

A Self-Assessment Instrument Designed for Measuring Independent Mobility in RP Patients: Generalizability to Glaucoma Patients

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PURPOSE. To determine whether the patient-based assessment of difficulty in mobility, developed and validated in a group of patients with retinitis pigmentosa (RP), is valid for measuring perceived visual ability for independent mobility in patients with glaucoma.

METHODS. A mobility questionnaire that had previously been developed was administered to 83 patient-volunteers who had various amounts of visual impairment caused by glaucoma. Each volunteer rated the perceived difficulty of walking independently in each of 35 mobility situations. A Rasch analysis of the ordinal difficulty ratings was used to estimate interval measures of perceived visual ability for independent mobility.

RESULTS. The instrument showed good construct and content validity and high reliability scores. Criterion validity of the instrument was demonstrated by its ability to discriminate mobility-related behaviors such as fear of falling, asking for accompaniment, and believing their ability to travel independently is less than that of persons with normal vision. To make the perceived mobility scale comparable for the two diagnostic groups the questionnaire was restricted to those items whose difference in item-logit distributions was within ± 3 (18 items). Using the same instrument calibration, we compared the person measures between the patients with glaucoma and those with RP. Patients with glaucoma had, on average, higher perceived visual ability for independent mobility than those with RP.

CONCLUSIONS. The instrument developed for patients with RP, to determine difficulty across a range of mobility situations, is a valid measure of perceived ability for independent mobility in patients with glaucoma. (*Invest Ophthalmol Vis Sci.* 2002;43:2874-2881)

In an earlier study, we developed and validated a self-assessment instrument designed to measure the ability of patients with retinitis pigmentosa (RP) to find their way, walk, and travel safely and independently.¹ This 35-item instrument asked patients to rate the difficulty they had with mobility in different situations. Using Rasch analysis, interval measures of perceived visual ability for independent mobility for each patient (person measure) and the required visual ability for each mobility situation (item measures) were estimated from the ordinal difficulty ratings. For patients with RP, “moving about

in the home” and “walking in familiar areas” required the least visual ability (i.e., were the easiest for patients with RP), whereas “walking at night,” “moving about in crowded situations,” and “avoiding bumping into low-lying objects” required the most visual ability (i.e., were the hardest for patients with RP).

The question that we addressed in this study is whether this self-assessment instrument is a valid measure of self-perceived ability for mobility in patients with glaucoma. We expected that patients who have visual impairments similar to those that accompany RP would have similar losses in mobility function. Although glaucoma and RP are very different diseases, both are characterized by progressive constriction of the visual field beginning in the midperiphery, progressive losses of contrast sensitivity, and sparing of the central field with good visual acuity until late in the disease. Patients with RP and those with glaucoma differ in the age of onset of visual impairments, rate of degeneration, and severity of night vision problems.

Patients with advanced RP or glaucoma require orientation-mobility services.²⁻⁶ To measure a patient’s need for rehabilitation and the effectiveness of orientation and mobility instruction, it would be helpful to have a single instrument that is valid for all patients and produces a common measurement scale across diagnostic categories. The purpose of the present study was to test the validity of our instrument (which had been validated in patients with RP) for patients with glaucoma.

The second purpose of the study was to determine the relationship between perceived visual ability for independent mobility and a physical measure of mobility performance in patients with glaucoma. We have noticed that persons with similar degrees of visual field loss do not always perform with the same mobility skill.^{2-4,7} Differences in physical ability may account for some of this variation, but differences in perceived ability may also be responsible. Two studies have examined the relationship between self-report and actual mobility performance, although only a small subset of the questions pertained to mobility.^{8,9} Both studies involved a heterogeneous group of patients with low vision. One study did not report the association of the relationship between self-report and performance⁸; however, the other study showed a moderate correlation ($r = 0.56$) between self-report and specialists’ ratings of mobility performance.⁹

In this study, we restricted our population to patients with glaucoma and determined the distribution of perceived ability for independent mobility and its relationship with mobility performance.

METHODS

Subjects

Questionnaires were administered to 83 patient-volunteers with glaucoma recruited from the Wilmer Glaucoma Service. The subjects ranged from 26.9 years to 79.7 years, with a mean age of 61.7 ± 12.3 years (SD). All had a complete ophthalmic examination by a glaucoma specialist (HAQ) on the day of testing.

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Supported by National Eye Institute Grants EY07839 (KAT) and EY12045 (RWM).

Submitted for publication February 4, 2002; revised April 17, 2002; accepted May 22, 2002.

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Open-angle glaucoma was defined as present when a subject had gonioscopically open angles in both eyes and a reproducible visual-field abnormality in at least one eye. Field abnormality consisted of a Glaucoma Hemifield Test result of "outside normal limits" or a Corrected Pattern Standard Deviation (CPSD) result with less than a 5% chance of being within normal limits on Humphrey program 24-2 testing (Humphrey Instruments, San Leandro, CA). In addition, the optic disc of an eye with field defect had to have a finding compatible with glaucoma damage, including notch defect of the neuroretinal rim; a cup-to-disc ratio more than 0.7; or excavation of disc rim. Patients with glaucoma with apparent nonglaucomatous retinal disease or other ocular disease were excluded from the study. Subjects were not excluded on the basis of lens opacities. A retrospective analysis showed that of the 46 (55%) subjects whose lens status had been documented, 16 had cataracts. However, the majority (10/16) of the cataracts were reported as mild or "trace." Of the subjects with cataracts, only four had a presenting binocular acuity less than 20/30. The subjects for whom we had lens data did not differ in age, logarithm of the minimum angle of resolution (logMAR), mean deviation (MD), or CPSD from those for whom we had no lens data.

