The Impact of Vision Impairment Questionnaire: An Assessment of Its Domain Structure Using Confirmatory Factor Analysis and Rasch Analysis

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Purpose. To assess and validate the subscale structure of the 28-item Impact of Visual Impairment (IVI) Scale by using confirmatory factor analysis (CFA) and Rasch analysis for use as an outcome measure.

Methods. Three hundred nineteen participants completed the IVI questionnaire, and the responses then were subjected to Rasch analysis by RUMM2020 software. With the person estimates for each item, CFA was used to assess two hypothesized structures: three-and four-factor models. The subscales of the model with the best fit were then further validated by Rasch analysis.

Results. CFA supported a three-factor model that included items from the emotional well-being, reading and accessing information, and mobility and independence subscales. Almost all the selected goodness-of-fit statistics for the three-factor model were better than the recommended values. The factor loadings of the items on their respective domains were all statistically significant ($P < 0.001$) and ranged between 0.54 and 0.81. The three subscales individually fitted the Rasch model according to the item–trait interaction test (mobility and independence χ^2 [df] = 45.9 [44], P = 0.39; emotional well-being = 28.4 [32], P = 0.65; and reading and accessing information = 43.5 [36], P = 0.18). The item-fit residuals values of the three subscales were <2.5 and showed mean and standard deviations approximating 0 and 1, respectively. The internal consistency reliability of the subscales (α) was substantial, ranging between 0.89 and 0.91.

Conclusions. An examination of the IVI dimension confirmed a three-subscale structure that displays interval measurement characteristics likely to provide a valid and reliable assessment of restriction of participation. The findings provide an opportunity for a more detailed measurement of the effects of different types of low-vision rehabilitation programs. (*Invest Ophthalmol Vis Sci.* 2007;48:1001–1006) DOI:10.1167/iovs.06-0361

The Impact of Vision Impairment (IVI) questionnaire was designed to assess participation in daily activities and determine the outcome of low-vision rehabilitation on quality of life in people with low vision.[1–5] The IVI has been validated and shows good discriminative ability and reliability, with consistent results found between different forms of administration.[1] It has a good range of items and, as opposed to most vision-specific questionnaires which typically assess visual functioning, has been designed to assess restriction of participation in daily living as well as to provide a tool to determine the effectiveness of low-vision rehabilitation. The original IVI questionnaire contained 32 items grouped under five domains of participation: leisure and work, consumer and social interaction, household and personal care, mobility, and emotional reaction to vision loss.

The grouping of items within domains is important because they can form subscales that allow for the assessment of intervention at more specific levels. This is particularly relevant to low-vision care, as management is typically undertaken on a task-specific basis, and so it is possible that real gains in one or two areas may be obscured within a large scale assessing overall performance. Subscale measurements of outcome provide a more detailed insight into the effectiveness aspects of low-vision rehabilitation. In the initial validation of the IVI questionnaire, principal components analysis (PCA) was used to explore the underlying structure of the scale, but no Rasch analysis was undertaken, making the findings essentially inferential.[1] However, the analysis did not confirm the five domains specified a priori by the authors. Rather, it identified a three-factor solution that was supported by an examination of the scree plot. The authors did not either formally reject the five domains identified a priori or recommend the three-factor structure identified by PCA. The equivocal nature of the factors underlying the IVI may confuse potential users in how best to interpret the results and indicates that further scrutiny of IVI structure is needed.

Further examination of the domain structure is also warranted, as the IVI has recently undergone further validation using Rasch analysis which is a sophisticated approach to questionnaire development using modern psychometric methods.[6] Rasch analysis converts categorical data into a linear scale, calculates item difficulty in relation to patient ability, and provides estimates of item and person measures on an interval scale.[7–15] Rather than an exploratory approach as used in the initial study (i.e., PCA),[1] the IVI subscale needs to be validated using a confirmatory process, especially if the outcome of low-vision rehabilitation and the sensitivity to change of specific aspects of quality of life (i.e., mobility, emotion, and leisure) are desired. The main objectives of this study were therefore to (1) assess the dimensions of the 28-item IVI using CFA performed on person-item measures derived from the Rasch analysis of the instrument and (2) to use Rasch analysis to validate the factors of the best-fitting model as viable traits for measuring specific aspects of restriction of participation for people with impaired vision.

