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Development and validation of the 21-item Children's Vision for Living Scale (CVLS) by Rasch analysis

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Background: The aim was to develop and validate an instrument called the 'Children's Vision for Living Scale' (CVLS) for the assessment of vision-related quality of life in Saudi Arabian children with and without amblyopia.

Methods: A 43-item child self-report questionnaire was initially developed based on interviews with children with amblyopia, their parents and eye-care professionals, and a literature review. Following a process that involved the removal of redundant items, 28 items remained and were piloted on children aged five to 12 years with and without amblyopia (n = 48 amblyopic, n = 53 non-amblyopic) living in Saudi Arabia. Rasch analysis was applied to determine whether the 28-item questionnaire fitted the Rasch model. Rasch analysis was used to assess the validity and reliability of the questionnaire. Principal components analysis (PCA) was used to check dimensionality. A 21-item questionnaire resulting from this process was administered in children with (n = 81) and without (n = 82) amblyopia in Saudi Arabia for further validation.

Results: The final 21-item questionnaire had good validity and reliability as demonstrated by person separation of 2.02, person reliability of 0.80 (mean square and standard deviation: infit = 1.01 ± 0.39; outfit = 1.01 ± 0.40) and item reliability of 0.93 (item infit range = 1.33 to 0.78; item outfit range = 0.78 to 1.30). The mean difference between person and item scores of 0.33 ± 0.53 logits (scale range, 2 to -2) indicates that the items are well targeted to the populations. The PCA (dimensionality measures) shows the percentage of variance explained by measures equal to 26.4 per cent (modelled 26.9 per cent) and an eigenvalue of the first contrast of 2.5, which demonstrated good stability.

Conclusion: The 21-item CVLS is a valid uni-dimensional child self-report instrument for the assessment of the impact of amblyopia on vision-related quality of life in children with and without amblyopia living in Saudi Arabia.

Key words: amblyopia, children, questionnaire, vision-related quality of life, Rasch analysis.

Amblyopia is defined as reduced visual function due to abnormal visual experience (such as strabismus, anisometropia or visual form deprivation) in early life, in the absence of ocular pathology.[1] It is the most common cause of unilateral visual impairment[2] and can affect 3.5 to 5.0 per cent of the general population.[3] It has the potential to impact on quality of life (QoL) especially vision-related aspects, such as academic performance, social life, sporting and physical activities in children and adults[4] and on ability to do some visually guided tasks.[5]

In Australia, amblyopia may impact on self-esteem[6] in children. Stereopsis is often poor in amblyopia, and individuals, who lack stereopsis have difficulty carrying out fine motor tasks that require three-dimensional vision, which may in turn impact on educational and physical activities.[7] Therefore, vision-related QoL of children with amblyopia may be poorer than in children without amblyopia.[8]

Quality of life is 'an individual's perception of their life situation in the environment of the culture and value systems in which they live and in relation to their aims, potential, concerns and standards'.[9] Several studies have reported that social factors such as financial status or poverty,[10] education,[11] leisure and recreation,[12] emotional well being,[13] family interactions[14] and vision[15] may influence an individual's QoL. Vision-related QoL is defined as those aspects of QoL affected by vision and is intrinsically related to the culture and values of the community, in which individuals live. For example, children living in different cultures will grow up with different expectations (social, educational and occupational), activities and social structure.[13]

Instruments for the assessment of health-related QoL in children,[16] vision-related in adults[17] and children,[18–21] QoL in amblyopia and/or strabismus in adults[22] and children,[23] visually-impaired children[24–26] and the impact of amblyopia treatment on the child and family[27] have been developed. Most such instruments have been developed for application in Western countries[16,17,22,24] and to our knowledge vision-related QoL of children, specifically the effect of amblyopia on children's QoL has not been studied in other cultures.

Children with amblyopia	Parents	Eye-care professionals
1. Do you experience any problems in your games activities, school work, relationships with family and friends or other issues that are caused by your affected eye? If YES, what are they? 2. Have you noticed any differences in your vision before and during the treatment? If YES, what are these differences? What do you think are the causes of these differences? 3. Do you like or dislike occlusion treatment for your vision? Why?	1. Are there any effects of amblyopia on your child's sport activities, school performance, relationships with family and friends or other lifestyle? If YES, what are they? 2. Have you noticed any differences in your child's quality of life before, during, and after commencing the treatment for amblyopia? If YES, what are these differences? What do you think are the causes of these differences? 3. Do you feel that amblyopia and its treatment influence your child's quality of life? If YES, please explain how? 4. Do you think that your child's QoL during treatment is affected by social or cultural factors? Please explain.	1. If amblyopia were to remain untreated, what effects would you expect on children's sport activities, school performance, relationships with family and friends or any other aspects related to quality of life? 2. Do you notice any differences between treated and untreated amblyopic children in regards to their quality of life? If YES, what are these differences? What do you think are the causes of these differences? 3. In your experience, do amblyopic children and/or their parents feel that amblyopia and its treatment influence their life? Please explain.

Table 1. Examples of questions used in individual interviews with children, parents and eye-care professionals for development of items for the Children's Vision for Living Scale questionnaire

There are cultural differences between Western and Middle Eastern countries such as Saudi Arabia, including differences in social and educational expectations and activities. For example, female children in Saudi Arabia do not typically play sport at school (although they may play sporting activities at home), while it is a requisite part of school education and recreation for both male and female children in Australia.[28] In addition, most children in Saudi Arabia do not use public transport and do not go to the cinema.[29] Existing instruments for the assessment of children's vision-related QoL[25,27] may include items relating to activities of this kind, so are not targeted to the life experience of the children in Saudi Arabia.[29,30]

Furthermore, culture can impact on whether vision deficits and their treatment result in good or bad social experiences. For example, in Mexico, children who had refractive errors were found to be concerned about their appearance when wearing spectacles or being teased by peers because of their spectacles.[31] In India, squint in children is considered to be a sign of good luck.[32]

For these reasons, amblyopia and its treatment may affect children's QoL in Saudi Arabia and in a way specific to the country. So, the aim of this study was to develop and validate a child self-report questionnaire for the assessment of vision-related QoL of Saudi Arabian children with and without amblyopia.