Potential subjects were asked a number of health-related questions by the interviewer before their selection as subjects in the experiment. Any subject with musculoskeletal limitations (e.g., orthopedic), cognitive or neural limitations (e.g., Alzheimer disease), or endurance limitations (e.g., coronary problems), was excluded from participation. Informed consent was obtained from each subject after the nature and possible consequences of the study were described. The research followed the tenets of the Declaration of Helsinki and was approved by the Johns Hopkins Medical Institution's committee on human experimentation.

Instrument

The instrument was administered face to face by a single interviewer. In part 1, subjects were instructed to rate on a scale of 1 ("no difficulty") to 5 ("extreme difficulty") the level of difficulty they experienced in each of 35 mobility situations when they did not have an accompanying person or mobility aid to assist them. In part 2, subjects were also asked a series of questions about mobility-related behavior, such as:

- Do you limit travel by yourself due to your vision loss? (yes/no)
- Do you believe that your ability to travel on foot by yourself is less than that of people with normal vision? (yes/no)
- How often do you ask someone to accompany you when you leave your house? (Always/Usually/Sometimes/Never)
- Have you fallen in the last year? (yes/no)
- Have you had a fear of falling in the last year? (yes/no)

The questionnaire is printed in the Appendix of Turano et al.¹

Mobility Test

The mobility course was a hallway 29 meters long, and consisted of a course through a clinic waiting room with chairs and tables. It included four right-angle turns and moderate pedestrian traffic. The median number of persons in view was 3.5 during testing (lower quartile, 1; upper quartile, 7.5). The median number of persons within 2 feet of the subject was 2 (lower quartile, 1; upper quartile, 4.5). Illumination along the path ranged from 88.3 to 199.1 lux. The subject was instructed to walk through the waiting room, making the appropriate turns. Before beginning the path, the subject repeated the directions to assure that they were understood. A trained observer always followed closely. The subject walked the course with his or her normal refractive correction. Each subject traveled each path twice. The second time through on each path, the direction of the course was reversed. Travel time was converted into walking speed (meters per second) by dividing the distance of the established travel path by the time to complete the course. The converted measure permits a direct comparison of mobility performance across other routes and studies.

The mean walking speed of the two passes on the course served as the estimate of walking speed.

Visual Field Test

Visual fields were measured monocularly with the 24-2 threshold program of the Humphrey Visual Field Analyzer (Humphrey Instruments).¹⁰ Global indices, such as the MD and the CPSD, were determined from local threshold measures. MD is the average of the differences in decibels between the age-corrected normal threshold and the threshold of the subject over all 54 tested points that are located within the central $\pm 24^\circ$. The measure is an estimate of the general loss of sensitivity. The CPSD is an estimate of localized loss and is determined by adjusting the differences in decibels between the age-corrected normal threshold and the subject's threshold for shifts in overall sensitivity and intratest variability. Both global indices are used as indicators of the stage of disease.

Visual Acuity Measures

Presenting visual acuity was measured binocularly with an ETDRS acuity chart (Lighthouse)¹¹ transilluminated at approximately 100 cd/m². The viewing distance was 3 m. Visual acuity was reported as the logMAR, computed by multiplying the number of letters correctly read by 0.02 and subtracting from 1.22. Best corrected Snellen acuity was obtained monocularly and converted into logMAR by taking the logarithm of the inverse.

RESULTS

In part 2 of the questionnaire, the subject is asked whether there are "other health problems that contribute to limitations in walking around." One subject was excluded from the study because she reported that inner ear problems contributed to limitations in walking around. Interval measures of perceived visual ability for independent mobility were estimated from the ordinal ratings of difficulty by performing a Rasch analysis¹² on the matrix of difficulty ratings by the 83 subjects for the 35 mobility situations. We used BIGSTEPS (University of Chicago, Chicago, IL),¹³ an unconditional maximum likelihood estimation routine that estimates the parameters of the Wright and Masters¹² version of the Rasch model for polytomous rating scale data. Among other model parameters and fit statistics, BIGSTEPS provides estimates of the perceived ability for independent mobility for each person and the required visual ability for each of the mobility situations.

If a person's perceived visual ability for independent mobility is less than the visual ability required in a particular situation, we expect that the person will have a high probability of rating the situation in the "extreme difficulty" category (rating 5). In contrast, if a person's perceived visual ability for independent mobility far exceeds the visual ability required for independent mobility in a particular situation, we expect that the person will have a high probability of rating the situation in the "no difficulty" category (rating 1). Extending these examples, we expect that the probability of using any particular rating category will scale with the difference between the patient's perceived visual ability for independent mobility and the visual ability required for the situation described in the item.