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Materials and Methods

Participants

Individuals referred to low-vision rehabilitation centers across the state of Victoria (Australia) were recruited. An ophthalmologist's report, providing the cause of vision loss and visual acuities, was obtained for each participant. The eligibility criteria for the study included presenting visual acuity <6/12 (or ≥6/12 with restricted fields), ≥18 years of age and the ability to converse in English. Individuals who agreed to participate signed a consent form that allowed access to low-vision rehabilitation records. Ethical approval was obtained from the Royal Victorian Eye and Ear Hospital's Human Research and Ethics Committee, and the research adhered to the tenets of the Declaration of Helsinki.

Measures

The IVI questionnaire, sociodemographic, and clinical data were collected. Participants also completed the SF-12 from which the physical and mental component summaries (PCS-12 and MCS-12, respectively) were computed.[16] Each summary scale was scored from 0 to 100, where a score of 100 indicates the best possible score and 0 represents the worst possible score. The PCS-12 and MCS-12 scores were included, to validate the IVI subset of items.

The IVI Questionnaire

The 32-item IVI instrument was either self- or interviewer-administered, to measure vision-related restriction of participation in daily living, as described previously.[1,2] Responses to the IVI items were rated on a five-category Likert scale: not at all, 0; hardly at all, 1; a little, 2; a fair amount, 3; a lot, 4; and can't do because of eyesight, 5; with an additional response category, don't do because of other reasons, for 19 items. The latter response was not included in computing the average overall or domain score. The wording preceding these items was, ***In the past month, how much has your eyesight interfered with the following activities***. For the remaining 13 items, the rating scale used was: not at all, 0; very rarely, 1; a little of the time, 2; a fair amount of the time, 3; a lot of the time, 4; and all the time, 5. The wording preceding these items was, ***In the past month, how often has your eyesight made you concerned or worried about the following***.

Statistical Analysis

Most of the Rasch analyses were performed with RUMM2020[17] but Winsteps (ver. 3.61)[18] was used to generate transformed individual person scores for all items, as this feature is not currently available in RUMM. Individual person measures for all items in Winsteps were estimated by assigning a category threshold for each item and converting raw scores to Rasch category estimates. These data were required for CFA. The compatibility of the results from the two Rasch analysis software programs was tested by comparing person measures. These results were identical with one decimal place for 94% of cases, with greater deviation only occurring for extreme responders. This deviation arises from the different assumptions used to calculate extreme results.

Confirmatory factor analysis (performed with AMOS, ver. 6; SPSS Science, Chicago, IL) was used to confirm the hypothesized structure statistically. CFA allows for assessment of the overall model fit, the statistical significance tests for theorized relations in the model, and the estimation of latent concepts free of measurement error. CFA was undertaken to assess two hypothesized measurement models based on the findings of previous exploratory investigation[1,2] and similar work.[19] The first, a three-factor model, comprised three latent traits: mobility and independence (11 items), emotional well-being (8 items), and reading and access to information (9 items). The second was a four-factor model that assessed the interrelationship of four latent traits: mobility and safety (6 items), emotional well-being (8 items), independence (8 items), and reading and near-vision activities (6 items).

CFA with the maximum-likelihood estimation was conducted on the calibrated person-item scores to evaluate model fit of each proposed model. A good model fit can be indicated by a nonsignificant item–trait interaction χ^2 probability value. However, because the χ^2 test has been criticized for its dependence on sample size, a range of fit statistics were assessed. A relative χ^2 is usually used (ratio of χ^2 to degrees of freedom- χ^2/df) with a recommended range of 1.0 to 2.0.[20] The root mean square error of approximation (RMSEA) is the one of the most informative statistics in determining model fit, as it takes into account the number of variables that are estimated in the model.[21–23] RMSEA values are required to be ≤0.05 to indicate good fit. Values between 0.05 and 0.08 indicate reasonable fit.[21–23] For the incremental fit statistics (goodness of fit index: GFI; the Tucker-Lewis index: TLI; and the comparative fit index: CFI) <0.90 indicates lack of fit, between 0.90 and 0.95 indicates reasonable fit, and between 0.95 and 1.00 indicates good fit.[21–23]

The latent variables or subscales of the model identified by CFA as providing the best fit were then examined with Rasch analysis using RUMM[17] with the purpose of assessing how well the subscales fit the Rasch model. Fit was evaluated by using person and item fit residual statistics, which are transformed weighted mean squares. The transformed mean squares are normally distributed with an expected value of 0 and an expected variance of 1. An item–trait interaction score (χ^2) with a statistically nonsignificant probability ($P > 0.05$) indicates fit to the model. An estimate of person separation reliability which indicates how well the items of the instrument separate or spread out the subjects in the sample was also reported.[24] The unidimensionality of the each subscale after overall fit to the Rasch model was determined using principal components analysis of the residuals available in RUMM. Unidimensionality is tested by allowing the pattern of factor loadings on the first residual to determine subsets of items. If person estimates derived from these subsets of items differ significantly from the estimates derived from the full subscale, local independence is considered to be compromised.[25]