METHODS

Item identification

The Children's Vision for Living Scale (CVLS) was developed and validated according to published criteria.[30,33] To optimise the construct validity in the target population, a range of items (questions) relevant to vision-related QoL in amblyopic boys and girls in Saudi Arabia was initially identified based on three sources:

1. individual interviews with school-age (five to 12 years) amblyopic children (n = 30) and their parents (n = 30) in Saudi Arabia,
2. interviews with paediatric eye-care professionals, including optometrists, ophthalmologists and orthoptists in both Saudi Arabia (n = 8) and Australia (n = 3) and
3. a review of the literature on QoL[34–37] and vision-related QoL,[38,39] including existing questionnaire items relating to amblyopia and its treatment.[22,24,40]

Open-ended interview questions were used to ask paediatric eye-care professionals, parents/caregivers and children about factors with potential impact on ability in coping with social, family and school life in Saudi Arabia. Interview questions covered the issues of problems related to activities such as games, school performance and relationships with family and friends, which may be caused by having an amblyopic eye and/or occlusion treatment, differences in visual function before, during and after treatment and attitudes toward the treatment of amblyopia. The interview questions were written in English by the research team and then were translated into Arabic by the bilingual first author. Children (n = 30) and their parents were interviewed face-to-face (the average age of the children was 9.00 ± 2.86 years). The interviews with children were conducted individually in the presence of parents and the researcher (first author), who ensured that children responded freely without communication with the parents. Each question was asked verbally by the interviewer and the respondent was asked to explain and expand on their answers as necessary. Similar issues were raised in questions for parents and eye-care professionals (Table 1). The responses were recorded by the interviewer as hand-written notes in Arabic and then translated to English for the development of items.

Thematic analysis was conducted where data were coded, so that similar ideas were categorised into themes. The frequency with which similar ideas/issues were raised was determined. The final questionnaire included items developed from the interview responses and questions from existing questionnaires, which were related to the themes raised by the interview participants.

Issues raised by the interviewees were developed into questionnaire items relating to vision-related QoL. For example, a ques-

tionnaire item 'If you have a sister or brother, how much do you enjoy playing with them?' (Table 2) was based on a child's interview response '*My brother laughs and won't play with me when I am wearing an eye patch'*. In addition, some items were generated from interviews with parents. For example, a questionnaire item 'How good are you at writing exactly on the line?' was based on a parent's interview response '*I noticed that my child doesn't write words on the line when he is doing his homework, especially when he covers his eye'*. Comments from eye-care practitioners also formed the basis of items. For example, a questionnaire item 'How much do you feel that your eyes are different from other children's eyes?' was based on an eye-care professional's observation *'Children might feel that the child with an eye patch is different'*.

Existing questionnaires were sourced by a review of the literature and were examined for items (Table 2) that were relevant to issues raised by the interviewees and appropriate to the life-experience of the target group of school-aged children of both genders in Saudi Arabian society.[29] The issues concerning children's vision-related QoL included items to assess self-rating of mood, self-esteem, social relations, functional vision, visuo-motor and school performance (Table 2).

Forty-three items were generated via this process (25 items from existing questionnaires and 18 items from interviews) and were then reviewed by the authors to identify items, which overlapped in themes based on content and face validity.[a] Repetition of themes was addressed by eliminating items so the number of items was reduced to 28. The sources of the 28 items and the aspects of vision-related QoL they are intended to assess are listed in Table 2. The questionnaire was translated into Arabic by the first author and then translated back into English by another bilingual Saudi Arabian to ensure that the phrasing of each item was unchanged and that the Arabic translation was accurate.

During the pilot process, the Arabic version of each of the 28 items was read to 10 amblyopic and eight normally sighted Saudi Arabian children (aged five to 12 years) at King Abdulaziz University Hospital (KAUH) and Al-Habib Medical Group (HMG) with the aim of identifying item ambiguity and preference for positive or negative phrasing of items. All children preferred to be asked questions in a positive format such as 'how easy . . . , how happy . . . , how clearly . . .' rather than 'how difficult'. Items that the children identified as ambiguous or difficult to understand were rephrased.

Note that some of the items do not ask directly about vision but in the context of this questionnaire, they are included to assess whether children with amblyopia have difficulties with any of a range of visual, motor, social and other functions. All items require the child to self-rate, so responses to questions such as 'How often do you do the right thing' (item 27) do not necessarily reflect actual performance but the child's assessment of this.

Response scale

A response scale for application in children needs to be one they can understand and use. Several scale types, including visual analogue scales, were trialled in normally sighted children to check scale reliability (repeatability of response). From this process, a Likert scale with five categories ('Not at all', 'A little', 'Moderately', 'A lot', 'Extremely') was found to be appropriate for our sample of children. All children responded without seeking clarification regarding any item or the response scale categories, suggesting that the questionnaire was clear and easy to understand for this age group.

Subjects

Children with and without amblyopia were identified and recruited at paediatric ophthalmology clinics at King Abdulaziz University Hospital, a public hospital, and Al-Habib Medical Group, a private hospital, in Riyadh, Saudi Arabia. Children with amblyopia were undergoing occlusion treatment at one of the hospitals and non-amblyopic participants were healthy visitors to the hospitals, who did not have a history of systemic or ocular disease and had normal visual acuity.