We defined α_n as person n 's perceived visual ability for independent mobility and p_i as the visual ability required for independent mobility in situation i . According to the Wright and Masters version, the conditional probability that person n will respond with difficulty category x ($x = 1-5$) rather than with category $x - 1$ to item i is:

TABLE 1. Summary of the Analysis of the Response Categories for Difficulty of the 35 Mobility Situations

Difficulty Rating	Count	Step Measure	Infit MNSQ	Outfit MNSQ	Expected Score at Measure
1	1235	-3.17	0.98	0.98	(-2.76)
2	530	-1.40	1.08	0.75	-1.17
3	377	-0.55	1.08	1.17	0.02
4	179	0.33	0.97	0.94	1.17
5	94	1.09	0.96	0.98	(2.72)

MNSQ, mean square.

$$\phi(x|\alpha_n, \rho_i) = \frac{e^{\alpha_n - \rho_i - \tau_x}}{1 + e^{\alpha_n - \rho_i - \tau_x}}$$

where ρ_i is the visual ability required to respond with a category of x on item i , and τ_x is the response category threshold.¹⁴ The “odds” that person n responds with category x to item i , instead of responding with category $x - 1$, is the ratio of $\phi(x|\alpha_n, \rho_i)$ to $1 - \phi(x|\alpha_n, \rho_i)$. The logarithm of the odds ratio (logit) is the difference between the person parameter (α_n) and the sum of the item response parameter (ρ_i) and the response category threshold (τ_x).

The person logit corresponds to the difference between each person’s perceived visual ability (α_n) and the mean item measure ($\bar{\rho}$). If the person logit is positive, the person’s per-

ceived visual ability is greater than the average required visual ability for the 35 mobility situations. If the person logit is negative, the person’s perceived visual ability is less than the required visual ability. In our sample, the mean of the distribution was 1.99 ± 1.57 . This result indicates that the perceived visual ability of the subjects in our sample was greater than the average required visual ability for the 35 mobility situations.

Table 1 is a summary of the analysis of the five response categories for the difficulty ratings. The Count is the number of times the rating was used across all mobility situations and subjects. Rating categories 1 (“no difficulty”) and 2 were used more often than the three higher categories. Step Measure is the estimate of τ_x in the model. When added to the item logits in Table 2, τ_x represents the expected values of α at which a subject would be equally likely to choose that rating or the next lower category for the item. The expected score at measure is the value of $\alpha - \rho$ at which that rating is most probable (i.e., the peak of the response-probability function).

Reliability is the ratio of the adjusted SD to the observed SD of the person or item measure distribution. The adjusted SD is the square root of the difference between the observed variance and the SE.² Thus, the reliability coefficient is the fraction of variability in the observed measurement distribution that can be attributed to the true variance of the person or item measure. A value of 1.0 indicates that all observed variance is due to the variance in the measure (i.e., none of the observed variability can be attributed to measurement error). In our sample, the reliability values of the person and item measures

TABLE 2. Results of Rasch Analysis Applied to Glaucoma Subjects’ Ratings of Difficulty for Each Mobility Situation

Item	Mobility Situations	Logit $-r_i$	Error	Infit		Outfit	
				MNSQ	Z _{STD}	MNSQ	Z _{STD}
✓ 1	Walking in familiar areas	2.11	0.30	1.29	0.90	0.65	-0.40
✓ 3	Moving about in the home	1.94	0.28	1.22	0.70	1.78	1.00
✓ 4	Moving about at work	1.70	0.44	0.81	-0.40	0.36	-0.50
29	Avoiding bumping into waist-height objects	1.01	0.21	0.94	-0.20	0.95	-0.10
✓ 26	Avoiding bumping into walls	0.92	0.21	0.82	-0.80	0.67	-0.70
✓ 13	Walking up steps	0.88	0.20	1.12	0.50	1.01	0.00
28	Avoiding bumping into shoulder-height objects	0.84	0.20	0.92	-0.40	0.97	-0.10
34	Finding restrooms in public places	0.79	0.20	10.60	0.30	0.70	-0.70
✓ 17	Walking through doorways	0.65	0.19	0.89	-0.50	0.63	-0.90
✓ 5	Moving about in a classroom	0.59	0.31	1.00	0.00	0.79	-0.30
25	Avoiding bumping into people	0.54	0.19	1.21	1.00	1.07	0.20
33	Moving around in social gatherings	0.54	0.19	0.86	-0.70	0.57	-1.10
✓ 35	Seeing cars at intersections	0.52	0.19	1.46	2.20	1.26	0.70
✓ 11	Detecting ascending stairwells	0.34	0.18	0.91	-0.40	0.65	-1.00
✓ 6	Moving about in stores	0.25	0.18	0.88	-0.60	0.75	-0.70
✓ 10	Using public transportation	0.19	0.21	1.04	0.20	0.90	-0.20
✓ 24	Being aware of another person’s presence	0.12	0.17	0.85	-0.80	0.64	-1.10
✓ 27	Avoiding bumping into head-height objects	0.10	0.17	1.52	2.70	1.69	2.10
30	Avoiding bumping into knee-height objects	0.07	0.17	1.00	0.00	0.85	-0.50
7	Moving about outdoors	-0.11	0.17	0.86	-0.70	0.84	-0.50
15	Stepping onto curbs	-0.28	0.16	0.70	-1.60	0.71	-1.00
8	Moving about in crowded situations	-0.48	0.16	0.84	-0.80	0.71	-1.10
✓ 2	Walking in unfamiliar areas	-0.48	0.16	0.84	-0.90	0.86	-0.50
14	Walking down steps	-0.49	0.16	1.18	1.00	1.00	0.00
✓ 12	Detecting descending stairwells	-0.51	0.16	0.99	-0.10	0.76	-0.90
22	Adjusting to lighting changes at night: street lights to indoors	-0.55	0.16	1.50	2.80	1.43	1.70
16	Stepping off curbs	-0.67	0.15	0.74	-1.50	0.69	-1.30
✓ 31	Avoiding bumping into low-lying objects	-0.67	0.15	0.96	-0.20	0.84	-0.60
21	Adjusting to lighting changes at night: indoors to street lights	-1.13	0.15	0.98	-0.10	0.92	-0.40
19	Adjusting to lighting changes during the day: in- to outdoors	-1.18	0.15	1.08	0.50	1.21	1.00
✓ 20	Adjusting to lighting changes during the day: out- to indoors	-1.20	0.15	1.40	2.40	1.22	1.10
32	Avoiding tripping over uneven travel surfaces	-1.20	0.15	0.94	-0.30	1.17	0.90
✓ 23	Walking in dimly lit indoor areas	-1.43	0.14	0.96	-0.20	0.98	-0.10
9	Walking at night	-1.78	0.15	0.99	0.00	1.00	0.00
18	Walking in high-glare areas	-1.96	0.14	0.95	-0.30	1.13	0.70

