Mobility function in older veterans improves after blind rehabilitation

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Abstract—This study was conducted to investigate the effects of blind rehabilitation training on self-reported mobility function in visually impaired adults. Mobility function was assessed with a questionnaire administered before and 2 months after subjects completed a comprehensive blind rehabilitation program that included orientation and mobility training. Subjects rated the level of difficulty performing in 26 of 34 mobility situations as significantly lower after rehabilitation. Subjects also rated their confidence as higher after rehabilitation. Substantial improvement occurred in the self-reported mobility function of visually impaired adults after blind rehabilitation and mobility training.

Key words: mobility performance, orientation and mobility training, visual function, visual impairment.

INTRODUCTION

The visual system provides most of the information we use during day-to-day travel. When vision is impaired a person’s ability to obtain information about the environment is reduced, along with the capacity to perform certain functions. One of these is safe and efficient movement through the environment, or mobility. Reductions of mobility are most obvious for those who are totally blind. However, visually impaired persons generally have greater difficulty performing mobility tasks than persons with normal vision [1–3].

Orientation and mobility training maintains travel independence by teaching visually impaired persons new skills to compensate for the reduced quality of visual information. These skills can include techniques to effectively use remaining vision or other sensory systems as well as training in the use of aids such as the long cane. Structured orientation and mobility training has been around for over 50 years and is usually part of a larger program of vision or blind rehabilitation.

Persons providing or receiving mobility training generally regard it as effective in improving mobility performance. However, only three studies have objectively assessed the effectiveness of training and all did not obtain the same results. Geruschat and Del’Aune [4] and later, Straw and Harley [5], found significant improvements in mobility performance after orientation and mobility [6] found that mobility performance did not progress immediately after orientation and mobility training.

Abbreviations: CS = contrast sensitivity, O&M = orientation and mobility, SBRC = Southeastern Blind Rehabilitation Center, SF-12® = Short Form-12 Question Health Survey, VA = Department of Veterans Affairs.

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As Soong et al. [6] point out, the results of all of these studies, including their own, may have been influenced by factors other than the mobility training itself, leaving the question about its effectiveness unanswered. The improvements reported by Gerushat and Del’Aune [4] may have been the result of a practice effect rather than mobility training because they assessed performance before and after training on the same routes. The subject sample in Straw and Harley’s study [5] did not represent the majority of visually impaired adults, because only 15 percent of the subjects had better than light perception only. It is also unclear if canes were used and when and how many subjects had prior training.

For their own study, Soong et al. identify two factors that may have led to their failure to find improved performance after mobility training. First, their outcome measures of percentage of preferred walking speed and errors may not have been appropriate given the large percentage of training group subjects who used a long cane on the posttest, but not on the pretest. This device requires good motor coordination and maneuvering, which in the close quarters of the obstacle course may have been difficult for newly trained subjects and contributed to slower walking speeds and more errors. Second, the training group may have been at a disadvantage because performance was assessed immediately after training and before newly learned skills were sufficiently practiced. Soong et al. suggested several alternatives that might solve these problems, among them the application of self-report measures and waiting several months after training before assessing performance.

Several years ago we began collecting self-report data on mobility function from visually impaired older adults before and after they completed a comprehensive blind rehabilitation program. This program included orientation and mobility training. Our results address the issues raised by Soong et al. [6] of using self-report and having a waiting period before the final assessment. Furthermore, they indicate a positive rather than a negative outcome. We found that 2 months after completing blind rehabilitation, subjects reported significantly less difficulty and increased confidence performing in a variety of mobility situations.

METHODS

Subjects

Subjects were 128 visually impaired veterans who completed a comprehensive inpatient blind rehabilitation program at the Department of Veterans Affairs (VA) Southeastern Blind Rehabilitation Center (SBRC) in Birmingham, AL. The mean age of the subjects was 70.86 (±12.2) years, ranging from 30 to 91 years of age. The majority were Caucasian males (82%). The sample was heterogeneous with regard to cause of vision loss, as shown in Figure 1, although 55 percent of subjects had some form of macular disease.