Results

The personal and clinical characteristics of the 319 participants of the study appear in Table 1. The mean PCS-12 and MCS-12 components of the SF-12 were 36.7 and 47.7, respectively, and were comparable to mean scores reported for Americans of similar age groups (38.7 and 50.0 for PCS-12 and MCS-12, respectively).[16] Compared with the initial validation study,[1] the two samples were similar on personal and clinical characteristics, except for distance visual acuity and main cause of vision loss. In the present study, there was a greater percentage of participants with distance visual acuity <6/18 to 6/60 (47% vs. 29%) and age-related macular degeneration (54% vs. 39%) compared with the initial study.

Confirmatory Factor Analysis

Before undertaking CFA, the IVI questionnaire was re-examined by using the Rasch analysis. This resulted in a 28-item questionnaire and a four-category response scale for 26 items and a three-category response scale for two items. The revised questionnaire had an excellent internal consistency, as illustrated by the following statistics: Item–trait interaction χ^2 = 118, $P = 0.32$; mean ± SD person fit residual values = 0.068 ± 0.85; mean ± SD item fit residual values = −0.203 ± 1.45 and person separation reliability = 0.95. Rasch calibrated person measures across all items were then generated and CFA was used to assess the hypothesized models. The various goodness-of-fit statistics for the two hypothesized models are shown in Table 2. The indices showed a good fit between the IVI data and proposed measurement models. The fit indices for these two models were almost identical (Table 2). The ratio of χ^2 to degrees-of-freedom value (χ^2/df) is 1.41 in both models and

Table 1. The Characteristics of the 319 Study Participants

Age (y)	
Mean ± SD	78.4 ± 12.9
Range	21–102
Gender	
Men	117 (37%)
Women	202 (63%)
Presenting visual acuity	
≥ 6/12 with field loss	45 (14%)
<6/12 to 6/18	88 (28%)
<6/18 to 6/60	149 (47%)
<6/60	37 (11%)
Near vision	
N8 or better	158 (49%)
<N8–N20	94 (30%)
<N20–N48	36 (11%)
<N48	22 (7%)
Main cause of vision loss	
Age-related macular degeneration	171 (54%)
Diabetic retinopathy	50 (16%)
Glaucoma	38 (12%)
Other	60 (18%)
Duration of vision impairment (y)	
Median (min, max)	3 (0,84)
Comorbidity	
Yes	259 (81%)
No	57 (19%)
Comorbidity affects daily living?	
Not at all	60 (19%)
A little	92 (30%)
A great deal	109 (34%)
No response	58 (17%)
PCS-12	
Mean ± SD	36.7 ± 11.6
MCS-12	
Mean ± SD	47.7 ± 11.5

The summary scale ranges between 0 and 100 where 0 and 100 indicate the best and worst possible scores, respectively. PCS-12, physical component summary of the SF-12; MCS-12, mental component summary of the SF-12.

falls well within the recommended range of 1.0 to 2.0.[20] The RMSEA, CFI, and TLI in both models averaged 0.5, 0.94, and 0.94, respectively, and were better than the recommended values. For both models, the goodness-of-fit index (GFI) of 0.85 was slightly less than the benchmark of 0.9.

Inspection of the correlations between the four-factor solution, however, indicated there were high values between the independence and reading subscales (0.91) as well as between the independence and mobility subscales (0.92). Given the evidence of strong overlap between these latent traits and in the interest of model parsimony, the best-fitting model for these data was a three-correlated-factor model (Table 3) representing latent trails of mobility and independence (11 items), reading and accessing information (9 items), and emotional well-being (8 items). The β coefficients of the 28 items were all statistically significant ($P < 0.001$) and ranged between 0.62 and 0.77, 0.65 and 0.81, and 0.54 and 0.78 for the mobility and independence, emotional well-being and reading and accessing information subscales, respectively. The interfactor correlations were 0.85 (reading and accessing information and mobility and independence), 0.61 (reading and accessing information and emotional well being), and 0.80 (mobility and independence and emotional well being). The items—Finding what you want during shopping? ($\beta = 0.80$); Interfered with your life in general? ($\beta = 0.81$), and Getting about outdoors? ($\beta = 0.77$)—showed the strongest loading for the mobility and independence, emotional well-being and reading and accessing information subscales, respectively.

