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Full Length Article

Evaluation and application of a Chinese version symptom questionnaire for visual dysfunctions (CSQVD) in school-age children

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ABSTRACT

Objective: To develop and evaluate a Chinese version of the Symptom Questionnaire for Visual Dysfunctions (CSQVD) to quantify visual dysfunction symptoms in school-age children with various eye diseases, and to explore the relationship between ophthalmological disorders and visual dysfunction symptoms.

Methods: Following standard scale adaptation procedures, the Symptom Questionnaire for Visual Dysfunctions (SQVD) was translated into Chinese (CSQVD). We employed random sampling to survey 198 outpatients aged 7–18 to assess the psychometric properties of the CSQVD. Using the reliable and validated questionnaire, we evaluated the determinants of visual dysfunction symptoms among 406 school-age patients at an eye center. The CSQVD scores were correlated with demographic and clinical variables, including gender, age, eye position, refractive power, and best-corrected visual acuity. Univariate analysis identified potential risk factors, followed by binary logistic regression and multiple linear regression analysis on factors with a *P*-value <0.05.

Results: The CSQVD scale's critical ratio (CR) values ranged from 6.028 to 10.604. The Cronbach's Alpha coefficient was 0.779, and Spearman-Brown split-half reliability was also 0.779. The I-CVI varied from 0.83 to 1.000, the S-CVI/Ave was 0.857, and the KMO value was 0.821. Multifactorial regression analysis indicated that high myopia (OR = 5.744, 95% CI [1.632, 20.218], $P = 0.006$) and amblyopia (OR = 9.302, 95% CI [1.878, 46.058], $P = 0.006$) were significant predictors of CSQVD symptoms. Multiple linear regression analysis showed that BCVA of amblyopic eyes (B = −5.052, 95% CI [−7.779, 2.325], $P = 0.000$) and SE power (B = −0.234, 95% CI [−0.375, 0.205], $P = 0.001$) significantly affected the CSQVD scale scores.

Conclusions: The Chinese version of the SQVD scale (CSQVD) demonstrates good feasibility, discriminatory power, validity, and reliability in assessing Chinese school-aged children. Furthermore, those who have severe myopia and amblyopia reported more visual dysfunction symptoms.

1. Introduction

Visual discomfort is initially defined as a subjective visual perception, characterized by individual responses to specific visual stimuli, such as high-contrast striped patterns, small-font text, and flickering lights.[1–4] Individuals may experience graphic distortions, hallucinations, nausea, headaches, blurred vision, and eye pain. This condition originates from maladaptive neurological responses to visual input or faulty eye alignment, which, under certain conditions, manifests symptoms of discomfort.[3–5] However, clinicians may overlook these symptoms if no overt eye diseases are present and the patient's entrance visual acuities are 20/20 Oculus Unitatis (OU), potentially leading to unrecognized suffering. Thus, an ideal visual state should extend beyond mere 20/20 vision with corrective measures to encompass good refractive status, comprehensive visual functionality, and proficiency in complex visual tasks such as navigation and complicated decision-making.[6,7]

Patients with visual function abnormalities may exhibit symptoms including impaired vision, fragmented attention, headaches, and eye pain.[8–10] The increasing use of electronic screens is contributing to a rise in myopia prevalence, which has emerged as a significant concern in ophthalmology.[11] For school-aged children, uncorrected refractive errors (URE) are the primary cause of visual impairment, affecting between 51.8% and 66.6% of adolescents in China.[12,13] These conditions can diminish concentration levels, thus affecting academic achievement, social interactions, psychological development, and overall quality of life.[14,15] Amblyopia and strabismus, two prevalent childhood eye

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conditions in China, affect approximately 3.53% and 1.43% of the youth, respectively.[16] The underdevelopment of central visual pathways and improper eye alignment adversely affect the development of visual and binocular functions, leading to reduced academic participation, declining grades,[17] and potential consequences for psychological and social well-being.[16,18] Therefore, a holistic and balanced evaluation of quantitative measurements of subjective symptoms, along with clinical findings, is essential for the assessment of visual function impairments.

Although numerous visual symptom scales exist, these questionnaires vary significantly in their objectives, content, and evaluation of psychometric properties. The Convergence Insufficiency Symptom Survey (CISS) and its parental version are specifically designed for individuals with convergence insufficiency (CI).[19,20] The Visual Discomfort Scale, developed by Conlon et al. is employed to identify visual discomfort[21] but is not intended to diagnose specific visual impairments. Currently, there is no unified scale that comprehensively addresses various visual function deficits, including refractive errors, strabismus, and amblyopia.