Data on monocular visual acuities, ocular alignment and occlusion treatment modality were obtained from children's record files in the hospital. Demographic data such as age and gender were obtained during the pilot phase of questionnaire development. Inclusion criteria for amblyopic children were age between five and 12 years with a diagnosis of amblyopia, currently being treated. Amblyopia was defined for the purpose of subject allocation as an interocular difference in logMAR visual acuity (VA) of 0.2 or greater (at the time of diagnosis) in the presence of an amblyogenic factor such as anisometropia or strabismus.[1,41] Children aged five to 12 years with normal vision (interocular VA difference 0.1 logMAR or less and no history of amblyopia) were recruited as a control group. Exclusion criteria were ocular or systemic surgery (other than refractive or strabismic for amblyopes), ocular or systemic disease and medication that might alter visual function. The tenets of the Declaration of Helsinki were followed and the study was approved by the Human Research Ethics Committee of the University of the New South Wales, Australia, the Institutional Review Board at KAUH and the paediatric ophthalmology group in HMG in Saudi Arabia. Informed consent was obtained from all parents and caregivers after the nature of the study had been fully explained. In addition, children verbally acknowledged their willingness to participate.

Development phase: Pilot evaluation

The Arabic version of the pilot 28-item questionnaire was administered in face-to-face individual interviews with Saudi Arabian children with and without amblyopia to check content validity, reliability and the dimensionality of the 28 items. Children responded to the items by selecting one of the five response categories. Children (n = 48 amblyopes, n = 53 non-amblyopes) were seated individually in a quiet room, where parents and the researcher were present. The researcher read each question from the CVLS to children in the Arabic language. Children gave their answers to each item without prompting from parents or the researcher. None of the children declined to respond and all answered each item without seeking clarification for any questions. As expected, some younger children aged five to six years (n = 6 amblyopes; n = 2 non-amblyopes), who had not yet started attending school could not answer school-related items (8 items). The approximate duration of each interview was 15 minutes and there were no breaks during the interview.

For item analysis, the category scale of each item was scored, so that the response indicating the lowest self-rating for items was

a Note that 44 questions were asked in total, including 'Do you attend school yet?', which was a question but not an item. Forty-three of the questions were items asking about vision-related QoL.

Items	Reference	Aspect of vision-related QoL which is being investigated by this item
1. Usually, how happy do you feel?	Felius et al,[21] Harter.[36]	Mood
2. How much do you think that you are good looking?	Interview statements with the three groups; Harter.[36]	Self-esteem
4. How much do you feel that other children want to be your friend?	Interview statements with children and parents; Harter.[36]	Self-esteem
8. If you have a sister or brother, how much do you enjoy playing with them?	Interview statement with children and parents.	Social relations
9. Do you have many friends?	Felius et al,[21] Harter.[36]	Social relations
10. How much do you enjoy playing with your friends?	Interview statement with children and parents; Holmes et al.[27]	Social relations
11. How easy is it for you to make new friends?	Hatt et al,[23] Harter.[36]	Social relations
13. How clearly (well) can you see the picture on your TV?	Interview statement with eye-care professionals; Felius et al.[21] Khadka et al.[24]	Functional vision
14. How clearly (well) can you see the moving picture in hand-held computer games?	Interview statement with eye-care professionals; Felius et al.[21] Khadka et al.[24]	Functional vision
15. How clearly (well) can you see pictures in a book?	Interview statement with eye-care professionals; Felius et al.[21]	Functional vision
16. How easy is it for you to put the pen cap back on?	Interview statement with eye-care professionals; Van de Graaf et al.[22]	Visuo-motor function
17. How easy is it for you to pick up a cup from a table?	Interview statement with eye-care professionals; Van de Graaf et al.[22]	Visuo-motor function
18. How easy is it for you to cut shapes with scissors?	Interview statement with parents.	Visuo-motor function
19. How easy is it for you to draw a straight line with a ruler?	Interview statement with parents.	Visuo-motor function
20. How good are you at writing exactly on the line?	Interview statement with parent.	Visuo-motor function
22. How easy is it for you to catch an object (e.g. ball, toy, orange) when it is in the air?	Interview statement with eye-care professionals; Gothwal et al.[25]	Visuo-motor function
23. How easy is it for you to see steps when you walk up or down stairs?	Interview statement with eye-care professionals; Van de Graaf et al.[22]	Functional vision
24. Are you good at all kinds of sports?	Interview statement with eye-care professionals; Harter.[36]	Self-esteem
27. How often do you do the right thing?	Harter.[36]	Social relations
33. How much do you enjoy reading the smallest print in your textbook?	Khadka et al.[24]	Functional vision
36. How easy is it for you to draw, colour in a picture or write words at school?	Interview statement with eye-care professionals; Felius et al,[21] Khadka et al,[24] Holmes et al.[27]	Visuo-motor function
37. How clearly (well) can you see the smallest writing on the board at school?	Interview statement with eye-care professionals; Khadka et al.[24]	Functional vision
38. If the teacher asks you to read a story or a book to your class aloud, how happy do you feel?	Interview statement with children and parents.	Self-esteem
40. How easy is it for you to learn new things at school?	Interview statement with eye-care professionals; Harter.[36]	Academic performance
41. When you read a story, how easy is it for you to explain it to someone else?	Interview statement with parents and eye-care professionals.	Academic performance
42. How clever do you think you are?	Harter.[36]	Academic performance
43. How quick are you in finishing your homework?	Harter.[36]	Academic performance
44. How easy is it for you to answer the questions in the class at school?	Interview statement with children.	Academic performance

Items: The numbers of items as listed in the 43-item questionnaire.
44*: Although this questionnaire included 43 questions addressing vision-related quality of life, one question was "Do you go to school yet?", so there were 44 items in total.
References: The sources of items from existing questionnaires, interviews with children, parents, and eye-care professionals.
Note: Some items can assess more than one function (for example, item number 42 assesses both academic performance and self-esteem).