Fit of the Three Subscales to the Rasch Model

Subsequent to CFA supporting the three-factor model, its three domains were assessed separately by Rasch analysis. They all showed nonsignificant item–trait interactions, suggesting fit between data and model (mobility and independence χ^2 [df] = 45.9[44], P = 0.39; emotional well-being = 28.4 [32], P = 0.65; and reading and accessing information = 43.5 [36], P = 0.18). The fit residuals of all the items recorded values <2.5 and the three subscales showed mean and SD values close to 0 and 1, respectively, suggesting no misfit to the model by items and respondents. The person separation reliability scores ranged between 0.89 and 0.91, indicating a substantial ability to distinguish four strata of person ability (Table 4). The most difficult and easiest items (in logits) for the mobility and independence subscale were: Stopped you doing the things you want to do? (0.75) and Your general safety at home? (−1.42); for emotional well-being: Felt frustrated or annoyed? (1.1) and Have you felt lonely or isolated? (−1.42); and for the reading and accessing information: Reading ordinary-sized print? (1.92), and Generally looking after your appearance? (−1.13).

Test of Local Independence Assumption of the Three Subscales

No significant differences were found between the person estimates of the three subscales and their respective positive and negative subsets (t-test; P = 0.45–0.69). This finding suggests no breach of the assumption of local independence supporting the unidimensionality of the subscales.

Criterion-Related Validity

After Rasch analysis, the person measures of each subscale were used to assess the criterion validity of the subscales of the IVI. The reading and accessing information subscale recorded its strongest correlations with visual acuity, as these activities are critically dependent on near and distance vision (Table 5).

Table 2. Comparative Goodness-of-Fit Statistics for Two Hypothesized Models

Fit Indices	Recommended Value	Values: 3-Factor Model	Values: 4-Factor Model
χ^2	N/A	480.317	476.631
df	N/A	339	338
χ^2/df	≤2.00	1.412	1.410
Root mean square error of approximation (RMSEA)	≤0.08	0.048	0.050
Goodness of fit index (GFI)	≥0.9	0.848	0.846
Comparative fit index (CFI)	≥0.9	0.946	0.947
Tucker-Lewis Index (TLI)	≥0.9	0.940	0.941

Table 3. The Item Labels and Factor Loadings of the Three-Factor Model of the IVI Questionnaire

Item Labels	Mobility and Independence	Emotional Well-being	Reading and Accessing Information
1. Taking part in sporting activities?	0.74		
2. Visiting friends or family?	0.62		
3. Getting about outdoors?	0.77		
4. Made you go carefully to avoid falling or tripping?	0.64		
5. Interfered with travelling or using transport?	0.71		
6. Going down steps, stairs, or curbs?	0.68		
7. Your general safety at home?	0.71		
8. Spilling or breaking things?	0.67		
9. Your general safety when out of your home?	0.72		
10. Stopped you doing the things you want to do?	0.73		
11. Needed help from other people?	0.70		
12. Felt embarrassed?		0.71	
13. Felt frustrated or annoyed?		0.75	
14. Have you felt lonely or isolated?		0.70	
15. Have you felt sad or low?		0.75	
16. Worried about your eyesight getting worse?		0.65	
17. Concerned or worried about coping with everyday life?		0.77	
18. Interfered with your life in general?		0.81	
19. Felt like a nuisance or a burden?		0.75	
20. Ability to see and enjoy television?			0.65
21. Finding things during shopping?			0.80
22. Reading ordinary-sized print?			0.56
23. Recognizing or meeting people?			0.72
24. Getting information that you need?			0.54
25. Generally looking after your appearance?			0.60
26. Opening packaging?			0.66
27. Reading labels or instructions on medicines?			0.67
28. Operating household appliances and the telephone?			0.74

The emotional well-being factor recorded its strongest association with the mental component of the SF-12 (−0.56) which includes items pertinent to emotional and mental health. Equally, the mobility and independence domain recorded its strongest association (−0.43) with the physical component of the SF-12 health (PCS-12) which includes items associated with mobility. These correlations overall tend to support the definition of the new IVI subscale structure.