The Birmingham VA Medical Center’s Institutional Review Board approved this study. The subjects gave written informed consent after the nature and intent of the study had been fully explained to them, and they were read the informed consent document.

Vision Measures

Each subject’s visual function was assessed at the beginning of his or her blind rehabilitation program. All measurements were taken binocularly with subjects wearing their habitual spectacle correction. Four visual functions were assessed and included high-contrast letter acuity, contrast sensitivity (CS), visual field extent, and scanning ability.

High-contrast letter acuity was measured at 3 m with the use of the Bailey and Lovie chart [7], with chart luminance at 100 cd/m². If subjects could not detect letters on the top row, viewing distance was reduced to 1 m. If this was not successful an attempt was made to measure acuity with the Feinbloom chart. Acuity was expressed in units of LogMAR.

![Figure 1.](image.png)

Distribution of subjects as a function of primary cause of vision loss. GLC = glaucoma, DR = diabetic retinopathy, MD = macular disease, OND = optic nerve disease, RP = retinitis pigmentosa, O = other.
In cases where acuity could not be measured, the following convention was used to assign LogMAR scores: Count fingers at x distance in meters was scored as x/60 and then converted to LogMAR. Similarly, hand motion at x distance in meters was scored as x/300 and converted to LogMAR. The highest score for hand motion was 3.18, which is equivalent to hand motion at 20 cm. Light perception only and no light perception were assigned LogMAR scores of 3.48 and 3.7, respectively. This avoided placing subjects with unmeasurable acuity into only one group when some individuals clearly had different visual abilities than others, however limited.

We gauged CS using the Pelli-Robson chart [8] with surface luminance of the white areas at 100 cd/m². Viewing distance was 1 m and sensitivity was scored in log CS as the faintest triplet for which two of the three letters were named correctly.

The binocular visual field was assessed along 12 meridians with a Goldmann Perimeter and III 4/e target set at standard background luminance [9]. We removed the viewing tube to facilitate monitoring observer fixation. The amount of visual field extent (in degrees) along each meridian was determined. We summed these values to give the total visual field extent in degrees and then converted them to a percentage of a normal binocular field. The normal field extent of 846° was based on data for a young adult under the same testing conditions [9].

**Mobility Measure**

A two-part questionnaire developed by Turano et al. was modified and used as the primary assessment instrument [10]. Turano et al. developed their mobility questionnaire to assess perceived visual ability for mobility and evidence suggests it also can be used to assess this trait across major eye diseases [10,11]. To evaluate perceived visual ability, they asked subjects to rate difficulty performing tasks without any assistance. We modified the wording in the first part of the questionnaire and asked subjects to rate difficulty performing tasks with whatever assistance they normally used. We were not assessing visual ability but something more pragmatic and felt the wording change was necessary to get at the effects of rehabilitation. Rehabilitation usually does not change visual function to any great extent and would not be expected to have much effect on an individual’s visual ability to perform in different situations. However, rehabilitation and orientation and mobility training often involve instruction in the use of various devices, such as long canes and telescopes, as well as training in adaptive techniques, many of which are nonvisual and all of which can have an impact on mobility function.

In the first part of the questionnaire, subjects rated their level of difficulty performing in 35 mobility situations. We eliminated one of the 35 situations—travel in the workplace—because it proved to be irrelevant for most of our past-retirement age subjects. All ratings of difficulty were on a 5-point scale, with 1 defined as no difficulty and 5 as extreme difficulty. A record was kept of whether assistance was used.

In Part 2, subjects supplied information about falls, fear of falling, whether mobility aids and sun wear are normally used, and satisfaction with and limitations to their travel abilities. We added to Part 2 four questions that assessed subjects’ confidence traveling in familiar and unfamiliar areas, in stores, and outdoors. As with difficulty, all ratings of confidence were on a 5-point scale, with 1 defined as completely confident and 5 as not confident.

