Psychometric Assessment of the Persian Version of the Revised Convergence Insufficiency Symptom Survey in Young Adults with Convergence Insufficiency

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Abstract

Purpose: To translate the Convergence Insufficiency Symptom Survey (CISS) to Persian and to assess its validity and reliability in a group of young adult Iranian patients with convergence insufficiency (CI).

Methods: The questionnaire was translated in backward and forward phases. Face validity was measured using a 6-point scale (very weak, weak, moderate, good, very good, best), and a score of ≥4 for each item indicated an acceptable face validity. The content validity was assessed using three indices of relevancy, clarity, and comprehensiveness. Relevancy and clarity were checked for each item and for the whole scale using a 4-point scale (1-undesirable, 2-relatively desirable, 3-desirable, 4-completely desirable), and Item Content Validity Index (I-CVI) and Scale Content Validity Index (S-CVI) were calculated for the above indices. Comprehensiveness was measured at the scale level using a 4-point scale (1-incomprehensive, 2-relatively comprehensive, 3-comprehensive, 4-totally comprehensive), and S-CVI was calculated. The internal consistency and test-retest reliability were assessed using Cronbach's alpha coefficient and interclass correlation coefficient (ICC), respectively. To evaluate discriminant validity, CI was categorized into mild, moderate, and severe stages, and the mean overall CISS score was compared between these groups.

Results: Thirty CI patients aged 18–34 years participated in this study. On face validity assessment, all items finally had a score of ≥4. As for relevancy and clarity, I-CVI was above 80% for all items, and S-CVI was 98.8% and 96.6%, respectively. The S-CVI was 100% for comprehensiveness. The overall Cronbach's coefficient and ICC were 0.77 and 0.95, respectively. There was a significant difference in the overall score between the three severity groups.

Conclusion: The Persian CISS is a valid and reliable tool for clinical and research applications.

Keywords: Convergence insufficiency, Convergence Insufficiency Symptom Survey, Persian version, Reliability, Validity, Young adults

INTRODUCTION

Convergence insufficiency (CI) is a binocular vision anomaly which is characterized by decompensated near exophoria, a remote near point of convergence (NPC), and reduced positive fusional vergence (PFV) at near.[1] CI has the highest prevalence (3–5% of the general population) among all binocular vision disorders, and therefore, it has been the subject of many studies in this field.[2,3] CI is usually associated with multiple symptoms including eyestrain, headache, blurred

vision, diplopia, sleepiness, difficulty concentrating, and loss of comprehension during near-visual activities (especially reading), leading to impaired educational, occupational, and athletic performance and decreased quality of life.[3,4] Therefore, timely diagnosis and management of this disorder is an important issue in binocular vision practice.[5] Since assessment of symptoms is an essential component of the diagnosis and follow-up of CI patients,[6] the Convergence Insufficiency Symptom Survey (CISS) was designed by the Convergence Insufficiency and Reading Study group in 1999.[7] The first version of this questionnaire contained 13 questions. It was later revised to a 15-item questionnaire by increasing the number of response categories from 4 to 5, broadening the activities addressed to include all close work, and dividing one of the questions to two separate questions.[8,9] For each questionnaire's item, the patient chooses one of the five possible responses (never, infrequently, sometimes, fairly often, and always). Each answer is scored from 0 to 4, with 4 indicating the highest frequency of the symptom (always). The overall CISS score is the sum of the scores of all 15 items, ranging from 0 (completely asymptomatic) to 60 (completely symptomatic).[1,10]

This questionnaire is the first standard instrument that is able to measure the type and frequency of symptoms associated with CI.[1,10] The validity and reliability of the revised CISS have been measured in a number of studies in different age ranges including schoolchildren aged 9–18 years and young adults aged 19–30 years.[9-12] The revised CISS has also been translated into other languages.[4,9] The results have shown that this is a reproducible and valid instrument with a high internal consistency to discriminate between healthy subjects and CI patients and to assess clinical changes during the treatment process.[9-12] It has also been found that this instrument has an added value for the diagnosis of other non-strabismic binocular vision disorders as well as accommodative dysfunctions with symptoms similar to CI, including accommodative insufficiency.[9,13,14] In addition to its clinical applications, the CISS is extensively used for research purposes and is a vital component of the studies of binocular vision symptomatology.[1,4] Despite its importance and widespread application, to the best of our knowledge, the Persian version of this questionnaire is not available. As many Iranian patients are not familiar with English, there are limitations for using this valuable instrument by the Iranian clinicians and researchers. The present study was therefore conducted to prepare the Persian version of the revised CISS and determine its validity and reliability.