Table 2. References and reasons for including each of the 28 items in the Children's Vision for Living Scale

Visual acuity logMAR	Controls (n = 53)		Amblyopes (n = 48)	
	VA better eye Number (%)	VA worse eye Number (%)	VA better eye Number (%)	VA worse eye Number (%)
≤ 0	53 (100%)	51 (96%)	26 (52%)	1 (2%)
0.1 to 0.2	0	2 (4%)	18 (38%)	8 (17%)
0.3 to 0.4	0	0	4 (8%)	15 (31%)
0.5 to 0.6	0	0	0	10 (21%)
0.7 to 0.8	0	0	0	8 (17%)
0.9 to 1.0	0	0	0	5 (10%)
≥1.1	0	0	0	1 (2%)

Note: Subjects with VA in the worse eye of 0.2 or worse were classified as amblyopes on the basis of VA at diagnosis.

Table 3. Visual acuity of 101 children (number and %), who answered the 28-item Children's Vision for Living Scale

scored '1' and the highest ability or feeling was scored '5'. For example, in the item 'How easy is it for you to cut shapes with scissors?', if the child answered 'Not at all' in the response scale, then a score of '1' was recorded, while if the child answered 'Extremely' the recorded score was '5'.

Rasch analysis was conducted according to the partial credit methods (PCM) using the Winsteps program (version 3.72, Winsteps, Chicago, IL, USA)[42] to identify the response category functions for each item. Those items which had disordered categories were removed from the questionnaire. The Andrich rating scale model was then used to estimate person and item endorsability for responses scored in the five ordered categories.

The reliability and validity of the questionnaire were assessed using person and item reliability estimates, outfit and infit measures and a person-item map. Differential item functioning (DIF) shows whether the items have significantly different meanings for subsets (for example, gender, age) within the study population. Differential item functioning is small or absent, if the difference in item measure is 0.50 logit, minimal if 0.50 to 1.00 logit and notable if greater than 1.00 logit.[42] In addition, uni-dimensionality was assessed by using principal components analysis (PCA) and Cronbach's alpha to identify any items that did not fit with a single underlying construct and therefore should be removed.[30] The criteria used for item removal were applied in order as follows:[30]

1. outfit mean square outside the range 0.70 to 1.30.
2. infit mean square outside the range 0.80 to 1.20.
3. items with disordered categories were identified from probability functions.

Presence of negative point to measure correlation (PT-Measure)

The PT-Measure indicates the extent to which person measures are associated with item difficulty level for each item. In addition, zero and low positive correlations were considered for item removal:

1. items with a high proportion (more than 50 per cent) of missing data.
2. ceiling effect: a high proportion (more than 50 per cent) in item end-response category (5 'Extremely').
3. Skew and kurtosis outside the range -2.00 to +2.00.
4. Cronbach's alpha less than 0.7 or greater than 0.9.
5. presence of notable (greater than 1.0 logit) different item function.

Instrument development aims to arrive at the minimum number of items required to measure a domain with adequate reliability and separation ratio. Thus item removal was stopped when the separation ratio approached an unacceptable value (that is, less than 2.00).[30] The above procedure resulted in no change to the number of response categories (five) and a reduction in the number of items from 28 to 21.

RESULTS

Participant demographics

The study has different stages of the research and each stage has different participant demographics. Approximately half of the amblyopes (including sub-classifications of strabismic and non-strabismic) were recruited from each hospital (51 per cent of amblyopes were recruited at KAUH; 49 per cent of amblyopes recruited at HMG). The mean ages of amblyopic and non-amblyopic children aged five to 12 years was 7.91 ± 1.7 (SD) years for the amblyopes and 8.86 ± 2.05 years for non-amblyopes). There was no significant difference in age between the amblyopic and non-amblyopic groups ($p > 0.05$) but the possibility of an age-related difference in results due to the age gap of approximately one year is considered later. The amblyopic and non-amblyopic groups were gender matched (both groups were 51 per cent male). In addition, there was no statistically significant difference between other demographic information in terms of the parents' education, parents' age, number of siblings and the child's birth order in the two groups ($p > 0.05$).

All participating amblyopes were undergoing occlusion treatment at the time of questionnaire completion. The distribution of VA in both sound and amblyopic eyes for the 101 children who participated in piloting the 28-item CVLS is shown in Table 3. For some amblyopic participants, treatment was already partially successful as indicated by the VA.

28-item questionnaire response scale analysis

Response categories of three items (17, 40, 43) were disordered[42] and as a result, these items were removed from the 28-item questionnaire (Table 4). The five response categories of all other questions indicated good calibration and category utilisation. An example, derived from item 14, is provided in Figure 1, which is representative of the figures for all of the other items which had good calibration and category utilisation.

28-item questionnaire person and item estimates

Figure 2 shows the spread of item difficulty and person ability estimates determined by Rasch analysis for the 28-item CVLS. Subjects (indicated by symbols shown to the left

Items	Reason for removing the item
10. How much do you enjoy playing with your friends?	Small positive PT-measure correlation. The EXP. (expected correlation = 0.44) did not match the Rasch model (0.28).
17. How easy is it for you to pick up a cup from a table?	Empirical item category measure shows disordered categories (e.g., 23145).
22. When someone throws you an object, how easy is it for you to catch it (e.g. ball, toy)?	DIF by gender (DIF > 1.00).
24. Are you good at all kind of sports?	DIF by gender (DIF > 1.00).
38. If your teacher asks you to read a story or a book to your class aloud, how happy do you feel?	Outfit mean square (1.49) outside 0.70 to 1.30.
40. How easy is it for you to learn new things at school?	Empirical item category measure shows disordered categories.
43. How quick are you in finishing your homework?	Small positive PT-measure correlation. The EXP. (expected correlation = 0.43) did not match the Rasch model (0.31) and Empirical item category measure shows disordered categories.

