancy", "clarity", and "simplicity" above 0.96, suggesting excellent content validity [11]. In evaluating the validity of a test, after confirming the content validity, the determination of criterion validity is the second most crucial [28]. Criterion validity has two types, including predictive validity and concurrent validity [28]. The results of the present study showed that the concurrent validity of the IT-MAIS-P was confirmed. Concurrent validity indicated an agreement between the IT-MAIS-P and the CAP. Since both of these questionnaires measure listening skills, as expected, they had a high correlation. There-

Table 1. The scores of the participants according to the questionnaires

No.	Sex	CAP	SIR	IT-MAIS-P
1	M	5	1	33
2	M	7	4	38
3	F	5	3	32
4	M	5	2	33
5	M	5	2	40
6	F	3	4	20
7	F	5	3	34
8	M	4	1	33
9	M	6	1	36
10	M	5	2	34
11	M	9	3	39
12	M	5	2	38
13	M	4	4	27
14	M	8	3	40
15	M	2	3	19
16	M	3	4	23
17	F	5	3	18
18	M	8	4	40
19	M	3	2	26
20	F	7	3	40
21	F	5	4	33
22	F	9	3	39
23	M	2	3	22

JMR

Abbreviations: CAP: Categorical auditory performance; SIR: Speech intelligibility rating; IT-MAIS-P: The Persian version of infant–toddler meaningful auditory integration scale.

fore, the result of this study confirms the results of previous studies [31, 32]. The CAP is very widely used and very valid in examining the auditory perception of children with CI, and this test has been used in several studies [32-36]. Since the concurrent validity of IT-MAIS-P and CAP was confirmed, this test can be used in future studies to more accurately evaluate the hearing development of babies with HL. On the other hand, this test uses a Likert scale for scoring, while the CAP only classifies the child's listening comprehension. Therefore, IT-MAIS-P results are expected to be more accurate than CAP and better describe the listening comprehension skills of children with HL, especially CI. Therefore, it can be a useful tool in evaluating hearing performance and monitoring the benefits of CI in hearing-impaired children, and it is recommended to use the IT-MAIS-P in clinical and research work.

Table 2. Pearson correlation coefficient results for concurrent validity

Independent Variable	Indexes	CAP
IT-MAIS-P	Correlation coefficient	0.877
	Sig.	0.000
	No	23

JMR

IT-MAIS-P: The Persian version of infant-toddler meaningful auditory integration scale; CAP: Categories of auditory performance.

Table 3. Pearson correlation coefficient results for predictive validity

Independent Variable	Indexes	SIR
IT-MAIS-P	Correlation coefficient	0.311
	Sig.	0.148
	No.	23

JMR

IT-MAIS-P: The Persian version of infant-toddler meaningful auditory integration scale; SIR: Speech intelligibility rating.

Table 4. Kappa coefficient for inter-rater reliability

Inter-rater Reliability		Value	Asymptotic Standard Error	Approximate T[b]	Sig.
Measure of agreement	Kappa	0.446	0.105	8.839	0.000
No of valid cases		23			