METHODS

Study design
This validation study of the Persian version of "revised CISS" was conducted in two stages: the translation process and validity/reliability assessment.

Translation procedure
The CISS (revised version, release year; 2003)[11] was translated into two phases according to the International Quality of Life Assessment protocol[15] during a 3-month period from July to September 2018. In the first phase, forward translation was done by two experienced translators proficient in the Persian and English languages with experience in questionnaire translation (translators 1 and 2). The translators were asked to present a list of alternative suggestions for some words if needed. Then, the agreed Persian version was presented to two other translators who were skilled in Persian philology (translators 3 and 4) to assess the quality of translation in terms of aspects such as clarity of the text, usage of the common language, and conceptual equivalence (similarity of content/meaning). In the second phase (backward translation), two native English translators (translators 5 and 6) were asked to translate the approved Persian version confirmed in phase one into English. Finally, the backward version, along with all reports, were assessed and finalized by researchers.

Sample size calculation
The sample size was calculated based on the Cronbach's alpha index according to the Bonett's formula.[16] In this formula, k represents the number of items in the questionnaire (15). α and β are Types 1 and 2 errors which were considered 0.05 and 0.1, respectively. CA0 indicates the value of Cronbach alpha at null hypothesis, which is considered the minimum acceptable value of 0.70, and CA1 is the expected value of the Cronbach's alpha (0.92), which was extracted from one of the previous similar studies.[11] With this manner, the required sample size was estimated at 29, which was rounded up to 30 patients.

Study participants and examinations
Thirty patients aged 18–34 years (mean age = 25.70 ± 5.26 years) who presented to Bina Eye Hospital, Tehran, Iran between September and December 2018 with a diagnosis of CI were recruited to participate in this cross-sectional study and completed the final Persian version of the revised CISS.

All participants underwent complete optometric examinations, including the measurement of visual acuity, objective and subjective refraction as well as accommodative and binocular vision examinations (cover test and measurement of the NPC, fusional vergence ranges, and accommodative amplitude [AA]) by an experienced optometrist according to standard clinical protocols.[17] First, uncorrected distance visual acuity was measured using a Snellen E-chart at a distance of 6 m. Then objective refraction was done using the auto-refractometer (KR-8900; Topcon, Tokyo, Japan) and refined through retinoscopy (Heine Beta 200 retinoscope, Heine Optotechnik, Germany). The best optical correction was determined by the subjective refraction, and the best corrected distance visual acuity (BCVA) was recorded. In the next step, binocular vision and accommodative examinations were performed all through the best optical correction. The binocular alignment was tested by the unilateral and alternating cover tests at 6 m and 40 cm distances, and the magnitude of the distance and near heterophorias was measured using the alternating cover test and prism bar.

