Compensatory Strategy Use Identifies Risk of Incident Disability for the Visually Impaired

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**Background:** Use of compensatory strategies may be a marker for preclinical disability.

**Objective:** To determine, among persons who did not report mobility disability, if the reported use of compensatory strategies was a predictor of subsequent disability at 2 years in those who did and did not have visual impairment at baseline.

**Methods:** Within a population-based sample of 2520 persons aged 65 to 84 years, those who reported no difficulty walking or stair-climbing at baseline (not disabled) were studied. Visual impairment was defined as a visual acuity worse than 20/40, log contrast sensitivity less than 1.5, or more than 30 points missing in the visual field. Use of compensatory strategies at baseline was reported as changing the frequency or method used to walk or climb stairs. Incident disability was defined as report of new difficulty in mobility at 2 years.

**Results:** Those using compensatory strategies at baseline were 3 times more likely to report incident disability in walking and stair-climbing, compared with persons who did not use compensatory strategies. Visual field impairment was the most significant predictor of incident mobility disability of all the vision measures studied. Among those with visual field impairment, users of compensatory strategies were 3 times more likely to report incident walking disability (95% confidence interval, 1.87-5.58) and incident stair-climbing disability (95% confidence interval, 1.86-4.83) compared with those who did not use compensatory strategies.

**Conclusion:** Preclinical disability, characterized by use of compensatory strategies in those with no disability, is a predictor for subsequent disability and may help identify patients with visual impairment for whom mobility interventions are warranted.

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The impact of visual impairment on physical and psychological function has been the subject of intense inquiry during the past several years, with numerous questionnaires developed to ascertain decrements in functional domains associated with loss of vision. Most of the studies have been based on cross-sectional evaluations of persons with specific diseases or levels of visual loss, and their perceived level of difficulty performing various tasks or their perceived level of emotional or social dysfunction. Prospective studies primarily in patients with cataracts, have demonstrated the improvement in functional status in several domains with the restoration of sight following surgery. A few longitudinal studies of persons with specific ocular diseases have shown that with worsening of clinical disease over time, there is a concomitant decrement in functional status.

However, not all those with vision impairment, measured as acuity, contrast sensitivity, or visual field loss, report disability, and researchers have found that other variables, apart from vision status, are also predictive of scores. In particular, sex, comorbid conditions, education, and race are also predictive of self-reported function. Self-report of difficulty, or disability, is a composite of the importance placed by the participant on the task, the expectation of self-performance in doing the task, the use of compensatory strategies in performing the task, and the perception of current difficulty in performing the task. All of these factors are elements in assessing how difficult a task has become relative to one’s visual status, and can lead to different answers among individuals with the same degree of vision loss.

In geriatric research, the concept of preclinical disability is used to characterize those persons at high risk of developing difficulty in performing a task due to underlying disease or impairments. Those with preclinical disability may use compensatory strategies to function without the perception of disability, at least tem-
These strategies include using devices or changing the frequency or way in which a task is performed. The use of compensatory strategies is a marker for those at high risk of subsequent mobility disability.\(^1\) These considerations have led to one definition of preclinical disability as the use of compensatory strategies in the absence of perceived difficulty.\(^1\) This concept of preclinical disability has not been applied in vision research or investigated in persons with visual impairment. One can hypothesize that, among persons with visual impairment who report no disability in task performance, those who use compensatory strategies would be at greater risk of reporting new difficulties over time; alternatively, it is possible that the use of these strategies among persons with visual impairment delays the onset of disability. In either case, the use of compensatory strategies could be an important marker for onset (or delay) of disability in those with visual impairment.

To test these hypotheses, we used longitudinal data from the Salisbury Eye Evaluation Project, in which assessment of vision and self-report of difficulties doing various tasks has been performed over 2 rounds of data collection. We specifically focus on the outcome of incident disability in walking and climbing stairs (mobility) in those with visual impairment at baseline and contrast it in those without visual impairment.