**Procedures**

The mobility questionnaire was administered within the first 2 to 3 days after subjects were admitted to the blind rehabilitation program and before commencement of orientation and mobility training. Mobility measurements were taken again 2 months after subjects had completed the rehabilitation program. We selected 2 months as the time interval between completion of training and assessment, thinking this would be adequate time for subjects to practice and adapt new mobility skills to their home environment as well as to avoid any halo effects that might be present in a self-report assessment conducted immediately after rehabilitation was completed [12].

For the prerehabilitation assessment, we administered the mobility questionnaire in a verbal face-to-face interview. In addition, cognitive function and depression were assessed during the initial interview using the Short Portable Cognitive Function test and the Center for Epidemiological Studies Depression Scale [13,14]. At the same time, subjects were verbally given the SF-12® (the Short Form-12 Question Health Survey) to obtain information about their physical and mental health [15]. The measures of visual function were taken while subjects were in the rehabilitation program. Verbal administration was also used for the postassessment; however, it was completed in a telephone interview. A telephone interview was necessary because the majority of subjects...
did not live within commuting distance of the SBRC. Each administration took approximately 20 to 25 minutes.

**Orientation and Mobility Training**

Certified orientation and mobility specialists on staff at the SBRC provided the orientation and mobility training the subjects received after initial assessment. This training varied in focus and duration according to individual needs and type of vision loss. For example, the majority of subjects with central vision loss due to macular disease received limited instruction with the long cane that focused primarily on using it in emergency situations. Otherwise, training for these individuals was directed at maximizing their remaining vision, learning to use other sensory systems to obtain information about the travel environment, and other compensatory skills. In contrast, subjects with severe field restriction were likely to spend more time learning and practicing cane skills. Most clients in the blind rehabilitation program spend approximately 35 to 40 hours in orientation and mobility training over the average 6-week program.

**RESULTS**

**Subjects**

The average acuity of the subjects in the sample was 1.32 LogMAR (20/418), with a range of –0.2 to 3.7 LogMAR. The average extent of their binocular visual field was 53.9 percent (range 0% to 97%) of normal. Their letter CS was 0.58 Log CS (range 0.0 to 2.0), which is approximately a factor of 10 (1.0 log unit) below normal. The sample had normal cognitive function and levels of depression. They missed an average of 0.65 questions on the Short-Portable Cognitive Function test where the norm is one to two missed questions [13]. They scored a 5.76 on the Center for Epidemiological Studies depression scale where a score of 9 is the upper limit of normal symptoms [14]. Furthermore, the physical and mental health summary scales of the SF-12® fell within 1 to 2 points of the average for 65 to 74 year olds in the general U.S. population and had comparable variance [15]. At the initial interview, their physical health scale score was 44.35 (±10.82) and their mental health scale score was 49.54 (±11.71).

**Mobility Function**

**Situation Difficulty Ratings**

Listed in Table 1 are the average pre- and postrehabilitation scores for each of the 34 mobility situations. All but one of the 34 postrehabilitation ratings of difficulty moved in the direction of less difficulty compared to prerehabilitation levels. The probability of such an occurrence by chance is essentially nil (Sign Test, \( z = 5.326, p < 0.00003 \)). When prescore and postscore ratings for each situation were compared using the Wilcoxin Signed Ranks Test, significant differences \( p \leq 0.05 \) were found for 26 of the 34 situations (76%). These are denoted with an * in the column labeled “Difference.” At the 0.05 level of confidence and with 34 separate Wilcoxin tests, 1.75 of the significant differences could have occurred by chance. Even if this happened, difficulty ratings would still be significantly lower after rehabilitation for 70 percent of the situations assessed.

The largest changes in difficulty ratings were for using public transportation, avoiding tripping over uneven surfaces, seeing cars at intersections, and detecting descending and ascending stairwells. The largest decline was 0.73 points for using public transportation, an 18.25 percent change. The smallest changes were for moving about in a classroom, walking in familiar areas, moving about in the home, avoiding bumping into walls, and detecting shoulder-high obstacles. As illustrated in Figure 2, difficulty ratings prior to rehabilitation tended to cluster in the middle of the 5-point scale. After rehabilitation the distribution of scores shifts to the left in the direction of less difficulty with an average change across all situations of 0.37 (±0.17) points, which on the 1 to 5 scale is a 9.25 percent average change.