The target used for the cover test was a single letter one line above the BCVA on the distance and near Snellen charts. To measure NPC, an accommodative target (a single character one line above BCVA) was slowly moved toward the participants along the midline at a constant rate of 5 cm per seconds, and they were instructed to keep the target single for as long as possible until diplopia occurred or the examiner objectively observed a loss of binocularity. At this point, the NPC distance was measured from the spectacle plane (if any) or the participant's bony margin of the orbit near the lateral canthus using the 50 mm long ruler. Five measurements were done to improve test sensitivity, and the mean of the five recordings was considered the final NPC. AA was measured monocularly using the Donder's Push-up method. For this purpose, an accommodative target (a row of Snellen letters one line above BCVA) was slowly brought closer to the participant, and he/she was asked to keep a clear view of the target and to report when the print became blurred, and he/she was no longer able to clear it (first sustained blur). At this point, the near point of accommodation (NPA) was measured from the spectacle plane using the long 50 mm ruler. The NPA was measured three times for each eye, and the mean of the three recordings was considered the final NPA, which was then converted to AA in diopters (D). Positive and negative fusional vergence ranges were, respectively, measured using base-out and base-in prisms of a prism bar at 6 m and 40 cm distances. The target used for the test was a vertical row of 20/30 letters on the distance and near Snellen charts. The prism was placed in front of the participant's right eye, and the prism power was slowly increased in a constant rate of 2 prism diopters (PD)/s. The participants were asked to fix on the target and try to keep it single and clear and to report when they noticed first sustained blur and then the double vision. At this point, the participant was asked to report the recovery of a single vision while decreasing the prism power 2 PD/s. With this manner, the amounts of the prism at blur, diplopia, and recovery of fusion were recorded as blur/break/recovery values. Moreover, an ophthalmologist assessed ocular health status by the slit-lamp biomicroscope (BQ 900, Haag-Streit, Bern, Switzerland) using a +90 lens (Volk Optical, Mentor, USA). CI was diagnosed based on the accepted Scheiman and Wick's criteria,[1] including: (1) an exophoria at near at least 4 PD greater than at distance, (2) a receded NPC break (6 cm or greater), (3) insufficient PFV at near as a failure of the Sheard's criterion[18] (amplitude of PFV at near less than twice near exophoria), and (4) a normal monocular AA according to the Hofstetter's formula (measured monocular AA greater than minimum AA expected for age suggested by the Hofstetter's formula: $15 - 0.25 \times$ age).[19] The exclusion criteria were a visual acuity <20/25 in either eye, constant strabismus, a near stereoacuity threshold worse than 500 s of arc, manifest or latent nystagmus, a history of strabismus, refractive, or intraocular surgery, any ocular or systemic disease affecting binocular vision or accommodative function, a history of ocular trauma, and use of systemic or ocular drugs affecting binocular vision and accommodation.

Psychometric assessment of the questionnaire

In this stage, first, the validity of the finalized Persian CISS was assessed by a panel of six experts in the field of binocular vision. Face validity was assessed based on the aspects of fluency (use of meaningful words) and cultural acceptance in society using a 6-point Likert scale (very weak, weak, moderate, good, very good, best), and a score of ≥4 for each item was considered acceptable. Content validity was assessed based on three indices of relevancy (the extent to which the item of interest can reflect the characteristics of the content under study), clarity (appropriateness of the selected items in terms of concept and writing style), and comprehensiveness (the ability of the instrument to cover all domains related to the topic under study). Relevancy and clarity were checked for each item and for the whole scale using a 4-point Likert scale (1-undesirable, 2-relatively desirable, 3-desirable, 4-completely desirable), and the Item Content Validity Index (I-CVI) and Scale Content Validity Index (S-CVI) were calculated for the above indices accordingly. A conservative approach (universal agreement approach) was used to determine the I-CVI. In this approach, the number of experts who rate the clarity and relevancy of each item as desirable or completely desirable is divided by the total number of experts. Therefore, the I-CVI value is between zero and one (0–100%), and a value of 0.8 or higher is considered acceptable.[20] The S-CVI for relevancy and clarity was calculated by determining the average of all I-CVI values (average method). Comprehensiveness was only measured at the scale level using a 4-point Likert scale (1- incomprehensive, 2- relatively comprehensive, 3- comprehensive, and 4- totally comprehensive), and its S-CVI was estimated by dividing the number of experts who rated the questionnaire as comprehensive or totally comprehensive by the total number of experts. Then, the reliability of the questionnaire was assessed using internal consistency and test-retest reliability analysis. The participants were asked to participate in a second administration of the questionnaire 7–10 days later in order to provide data for the test-retest reliability. To assess discriminant validity, CI was categorized to three groups of mild (PFV ≥1.50 × near exophoria), severe (PFV < near exophoria), and moderate (values in between these ranges) based on the severity of clinical manifestations according to the Convergence Insufficiency Treatment Trial guideline,[21] and the mean overall CISS score was compared between the three groups.