### METHODS

#### POPULATION

This project was performed in the context of the Salisbury Eye Evaluation Project, a population-based study of 2920 residents of the community of Salisbury, Md, who were aged 65 to 84 years in July 1, 1993, when the study began. The selection of the sample, recruitment (64.5%), and the characteristics of the participants relative to the refusals have been described in detail in previous publications.\(^2\)\(^,\)\(^3\) There was no difference in the self-rating of vision among participants and refusals at baseline. Nonparticipants tended to be older and to have more difficulty performing tasks of daily living.\(^2\)\(^,\)\(^3\)

The population was reexamined at 2 years from baseline, with 94.4% of those still alive (n=2240) completing the follow-up visit. The reasons for no follow-up were death (n=147) and refusal or inability to locate a person (n=133).

For this study, the population at risk of incident disability was defined as those not reporting any disability at baseline in walking (n=2143) or stair-climbing (n=1610).

#### MEASURES OF VISION

Several vision tests were performed, and these have been described in detail in prior publications.\(^4\)\(^,\)\(^5\) In brief, acuity was measured using the Early Treatment of Diabetic Retinopathy Study charts following strict forced-choice testing procedures. Visual acuity with habitual correction was measured binocularly.\(^6\) Visual acuity was scored according to the number of letters read correctly and converted to logMAR units, according to the method recommended by Bailey et al.\(^7\) Visual acuity impairment at baseline was defined as acuity worse than 20/40, and progression of that impairment was defined as loss of more than 1 line between baseline and 2 years.

The visual field was tested for each eye using the 81-point single-intensity screening test strategy on a field analyzer (Humphrey Instruments, San Leandro, Calif). This strategy tests points in a 60° (radius) field with a single-target intensity of 24 dB. The binocular visual field was estimated from a composite of the left and right eye fields, using the more sensitive eye for a given visual field location.\(^8\) The number of points missed was calculated for the overall visual field, of a total of 96 points. In these analyses, more than 30 points missed in the binocular field at baseline was defined as impairment, and progression of impairment was defined as the loss of 10 or more points between baseline and 2 years.

Contrast sensitivity was measured with the Pelli-Robson letter sensitivity test.\(^9\) The test was administered under controlled room illumination (100 candela/m\(^2\)), and was scored as number of letters correct. A value of log contrast sensitivity worse than 1.5 in the better-seeing eye at baseline was defined as impairment, and progression of impairment was defined as more than 3 letters lost between baseline and 2 years. We have previously used a cutoff of worse than 1.35 to define impairment, but only 5 persons had this level of contrast sensitivity loss and reported no disability at baseline.

#### ASSESSMENT OF DISABILITY

The primary outcome was self-reported disability, in the realm of mobility (walking and stair-climbing) based on responses to the in-person interview. The questions were derived from those used in other geriatric assessment studies and have been described in detail in previous publications.\(^10\)\(^,\)\(^11\)\(^,\)\(^12\)

Basically, the questions ask for degree of difficulty in performing the stated task, with 5 possible responses ordered from “no difficulty” (not disabled) to having varying degrees of difficulty (disabled). At baseline, those who reported no difficulty in walking 1 block (45 m) are the subjects of the analyses for incident walking disability, and those who reported no difficulty climbing 10 stairs are the subjects for incident stair-climbing disability. Two years later at follow-up, those who reported having difficulty in the mobility tasks were defined as having incident disability.

#### ASSESSMENT OF COMPENSATORY STRATEGIES

For the mobility tasks (walking and stair-climbing), a series of questions was asked about altering the way in which the task was performed, by changing either the frequency with which the task is performed or the method used to perform the task (the latter question can include the use of devices, like canes or stair rails). These alterations constitute the use of compensatory strategies.\(^1\)\(^,\)\(^2\)\(^,\)\(^3\) Those who reported at baseline changing the frequency or the way in which they walked or climbed stairs were considered to be using compensatory strategies to perform the task.