In accordance with the patient-reported outcomes (PROs) guidance document published by the Food and Drug Administration (FDA),[22,23] Cacho-Martinez P. et al. created a Symptom Questionnaire for Visual Dysfunctions (SQVD) for the purpose of identifying symptoms in individuals with any form of visual dysfunction.[24,25] This questionnaire was initially developed based on a literature review,[8–10] then gradually refined through expert consultations pre-testing, pilot testing, and retesting, affirmed it high psychometric properties. Due to its pragmatic utility, our team plans to implement this survey among youngsters of school age. Nevertheless, there has been no observation or confirmation of the SQVD scale being adapted or validated in the Chinese context.

Therefore, the objective of this study was to propose a Chinese version of the SQVD scale, which would be referred to as CSQVD. Face-to-face surveys were conducted with a clinical sample of school-aged patients with various ophthalmologic disorders (including refractive errors, strabismus, and amblyopia). The purpose was to evaluate the psychometric characteristics of the survey and determine the relationship between symptoms of CSQVD (Computer Screen-Related Visual Discomfort) and clinical measurements.

2. Materials and methods

This study was approved by the Second Affiliated Hospital of Zhejiang University Institutional Review Board (approval number: 2023–1255), and we adhere to the principles of Good Clinical Practice (GCP) and the Declaration of Helsinki. Consent was obtained from patients and their parents/guardians after fully informing them of the details.

2.1. Patients

This study is a single-center prospective cohort study conducted by the Eye Center at the Second Affiliated Hospital of the College of Medicine. Children receiving treatment at the hospital were randomly selected as research subjects from December 2023 to February 2024.

The inclusion criteria are as follows: (1) Patients aged 7 to 18 regardless of gender. (2) Ophthalmological criteria include (a) absence of acute ocular trauma or pain and (b) absence of organic diseases such as glaucoma, optic neuritis, or keratitis. (3) Health criteria: absence of systemic diseases such as heart disease or diabetes. (4) Parents or legal guardians must have adequate literacy skills in Chinese and provide informed consent for their child's participation in the study.

2.2. Subjects' information and examinations

General Information Surveys were compiled by the research team, including the patients' names, genders, and ages. All patients underwent a comprehensive ophthalmic evaluation for both eyes, which included measurements of refractive power, best-corrected visual acuity (BCVA), and eye position. A designated ophthalmologist was responsible for administering and collecting the questionnaires.

2.3. SQVD scale

The SQVD Scale is a self-assessment tool developed by Cacho-Martinez P. and colleagues for patients with various types of visual function impairments.[24,25] The assessment examines symptoms, including blurred vision, binocular visual impairment, eye discomfort, difficulty in concentration, issues in reading, and headaches. Scoring ≥ 6 indicates significant visual discomfort. The scale employs a three-level Likert scoring system to assess symptom frequency: 0 = None: symptoms never occur; 1 = Occasionally or frequently: symptoms occur at least once every 15 days or once or twice a week; 2 = Always, symptoms occur almost daily. Scores range from 0 to 28. The authors also offer a method for converting ordinal data into interval-level data for statistical analysis (S2, Supplementary Data).

2.4. Translation of the Chinese version of the SQVD

Following the acquisition of permission from the original creators of the SQVD Scale, a forward-backwards technique was utilized to translate it into Chinese, employing the Brislin translation model.[26] Initially, two bilingual ophthalmology researchers who were fluent in two languages independently translated the scale and combined their translations to create a consensus version. Afterwards, two skilled translators rendered the Chinese version back into English. An exhaustive evaluation carried out by a panel of specialists was undertaken to guarantee uniformity in ideas, substance, and vocabulary. Following adjustments and enhancements, three ophthalmology experts were extended an invitation to evaluate the scale. Considering the varying linguistic understanding capacities of patients across different age groups, two versions were developed to cater to the 7–10 age group and the 11–18 age group. This customization was designed to ensure the scientific rigor and efficacy of cross-cultural applications, while also taking into account the varying cognitive skills of patients across different age groups in the Chinese cultural context.

The core cultural adaptation group consisted of 11 individuals with diverse backgrounds, including three ophthalmologists, three optometrists, three nurses, and two clinical eye disease patients. Two cultural adaptation sessions were held to ensure that the Chinese version of the scale had all the essential information from the original version, promoting successful cross-cultural communication and local adaptation. Details of the Chinese version of the CSQVD are available in the Supplementary data1.