JMR

In all children, especially children with HL, listening skills usually have a direct impact on speaking skills [10, 29, 37]. Therefore, it is expected that the listening skills of hearing-impaired children can predict their speaking skills. The SIR is very widely used and valid in classifying the speech intelligibility of children with HL [32, 33, 35]. Predictive validity indicates to what extent the index test scores accurately predict a criterion measure scores [18]. Among the various validation strategies, predictive validity plays a crucial role, because in this type, the efficiency and accuracy of the index test are somehow predicted in the future [18]. In this study, we decided to use the SIR as a criterion to confirm the predictive validity of the IT-MAIS-P. However, in this study, predictive validity was not confirmed. In other words, no significant agreement was observed between the IT-MAIS-P and the SIR scores. One of the reasons for this contradiction is probably the difference in the way these two questionnaires are scored. The IT-MAIS-P uses a Likert scale for scoring, while the SIR only classifies the speech intelligibility of children with HL into five categories. Another reason for this discrepancy is probably the range of scores of these two questionnaires. The range of IT-MAIS-P scores is wide from 0 to 40, while the range of SIR scores is limited to only five scores (from 1 to 5), which reduces the power and accuracy of scoring and, as a result, the accuracy of SIR prediction. Also, in another study, results similar to the results of the present study were reported, in terms of non-agreement between IT-MAIS-P and SIR scores [32]. These results indicated that SIR is not a suitable test to be selected as a criterion test. In this study, we have not chosen a suitable test for the criterion test to evaluate the predictive validity of the IT-MAIS-P. In the last decade, the intelligibility context scale (ICS) has been widely used to evaluate speech intelligibility, and recently to evaluate the speech intelligibility of children with CI [10, 29]. The ICS scores different speech situations based on the Likert scale, while the SIR only classifies the speech intelligibility of children with HL into five categories. Therefore, ICS results are expected to be more accurate than SIR and better describe the speech intelligibility of children with

HL, especially CI. Therefore, it is better to use ICS in future studies to evaluate the predictive validity of the IT-MAIS-P.

Also, the results of this study showed that IT-MAIS-P has good inter-rater reliability. This result can be interpreted as it does not matter whether the child's father or mother completes this questionnaire. Because both comments and answers are almost similar and both answers are equally reliable. This has been proven in recent studies. IT-MAIS-P can be used to measure the outcome for the evaluation of primary hearing interventions and cochlear implantation, equally from the parent's point of view. Our result is consistent with a similar study that reported a very good intra-class correlation (ICC=0.96) for the Persian version of the IT-MAIS [11]. Another study examined the psychometric properties of the IT-MAIS questionnaire in Chinese. The results of the ICC and Cronbach α of the questionnaire were 0.92 and 0.83, respectively [21]. Similar results across different cultures and languages can be attributed to the similarity in the development of primary prelingual hearing ability in all infants. Because all original scale items are preserved in IT-MAIS interlanguage versions [19].

This study, like previous studies [11, 20], suggested that the Persian version of the IT-MAIS was a valid scale to assess the hearing performance of Persian-speaking children with HL. For future studies, larger samples with different study conditions, for example, different clinical conditions, comparison with control group outcomes, various interventions, and various questionnaires, such as ICS, may be included to further clinical use of the IT-MAIS-P.

Conclusion

The psychometric properties of the IT-MAIS-P in young Persian-speaking children with hearing loss indicated that this questionnaire is a good instrument to investigate the progress of auditory skills and listening development after cochlear implant surgery in infants. Due to the wrong selection of SIR as a criterion test, the predictive validity of the IT-MAIS-P was not confirmed. Due to the limited sample size, it is better to expand the sample size for more certainty in future studies.

Ethical Considerations

Compliance with ethical guidelines

All procedures of this study were performed following the principles of the Helsinki Declaration and were approved by the Ethics Committee of the Tehran University (Code: IR.UT.PSYEDU.REC.1401.005). In conducting this study, we committed to respecting the decision of parents to accept or reject cooperation in this research, to prevent harm to parents or babies and damage to hearing aids and cochlear implants, to act in the interest of parents and child and to balance the benefits against the risks (if necessary, providing counseling or referral to speech therapy), and in the distribution of benefits and risks and ensuring fair access to the rehabilitation program needed by each child.

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Authors' contributions

Conceptualization and Supervision: Shiva Panahiaboozar and Saeid Hassanzadeh; Methodology: Shiva Panahiaboozar and Masoud Gholamali Lavasani; Data collection: Shiva Panahiaboozar; Data analysis: Alireza Aghaz; Investigation, Writing-original draft, and Writing-review & editing: All authors; Funding acquisition and Resources: Saeid Hassanzadeh.

Conflict of interest

All authors declared no conflict of interest.

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