#### OTHER VARIABLES

Age, race, and sex were assessed at baseline from the Medicare database, which was the source of the study population, and verified again by home questionnaire. Educational status was assessed on the home questionnaire. Comorbid conditions were assessed by the home questionnaire section on medical history and were validated by medical records. Fifteen self-reported conditions were validated using a set of algorithms that included medication use, clinical examination and laboratory test results, and review of medical records. Cognitive status was assessed using the Mini-Mental State Examination, with scores in this population ranging from 18 to 30, where lower scores indicate cognitive impairment.
Table 1. Baseline Characteristics of the Sample at Risk of Disability for Each Outcome

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No Walking Disability at Baseline (n = 2143)</th>
<th>No Stair-climbing Disability at Baseline (n = 1610)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>65-74</td>
<td>66.9</td>
<td>68.3</td>
</tr>
<tr>
<td>≥75</td>
<td>33.1</td>
<td>32.7</td>
</tr>
<tr>
<td>No. of comorbid conditions, mean</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>Mini-Mental State Examination score, mean</td>
<td>27.3</td>
<td>27.4</td>
</tr>
<tr>
<td>Visual acuity &lt;20/40</td>
<td>5.1</td>
<td>5.0</td>
</tr>
<tr>
<td>Log contrast &lt;1.5</td>
<td>19.2</td>
<td>18.2</td>
</tr>
<tr>
<td>&gt;30 Points missed on the visual field</td>
<td>28.1</td>
<td>25.5</td>
</tr>
<tr>
<td>Those using missed compensatory strategies</td>
<td>10.3</td>
<td>22.9</td>
</tr>
</tbody>
</table>

*Data are given as percentage of each group unless otherwise indicated.

STATISTICAL ANALYSES

The initial approach was to compare the rate of reporting incident disability in those with visual impairment at baseline between those who did and did not use compensatory strategies. This comparison is contrasted to the same comparison in the groups without visual impairment who did or did not use compensatory strategies. We then combined the groups to determine the role of baseline visual impairment itself, and the effect of using compensatory strategies, in predicting incident disability. Multiple logistic regression models predicting incident disability were created, with baseline vision status, progression of visual loss, age, sex, cognitive score, and number of comorbid conditions as predictors along with use of compensatory strategies at baseline. Interaction terms were included to explore if those with visual impairment had a different risk of disability associated with use of compensatory strategies compared with those without visual impairment. All protocols and procedures were reviewed and approved by The Johns Hopkins University Institutional Review Board, in accordance with the Declaration of Helsinki.

RESULTS

In the full Salisbury Eye Evaluation Project sample at baseline, the proportion who reported no disability in stair-climbing was lower than the proportion who reported no disability in walking (63.9% vs 85.0%). Table 1 shows the characteristics of the subgroups who are at risk of incident disability.

Among persons with visual impairment, those who reported use of compensatory strategies for either task were more likely to be older and to have more comorbid conditions compared with those who did not use compensatory strategies (Table 2). Those who reported using compensatory strategies for walking were also more likely to have lower Mini-Mental State Examination scores compared with those who did not report use. For stair-climbing, those reporting use of compensatory strategies were more likely women. A similar pattern was seen for those without visual impairment, although this group as a whole tended to be younger and white compared with the group with visual impairment.

Among those with visual impairment at baseline, whether in acuity, contrast sensitivity, or visual fields, the use of compensatory strategies identified those more likely to have incident disability in walking or stair-climbing. From one third to two thirds of those with visual impairment who reported use of compensatory strategies announced incident disability at 2 years. This was also true for those without visual impairment (Figure, A and B).