2.5. Data analysis

Data were statistically analyzed using SPSS Ver. 26 (IBM Corporation, NY, USA). For describing baseline characteristics, continuous data that followed a normal distribution were presented as the mean ± standard deviation ($\bar{x} \pm s$), Otherwise, they were shown as the median (range). Categorical data were represented as the number of cases and percentages. Item analysis utilized the correlation coefficient and the extreme group method. Scale reliability was evaluated using internal consistency, Cronbach's alpha, and the split-half coefficient. Scale validity was assessed through content validity and structural validity. To test different degrees of visual impairment and clinical characteristics, we employed an independent samples *t*-test or one-way ANOVA for equal variances, and non-parametric tests, such as the Chi-square test (χ^2 test) and the Mann-Whitney *U* test for unequal variances. Values of $P < 0.05$ was considered statistically significant across all analysis and were included in multiple linear regression analysis and binary logistic regression modelling. Additionally, we plotted the receiver operating characteristic (ROC) curve and calculated the Youden index to determine the optimal cutoff value. $P < 0.05$ is considered statistically significant.

3. Results

3.1. Scale evaluation

During the validity testing phase, participants suffering from various conditions were included. They ranged in age from 7 to 18 years, with an average age of 10.22 ± 0.205 years.

3.1.1. The feasibility analysis of the CSQVD scale

We collected 198 valid questionnaires, achieving a recovery rate of 86.67% and an efficacy rate of 97.60%, both exceeding the 85% benchmark.[27] According to the guidelines set by the original authors, participants should complete it within 5 min. This study confirmed that all participants completed the questionnaire within this timeframe, with times ranging from 46 to 300 s (165 ± 60 s), without any reported difficulties in understanding or answering. These findings suggest that the CSQVD questionnaire is practical and feasible.

3.1.2. The item analysis and reliability analysis of the CSQVD scale

The item analysis of the CSQVD was performed utilizing the Critical Ratio (CR) technique. Afterwards, the Mann-Whitney *U* test was applied to compare the scores of each item between these dichotomous groups. The CR values of the 14 items ranged from 4.471 to 7.220 ($P < 0.001$), indicating a high level of discriminate ability. Spearman rank correlation analysis revealed a significant correlation ($P < 0.05$), with correlation coefficients ranging from 0.447 to 0.731. The Cronbach's Alpha coefficient of the CSQVD scale is 0.779, and the Spearman-Brown split-half reliability is 0.779, which suggests that the evaluation tool has a high level of reliability. Table 1 displays the distribution of scores for the CSQVD questionnaire.

3.1.3. Validity test of CSQVD

(1) Content Validity

Following the content validity index (CVI) suggested by Hambleton and Lynn,[28,29] three ophthalmology specialists and three optometry experts were consulted for evaluation. The item-level content validity index (I-CVI) ranged from 0.83 to 1.000, and the scale-level average content validity index (S-CVI/Ave) was 0.857 (Table 2). These values indicate that the scale has a high level of content validity.

(2) Construct Validity

The KMO value was 0.821 (>0.6), and Bartlett's test of sphericity yielded $\chi^2 = 529.165$, sig = 0.000 < 0.001, making it suitable for factor analysis. Principal component analysis, using orthogonal varimax rotation, revealed the presence of four common components that collectively accounted for 52.528% of the total variation in the data. These factors individually explained 16.106%, 12.592%, 12.428%, and 11.402% of the variance, respectively. The scree plot (Fig. 1) showed a continuous decrease in eigenvalues (<1) starting with the 5th component, which supports the suitability of having four factors. Table 3 shows that the factor loadings for each item were more significant than 0.4, and the cumulative variance contribution was over 50%. This indicates that CSQVD has satisfactory construct validity.

3.2. Application of the CSQVD scale

During the clinical application phase of the scale, we reincorporated 406 valid datasets following the criteria outlined in section 2.1.

3.2.1. Demographics and ophthalmological examination results

In the dataset preprocessing stage, we eliminated outliers, missing values, responses exceeding the 5-min threshold, and daily use of contact lenses. We enrolled 406 patients aged between 7 and 18 years (average 10.23 ± 2.801 years). Among them, 216 (53.2%) were male, and 130 individuals (32.0%) exhibited symptoms of visual impairment according to the CSQVD scale. Approximately 96.31% (391 patients) presented with some ophthalmological disorder, with 361 cases of refractive errors, 96 cases of strabismus (18 esotropia and 78 exotropia), and 11 cases of amblyopia. The sample was categorized by refractive error into 45 emmetropic, 285 myopic, and 76 hyperopic patients.

