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Relationship between vision impairment and ability to perform activities of daily living

Sharon A. Haymes, Alan W. Johnston and Anthony D. Heyes

Department of Optometry and Vision Sciences, The University of Melbourne, Parkville, Victoria 3010, Australia

Abstract

Purpose: To determine the relationship between clinical measures of vision impairment and the ability to perform activities of daily living (ADLs).

Methods: One hundred and twenty subjects with low vision from a variety of causes participated in the study. Vision impairment was assessed under binocular conditions by measuring distance visual acuity, near word acuity, Melbourne Edge Test contrast sensitivity, Pelli–Robson Chart contrast sensitivity and visual fields. The ADL performance was assessed using the Melbourne Low Vision ADL Index (MLVAI), which is in part an observed performance assessment of instrumental ADLs and in part a self-report assessment of basic self-care ADLs.

Results: All vision measures had a high, statistically significant correlation with MLVAI total score. Near word acuity, had the strongest correlation ($r_s = -0.86$, $p < 0.001$), followed by Melbourne Edge Test contrast sensitivity ($r_s = 0.80$, $p < 0.001$). Visual field had the weakest correlation ($r_s = 0.56$, $p < 0.001$). Together, age, near word acuity, Melbourne Edge Test contrast sensitivity and visual field accounted for 82.2% (adjusted R^2, $p < 0.001$) of the variance in MLVAI total score. All correlations obtained were higher for the observed performance assessment of instrumental ADLs than for the self-report assessment of basic self-care ADLs.

Conclusions: Clinical vision impairment measures are highly correlated with capacity to perform ADLs, as measured by the MLVAI.

Keywords: activities of daily living, disability, functional assessment, low vision.

Introduction

Vision impairment, or low vision, has a considerable impact on a person's ability to function in daily life and, therefore, is a significant cause of disability. However, little is understood about the precise relationship between vision impairment, as measured by clinical tests such as visual acuity, and the resulting disability in activities of daily living (ADLs).

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Correspondence and reprint requests to: Dr Sharon A. Haymes. Tel.: +61 3 9349 7419; fax: +61 3 9349 7498.
E-mail address: s.haymes@optometry.unimelb.edu.au

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Until recently there had been few investigations on the relationship between vision measures and performance of ADLs (Elliott *et al*., 1990; Ross *et al*., 1991; Mangione *et al*., 1992; Vlahakis, 1993; Steinberg *et al*., 1994; Turco *et al*., 1994). These investigations yielded variable results. During the past 5 years, many more studies have been undertaken that have contributed to the scientific understanding of how vision measures relate to performance of ADLs (Parrish *et al*., 1997; Szlyk *et al*., 1997, 2001; Boisjoly *et al*., 1998; Carta *et al*., 1998; Mangione *et al*., 1999, 2001; Cole *et al*., 2000; Hazel *et al*., 2000; McClure *et al*., 2000; Wolffsohn and Cochrane, 2000; Klein *et al*., 2001). However, the results remain variable. Part of the reason for this is that there is no consensus on which activities comprise the relevant ADLs, nor is there any consensus on how to measure a person's performance of ADLs. Furthermore, such activities are intertwined with medical, psychological and social well-being, which makes independent measurement exceedingly difficult (Kane and Kane, 1981). Often performance of ADLs forms part of 'quality of life' assessment. Although some measures have been developed (Newman and Houser, 1991; Ross *et al*., 1991; Mangione *et al*., 1992, 1998, 2001; Long, 1993; Vlahakis 1993; Scott *et al*., 1994; Steinberg *et al*., 1994; Turco *et al*., 1994; Szlyk *et al*., 1997; Carta *et al*., 1998; Pesudovs and Coster, 1998; Hart *et al*., 1999; Hassell *et al*., 2000; Wolffsohn and Cochrane, 2000), not one has yet gained acceptance in low vision rehabilitation. This may be because many have unknown psychometric properties and because many were developed for specific groups.