Compensatory strategy use may simply be a marker for the visually impaired whose vision declined during the interval. This was evaluated by comparing those whose visual impairment worsened with those whose visual impairment was stable (Table 3). Only 6 persons in this group at risk of incident disability had worsening visual acuity during the 2-year interval; therefore, progression could not be studied for this measure of visual impairment. Use of compensatory strategies was still a strong predictor of incident disability in the visually impaired group, regardless of whether they remained stable or progressed over 2 years. Results in the groups who progressed were not individually significant, likely because of small numbers, but were in the direction expected. Progression of visual loss did not seem to explain the association of use of compensatory strategies with incident disability.

Incident disability was modeled as a function of use of compensatory strategies and of impairment in each of the vision domains, to determine the measure of visual impairment most associated with disability. Only visual field impairment at baseline was independently associated with incident walking and stair-climbing disability, after adjustments for age, race, sex, number of comorbid conditions, and cognition (Table 4). The use of compensatory strategies was an independent predictor of incident walking disability and incident disability in stair-climbing. Within the groups of persons impaired according to each measure of visual impairment, the use of compensatory strategies was a significant predictor of incident disability. We show data for those with visual field impairment because it was the one vision measure independently associated with incident disability. Those using compensatory strategies at baseline were more likely to develop incident walking (odds ratio, 3.23; 95% confidence interval [CI], 1.87-5.58) or stair-climbing (odds ratio, 3.00; 95% CI, 1.86-4.83) disability compared with those not using compensatory strategies, after adjusting for age, sex, Mini-Mental State Examination score, and number of comorbid conditions.

For either walking or stair-climbing disability, there was no evidence of an interaction between use of compensatory strategies and visual impairment, suggesting that the predictive ability of use of compensatory strategies was similar whether the person was visually impaired or not (data not shown).

Persons could report use of compensatory strategies as changing the frequency of task performance or changing the method of doing the task. We postulated that persons who simply decreased the frequency may be more at risk of disability compared with those who altered the method of undertaking the task. The data suggest that either type of compensatory strategy is associated with
a greater risk of incident disability. However, those who change the frequency of walking (odds ratio, 5.80; 95% CI, 3.30-10.21) or stair-climbing (odds ratio, 3.23; 95% CI, 1.97-5.25) are at higher risk of incident disability than those who change the method of walking (odds ratio, 2.04; 95% CI, 1.24-3.37) or stair-climbing (odds ratio, 2.60; 95% CI, 1.86-3.62), after adjusting for impairments in acuity, contrast, and visual field, and progression of impairment, age, sex, comorbid conditions, and Mini-Mental State Examination score.

The use of compensatory strategies in those with visual impairment (and those without visual impairment) seems to identify a subgroup of persons at high risk of incident disability in mobility. The findings in the group without visual impairment are similar to those found by Fried et al17 in a population sample of 436 elderly women. They have also demonstrated validity for the preclinical disability state for mobility, because the group using compensatory strategies had markers such as knee extensor strength midway between those with disability and those without disability.15 We add to the validity by showing that those persons with preclinical disability are also more likely to have visual impairment.

To our knowledge, our findings are the first to support a preclinical disability state in persons with visual impairment who report no difficulties with mobility. The use of compensatory strategies, the marker for preclinical disability, clearly identifies a subgroup of persons with visual impairment at high risk of 2-year incident mobility disability. The increased risk was not explained by progression of visual loss or other confounders that have been identified as associated with mobility disability. In our population-based study of older persons, almost half of those with any visual impairment reported no disability climbing stairs and