Subsequently, we converted the original CSQVD scores (ranging from 0 to 28 points) into equivalent values on a logit scale, based on previous literature[24] (S2, Supplementary Data). This transformation resulted in a normalized CSQVD score of 7.2823 ± 3.935.

Table 1
The correlation between each item and total score and critical ratio on the CSQVD scale.

Question number	Correlation Coefficient	Critical Value (Z)	Score (x ± s)	Cronbach's α coefficient after item deletion	Correlation with total score (r)
1	0.447	4.471	0.14 ± 0.349	0.773	0.304
2	0.621	4.979	0.24 ± 0.450	0.760	0.465
3	0.604	6.257	0.20 ± 0.411	0.770	0.348
4	0.560	6.238	0.62 ± 0.700	0.754	0.539
5	0.682	6.762	0.21 ± 0.434	0.756	0.488
6	0.641	6.086	0.20 ± 0.450	0.757	0.502
7	0.552	5.402	0.22 ± 0.463	0.762	0.436
8	0.613	5.517	0.27 ± 0.455	0.772	0.336
9	0.552	5.623	0.29 ± 0.519	0.781	0.282
10	0.631	6.022	0.40 ± 0.628	0.789	0.218
11	0.599	5.650	0.50 ± 0.689	0.765	0.399
12	0.652	6.333	0.32 ± 0.520	0.758	0.494
13	0.625	5.955	0.23 ± 0.455	0.760	0.48
14	0.731	7.220	0.48 ± 0.594	0.762	0.46
Total	1	9.071	4.33 ± 3.687	–	–

3.2.2. Comparison between symptomatic and asymptomatic groups

The subjects were categorized into two groups based on their CSQVD scale scores: an asymptomatic group (original CSQVD score <6 points) and a symptomatic group (original CSQVD score ≥6 points). The results of the non-parametric analysis (Table 4) showed that male gender, lower best-corrected visual acuity, and amblyopia may be related to visual symptoms (all $P < 0.05$). The ability of the CSQVD scale to distinguish between different levels of illness severity was further assessed (Table 5).

Table 2
The Experts ratings and calculation of CVIs of CSQVD scale.

items	Experts' Ratings						Number of 3 or 4	I-CVI	P_c	K^*	Evaluation
	A	B	C	D	E	F					
1	2	3	3	4	4	3	5	0.83	0.094	0.81	Excellent
2	4	3	3	4	4	3	6	1	0.016	1	Excellent
3	3	4	3	4	3	3	6	1	0.016	1	Excellent
4	3	4	3	3	4	4	6	1	0.016	1	Excellent
5	4	4	3	4	3	4	6	1	0.016	1	Excellent
6	3	4	4	3	3	3	6	1	0.016	1	Excellent
7	4	3	4	3	4	4	6	1	0.016	1	Excellent
8	4	3	3	3	3	4	6	1	0.016	1	Excellent
9	4	4	4	4	4	4	6	1	0.016	1	Excellent
10	4	4	4	3	3	3	6	1	0.016	1	Excellent
11	3	4	3	3	4	3	6	1	0.016	1	Excellent
12	4	4	4	4	3	4	6	1	0.016	1	Excellent
13	3	3	3	3	2	4	5	0.83	0.094	0.81	Excellent
14	4	3	4	4	3	3	6	1	0.016	1	Excellent

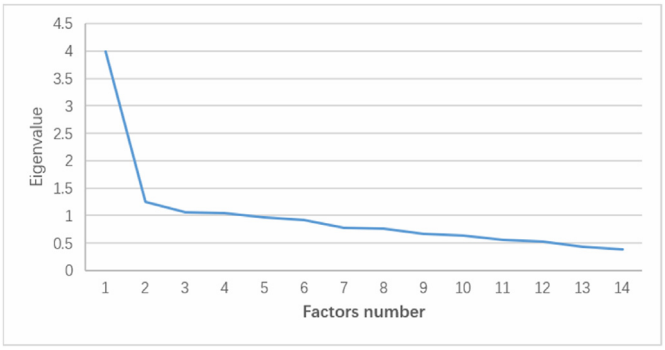

Fig. 1. Principal components analysis of the Chinese CSQVD: Seree plot shows the number and eigenvalue of principal components of the CSQVD questionnaires. The scree plot showed a gradual decrease in the eigenvalues (<1) of the 5th factor, indicating that four factors are appropriate.

Table 3
Structural validity analysis of CSQVD.