Statistical analysis

The Statistical Package for the Social Sciences Software version 20 (SPSS Inc, Chicago, USA) was used for statistical analysis. Descriptive data of clinical characteristics, including mean, standard deviation, and range, as well as the data related to content validity analysis, including I-CVI and S-CVI values, were presented in separate tables. To assess internal consistency, Cronbach's alpha coefficient was calculated at the scale level and after removing each item, and values >0.70 were considered acceptable.[22] Test-retest reliability was measured using interclass correlation coefficient (ICC) at the scale level and for each item

separately, and values >0.75 were considered acceptable.[23] One-way analysis of variance (ANOVA) was applied to compare the overall CISS score between different groups of CI severity. A value of $P < 0.05$ was considered statistically significant.

Ethical issues

The protocol of the study was approved by the Ethics Committee of Iran University of Medical Sciences (Registration code: IR.IUMS.REC.1397.936). Written informed consent was obtained from all participants before the study.

RESULTS

Thirty CI patients with a mean age of 25.70 ± 5.26 years (range, 18–34 years) participated in this study. Half of the participants (50%, $n = 15$) were male. Table 1 presents the distribution of clinical characteristics, including near exophoria, NPC, near PFV, AA, and CISS score.

On face validity assessment, all items except item 11 had a score of equal to or above 4. Therefore, item 11 was modified according to the experts' comments, resulting in a final score of 4 for this item. Table 2 shows the results of content validity analysis for the relevancy index. According to Table 2, I-CVI was above 80% for all items, and S-CVI was 98.88%.

Table 1: Clinical characteristics of the study participants

Index	Mean	SD	Minimum	Maximum
Near exophoria (PD)	12.06	1.92	9.00	15.00
NPC (cm)	17.50	3.63	11.50	28.00
Positive fusional vergence at near (PD)	9.53	2.76	4.00	16.00
AA (D)	9.75	2.06	6.50	14.50
CISS Score	31.86	3.91	24.00	39.00

PD: Prism diopter, D: Diopter; CISS: Convergence Insufficiency Symptom Survey, NPC: Near point of convergence, AA: Accommodative amplitude, SD: Standard deviation

Table 3 presents the results of content validity analysis for clarity index. The I-CVI was above 80% for all items, and S-CVI was 96.66%.

As for comprehensiveness, five experts assigned a score of 4, and one expert gave a score of 3 to the overall comprehensiveness of the questionnaire; therefore, the S-CVI was 100% for the comprehensiveness index.

The overall Cronbach's alpha coefficient of the questionnaire was 0.77, indicating its acceptable internal consistency. The results of the internal consistency analysis are presented in Table 4.

The overall ICC was 0.95 (95% confidence interval: 0.90–0.97), and the 95% limits of agreement (LOA) were -7.8 to 15.6. The mean time between the two administrations of the questionnaire was 8.03 ± 0.95 days. The mean difference in the overall CISS score between the first and second administrations was 0.60 ± 1.10 points. Table 5 shows the ICC values for each item. According to Table 5, nine items had excellent (above 0.90) and six items had good test-retest reliability (0.75–0.90). The highest and lowest ICC value was related to item 4 and 14, respectively.

The mean overall CISS score was 26.00 ± 2.00, 29.50 ± 1.22, and 33.40 ± 0.70 in mild, moderate, and severe CI groups, respectively. Figure 1 shows the mean overall CISS score in different CI severity groups. One-way ANOVA showed a significant difference in the mean overall CISS score between different levels of CI severity ($P = 0.002$). According to the Bonferroni *post hoc* test, there was a significant difference between mild and severe CI ($P = 0.014$) and between moderate and severe CI groups ($P = 0.023$), but no significant difference was observed between mild and moderate levels of CI ($P = 0.548$).

DISCUSSION

As mentioned earlier, the CISS is a standard tool with wide applications in clinical practice and research into binocular

Table 2: Content validity analysis for relevancy index

Item	Score given by experts (1-6) to relevancy of each item						Number of agreements observed for score of ≥3	I-CVI	S-CVI
	1	2	3	4	5	6			
1	4	4	4	4	4	4	6	100	98.88
2	4	4	4	4	3	4	6	100	
3	4	4	4	4	4	4	6	100	
4	4	4	4	4	3	3	6	100	
5	4	3	3	3	4	4	6	100	
6	3	4	4	4	4	4	6	100	
7	4	4	4	4	4	4	6	100	
8	4	4	4	4	3	3	6	100	
9	3	4	3	4	3	4	6	100	
10	4	4	4	4	3	3	6	100	
11	4	2	4	3	3	3	5	83.3	
12	4	4	4	4	4	4	6	100	
13	4	4	4	4	3	4	6	100	
14	4	4	4	4	3	3	6	100	
15	3	4	3	4	4	4	6	100	