**Situation Confidence Ratings**

We added four questions to the original instrument to assess confidence traveling in four common situations. These included familiar and unfamiliar areas, in stores, and outdoors. The pre- and postrehabilitation scores for the four situations are illustrated in Figure 3. Subjects reported significantly increased confidence after rehabilitation for travel in unfamiliar areas, in stores, and outdoors (Wilcoxin \( p < 0.05 \)). The only item where confidence remained at prerhabilitation levels was for travel in familiar areas. It was also the area where subjects had the highest confidence before rehabilitation.
The difficulty scores for the four situations rating confidence can be obtained from Table 1. From Table 1 and Figure 3, we determined that both before and after rehabilitation, as difficulty scores increased so did the confidence scores. However, since the relationship between scores and difficulty or confidence levels go in opposite directions, higher perceived difficulty is associated with lower perceived confidence and vice versa. Since situation difficulty generally declined after rehabilitation while confidence levels increased, an obvious question is: What form does the relationship between the two take? Figure 4 illustrates where changes in difficulty and confidence are plotted for the four situations listed left to right in order of difficulty (the order of least to most difficult did not change after rehabilitation). For the two easiest tasks, travel in familiar areas and outdoors, the declines in difficulty after rehabilitation are matched by equal increases in confidence. For the two more
difficult tasks, the increases in confidence are greater than the declines in difficulty. Confidence increased for travel in unfamiliar environments twice as much as difficulty decreased.

Situation Difficulty Rankings

Table 1 also lists the pre- and postrehabilitation rankings of the 34 mobility situations in order from least to most difficult. As expected from the difficulty ratings where the magnitude of change varied among the situations, changes occur in the ordering from least to most difficult after rehabilitation. Situations that were easy or difficult prior to training tended to remain that way afterward. For example, comparing the six least and six most difficult tasks before and after rehabilitation shows that most tasks listed in either group before rehabilitation were listed in the same group after rehabilitation. For most situations, changes in rank were two to three positions up or down. However, several of the position shifts were quite large and predictably they were for the situations where difficulty ratings changed either the most or the least.

In the direction of less difficulty after rehabilitation, the largest shifts were for using public transportation, avoiding tripping over uneven surfaces, and detecting descending stairwells. The largest shifts in the direction of more difficulty were for moving about in classrooms, being aware of others, and walking in dimly lit areas. The large shifts in rank for these latter items occurred because the changes in difficulty associated with them were smaller than average. In other words, as the distribution of scores shifted downward by 0.37 units, these items were left behind because they changed less than average.

Additional Mobility Indicators

Results from questions in the second part of the questionnaire are summarized in Table 2. Most were “yes/no”
questions, with “yes” scored as 1.0 and “no” as 0. Scoring for questions that were not “yes/no” is obvious or indicated in the table.

Prior to rehabilitation, 45 percent of subjects reported having fallen in the past year and the number of falls for these individuals averaged six per person. At the same time, only 25 percent of subjects reported a fear of falling. The number of falls declined significantly after rehabilitation by approximately 50 percent, although there were no significant changes in the percentage of subjects who reported a fall or a fear of falling. The postrehabilitation data must be interpreted with caution since the two 1-year time periods over which subjects were asked to provide data overlapped by approximately 8 months. This occurred because the second assessment was taken approximately 4 months after the first. The 4-month interval represents 6 to 8 weeks in rehabilitation plus the 2-month wait before the postrehabilitation assessment.

Prior to rehabilitation, nearly three of every four subjects reported that they limited travel because of their vision loss. On the other hand, a surprisingly high percentage of subjects reported they were satisfied with their level of travel prior to rehabilitation. After rehabilitation fewer subjects limited their travel and more were satisfied with their abilities. Subjects also reported asking someone to travel with them most of the time and the majority indicated that their level of mobility was below that of persons with normal vision. There were no significant changes in these two variables after rehabilitation.