DIF: Differential item functioning

Table 4. Reasons for removal of seven items from the 28-item Children's Vision for Living Scale

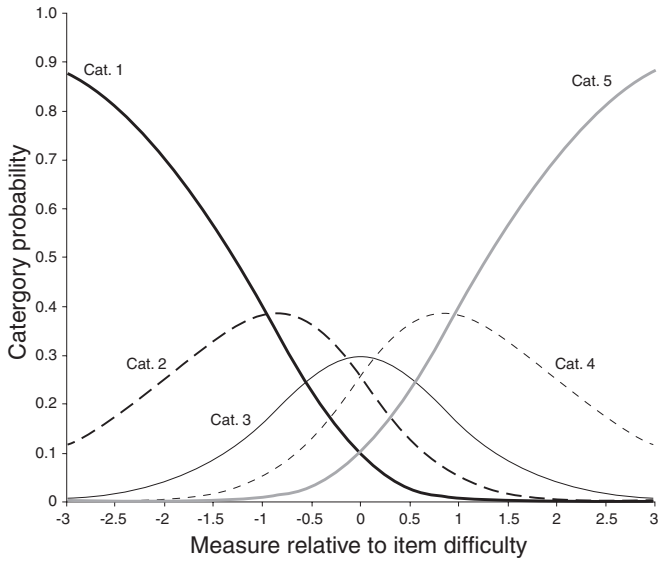

Figure 1. Category probability curves of five response categories for item no.14 illustrating the range of the scale over which each of the five categories is most likely to be chosen. All items have the same curve as shown in this example. Boundaries occur at points along the scale where the category most likely to be chosen changes from one to the next. Category 1: Not at all, Category 2: A little, Category 3: Moderately, Category 4: A lot, Category 5: Extremely.

of the vertical dashed line) are shown in ascending order of their mean score over all items. Item numbers appear on the right of the diagram. The order of the items indicates the level of difficulty of a task (such as cutting shapes with scissors) or extent to which a state (such as happiness) was achievable. Items at the lower end of the scale are those that are easier for the participants to do or achieve, while items at the higher end of the scale are those that are harder for the participants to do or achieve.

Table 5 shows Rasch fit statistics of the 28-item questionnaire. The mean difference between person and items was 0.34 logits. The root mean square error over all the items is 1.04 and item reliability is 0.92 (item separation is 3.41) indicating stability of the item estimate. Person reliability is 0.84 (person separation is 2.28), beyond the recommended minimum of 2[30,43] and Cronbach's alpha is 0.88 for this sample indicating good reliability.[30] Using PCA, the percentage of the variance explained by measure is 26.4 per cent (modelled 27.0 per cent) and the eigenvalue of the first contrast is 3.0 and eigenvalue of the second contrast is 2.4, which indicates multidimensionality of the 28-item questionnaire.

Summary of item reduction

In total, seven items (10, 17, 22, 24, 38, 40, 43) were removed according to the process described in the methods. Table 4 shows the reasons for removing these items. The item-person map of the 28-item CVLS (Figure 2) shows that some items measured the same level of ability or state, such as items 10, 13, 19 and 36 (Figure 2), although they assess different types of vision-related activity. For example, item 10 assesses social relations; item 13 assesses functional vision, while items 19 and 36 assess visuo-motor function; however, item 10 was redundant and was removed from the instrument (Table 5).

Validation phase

The 21-item questionnaire was administered to children with and without amblyopia in

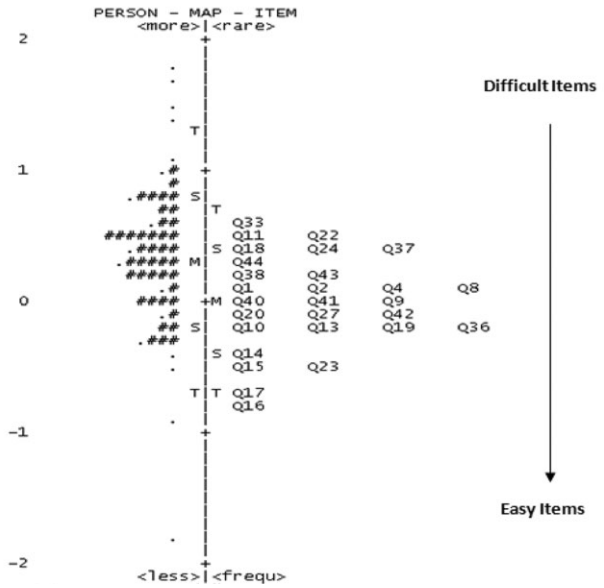

Figure 2. Person/item map for the 28-item Children's Vision for Living Scale (CVLS). Items are denoted by Q followed by item number shown on the right. On the left of the dashed line are the subjects, represented by # ('# ' = 2 subjects; '. ' = 1 subject). The map shows the location of items (the cumulative logit value for the item as a whole) on the logit scale as determined by their degree of difficulty and the participants' abilities are placed on the scale, as determined by their degree of ability. The map also shows the matching between children's abilities and item difficulties. Participants with poorer vision-related function are near the bottom of the diagram and participants with better vision-related function are near the top. Items that are less affected in participants with amblyopia are near the bottom of the diagram and items near the top are those more affected by amblyopia. This map shows some items in the same level of difficulty, which are redundant items and need to be removed from the questionnaire. The scale is in logit units (2 to -2)
M: mean, S: 1 standard deviation from the mean and T: 2 standard deviations from the mean.

Saudi Arabia for further validation. A total of 163 children (n = 81 amblyopes, n = 82 non-amblyopes) were recruited from the KAUH and HMG using the same inclusion and exclusion criteria as described previously, to determine questionnaire validity, reliability and the scale dimensionality using the procedure described in the section (Development phase: pilot evaluation).

Assessment of the validity, reliability and dimensionality of the 21-item CVLS

Rasch analysis was performed on the 21-item CVLS and indicated that the 21 items were targeted to the subjects with a mean difference of 0.33 logits (Figure 3). All the 21 items had good fit statistics (infit inside the range 0.70 to 1.20; outfit inside the range 0.80 to 1.30) and good measurement precision[30] indicated by high person and item reliability (0.80 and 0.93, respectively) and person and item separation (2.02 and 3.61, respectively). Skew and kurtosis values were within normal limits (-2.00 to +2.00)[30] and Cronbach's alpha of 0.87 indicates good reliability. Rasch analysis of the 21-item CVLS also confirmed correct ordering of response categories (threshold ordering) (for example, Figure 1).