I-CVI: Item Content Validity Index, S-CVI: Scale Content Validity Index

Table 3: Content validity analysis for clarity index

Item	Score given by experts (1-6) to relevancy of each item						Number of agreements observed for score of ≥3	I-CVI (%)	S-CVI (%)
	1	2	3	4	5	6			
1	4	4	4	4	4	4	6	100	96.66
2	4	4	4	4	3	4	6	100	
3	4	4	4	4	4	4	6	100	
4	4	4	4	4	3	4	6	100	
5	4	2	4	4	4	4	5	83.3	
6	4	4	4	4	4	4	6	100	
7	4	4	4	4	3	4	6	100	
8	4	4	4	4	3	4	6	100	
9	3	3	3	4	4	3	6	100	
10	4	3	3	2	3	3	5	83.3	
11	3	2	3	3	3	3	5	83.3	
12	4	4	4	4	4	4	6	100	
13	4	4	4	4	3	4	6	100	
14	3	4	3	4	3	4	6	100	
15	4	4	4	4	4	4	6	100	

I-CVI: Item Content Validity Index, S-CVI: Scale Content Validity Index

Table 4: Internal consistency analysis of the Persian Convergence Insufficiency Symptom Survey questionnaire

CISS item	Cronbach's alpha if item deleted	Item-total correlation
1	0.73	0.70
2	0.75	0.54
3	0.75	0.52
4	0.76	0.37
5	0.75	0.46
6	0.77	0.22
7	0.78	0.19
8	0.76	0.36
9	0.75	0.48
10	0.74	0.60
11	0.77	0.27
12	0.78	0.15
13	0.78	0.14
14	0.77	0.26
15	0.78	0.19

CISS: Convergence Insufficiency Symptom Survey

Figure 1: Mean overall Convergence Insufficiency Symptom Survey score in different convergence insufficiency severity groups

vision disorders.[1,4] In this study, we prepared the Persian version of this questionnaire and assessed its validity and reliability in Iranian CI patients aged 18–34 years. To the best of our knowledge, this is the first psychometric assessment of the CISS in Iran. The psychometric properties of the original version of the revised CISS were assessed by Borsting *et al.* in children aged 9–18 years,[11] and by Rouse *et al.* in young adults with the age range 19–30 years,[12] and its validity and reliability were confirmed in both age groups.

In this study, we comprehensively assessed the content validity of the Persian CISS using the approach suggested by Lynn,[24] which is one of the most comprehensive approaches for assessment of content validity that uses the three indices of relevancy, clarity, and comprehensiveness in details and
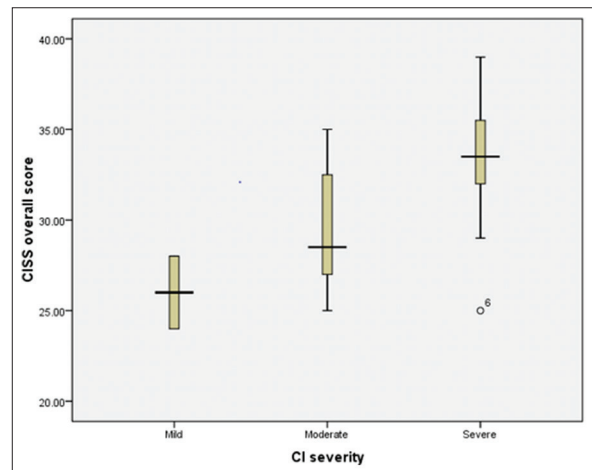
calculates the CVI for each index separately. As for relevancy, the I-CVI of all items was above 80% (I-CVI was 100% for 14 items and 83.3% for 1 item), and the S-CVI was estimated at 98.88%, indicating the high capability of the Persian CISS to reflect the characteristics of the content under study. As for clarity, I-CVI was above 80% for all items (100% for 12 items and 83.3% for 3 items) with an S-CVI of 96.66%, indicating the appropriateness of all selected items in terms of writing style and concept. The S-CVI was 100% for comprehensiveness, indicating the excellent capability of the Persian CISS to cover all aspects of CI related symptomatology. A characteristic of the present study was comprehensive assessment of the content validity process. This process was not addressed in details in previous studies, and CVI was not reported.