were 0.94 and 0.98, indicating the estimated measures were reliably separating persons and items.

The reliability coefficients can be interpreted as indices of person and item separation—that is, how broadly the measures are distributed along the visual ability dimension relative to the estimation error. For an instrument to have high content validity, the items must be distributed sufficiently to measure meaningful differences. The separation index is simply the SD of the person or item measure distribution in SE units. The separation indices were 4.05 for the person measures and 4.85 for the item measures. If we consider differences of 3 SEs to be statistically resolvable, then the separation indices indicate that our sample (mean \pm 2 SD) had five statistically resolvable levels of person measures and six statistically resolvable levels of item measures.

The infit and outfit statistics indicate how well the data agree with the expectations of the model. The outfit statistic is the mean square of the normalized response residuals (i.e., difference between the actual response of person n to item i and the expected response, normalized to the model's expectation for the response SD). Values close to 1.0 indicate that the distribution of the residuals has a variance close to that expected by the model, values greater than 1.0 indicate that the variance of the residuals is greater than the expectation of the model, and values less than 1.0 indicate that the variance is smaller than expectation, suggesting that the responses are influenced by a strong covariance term. In our sample, the average outfit statistic of the person and item measures were 0.94 and 0.93. The infit statistic normalizes the mean square of the residuals to the average expected variance. Thus, the infit statistic is less sensitive to the influence of outliers. In our sample, the average infit statistic of the person and item measures were 1.00 and 1.02.

The infit and outfit mean square distributions can be transformed to standard normal distributions with Wilson-Hilferty transformation¹⁵ and presented as z -scores. The expected values of the z -transformed infit and outfit mean squares are 0 and the SD is 1. Figure 1 plots the person measures against the z -transformation of infit values for the 82 subjects whose responses were included in the final analyses. Data points for the persons with the most visual ability for mobility are located at the top of the graph and those for persons with the least visual ability are located at the bottom. Infit values are positioned along the x -axis. Infit mean squares that are more than 2 SD from the mean (located in the shaded regions of the graph) indicate that the mean square was greater than or less than the model's expectation by more than 2 SDs. In our sample, 11 (13%) persons did not fit the model.

Table 2 itemizes the 35 mobility situations in our questionnaire, listed in order of least to most visual ability required for independent mobility. The Item # column lists the order of the mobility situations on the questionnaire. Logits lists the values that correspond to the difference between the item measure (in logit units) for each mobility situation (ρ_i) and the mean item measure for the 35 mobility situations ($\bar{\rho}$). The item measure corresponds to the visual ability required for the mobility situation, and it has the opposite sign from the item logit value. A positive item logit value indicates that the required visual ability for that mobility situation is greater than the mean required visual ability of all 35 mobility situations, and a negative value indicates that the required visual ability for that mobility situation is less than the mean.

Table 2 shows that "walking in familiar areas," "moving about in the home," and "moving about at work" require the least visual ability, whereas "walking in high-glare areas," "walking at night," and "walking in dimly lit indoor areas" require the most visual ability.