Internal Consistency Reliability

The internal consistency reliability of the three-factor model was estimated by Cronbach's α using the person measures across items. The mobility and independence, emotional well-being, and reading and accessing information subscales recorded α values ranging between 0.89 and 0.91. These values are above the suggested moderate level of internal consistency among the instrument items[26] and indicate that the items under each subscale consistently measure the same construct.

Scoring of the IVI Subscales

Other investigators wishing to use the IVI subscales can use these validation data to convert raw scores into Rasch person measures without having to perform Rasch analysis. This conversion mainly holds for patients with complete data. Raw scores are calculated by first reversing the scores (0, 1, 2, 3, 4, 5) (5, 4, 3, 2, 1, 0) to give better IVI scores to those experiencing less restriction of participation. The categories are then collapsed to 4(3, 2, 2, 1, 1, 0) or 3(2, 1, 1, 1, 1, 0), as described previously.[6] Then, for each subscale the average of the items gives the IVI raw score. This score is related to the IVI Rasch person measure, as illustrated in Figure 1. The relationship is double-asymptotic because the average raw rating has a floor and a ceiling (at 0 and 3). The relationship can be described as double-asymptotic nonlinear regression.[27] The equations listed in Table 6 can be used to convert raw scores to Rasch person measures for each subscale.

Discussion

In the present study, CFA was used to assess the dimension of the IVI and provide evidence of the factorial structure and reliability of the recently Rasch-scaled IVI instrument.[6] Two models were proposed a priori and a resultant three-factor model provided the best-fit statistics and most parsimonious

Table 4. The Mean ± SD Person and Item Fit Residual Values, Person Separation Reliability Scores, and Range of Item Fit Residual Values of the Three Domains of the IVI

Domains	Mean ± SD Person Fit Residual	Mean ± SD Item Fit Residual	Person Separation Reliability	Item Fit Residual (Range)
Mobility and independence	−0.31 ± 1.23	0.08 ± 0.99	0.91	−1.31–2.1
Emotional well-being	−0.28 ± 1.10	0.06 ± 1.31	0.90	−1.96–2.1
Reading and accessing information	−0.41 ± 0.91	−0.42 ± 0.71	0.89	−1.13–0.59

TABLE 5. Correlation between the Participants' Characteristics and the Person Measures of the New IVI Subscales

	Mobility and Independence	Emotional Well-being	Reading and Accessing Information
Near vision	0.33*	0.18*	0.43†
Presenting distance visual acuity	0.35†	0.31†	0.52†
PCS-12	−0.43†	−0.17*	−0.29†
MCS-12	−0.32†	−0.56†	−0.19*

* $P < 0.05$.
† $P < 0.001$.

measure of restriction of participation in quality of life in patients with low vision. The confirmed dimensions of the IVI represent items from the emotional well-being, reading and accessing information, and mobility and independence, respectively. Our finding supports the recent work of Massof et al.,[19] who also used person measures estimated from subsets of functionally grouped items to assess the dimensionality of a vision disability questionnaire. They confirmed a two-factor structure: reading and mobility. Massof et al. did not find an emotional well-being subscale, as their questionnaire, the Activity Breakdown Structure (ABS), did not have such content, because it assesses the difficulty undertaking daily tasks. On the other hand, a critical component of the IVI is the assessment of the emotional impact of visual impairment in people with low vision. With the confirmation of an emotional subscale, it is now possible to provide a more specific assessment of the emotional consequences associated with vision loss as well as to evaluate the effect of rehabilitation programs on emotional health.

Only one factor identified a priori in the initial validation study[1] (i.e., emotional well-being) was confirmed in the study. Discrepancy between the initial and current studies could be linked to different factor analysis techniques. The initial study used exploratory methods, whereas the current one used a confirmatory approach. Also, in the present study, Rasch-calibrated person measures were used compared with raw scores used in the initial study. Factor analysis of raw scores can lead to item grouping based on item difficulty. The difference in sample size could also explain the dissimilarity between the two studies. Only 86 participants were included initially, compared with 319 in the present study. It is likely that a bigger sample size provided a better capacity to undertake factor analysis, as it has been suggested that small data sets tend not to generalize as well as those derived from large samples. Tabachnick and Fidell[28] have suggested that a ratio of five cases to one item is adequate. In the present study, our ratio was 10.3 compared with 3.1 in the initial study.