Some studies in this area have shown a strong correlation between clinical measures of vision impairment and performance of *specific* ADLs such as face recognition (Bullimore *et al*., 1991) and reading (Legge *et al*., 1985; Leat and Woo, 1997) [more correctly known as *instrumental* ADLs (Kane and Kane, 1981), as distinct from the basic self-care ADLs, such as eating and dressing]. Also, several studies have shown a strong correlation between clinical vision measures and mobility performance (Marron and Bailey, 1982; Brown *et al*., 1986; Lovie-Kitchin *et al*., 1990; Haymes *et al*., 1996; Black *et al*., 1997; Geruschat *et al*., 1998; Kuyk *et al*., 1998; Turano *et al*., 1999). However, most of the research on vision impairment and more global performance of basic and instrumental ADLs indicates that the usual vision measures, such as visual acuity, contrast sensitivity and visual fields, are poor predictors of overall disability. With the exception of one study (Hazel *et al*., 2000), the correlation coefficients obtained have been low to moderate ($r = 0.30$–0.64) and vision measures have explained no more than 35–59% of the variance in ADL performance. Therefore, an important question follows: is the unexplained variance, of which there is a considerable amount, caused by the problems with the methods used to study the relationship between vision impairment and ADL performance, or are there other factors involved?

Indeed, some studies indicate that part of the variance in performance of ADLs is explained by demographic variables (Vlahakis, 1993; Steinberg *et al*., 1994; Turco *et al*., 1994; Klein *et al*., 2001), the most significant of which seems to be age (Vlahakis, 1993; Klein *et al*., 2001). This is reasonable given that many vision disorders are age-related and there is well known functional decline with age (Orr, 1992). Nevertheless, incorporating these variables has explained only a small proportion of the variance. Some have speculated that other factors such as personality traits, motivation, confidence and social support may explain a substantial proportion of the variance in performance of ADLs (Szlyk *et al*., 1990; Rosenbloom, 1992; Davis *et al*., 1995). However, with the exception of Beggs (1991), the scientific evidence is limited and suggests only a weak correlation, if any (Clark-Carter *et al*., 1986; Davis *et al*., 1995; Haymes *et al*., 1996).

Although the low correlations obtained in ADL performance studies in part may have been because other factors are involved, it is also possible that it may have been because of the use of inappropriate vision and ADL measures. For instance, some studies on mobility have found that vision measures are poor predictors of performance (Clark-Carter *et al*., 1986; Dodds and Davis, 1989; Long *et al*., 1990). However, unlike studies on ADL performance, several studies on mobility have shown a strong correlation between certain vision measures and performance (Marron and Bailey, 1982; Brown *et al*., 1986; Lovie-Kitchin *et al*., 1990; Haymes *et al*., 1996; Black *et al*., 1997; Geruschat *et al*., 1998; Turano *et al*., 1999). We suggest that the strong correlations obtained in some studies were the result of using valid vision measures and in particular, valid and reliable measures of mobility performance. This remains to be demonstrated in research on ADL performance.

Thus, the aim of this study was to further investigate the relationship between vision impairment and performance of ADLs using measures with tested psychometric properties. For this purpose, a new ADL instrument with high validity and reliability was developed and used: the Melbourne Low Vision ADL Index (MLVAI). It is described in detail elsewhere (Haymes *et al*., 2001).

Methods

Subjects

One hundred and twenty vision impaired adult subjects were recruited from several sources: the Vision Australia Foundation Kooyong Low Vision Clinic, the Macular Vision Loss Support Society of Australia and Retina Australia. The criteria for inclusion were: any type of ocular pathology, stable vision impairment (self-report of no deterioration in vision over the previous 12 months) and ability to speak and read English. Subjects were excluded if they had total blindness, cognitive impairment, physical impairment or hearing impairment such that they were not able to manage a simple conversation in a quiet room. The records of patients recently attending the Low Vision Clinic were screened with regard to the eligibility criteria. If a patient met the criteria, they were sent a letter of invitation to participate in the study. Members of the two support groups were recruited by placing an advertisement in newsletters. Eligibility criteria were determined during an initial interview that included general medical history.