To check the dimensionality of the 21-item CVLS, PCA of the residuals was performed and indicated that 26.4 per cent of the variance was explained by Rasch measures (modelled 26.9 per cent), eigenvalue of the first contrast 2.5 and eigenvalue of the second contrast 2.1. The unexplained variance of the first contrast is somewhat higher than the chance value of 2.0, which suggests a notable secondary dimension in the items; however, all 21 items were scattered in the PCA factor plot of the first contrast (Figure 4) with no grouping of items to form a subscale. Previous work in this area has separated items based on the PCA factor plot to indicate more than one dimension, which could form subscales.[44]

As a check of dimensionality, items were grouped into two subscales: activities limitation (items 13, 14, 15, 16, 18, 19, 20, 23, 33, 36, 37 and 44) and emotional well-being (items 1, 2, 4, 8, 9, 11, 27, 41 and 42) (Table 2) on the basis of face validity. Rasch analysis was performed on each subscale. The results showed that neither subscale was valid on the basis of person separation (1.43 and 1.71, respectively) being below the acceptable limit. In addition, the person reliability of each subscale (0.67 and 0.70, respectively) was low (less than 0.80). This suggests that while the CVLS does include a range of items that assess various aspects of vision-related QoL, these cannot be subdivided into valid subscales.

To check construct validity of the 21-item questionnaire for the target group, Rasch analysis was performed separately in the amblyopic and non-amblyopic groups (Figure 5). The results show that the abilities of our sample of amblyopes were targeted with the items in terms of item difficulty and person ability (Figure 5A) and indicate that the 21 items of the CVLS are appropriate for the targeted population of amblyopes, according to the Rasch model.[42] In addition, the results of the analysis of data from the amblyopes confirmed that the instrument had high measurement precision[30,42] (person separation 2.21, reliability 0.83; item separation 2.32, reliability 0.84), Cronbach's alpha of 0.90, the percentage of variance explained by measure 29.5 per cent (modelled 29.8 per cent) and eigenvalue of the first contrast 2.3. None of the 21 items showed notable differential item function (DIF) by group (control and amblyopic), gender or age (DIF less than 1.0 logit).

Some of the participants (15 amblyopes, 30 non-amblyopes) had high ability and

Items	MnSq infit (ZSTD)	MnSq outfit (ZSTD)	Item measure (SE)
1. Usually, how happy do you feel?	1.0 (0)	0.97 (-0.2)	0.13 ± 0.09
2. How much do you think that you are good looking?	0.97 (-0.2)	0.95 (-0.4)	0.09 ± 0.09
4. How much do you feel that other children want to be your friend?	0.86 (-1.2)	0.87 (-1.1)	0.11 ± 0.09
8. If you have a sister or brother, how much do you enjoy playing with them?	1.01 (0.1)	0.98 (-0.1)	0.05 ± 0.09
9. Do you have many friends?	0.90 (-0.8)	0.91 (-0.7)	0.03 ± 0.09
10. How much do you enjoy playing with your friends?	1.09 (0.8)	1.13 (1.0)	-0.24 ± 0.10
11. How easy is it for you to make new friends?	1.04 (0.4)	1.07 (0.6)	0.50 ± 0.09
13. How clearly (well) can you see the picture on your TV?	0.84 (-1.3)	0.88 (-0.9)	-0.19 ± 0.10
14. How clearly (well) can you see the moving picture in hand-held computer games?	1.03 (0.3)	1.01 (0.1)	-0.40 ± 0.10
15. How clearly (well) can you see pictures in a book?	0.78 (-1.7)	0.79 (-1.5)	-0.46 ± 0.10
16. How easy is it for you to put the pen cap back on?	1.06 (0.4)	1.02 (0.2)	-0.79 ± 0.12
17. How easy is it for you to pick up a cup from a table?	1.04 (0.3)	1.00 (0.1)	-0.73 ± 0.11
18. How easy is it for you to cut shapes with scissors?	1.01 (0.1)	1.01 (0.3)	0.38 ± 0.09
19. How easy is it for you to draw a straight line with a ruler?	1.04 (0.4)	1.06 (0.5)	-0.18 ± 0.10
20. How good are you at writing exactly on the line?	0.93 (-0.5)	0.96 (-0.3)	-0.07 ± 0.10
22. How easy is it for you to catch an object (e.g. ball, toy, orange) when it is in the air?	0.96 (-0.3)	0.95 (-0.4)	0.42 ± 0.09
23. How easy is it for you to see steps when you walk up or down stairs?	1.11 (0.8)	1.09 (0.7)	-0.50 ± 0.10
24. Are you good at all kinds of sports?	1.17 (1.4)	1.14 (1.1)	0.44 ± 0.09
27. How often do you do the right thing?	0.86 (-1.1)	0.89 (-0.8)	-0.08 ± 0.10
33. How much do you enjoy reading the smallest print in your textbook?	1.20 (1.6)	1.21 (1.6)	0.58 ± 0.09
36. How easy is it for you to draw, colour in a picture or write words at school?	0.95 (-0.4)	0.94 (-0.4)	-0.18 ± 0.10
37. How clearly (well) can you see the smallest writing on the board at school?	1.40 (3.1)	1.49 (3.5)	0.23 ± 0.09
38. If the teacher asks you to read a story or a book to your class aloud, how happy do you feel?	0.90 (-0.8)	0.88 (-0.9)	0.05 ± 0.10
40. How easy is it for you to learn new things at school?	1.08 (0.7)	1.07 (0.6)	0.49 ± 0.09
41. When you read a story, how easy is it for you to explain it to someone else?	0.95 (-0.4)	0.95 (-0.3)	-0.04 ± 0.10
42. How clever do you think you are?	0.82 (-1.5)	0.80 (-1.6)	-0.12 ± 0.10
43. How quick are you in finishing your homework?	1.20 (1.6)	1.22 (1.7)	0.21 ± 0.09
44. How easy is it for you to answer the questions in the class at school?	1.01 (0.2)	1.00 (0.0)	0.27 ± 0.09

MNSq: mean square fit statistic, ZSTD: fit statistic standardised as a z-score, SE: standard error.
Items with highest negative item measure are the most difficult items.