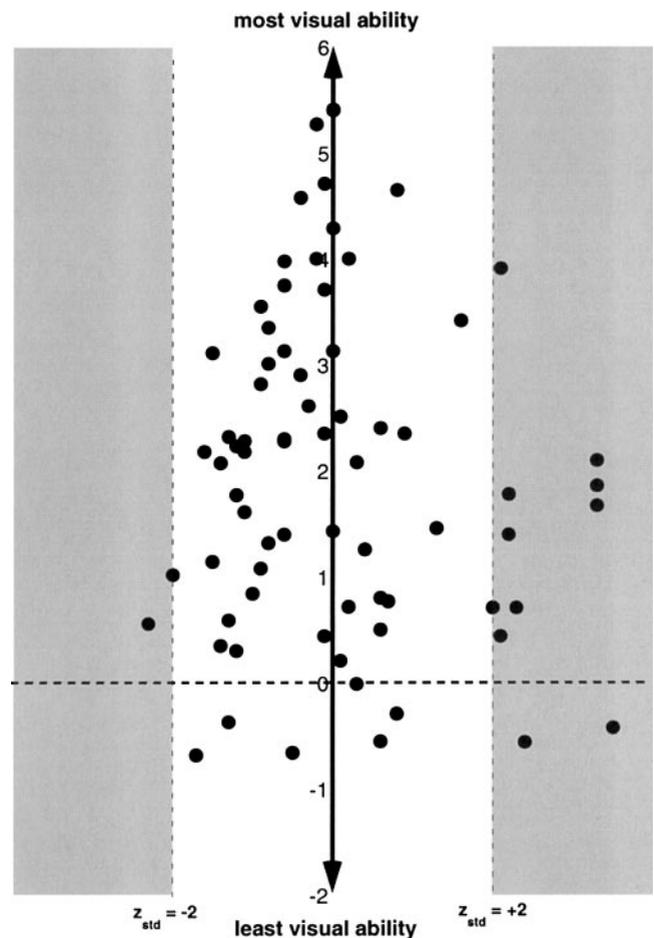


FIGURE 1. Person measures of perceived visual ability for independent mobility (α) versus the z -transformed infit mean squares (z_{std}). Data points for the persons with the most visual ability for mobility are located at the *top* of the graph and those for persons with the least visual ability are located at the *bottom*. Normalized infit values that exceed ± 2 (located in shaded regions of the graph) indicate that the mean square exceeded the model's expectation by more than 2 SDs.

In our sample, four situations were misfits. The following situations had infit or outfit values that exceeded the model's expectations by more than 2 SDs: "avoiding bumping into head-height objects," "adjusting to lighting changes at night: streetlights to indoors," "adjusting to lighting changes during the day: outdoors to indoors," and "seeing cars at intersections."

Relationship of Person Score and Stage of Glaucoma

To determine whether perceived ability relates to stage of glaucoma, we computed the Pearson product-moment correlation between α_n and the global scores from the Humphrey Field Analyzer, MD and CPSD. Advanced stages of glaucoma are associated with lower MDs and higher CPSDs. The MD scores ranged from -30.7 to 1.87 (mean, -7.2 ± 8.6 ; median -3.4) in the better eye. In the worse eye, the MD scores ranged from -30.92 to 2.62 (-13.3 ± 10.4 ; median, -12.1). The CPSD scores ranged from 0 to 13.2 (mean, 4.0 ± 3.6 ; median, 2.2) in the better eye. In the worse eye, the CPSD scores ranged from 0.6 to 16.2 (mean, 7.0 ± 4.1 ; median, 7.9).

The correlation coefficients for α_n and MD were 0.32 and 0.20 for the better and worse eyes, respectively. For CPSD and α_n , the correlation coefficients were -0.17 and -0.07 . The

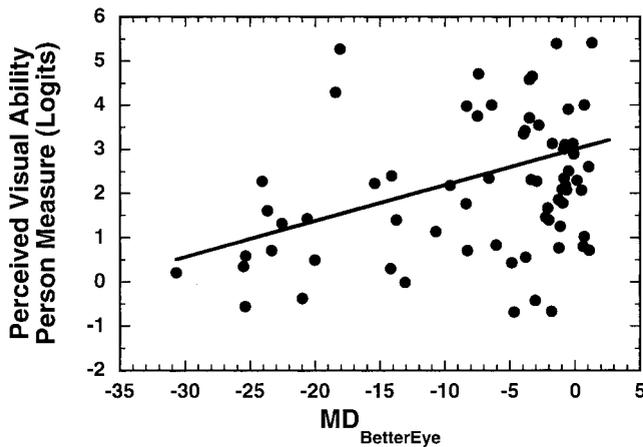


FIGURE 2. Perceived visual ability person measures versus better-eye MD. Line: trend estimated from bivariate linear regression.

relationship between α_n and MD in the better eye was the only statistically significant correlation, $P < 0.01$. Figure 2 compares perceived visual ability person measures with better eye MD. The solid line is the trend estimated from bivariate linear regression. The relationship between perceived visual ability person measure and MD can be represented as $\alpha_n = 0.08 \cdot MD_{\text{BetterEye}} + 3.0$. The trend line indicates that average perceived visual ability decreased by 0.08 logits per unit decrease in MD score.

The MD score, a measure of overall reduced sensitivity, varies in a linear manner with the progression of glaucoma, whereas the CPSD score, a measure of localized sensitivity loss, varies with the progression of disease in a nonmonotonic fashion. Therefore, a higher correlation of perceived ability with MD than with CPSD is not surprising.

Studies have shown that cataracts can have a modest effect on the MD score. One study showed that, after cataract extraction, MD improved an average of 1.68 dB.¹⁶ (An even smaller improvement occurred in subjects whose logMAR improved < 0.3 .) Although an analysis of a subsample (55%) of our subjects revealed that some subjects had cataracts, their good visual acuity (only four had a presenting binocular acuity $< 20/30$) suggests that the effect of cataract on our results was small.

On the suggestion of an anonymous reviewer, we conducted a separate analysis on the more advanced patients (i.e., excluding patients with better-eye MDs in the upper quartile). The Pearson product-moment correlation coefficients were 0.32 and 0.15 for α_n and $MD_{\text{BetterEye}}$ and α_n and $MD_{\text{Worse Eye}}$, respectively. For CPSD, the correlation coefficients with α_n were -0.15 and 0.01 . These values are very similar to those obtained in all subjects. Similar to the results found in all subjects, the only statistically significant correlation was between α_n and MD in the better eye ($P < 0.01$).