Dimension	Question number	Factor 1	Factor 2	Factor 3	Factor 4
1	12	0.658			
1	13	0.644			
1	11	0.630			
1	5	0.516		0.365	
1	14	0.448			
2	10		0.850		
2	3		0.695		
2	7	0.354	0.464		
3	1			0.693	
3	9			0.605	
3	2			0.523	0.429
4	4				0.760
4	8			0.385	0.625
4	6	0.492			0.534

Among patients with different degrees of myopia, individuals with high myopia exhibited a significantly higher proportion of visual symptoms compared to other categories. Patients with partial, non-accommodative esotropia among different types of strabismus showed a higher rate of visual symptoms (71.4%), which was significantly different from the intermittent exotropia group. Nevertheless, there were no notable disparities in the occurrence of visual symptoms across different forms of strabismus, as well as in relation to the severity of anisometropia and astigmatism.

3.2.3. *Differences in CSQVD scale scores among various disease types*

Table 6 explores the relationship between different genders and age groups, types of refractive errors, types of amblyopia, types of strabismus, and the standardized scores on the CSQVD scale. Age-wise, patients were categorized into a younger cohort (≤7 years old) and an older cohort (> seven years old). The findings revealed that the myopia group had the highest average CSQVD score (7.81 ± 3.65), with a significant difference between emmetropia and hyperopia groups (F = 10.129, P = 0.000). Furthermore, the group with amblyopia had significantly higher scores than the group without (F = 16.919, P = 0.000). However, there were no significant differences in CSQVD scores based on gender, age, and types of strabismus (P > 0.05).

3.2.4. *Logistic regression analysis of risk factors for CSQVD symptoms*

The binary Logistic regression analysis model (Table 7), using the presence of CSQVD symptoms (yes = 1, no = 0) as the dependent variable, indicates a significant association between high myopia, amblyopia, and the occurrence of CSQVD vision impairment symptoms. The fitness of the model was evaluated using the Hosmer-Lemeshow test, which yielded a chi-square statistic of 10.053, P = 0.261 > 0.05, with a prediction accuracy of 72.4%. Both high myopia (OR = 5.744, 95% CI [1.632, 20.218], P = 0.006) and the presence of amblyopia (OR = 9.302, 95% CI [1.878, 46.058], P = 0.006) significantly increased the risk of vision impairment symptoms. Other refractive statuses, types of strabismus, age, and gender can have an impact, they did not show statistical significance in this study, although influential, were not statistically significant.

3.2.5. *Multiple linear regression analysis of risk factors for CSQVD symptoms*

The multiple linear regression analysis (Table 8) demonstrates that the best-corrected visual acuity (BCVA) of the amblyopic eye and spherical equivalent (SE) are significant predictors of the outcome variable. However, gender, age, and strabismus do not show significant predictive value. As myopia increases (the SE value decreases), the CSQVD symptoms of the subjects may gradually worsen (95% CI [−0.375, 0.205], P = 0.001). Specifically, for every one-unit decrement in LogMAR BCVA, there is a corresponding increase of 5.052 points on the symptom scale (95% CI [−7.779, 2.325], P = 0.000).

4. Discussion

This study adapted the English version of the SQVD scale as a blueprint and, after translation and cultural adjustment, developed a Chinese version Symptom Questionnaire for Visual Dysfunctions (CSQVD) suitable for school-age children in China. Following the reliability and validity tests, we evaluated the scale's suitability in clinical settings, conducting initial applications and assessments on school-aged children.

This customization method was implemented to guarantee acceptability and feasibility among participants across various age groups. The

Table 4
Characteristics of symptomatic and asymptomatic groups in various characteristics.

Characteristics	Category/Description	Symptomatic	Asymptomatic	χ^2/Z	*P*
		n = 276	n = 130		
Gender [n (%)]	Male	137 (63.4)	79 (36.6)	$\chi^2 = 4.398$	**0.036**
	Female	139 (73.2)	51 (26.8)		
Age [Median (QR), year]		10 (3)	10 (6)	Z = −1.028	0.304
BCVA [Median (QR)]	OD	1.0 (0)	1.0 (0)	Z = −2.190	**0.029**
	OS	1.0 (0)	1.0 (0)	Z = −2.563	**0.010**
Refractive state [n (%)]	Emmetropia	35 (77.8)	10 (14.4)	$\chi^2 = 3.047$	0.218
	Myopia	187 (65.6)	98 (34.4)		
	Hyperopia	54 (71.7)	22 (28.9)		
Amblyopia [n (%)]	None	274 (69.4)	121 (30.6)	$\chi^2 = 12.881$	**0.001**
	Amblyopia	2 (18.2)	9 (81.8)		
Strabismus [n (%)]	None	212 (68.4)	98 (31.6)	$\chi^2 = 5.126$	0.077
	Exotropia	56 (71.8)	22 (28.2)		
	Esotropia	8 (44.4)	10 (55.6)		

Note: X^2 -the use of the Chi-square test. Z -the use of the Mann-Whitney U rank-sum test.