Table 5. Descriptive statistics, Rasch fit statistics of the 28-item Children's Vision for Living Scale

were not targeted by any items (Figures 5A and 5B). On further analysis, the visual characteristics of those children were found to be slightly although not significantly better than the remaining group (Table 6). This finding is as expected and shows that the scale is working as intended, as children with better vision are expected to rate themselves more highly on this vision-related scale.

The person-item maps of data from the amblyopic (Figure 5A) and non-amblyopic (Figure 5B) children differ in terms of person-item alignment and the nature of items that were of high or low difficulty for each group. The control (non-amblyopic) children's average self-rating was shifted toward more difficult items (Figure 5B), as they had better vision (Table 6) indicating that the scale functioned as expected and appropriately.

DISCUSSION

The 21-item CVLS was developed using a systematic process[30,43] encompassing qualitative and Rasch analysis[33,42] to construct a valid and reliable instrument. Unidimensionality, as measured by Cronbach's alpha, fit statistics, PCA and the response categories function verified that all items fit with a single underlying construct. The absence of notable DIF by gender or group indicates that the 21 items had similar meanings for male and female, amblyopic and non-amblyopic children.

Although the validation of the 21-item CVLS suggests uni-dimensionality, it includes a range of items that assess various aspects of vision-related QoL, such as social relations, functional vision and academic performance. Lower person separation (less than 2.0) on each subscale indicates that levels of QoL would not be adequately discriminated within each subscale.[44]

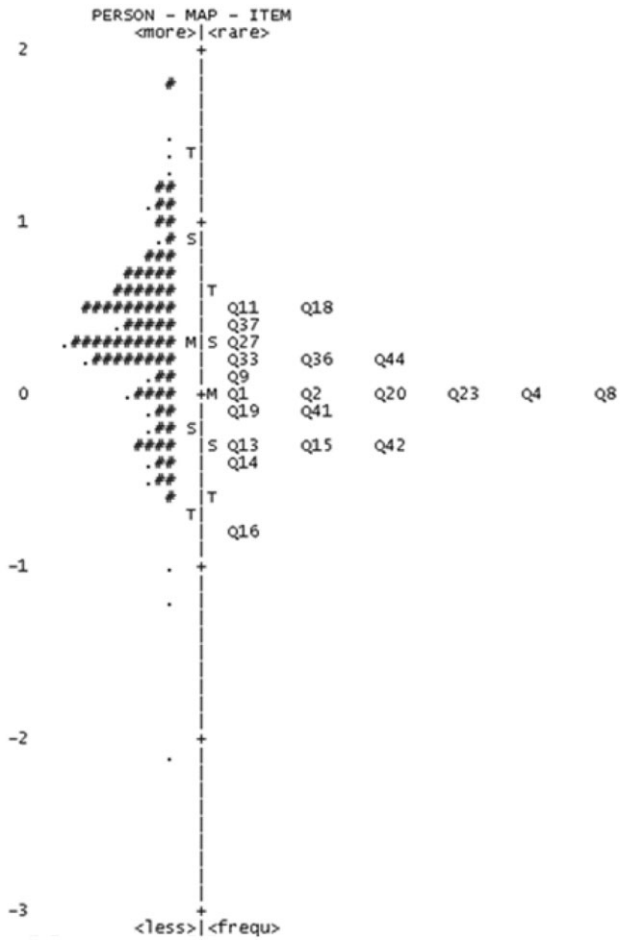

Figure 3. Person-item map of the 21-item final Children's Vision for Living Scale (CVLS) on 163 participants (n = 81 amblyopes; n = 82 non-amblyopes). Subjects located on the left of the dashed line and represented by '#' (= 2 subjects) and '.' (= 1 subject). This question group exhibits excellent targeting of items to subjects, that is the subjects and the questions overlap well on the scale.

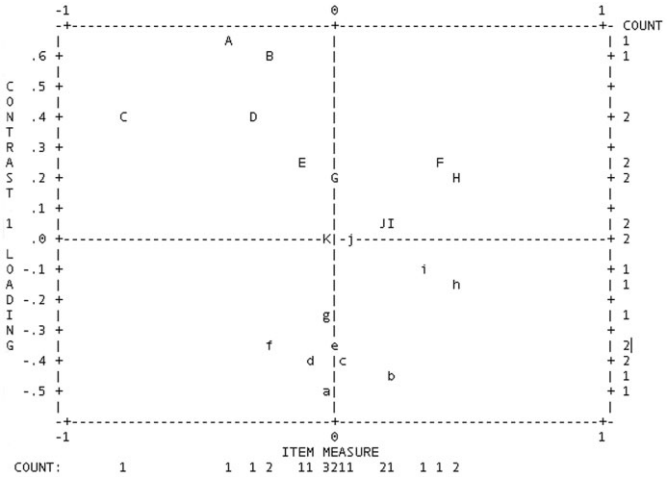

Figure 4. Plot of principal components analysis (PCA) of residuals for the 21 items.
All items scattered in the PCA factor plot of the first contrast with no grouping of items to form a subscale, which indicated a uni-dimensional scale. Each letter describes an item: A = 14, B = 13, C = 16, D = 15, E = 19, F = 37, G = 20, H = 18, I = 36, J = 33, K = 23, j = 9, a = 8, b = 44, c = 2, d = 41, e = 4, f = 42, g = 1, h = 11 and i = 27.