The overall Cronbach's alpha coefficient was 0.77 in this study. Moreover, no item had a negative correlation with the overall CISS score, indicating that the Persian version of the

Table 5: Test-retest reliability analysis of the Persian Convergence Insufficiency Symptom Survey questionnaire

CISS item	ICC value	95% CI
1	0.95	0.90-0.97
2	0.95	0.89-0.97
3	0.91	0.81-0.95
4	0.97	0.95-0.98
5	0.95	0.89-0.97
6	0.86	0.71-0.93
7	0.96	0.91-0.98
8	0.90	0.79-0.95
9	0.94	0.88-0.97
10	0.93	0.85-0.96
11	0.82	0.64-0.91
12	0.83	0.64-0.92
13	0.78	0.53-0.87
14	0.75	0.55-0.87
15	0.89	0.78-0.95

CISS: Convergence Insufficiency Symptom Survey, ICC: Interclass correlation coefficient, CI: Confidence interval

CISS had an acceptable internal consistency, and the items surveyed were not redundant. Bosrting *et al.* and Rouse *et al.* reported a Cronbach's alpha coefficient of 0.92 and 0.84 in their similar studies in age groups 9–18 years and 19–30 years, respectively.[11,12] Although the Cronbach's alpha coefficient of the present study was less than the two above studies, it was acceptable, indicating the good homogeneity of the items. It should be mentioned that some items like Question 1 (referring to eye tiredness), Question 2 (referring to eye discomfort), Question 3 (referring to headache), and Question 10 (referring to hurting of the eyes) had a stronger correlation with the overall CISS score compared to other items, which could indicate the higher occurrence of some visual symptoms in CI patients. Therefore, these symptoms may be considered more specific associated symptoms of CI.

In this study, the test-retest reliability of the Persian version of the CISS was assessed using ICC. Evaluation of test-retest reliability is important for investigating symptoms changes before and after the medical intervention.[25] The results showed an ICC of 0.95 (95% LOA: −7.8 to 15.6), indicating excellent test-retest reliability of the scale. Moreover, 9 items had excellent and 7 items had good repeatability. The mean difference in the overall CISS score between the first and second administrations was 0.60 ± 1.10 points, indicating minimum bias between these two administrations. Borsting *et al.* reported an ICC of 0.77 (95% LOA: −10.2 to 12.1) in children under 18 years of age,[11] and Rouse *et al.* found an ICC of 0.88 (95% LOA: −9.0 to 7.6) in the age group 19–30 years.[12] Therefore, the ICC was higher in the present study compared to previous studies, especially the study conducted in children, indicating the excellent test-retest reliability of the Persian CISS. One reason could be the older age range of the participants in the present study. Studies comparing children's and adults' responses

to surveys have found that adults' responses are far more reliable.[12,26]

The discriminant validity of the Persian version of the CISS was also assessed in this study. The results showed a significant difference in the mean overall CISS score between mild and severe and also between moderate and severe levels of CI, while the difference between mild and moderate CI was not statistically significant. Previous studies assessed the ability of the CISS to discriminate between CI patients and individuals with a normal binocular vision, and a symptom score of 21 or higher has been found to be significant in adults,[10-12] but its ability to discriminate between different levels of CI severity was not investigated in previous studies. Therefore, it can be concluded that the Persian version of the CISS has an acceptable discriminant validity and is especially able to detect patients with severe stages of CI. Caution should be exercised regarding the inability of the questionnaire to discriminate between mild and moderate levels of CI because of the small number of patients in the mild severity group.

This study had some potential limitations. For example, few studies have assessed the psychometric properties of the CISS in different ethnic groups, which hinders comparison. Moreover, due to the subjective nature of this tool, the possibility of information bias cannot be entirely ruled out. Moreover, the results were not compared between CI patients and healthy subjects. In conclusion, the Persian version of the revised CISS is a valid and reliable tool for clinical and research applications in the field of binocular vision.

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Conflicts of interest

There are no conflicts of interest.

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