Table 5
Characteristics of symptomatic and asymptomatic groups in different disease severities.

Characteristics	Category/Description	Symptomatic	Asymptomatic	χ^2/Z	*P*	Comparison pair by pair
		n = 276	n = 130			
Refractive state [n (%)]	None	35 (77.8)	10 (22.2)	$\chi^2 = 17.597$	**0.007**	*P* < 0.05
	Mild Myopia	139 (70.2)	59 (29.8)			*P* < 0.05
	Moderate Myopia	42 (61.8)	26 (38.2)			*P* < 0.05
	Severe Myopia	6 (31.6)	**13(68.4)***			
	Mild Hyperopia	35 (76.1)	11 (23.9)			*P* < 0.05
	Moderate Hyperopia	11 (57.9)	8 (42.1)			*P* < 0.05
	Severe Hyperopia	8 (72.7)	3 (27.3)			*P* < 0.05
Anisometropia [n (%)]	None	198 (68.8)	90 (31.3)	$\chi^2 = 3.08$	0.214	
	Mild Anisometropia	60 (70.6)	25 (29.4)			
	Severe Anisometropia	18 (54.5)	15 (45.5)			
Astigmatism [n (%)]	None	209 (68.3)	97 (31.7)	$\chi^2 = 0.34$	0.952	
	Mild Astigmatism	48 (68.8)	22 (31.4)			
	Moderate Astigmatism	17 (63.0)	10 (37.0)			
	Severe Astigmatism	2 (66.7)	1 (33.3)			
Strabismus [n (%)]	None	194 (66.4)	98 (33.6)	$\chi^2 = 12.341$ (likelihood ratio)	**0.027**	
	Latent Exotropia	2 (66.7)	1 (33.3)			
	Intermittent Exotropia	61 (78.2)	17 (21.8)*			*P* < 0.05
	Accommodative Esotropia	12 (80.0)	3 (20.0)			
	Partial, Non-accommodative Esotropia	2 (28.6)	**5(71.4)***			
	Constant Exotropia	5 (45.5)	6 (54.5)			

Note: χ^2 -the use of the Chi-square test. Z -the use of the Mann-Whitney U rank-sum test.
*Bonferroni post hoc test ($P < 0.05$). Statistically significant group differences are indicated in bold.
Each superscript * indicates a subset of the category, showing no significant difference in the column proportions among these categories at the 0.05 level.

Table 6
Distribution of standardized CSQVD scores in clinical measures. (Score, $\bar{x} \pm s$).

Clinical measures	Category/Description	(n)	Standardized CSQVD scores	95%CI	*t/F*	*P*
Gender	Male	216	4.04 ± 0.28	6.99–8.07	$F = 1.848$	0.175
	Female	190	3.80 ± 0.28	6.46–7.54		
Age	≤7 year	73	7.06 ± 4.42	6.03–8.09	$t = 3.520$	0.061
	>7 year	333	7.33 ± 3.83	6.92–7.74		
Refractive state	Emmetropia	45	6.73 ± 3.71	5.61–7.85	$F = 10.129$	**0**
	Myopia	285	7.81 ± 3.65	7.38–8.24		
	Hyperopia	76	5.63 ± 4.59	4.58–6.68		
Amblyopia	None	395	4.44 ± 0.196	4.05–4.83	$F = 16.919$	**0**
	Amblyopia	11	9.36 ± 1.377	6.30–12.43		
Strabismus	None	310	7.19 ± 3.87	6.76–7.62	$F = 1.171$	0.311
	Exotropia	78	7.34 ± 3.96	6.45–8.23		
	Esotropia	18	8.64 ± 4.84	6.23–11.05		

Note:t -the use of an independent samples *t*-test, *F* -the use of a one-way ANOVA test. N: number.
Statistically significant group differences are indicated in bold.

Table 7
Binary logistic regression analysis of the influencing factors of CSQVD symptoms.