Relationship between Person Measure and Visual Acuity

To determine whether perceived ability relates to visual acuity, we computed the Pearson product-moment correlations between α_n and the best-corrected monocular logMARs and between α_n and the presenting binocular logMAR. The better of the two monocular logMARs ranged from -0.12 to 1.17 (mean, 0.10 ± 0.21). In the fellow eye, the scores ranged from -0.12 to 1.30 (mean, 0.29 ± 0.39). The presenting binocular logMARs ranged from -0.18 to 1.22 (mean, 0.11 ± 0.28). Correlation coefficients for α_n and logMAR were -0.22 , -0.22 , and -0.20 in the better-eye, fellow-eye, and both eyes,

respectively. The correlation coefficient between α_n and each monocular acuity was statistically significant at 0.05.

Relationship between Person Measure and Walking Speed

To determine whether perceived ability relates to actual performance, we computed the Pearson product-moment correlation between α_n and walking speed. The correlation was 0.43, significant at 0.01. Figure 3 plots walking speed (in meters/second) versus perceived visual ability person measures. The solid line is the trend estimated from bivariate linear regression. The relationship between walking speed and perceived visual ability person measure can be represented as $\text{Walking Speed} = 0.05 \cdot \alpha_n + 0.97$. This trend is interpreted as average walking speed increased by 0.05 m/sec per logit increase in perceived ability.

As shown in the figure and quantified by the magnitude of the correlation coefficient, the relationship between perceived ability and walking speed is not perfect. A given degree of perceived ability does not map onto a specific walking speed. This less-than-perfect correlation between the two factors was not unexpected (see the Discussion section).

Relationship of Person Score and Mobility-Related Behavior

To determine the instrument's ability to discriminate subjects on the basis of their self-reported mobility-related behavior, we performed a receiver operating characteristic (ROC) analysis on the person measures.^{17,18} The person measure distributions were divided into two groups: one for those who answered "yes" to the mobility-related questions in part 2 of the questionnaire and one for those who answered "no." (Part 2 was not included in the Rasch analysis.) We computed the area (A) of the ROC curve from the two distributions for each of five mobility-related questions and then compared these values to chance performance ($A = 0.5$) to test for significance.¹⁸ The person measures discriminated those who had a fear of falling ($A = 0.75$, $P < 0.05$), asked for accompaniment ($A = 0.74$, $P < 0.01$), and believed their ability to travel independently to be less than that of persons with normal vision ($A = 0.85$, $P < 0.01$). The person measure was less able to discriminate those who reported limited independent travel ($A = 0.71$, $P = 0.06$) and those who reported having fallen in the past year ($A = 0.62$, $P = 0.20$).

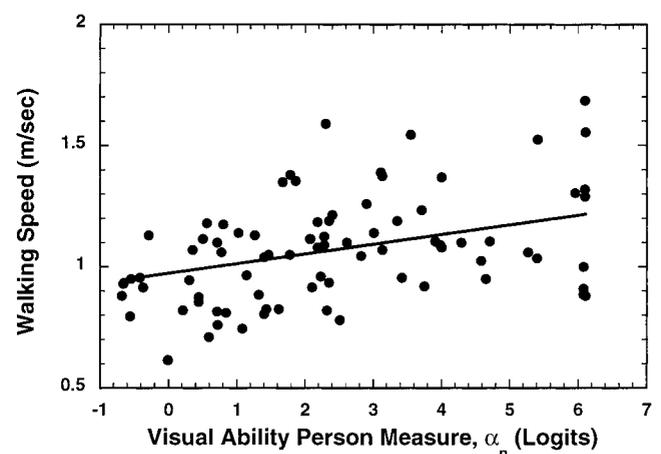


FIGURE 3. Walking speed and person measures of perceived visual ability. Line: major axis of the bivariate regression analysis.

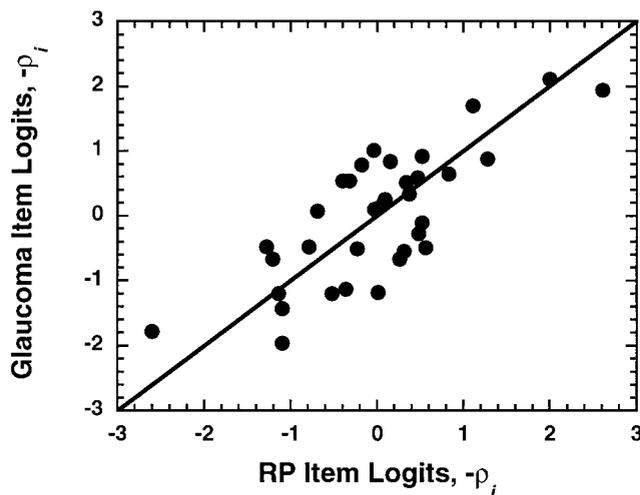


FIGURE 4. Item logits determined by the glaucoma subjects for the mobility situations versus the item logits determined by the RP group. *Unity line:* indicates where the data should fall if the item logits were the same in the two groups.

Glaucoma Versus RP

The results demonstrate that the patient-based assessment used in the present study is a valid instrument for measuring perceived ability for independent mobility in persons with glaucoma. Previously, we demonstrated that the instrument is valid for measuring perceived ability for independent mobility in persons with RP.¹ That the instrument was shown to be valid for both diagnostic groups does not guarantee that the scales from the two groups will be the same. Figure 4 plots the item logits determined for the glaucoma group for each of the 35 mobility situations versus the item logits determined by the RP group. The unity line on the graph indicates where the data would fall if the item measures were the same in the two groups. The Pearson product-moment correlation for the item logits of the two groups was 0.77.