In this study, the use of Rasch analysis has enabled a detailed examination of the operation of the subscales. Our findings show that the three domains possess viable measurement characteristics to assess specific aspects of restriction of participation in daily activities for individuals with impaired vision. The domains also possess demonstrated reliability and validity and show no evidence of multidimensionality. Because it had been shown that the Rasch scoring method had greater precision compared with standard Likert scoring and plays an important role in improving sensitivity to change,[14,29,30] our findings suggest that the greater accuracy of the Rasch-analyzed subscales could result in improved measurement of the specific outcomes of low-vision rehabilitation trials.[30,31] Future studies, however, are needed to substantiate this claim.

One important finding of the new IVI domain structure is the identification of a reading and accessing information domain. Activities related to near and distance vision have consistently been associated with increased difficulty for people with low vision[8,32,33] and with this revised IVI domain structure, the impact of these critical activities of daily living could be assessed individually and collectively. Of importance, a significant component of most low-vision rehabilitation programs includes the prescription of low-vision devices as well as strategies intended to improve visual functioning, and the Rasch-assessed domain structure of the IVI can now potentially assess the outcome of low-vision rehabilitation specific to reading and ability to undertake vision-dependent activities.

Finally, moderate correlations were found between the mental component of the SF-12 and the emotional well-being subscale; the physical component of the SF-12 and mobility and independence subscale; and visual acuity and the reading and access to information subscale. This finding provides further support of the new factorial model of the IVI, as the MCS-12 and PCS-12 contain several items specific to emotional well-being and mobility, respectively, and visual acuity functions are critical to distance reading and near vision performance.

In conclusion, through a confirmatory factor analysis and Rasch analysis, our examination of the dimensionality of the IVI questionnaire supported a three-subscale structure with interval level measurement characteristics likely to provide a reliable assessment of specific aspects of restriction of participation in daily living and effectiveness of rehabilitation in people with low vision. This new structure of the IVI opens the door to the exploration of three components of restriction of participation in daily living and a better understanding of the

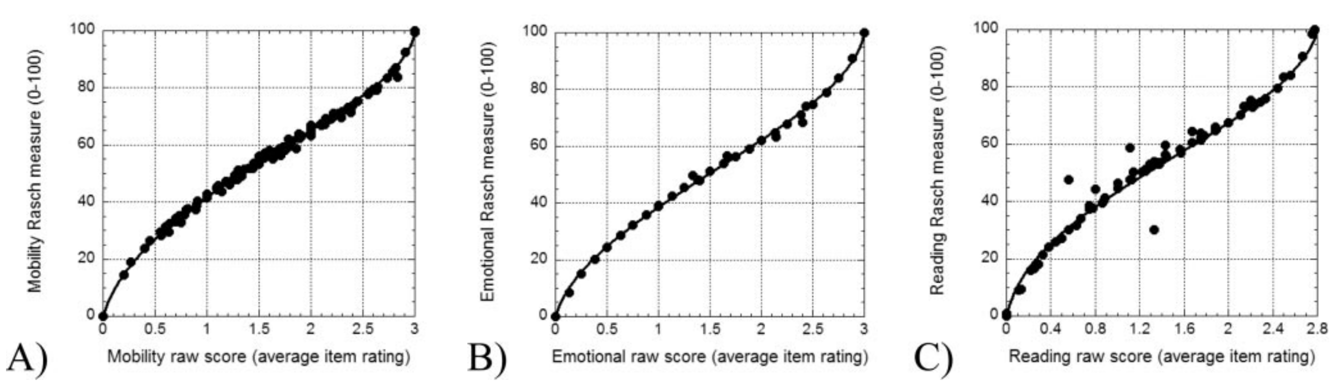

FIGURE 1. Scatterplots of the person measure estimated from Rasch analysis versus the average rating for each person across items (raw subscale score). The fit lines are generated with double asymptotic nonlinear regression. **(A)** Mobility and independence, **(B)** Emotional well-being, and **(C)** Reading and accessing information.

Table 6. Equations Converting Raw Score to the Rasch Person Measure

Subscale	Equation
Mobility and independence	$IVI_{person\ measure} = 33.79\log(IVI_{raw\ score}/3\text{-}IVI_{raw\ score}) + 53.39$
Emotional well-being	$IVI_{person\ measure} = 33.90\log(IVI_{raw\ score}/3\text{-}IVI_{raw\ score}) + 50.61$
Reading and accessing information	$IVI_{person\ measure} = 30.50\log(IVI_{raw\ score}/2.8\text{-}IVI_{raw\ score}) + 52.63$

effects of different types of intervention. Future work should evaluate the sensitivity of the IVI subscales to measure outcomes of low-vision rehabilitation.

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