Item selection was based on a literature review of existing questionnaires and the information provided by school-age children with amblyopia, parents and eye-care professionals (Table 2), without differentiating between types of amblyopia. Thus, it is possible that the ideal item set would be different if the questionnaire were developed for strabismic amblyopes alone or non-strabismic amblyopes alone. Vianya-Estopa, Elliott and Barrett[45] found limitations of the Amblyopia and Strabismus Questionnaire (A and SQ)[22] in assessment of vision-related QoL in subjects with non-strabismic amblyopia. The present study did not aim to differentiate between strabismic and non-strabismic amblyopes. Comparison between amblyopia subgroups (for example, strabismic and non-strabismic) using the newly developed and validated 21-item CVLS will be the subject of future analyses.

While most items were derived from existing QoL instruments (Table 2) based on our literature review, items 8, 18, 19, 20, 38, 41 and 44 are newly developed and differ from those found in existing QoL instruments. Some questions in the 21-item CVLS are similar to other questionnaires designed to assess different levels of visual impairment, such as the Cardiff Visual Ability Questionnaire for children[24] for application in children with visual impairment. This suggests that these questions are related to our sample population and children with visual impairment from the countries, in which these other questionnaires were developed (items 13, 14, 33, 36 and 37)[24] (Table 2). This suggests that at least some of the items in other instruments are likely to be relevant to children in Saudi Arabia. Conversely, items in the CVLS may be relevant to children from other countries. While there are cultural differences between Western and Saudi Arabian societies, Saudi Arabian children's perspectives are recognised by the

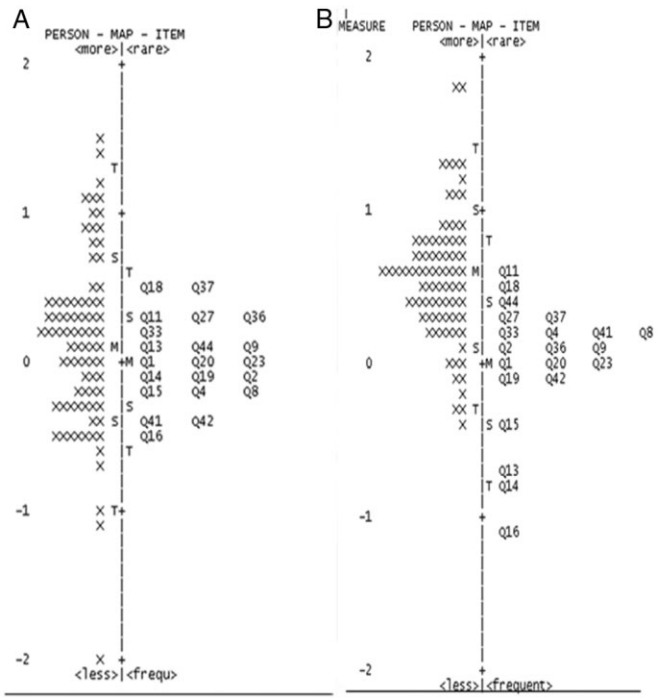

Figure 5. Person-item map of amblyopes (A) and non-amblyopes (B). Subjects located on the left of the dashed line and represented by x ('x' = 1 subject). This questions group exhibits excellent targeting of items to amblyopic and non-amblyopic subjects, that is, the subjects and the questions overlap well on the scale. There are a lot of subjects who are not being targeted by any items although the Children's Vision for Living Scale (CVLS) addresses the majority.

Groups	Visual Acuity (log MAR) Mean ± SD	
	Worse eye	Better eye
Amblyopes (n = 81)		
Targeted with items (n = 66)	0.50 ± 0.29	0.09 ± 0.10
Not targeted with items (n = 15)	0.38 ± 0.20	0.06 ± 0.11
Significance (p-value)	**0.88**	**0.71**
Non-amblyopes (n = 82)		
Targeted with items (n = 52)	0.00 ± 0.04	-0.02 ± 0.04
Not targeted with items (n = 30)	-0.01 ± 0.05	-0.03 ± 0.04
Significance (p-value)	**0.61**	**0.814**

Table 6. Statistical analysis of visual acuities in item/person targeted and non-targeted (higher functioning that the most difficult items) groups in amblyopes and non-amblyopes

CVLS. Validation of the CVLS for child populations outside Saudi Arabia is required but the newly developed items may be useful additions to computerised questionnaires, which draw items from a large pool or database of items.[46]

The development of the CVLS questionnaire meets a reported need for a vision-specific instrument to assess the impact of amblyopia and strabismus on children's QoL,[47] although at present it is validated only for children from Saudi Arabia. It is much more targeted than questionnaires such as the Amblyopia and Strabismus Questionnaire, which is validated to assess the QoL in amblyopia and/or strabismus in adults,[22] the LV Prasad-Functional Vision Questionnaire[25] and the Cardiff Visual Ability Questionnaire for Children,[24] which assess functional vision, not vision-related QoL and are intended for children with low vision, much more severe levels of visual impairment than expected from amblyopia and strabismus.

In conclusion, the Arabic version of the 21-item CVLS is the first questionnaire validated with the Rasch model for use in Saudi Arabia that can be used for assessment of vision-related QoL in Saudi Arabian children with or without amblyopia. The tool is a one-dimensional self-report instrument. While it uses items representing activities applicable to children from five to 12 years of age, potential applications are to detect changes with treatment or differences between groups (for example, amblyopes versus non-amblyopes).

Future studies are underway to validate the English version of the 21-item CVLS and use this newly developed and validated instrument to investigate the effect of amblyopia and its treatment on visual function, ability and difficulty in children within the society and culture of Saudi Arabia.

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A copy of the Arabic version of Children's Vision for Living Scale can be obtained from Kholoud Bokhary at email: optokholoud@hotmail.com.

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