Variables	Category/Description	β	Std. Error	Wald	OR	95% CI	*P*
Gender	Male						
	Female	−0.339	0.23	2.168	0.712	0.453–1.119	0.141
Age		0.032	0.045	0.524	1.033	0.946–1.127	0.469
Refractive state	None						
	Mild Myopia	0.242	0.399	0.367	1.273	0.582–2.783	0.545
	Moderate Myopia	0.374	0.47	0.633	1.453	0.579–3.647	0.426
	Severe Myopia	1.748	0.642	7.412	5.744	1.632–20.218	**0.006**
	Mild Hyperopia	−0.196	0.53	0.137	0.822	0.291–2.324	0.712
	Moderate Hyperopia	1.216	0.681	3.191	3.373	0.888–12.803	0.074
	Severe Hyperopia	0.558	0.796	0.492	1.748	0.367–8.312	0.483
Strabismus [n (%)]	None						
	Latent Exotropia	−0.396	1.279	0.096	0.673	0.055–8.260	0.757
	Intermittent Exotropia	−0.5	0.311	2.583	0.607	0.330–1.116	0.108
	Accommodative Esotropia	−1.099	0.789	1.941	0.333	0.071–1.564	0.164
	Partial, Non-accommodative Esotropia	1.579	0.898	3.094	4.849	0.835–28.166	0.079
	Constant Exotropia	0.628	0.675	0.866	1.874	0.499–7.032	0.352
Amblyopia [n (%)]	None						
	Amblyopia	2.23	0.816	7.466	9.302	1.878–46.058	**0.006**

Note: Statistically significant group differences are indicated in bold.

Table 8
Multiple linear regression analysis of the influencing factors of CSQVD scores.

Variables	Coefficients (B)	Std. Error	Standardized coefficients (β)	*P*	95% CI
Intercept	10.531	1.503		0	7.577–13.486
Gender	−0.336	0.378	−0.043	0.376	−1.079–0.408
Age	0.137	0.074	0.098	0.063	−0.008–0.282
Strabismus	0.109	0.154	0.035	0.479	−0.193–0.411
BCVA of Amblyopic Eye	−5.052	1.387	−0.176	0	−7.779–2.325
SE	−0.234	0.072	−0.171	0.001	−0.375–0.205

appropriateness and reliability of the items were tested by analyzing them using CR values and correlation coefficients. Significant disparities were noted in all items between the high and low groups ($P < 0.001$). All CR values were >3 (range, 4.471–7.220) (Table 2), indicating that all items in the CSQVD scale exhibited good distinguishability, with item averages significantly correlated with the total score, correlation coefficients ranging between 0.447 and 0.731 ($P < 0.001$).

The CSQVD scale demonstrated a Cronbach's α coefficient of 0.779 and a split-half reliability of 0.779, indicating good reliability in assessing school-aged children. Removing items 4 and 11 increased the Cronbach's α coefficient to 0.796, a minimal difference. Item 4, involving tilting the head or rotating objects during visual tasks, could remind conditions like ocular torticollis, such as superior oblique muscle palsy and nystagmus.[30,31] Item 11, related to squinting to see more clearly, is common among myopic individuals who narrow their pupils to enhance image clarity. Therefore, it was decided not to eliminate these items.

The item-level content validity index (I-CVI) of the CSQVD scale ranged from 0.83 to 1.000, and the scale-level average content validity index (S-CVI/Ave) was 0.857, suggesting that the CSQVD scale aligns well with the theme of "vision disorder symptoms". The KMO value was 0.821, with a significant Bartlett's test of sphericity ($\chi^2 = 529.165$, sig = $0.000 < 0.001$). Exploratory factor analysis revealed four common factors, with factor loadings of all items above 0.450, explaining 52.528% of the variance.

Epidemiological meta-analysis showed that the incidence rate of visual fatigue in minors is 19.7%.[32] Our study found that a significant number (32.0%) of school-aged children with CSQVD exhibit symptoms of visual impairment. This aligns with the features of the target group identified in hospitals, where individuals are more likely to present with visual dysfunctions.

In addition, our study revealed that children with amblyopia exhibited markedly elevated frequencies of visual impairment symptoms and standardized scores on the CSQVD scale. The correlation between best-corrected visual acuity (BCVA) and visual symptoms was significant, indicating a strong relationship between the severity of amblyopia and visual symptoms. Amblyopic patients experience visual impairment because of an imbalance in the development of binocular vision, which causes the weaker eye to be suppressed. If left untreated, this damage may result in poor monocular visual acuity, decreased contrast sensitivity, distortions of visual space and elevated visual crowding in the amblyopic eye.[33,34] Our investigation further highlighted that amblyopes exhibited a greater prevalence of several visual complaints, including headaches, blurred vision, decreased accuracy in depth perception, challenges with concentration, problems concentrating, concentrating, and light sensitivity.