To identify the mobility situations whose required visual ability was similar for the glaucoma and RP groups, we computed a z-score for the SE of the difference in item logits,

$$z(\text{SEdiff}) = \frac{\rho_{\text{RP}_i} - \rho_{\text{Glaucoma}_i}}{\sqrt{\text{Error}_{\text{RP}_i}^2 + \text{Error}_{\text{Glaucoma}_i}^2}}$$

The 18 items with differences within ± 3 SEs are indicated with a check in the leftmost column of Table 2.

We performed Rasch analysis on the two matrices of difficulty ratings for the 18 mobility situations to obtain estimates of perceived ability for independent mobility for each person (α_n) and the required visual ability for each of the difficulty situations (ρ_i).

The fit statistics from the Rasch analysis of the edited questionnaire were comparable (within 4%) to those of the unedited version. The reliability statistics were also comparable (3%–11%, glaucoma group person and item statistics: 0.86 and 0.87; RP group person and item statistics: 0.92 and 0.93).

The expected score measures (τ_x) for each of the difficulty ratings (1–5) used on the edited questionnaire were comparable for the glaucoma and patients with RP (Fig. 5). The similarity in the measures indicates that the patients with glaucoma and those with RP used the rating scale in the same way.

The histogram in Figure 6 shows a comparison of the perceived visual ability person measures of the patients with glaucoma and the patients with RP. The person measures of

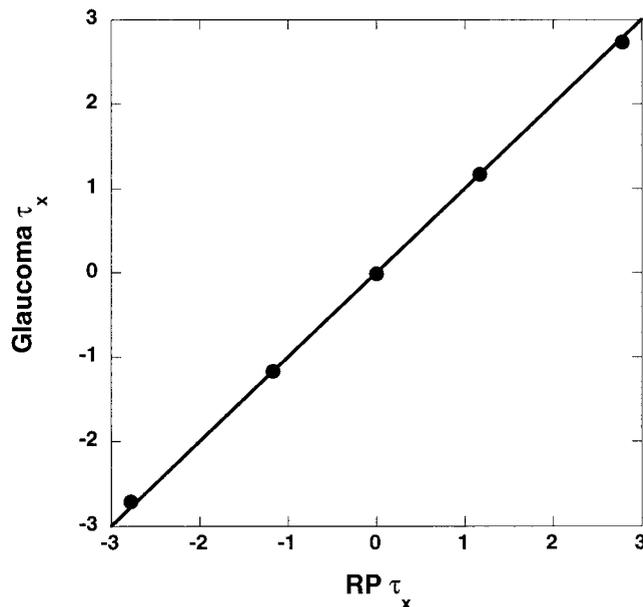


FIGURE 5. Expected score measures (τ_x) of each of the difficulty ratings of the patients with glaucoma versus those of the patients with RP. *Solid line:* unity line. The similarity in the measures indicates that the patients with glaucoma and those with RP used the rating scale in the same way.

the patients with glaucoma are shifted farther to the right than those of patients with RP. A t-test of the person measures for the two groups indicates that, on average, the patients with glaucoma had higher perceived visual ability for mobility than the RP subjects, $t_{(141)} = 2.87, P < 0.0001$.

We compared the item logits derived from the Rasch analysis of the difficulty ratings on the edited questionnaire for the patients with glaucoma and the patients with RP (Fig. 7). The Pearson product-moment correlation for the item logits for the two groups was 0.94, indicating high agreement in perceived required visual ability for each of the 18 mobility situations.

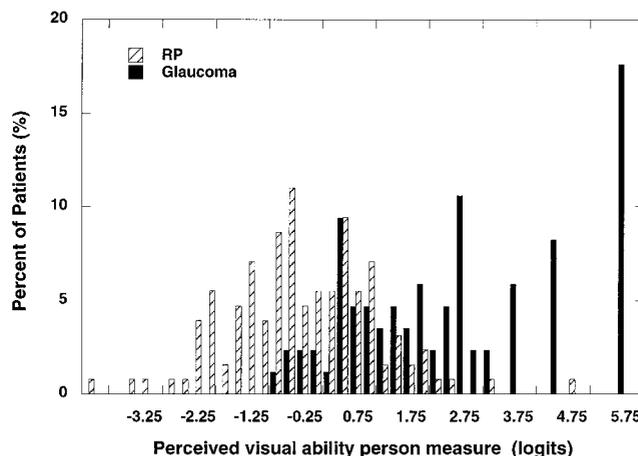


FIGURE 6. Person measures computed with the 18 items for the patients with glaucoma and those with RP. Note that the person measures of the patients with glaucoma are shifted farther to the right than the person measures of the patients with RP, indicating that those with glaucoma in our sample had higher perceived visual ability for mobility than did those with RP.

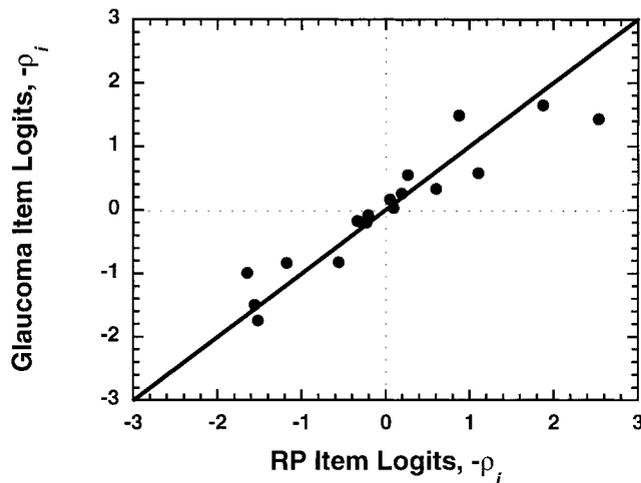


FIGURE 7. Item measures of the restricted set of mobility situations for the patients with glaucoma versus the item measures for the patients with RP. *Solid line*: unity line.