Twenty-nine percent of subjects reported having received prior training or rehabilitation, and this naturally increased to one hundred percent after the current rehabilitation episode. Nearly half of the subjects reported using a mobility aid before rehabilitation, and this figure almost about doubled after rehabilitation. Additional analysis (not shown) indicated that prior to rehabilitation, 40 percent and 23 percent of subjects reported using a long cane or a sighted companion and 16 percent used both. After rehabilitation the number of cane users approximately doubled to 78 percent, as did the number of sighted companion users, which rose to 42 percent. A 33 percent increase was reported in those who used both. Another type of aid most subjects used before and after rehabilitation were sunglasses (not counted as a mobility aid).

**DISCUSSION**

**Effect of Blind Rehabilitation and Orientation and Mobility Training on Perceived Difficulty in Different Situations**

We assessed subjects’ self-perceived functional mobility 2 months after they completed a blind rehabilitation program that included orientation and mobility training. We found that subjects rated their difficulty performing in a variety of mobility situations as significantly less after training. We take this as an indicator that training improves mobility function, and our results are consistent with several previous studies using more direct methods to assess mobility performance after rehabilitation [4,5].

<table>
<thead>
<tr>
<th>Question</th>
<th>% Yes Responses Prerehab</th>
<th>% Yes Responses Postrehab</th>
<th>Prepost Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you fallen in the past year?</td>
<td>45.0</td>
<td>37.0</td>
<td>−8.0</td>
</tr>
<tr>
<td>If yes, how many times have you fallen?</td>
<td>6.02</td>
<td>3.04</td>
<td>−2.98*</td>
</tr>
<tr>
<td>Have you had a fear of falling in the past year?</td>
<td>25.0</td>
<td>32.0</td>
<td>+7.0</td>
</tr>
<tr>
<td>Do you limit travel by yourself due to your vision loss?</td>
<td>73.0</td>
<td>63.0</td>
<td>−10.0*</td>
</tr>
<tr>
<td>Are you satisfied with your present level of travel?</td>
<td>63.0</td>
<td>73.0</td>
<td>+10.0*</td>
</tr>
<tr>
<td>How often do you ask someone to accompany you when you travel?</td>
<td>1.91</td>
<td>1.80</td>
<td>−0.11</td>
</tr>
<tr>
<td>0 = never to 3 = always</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you believe your travel abilities are less than those of people with</td>
<td>84.0</td>
<td>77.0</td>
<td>−7.0</td>
</tr>
<tr>
<td>normal vision?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have you ever had any training to help you move about?</td>
<td>29.0</td>
<td>1.0</td>
<td>+71*</td>
</tr>
<tr>
<td>Do you use a mobility aid (cane, dog, sighted guide, electronic device)?</td>
<td>48.0</td>
<td>83.0</td>
<td>+35*</td>
</tr>
<tr>
<td>Do you wear sunglasses/sunshades to control illumination?</td>
<td>79.0</td>
<td>89.0</td>
<td>+10*</td>
</tr>
</tbody>
</table>

*Statistically significant
In contrast, Soong et al. [6] recently reported no improvement in mobility performance after mobility training. They suspected their failure to find a significant change was related to their mobility measures and that they assessed performance immediately after training—before subjects had time to integrate and successfully apply newly learned skills to mobility problems. They suggested a delay between training and assessment might have yielded a different result and also that self-report or some other types of measures might provide better indicators of performance. Our findings lend support to these ideas.

We did not use a control group, so one could argue the effects we observed might not be due to training but to social interaction in the rehabilitation setting or to a property of the test, such as scores on a second administration were always higher. It seems that if either factor were involved the effects should be spread evenly across mobility situations. The difficulty level should decline by approximately the same amount for all tasks. However, this type of pattern was not found because changes ranged from 0 to 0.72 on a 4-point scale. Recent evidence suggests that a halo effect resulting from the rehabilitation process and the social interactions is dissipated 2 months after training [12].