Research on strabismus revealed that patients with partial, non-accommodative esotropia had a significantly higher prevalence of visual complaints (71.4%) compared to those with intermittent exotropia (21.8%). Similarly, Cacho-Martinez P. studied symptoms of visual impairment at a Spanish optometric clinic (primary care clinic); they found that among individuals with strabismus (17 individuals) and amblyopia (2 individuals), the symptoms of SQVD showed no significant difference in the Crude Odds Ratio when compared to 120 individuals without visual impairments.[35] Bade A. et al. (2013) also noted a lack of a strong correlation between the severity of convergence insufficiency signs and symptom frequency.[36] This implies that some individuals may deliberately avoid or inhibit near activities to alleviate visual symptoms. Patients with intermittent exotropia have significantly worse distance stereoacuity, although their near stereoacuity remains comparatively good.[37,38] It is believed that esotropia, compared to exotropia, has a more pronounced impact on near stereoacuity. This may explain why people with esotropia experience a higher number of visual symptoms during near activities such as reading and writing.

Both collinearity analysis and logistic regression analysis indicated

that high myopia is a significant risk factor for the deterioration of visual function. Demographic surveys on children with high myopia underscored its significance as an indicator for eye diseases like lens dislocation and systemic diseases such as Marfan syndrome.[39] Despite our study design having preemptively excluded cases of ocular organic lesions to limit the influence of other potential variables, high myopia itself was associated with poorer eye conditions. Likewise, a survey on the quality of life related to myopia found that patients with high myopia (< -10.00 D) had significantly lower visual function assessment (VF-14 questionnaire) scores and vision-related quality of life (VQoL scores) compared to those with low (≤ -4.00 D) and moderate (-4.00 to -9.75 D) myopia, particularly in psychological, cosmetic, practical, and financial aspects.[40] Research by Osuagwu U. L. et al. reached similar conclusions, highlighting the adverse effects of high myopia on patients' quality of life, including psychological and physical well-being, social and interpersonal relationships, environmental factors, and overall health.[41]

To investigate the association between high myopia and CSQVD-related visual symptoms, we examined the impact of amblyopia, anisometropia, and age factors among patients with different refractive errors (SE). Spearman's rank correlation analysis revealed a moderate negative correlation ($\rho = -0.377$, $P = 0.000$) between age and SE, indicating that myopia tends to worsen with increasing age. Factors such as the BCVA of amblyopic eyes ($\rho = -0.53$, $P = 0.286$) and anisometropia ($\rho = 0.036$, $P = 0.464$) demonstrated no linear correlation with refractive degree. The study further discovered that patients with myopia had significantly higher scores on the "squinting to see" item compared to individuals with normal vision or hyperopia ($P < 0.001$, one-way ANOVA). These findings suggest that the increased prevalence of CSQVD-related visual symptoms in patients with high myopia may not be attributable to amblyopia but rather to the severity of the myopia itself and its associated visual impairments, including deteriorated distance vision.

Our present study focuses on only certain disease categories. Future research should encompass a wider range of clinical features, such as refractive, accommodative, and/or binocular anomalies, and should include a more diverse spectrum of ophthalmological conditions, such as congenital cataracts and nystagmus.

5. Conclusions

In conclusion, the Chinese version of the SQVD scale demonstrated high feasibility, reliability, and validity in studying visual impairment symptoms in school-aged children. This scale can serve as a reference for further research on screening visual symptoms. By conducting logistic regression and multiple linear regression analyses, we discovered significant connections between the risk of visual symptoms on the CSQVD scale and high myopia and amblyopia. However, other refractive states (such as hyperopia and astigmatism), gender, and strabismus had some impact, albeit not statistically significant.

Study approval

The authors confirm that any aspect of the work covered in this manuscript that involved human patients or animals was conducted with the ethical approval of all relevant bodies and the study was performed in accordance with the Declaration of Helsinki, and the protocol was approved by the Second Affiliated Hospital of Zhejiang University Institutional Review Board (approval number: 2023–1255).

Author contributions

The authors confirm contribution to the paper as follows: Conception and design of study: XJ Tang, FY Chen; Data collection: PK Hu, X Zhang, FY Chen; Analysis and interpretation of results: LX Lou, XN Yu, WY Pan, FY Chen; Drafting the manuscript: XJ Tang, FY Chen; All authors reviewed the results and approved the final version of the manuscript.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.aopr.2024.05.001.

Abbreviations

CSQVD	Chinese version Symptom Questionnaire for Visual Dysfunctions
BCVA	best-corrected visual acuity
OU	Oculus Unati
SE	spherical equivalent
CR	critical ratio
URE	uncorrected refractive errors

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