### Table 2. Comparison of Baseline Characteristics of Those With Visual Impairment vs Those Without Visual Impairment, by Reported Use of Compensatory Strategies for Walking or Stair-climbing*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Visually Impaired Group</th>
<th>Not Visually Impaired Group</th>
<th>P Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Compensatory Strategies Not Used</td>
<td>Compensatory Strategies Used</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Walking‡</td>
<td>P Value†</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stair-climbing§</td>
<td>P Value†</td>
<td></td>
</tr>
<tr>
<td>Aged &gt;75 y</td>
<td>46.8</td>
<td>62.7</td>
<td>.002</td>
</tr>
<tr>
<td>Female sex</td>
<td>59.2</td>
<td>57.3</td>
<td>.62</td>
</tr>
<tr>
<td>Black race</td>
<td>33.2</td>
<td>39.1</td>
<td>.10</td>
</tr>
<tr>
<td>Mini-Mental State Examination score, mean</td>
<td>26.7</td>
<td>25.6</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>No. of comorbid conditions, mean</td>
<td>2.28</td>
<td>3.13</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td>44.4</td>
<td>58.0</td>
<td>.004</td>
</tr>
<tr>
<td>Female sex</td>
<td>51.4</td>
<td>62.0</td>
<td>.04</td>
</tr>
<tr>
<td>Black race</td>
<td>33.7</td>
<td>28.8</td>
<td>.73</td>
</tr>
<tr>
<td>Mini-Mental State Examination score, mean</td>
<td>26.8</td>
<td>26.3</td>
<td>.20</td>
</tr>
<tr>
<td>No. of comorbid conditions, mean</td>
<td>2.07</td>
<td>2.44</td>
<td>.003</td>
</tr>
</tbody>
</table>

*Data are given as percentage of each group unless otherwise indicated.
†Values are age adjusted for all characteristics except age.
‡In the visually impaired group, n = 669 for those in whom compensatory strategies were not used and n = 110 for those in whom compensatory strategies were used. In the not visually impaired group, n = 1253 for those in whom compensatory strategies were not used and n = 111 for those in whom compensatory strategies were used.
§In the visually impaired group, n = 383 for those in whom compensatory strategies were not used and n = 163 for those in whom compensatory strategies were used. In the not visually impaired group, n = 859 for those in whom compensatory strategies were not used and n = 205 for those in whom compensatory strategies were used.

### Figure

Two-year incidence rate of walking (A) and stair-climbing (B) disability by visual impairment status and use of compensatory strategies. All comparisons between use and no use of compensatory strategies within each visual impairment group were significant (P < .01).
among our 3 measures of visual impairment, the data suggested that visual field impairment was the most important measure of visual function in the prediction of incident mobility disability. Turano and colleagues26 have also found that visual field impairment is the most important marker of difficulties in mobility, measured using performance.27,28 In our study, use of compensatory strategies was a marker for those with visual field impairment at greater risk of subsequent disability compared with those who did not use compensatory strategies. We found no evidence for an interaction of use of compensatory strategies and visual impairment, suggesting that compensatory strategies as a marker behave similarly in those with and without visual field loss. Such data suggest that the strategies used by persons in this study are not compensating specifically for the difficulties caused by the visual loss, nor are the strategies enhancing the disabling effect of the visual loss.

The hypothesis that use of these strategies delays onset of disability was not supported by these data. Those who use compensatory strategies may have other, unknown, factors that predispose them to incident disability. The use of these strategies in this study is not at random, and other data suggest that those using compensatory strategies have physiologic findings midway between those disabled and those not disabled.13 Use of compensatory strategies in those already disabled may delay the progression of disability. We did not evaluate that outcome, and would need a longer follow-up to chart the course of those who were not disabled at baseline.

We are proposing that use of compensatory strategies in the visually impaired is a marker for incident disability. However, our data should not be used to suggest that avoiding compensatory strategies will protect against incident disabilities. We are proposing it as a marker for incident disability, and not a risk factor in the causal pathway. It may be likely that the use of such strategies changes the perception of those with visual impairment as to their level of disability, at least temporarily.

We, like others in the field of geriatrics, have chosen self-report of difficulty as a measure of disability. The test-retest reliability of self-report of difficulty has been reported elsewhere, and is good, with overall k values ranging from 0.74 to 0.86 depending on the task.29 In addition, the consistency of reporting during a 6-month period was also high and did not vary by starting level of reported disability.28 Such findings suggest good stability of our measure, and recent work15 demonstrates the clinical validity of self-report.