An additional indicator that training affected performance is that some of the largest declines in difficulty occurred for situations in which subjects received instruction very specific for those situations. These include using public transportation and detecting elevation changes such as stairs, curbs, and uneven surfaces. For example, mobility instructors often use riding the bus during training because it provides convenient access to urban environments. Subjects are instructed how to do this on their own and are expected to perform the task independently. Similar training and exposure occurs for using taxis to reach destinations such as restaurants, malls, and movie theaters after training hours and on weekends. Detection of elevation changes is specifically addressed throughout mobility training. Subjects are informed about visual cues associated with stairs and also trained in how to use the long cane to detect and negotiate them. Conversely, situations where there is exposure during rehabilitation but not specific training—traveling in unfamiliar areas, adapting to lighting changes, and avoiding obstacles above the protection range of the long cane—generally showed less change.

Effect of Blind Rehabilitation and Orientation and Mobility Training on Other Mobility Indicators

One might expect that the level of confidence traveling in different situations would be inversely related to difficulty, and if difficulty declined as a result of training, confidence would increase. The results for the four travel situations containing both types of data are generally consistent with these expectations. The data suggest that the relationship between changes in confidence and situation difficulty is not linear (Figure 4). For the two easiest tasks, travel in familiar areas and outdoors, the declines in difficulty after rehabilitation are matched by equal increases in confidence. For the two more difficult tasks, the increases in confidence are greater than the declines in difficulty. For travel in unfamiliar environments, confidence increased twice as much as difficulty decreased. Although this is an interesting relationship and speaks well of the effects of the confidence training individuals received, it is based on sparse data. Additional comparisons are needed to determine if it is valid or not.

The data on falling prior to rehabilitation are consistent with results reported by Turano et al. [10]. Nearly half of their subjects (46 percent) and ours (45 percent) reported falling in the past year. Despite the large number reporting falls, only 25 percent of our sample reported a fear of falling, which is considerably less than the 46 percent found by Turano et al. This figure surprises us, since our sample would generally be considered more severely visually impaired. This could be related to the type of vision loss, which in Turano’s study was a peripheral field restriction owing to retinitis pigmentosa (RP), whereas most of our sample had macular disease. One must ask why fear would vary with type of loss, given that both samples had equivalent fall rates. Perhaps the answer lies in male/female differences. Our sample was composed almost exclusively of males (94%). Although we do not know the sex distribution in Turano’s sample it was most likely more closely equal than ours. If males are significantly less inclined to report fear than females it could explain why so many fallers in our sample seemed unperturbed by the event and the prospect of more in the future.

We also found that after rehabilitation, the percentage of subjects reporting a fall in the past year did not decline appreciably, nor did the number reporting a fear of falling change. On the other hand, the number of falls declined significantly, which indicates that the fallers fell less frequently after rehabilitation. As noted previously, the
postrehabilitation falls data must be interpreted with caution because the reporting time period overlapped significantly with the prerehabilitation period. To overcome this limitation, we are currently collecting data at longer intervals after rehabilitation.

The majority of subjects indicated their level of mobility function was below that of persons with normal vision and they reported limiting travel because of their vision loss—not a particularly surprising result. Despite these negative responses, nearly the same proportion reported satisfaction with their level of travel. This apparent contradiction might be explained because so many subjects had macular disease, which generally does not result in severe mobility limitations [16]. The persons with macular disease may have been relieved that their eye disease resulted in mobility limitations that were relatively minor compared to the more severe curbing of activity that depends on good spatial resolution, such as reading, watching television, and viewing sporting events.

CONCLUSION

There was significant improvement in self-reported mobility function for a group of visually impaired subjects 2 months after completion of a comprehensive blind rehabilitation program that included orientation and mobility training. Our results support anecdotal reports that mobility training is effective and they are consistent with several studies [4,5] that used direct assessment of mobility performance to reach the same conclusion.

REFERENCES