DISCUSSION

The goal of this study was to determine whether the patient-based assessment of mobility difficulty, developed and validated in a group of persons with RP, could be used to determine perceived visual ability for independent mobility in a group of persons with glaucoma. Using Rasch analysis, we inferred a person score of perceived visual ability for each patient. As had been demonstrated previously in patients with RP, the instrument showed good content validity, demonstrated by good separation indices (4.05 and 4.85)—that is, high reliability scores (0.94 and 0.96) in the glaucoma group. In the patients with RP, the separation indices were 4.55 and 8.0, respectively, for the person and item measures (reliability scores were 0.96 and 0.98, respectively). Construct validity of the instrument was established with mean square fit statistics. Criterion validity was demonstrated by its ability to discriminate mobility-related behaviors such as fear of falling, asking for accompaniment, and believing that ability to travel independently is less than that of persons with normal vision.

Perceived Ability and Mobility Performance

Another purpose of the study was to determine the relationship between what a person perceives he or she is capable of doing and what the person actually does. We expected that mobility performance would covary with perceived ability. However, we did not expect a perfect correlation between the two because many physical factors contribute to mobility performance, such as frailty, height, and weight; our assessment of mobility performance, a multifaceted composite, was based on only one factor, walking speed (Walking speed is only one way to assess mobility performance. People may walk fast, yet bump into objects, or they may walk at the same speed as a normally sighted person but be unable to carry on a conversation simultaneously. A comprehensive picture of mobility performance would include a mix of observable behavior [e.g., walking speed, number of unintended bumps, and/or orientation errors] as well as an assessment of perceived difficulty and mental effort.^{3,19}) and our course sampled only a portion of the mobility situations that were queried on the questionnaire. That is, the questionnaire, which served as the basis for the perceived ability score, included questions concerning walking up (or down) steps, curbs, at night, and in crowded situations. The course in our study was located all on one level with no

changes in elevation and no stairs, it was well lit, and it contained few obstacles. Despite all the extraneous factors, the correlation between perceived visual ability of independent mobility and walking speed was strong ($r = 0.43$).

Glaucoma and RP

Many of the visual impairments that characterize glaucoma are similar to those in RP, such as progressive loss of contrast sensitivity and midperipheral loss of visual fields with sparing of the central field until late in the disease. These similarities led us to hypothesize that patients with glaucoma or RP would have similar losses in mobility function. A comparison of the item logits determined by the patients with glaucoma with those determined by the patients with RP for each of the 35 mobility situations revealed a strong association between the two groups ($r = 0.77$; Fig. 4). The mobility situations that were rated significantly different between the two groups primarily pertained to walking at night, lighting changes at night, social situations, and stepping down or walking on uneven surfaces. Patients with RP rated walking at night more difficult than did the patients with glaucoma, which is not surprising, given that RP is characterized by severe night vision problems. Patients with RP also rated getting around in social (or crowded) settings more difficult than did the patients with glaucoma. The patients with glaucoma rated lighting changes at night as more difficult than did the patients with RP. This may be a consequence of RP's limiting independent mobility at night. Patients with glaucoma also rated stepping down or walking on uneven surfaces as more difficult than did the patients with RP. It is possible that age may bias difficulty ratings, especially with respect to situations that are high risk for falling. In our samples, the patients with glaucoma were, on average, older than the patients with RP. The mean age for the glaucoma group was 61.7 years (26.9–79.7 \pm 12.3) and 49.1 years (18.1–79.2, \pm 14.4) for the RP group.

Universal Instrument

One of the goals of this study was to determine whether the patient-based assessment of difficulty in mobility developed for patients with RP was valid for other patients and whether it produced a common measurement scale across diagnostic categories. The results of the study showed that when used in patients with glaucoma the instrument has good content validity and high reliability scores. The instrument also has criterion validity, demonstrated by its ability to discriminate several types of mobility-related behaviors of the patients with glaucoma. However, in its original form, the instrument was associated with different calibrations for the two groups. We found that we could obtain a perceived mobility scale that could be applied to patients with glaucoma and those with RP with the same instrument calibration for both by restricting the questionnaire to a subset of the mobility situations. Using the edited version, we determined that the patients with RP had less perceived ability for independent mobility than the patients with glaucoma. However, both groups judged that moving about in the home, in familiar areas, at work, and walking up steps required the least visual ability. The mobility situations that were judged by both groups to require the most visual ability were walking in dimly lit areas, moving from outdoors to indoors, avoiding bumping into low-lying objects, walking in unfamiliar areas, and detecting descending stairwells.

In summary, the instrument developed for patients with RP to determine difficulty across a range of mobility situations is a valid way to measure perceived ability for independent mobility in patients with glaucoma. By restricting the questionnaire to a subset of the mobility situations we were able to obtain a perceived mobility scale that could be applied to patients with

glaucoma and those with RP with the same instrument calibration for both.

Acknowledgments

The authors thank the subjects for participating in this study and Julie Stahl for collecting the data.

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