It could be argued that those who report use of compensatory strategies are by definition disabled because their impairment has led to an alteration in performance of daily tasks. Thus, use of compensatory strategies is merely part of the definition, and not a predictor. Clearly, this depends on one’s definition of disability and the intended use of that definition. In most gerontological literature, the patient’s perception of difficulty is used as the definition of disability, and most studies do not ascertain use of compensatory strategies to add to that definition. We believe that ascertaining the use of compensatory strategies has more utility as a marker of incipient disability. Among our visually impaired group that reports no difficulty in mobility, there is a pronounced difference in risk of changing the perception to incident disability according to use of compensatory strategies. In a clinical setting, ascertainment of changing the frequency or method of walking or stair-climbing would allow the opportunity for intervention before frank disability of a group at high risk.

### Table 3. Two-Year Incident Rate of Disability in Walking and Stair-climbing in Visually Impaired Subjects With and Without Progression of Visual Loss by Use of Compensatory Strategies

<table>
<thead>
<tr>
<th>Progression of Visual Impairment*</th>
<th>Use of Compensatory Strategies</th>
<th>Walking Disability</th>
<th>Stair-climbing Disability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>No progression</td>
<td>12.1 (.01)</td>
<td>31.8 (.08)</td>
<td>19.4 (.07)</td>
</tr>
<tr>
<td>Progression</td>
<td>3.09 (2.10-4.57)</td>
<td>2.76 (2.05-3.71)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Incident Walking Disability†</th>
<th>Incident Stair-climbing Disability†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual acuity impairment</td>
<td>1.50 (0.75-3.01)</td>
<td>1.59 (0.79-3.19)</td>
</tr>
<tr>
<td>Contrast sensitivity impairment</td>
<td>1.11 (0.71-1.71)</td>
<td>0.80 (0.53-1.28)</td>
</tr>
<tr>
<td>Visual field impairment</td>
<td>1.67 (1.15-2.44)</td>
<td>1.91 (1.36-2.68)</td>
</tr>
<tr>
<td>Use of compensatory strategies</td>
<td>3.09 (2.10-4.57)</td>
<td>2.76 (2.05-3.71)</td>
</tr>
</tbody>
</table>

Data are given as odds ratio (95% confidence interval).

†Data include adjustment for age, sex, race, Mini-Mental State Examination score, and number of comorbid conditions.

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It could also be argued that the group using compensatory strategies represents a subset of patients who were disabled, undertook compensatory strategies to remove the disability, and are at higher risk at subsequent time points but at least delayed the reemergence of the perception of disability. This scenario may exist, but we do not have sufficient time points in these analyses to test that assumption. It does not change the finding that use of compensatory strategies is still a marker for incident disability in those who do not report difficulty, regardless of their previous status.

We can only speculate on why those who report no disability also report using compensatory strategies at baseline. In the geriatric literature, compensatory strategy is a concept used to characterize a set of behaviors meant to reduce difficulty in task performance and maintain independence. From the subject’s perspective, these behaviors are undertaken to avoid disability. Therefore, subjects report no disability because they either have compensated and have no perception of disability or have not compensated and have no perception of disability.

We did not obtain detailed information on the type of compensatory strategy used, only on whether persons changed the frequency or the way in which they walked or stair-climbed. We found modest evidence for a difference in the strength of predicting subsequent disability between the 2 types of compensatory strategies, with those who were decreasing the frequency of the task more likely to develop incident disability. However, changing the method of walking or stair-climbing did not eliminate the risk of subsequent disability, because the risk was still more than 2-fold compared with no compensation.

In summary, our longitudinal data provide evidence that for patients with visual impairment, there is a condition of preclinical disability for mobility that can be characterized by use of compensatory strategies. Further interventions to delay the onset of disability could be targeted at this high-risk group, and deserve further study.

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