The study was conducted in accordance with the tenets of the Declaration of Helsinki. Informed consent to participate was obtained from all subjects and the research was approved by the University of Melbourne Human Research Ethics Committee.

Demographics

The following demographics were recorded: age, gender, ocular pathology, duration of ocular disorder in years, living arrangement (categorised as either alone or not alone), education (ranked according to primary, secondary incomplete, secondary complete, vocational diploma, tertiary under-graduate degree, tertiary postgraduate diploma or degree), and occupation (ranked according to the Australian Bureau of Statistics, 1994).

Vision impairment measures

All vision measures were recorded under binocular conditions. Subjects were tested wearing their habitual refractive correction for the appropriate distance.

Visual acuity was measured using the Bailey–Lovie distance visual acuity chart (Bailey and Lovie, 1976) and the Bailey–Lovie near word acuity chart (Bailey and Lovie, 1980). Distance visual acuity was recorded at 2.4 m and scored according to the per-letter method, as this finer grading scale has been shown to be more reliable than the line method (Arditi and Cagenello, 1993). If the subject was unable to read the top row of letters at this distance, the chart was positioned at 1.2 m. Near word acuity was recorded at 25 cm and scored using the line method, that is, near visual acuity was recorded as the lowest line on which the subject identified more than half the words correctly.

Peak contrast sensitivity was measured using the Pelli–Robson Chart (Pelli *et al.*, 1988) and the Melbourne Edge Test (Verbaken and Johnston, 1986). Although both tests provide some measure of peak contrast sensitivity, the former uses a letter recognition task that is arguably more difficult than the edge detection task in the latter test. The intention was to determine if there was a difference in the predictive value of these tests for ADL performance. The Pelli–Robson Chart was administered at 1 m with a background luminance of 100 Cd m^{-2}. The subject was required to read triplets of letters that decrease in contrast, in logarithmic steps. Peak contrast sensitivity was recorded using the per-letter method and by counting as correct a call of 'C' for 'O' or a call of 'O' for 'C' (Elliott *et al.*, 1991). The Melbourne Edge Test was administered at 25 cm with a background luminance of 50 Cd m^{-2}. The subject was required to identify the orientation of edges that decreased in contrast, in logarithmic steps, until they made two successive errors. Contrast sensitivity was recorded as the last correctly identified edge, in decibels.

The binocular visual field of each subject was assessed using a Goldmann perimeter, which is an accepted method in low vision clinics (International Society for Low Vision Research and Rehabilitation, 1999). The main advantage over current automated perimeters is that the examination time can be controlled, thereby reducing the effect of fatigue and increasing the reliability of the results. A large, bright target was used: the III-4e target recommended in the *Guide to the Administration of the Social Security Act* (1991) for determining Australian legal blindness by the visual field criterion.

Although the Goldmann perimeter is effective for assessing the peripheral visual field, it is not as effective for assessing the central visual field. Therefore, the Goldmann full visual field assessment was supplemented with the Bjerrum tangent screen assessment of the central 30° visual field. To assess the binocular central visual field, the subject was seated at 1 m from a wall-mounted Bjerrum tangent screen in a well-illuminated examination room (240 lux). To assist subjects with a dense central scotoma to maintain central fixation, a cross made from white cord was placed over the central fixation point (Bailey, 1978). The target used was matt white and 3 mm in diameter. For both visual field assessments, the target was presented to the subject along each 15° meridian.

The 'Anatomical Total Visual Field Score' (*Figure 1*) was used for scoring the visual field (Haymes *et al.*, 1996). Although many other methods have been devised for scoring the visual field (e.g. Esterman, 1982; Marron and Bailey, 1982; Arditi, 1988; Ball *et al.*, 1990; Long *et al.*, 1990; Lovie-Kitchin *et al.*, 1990; Colenbrander *et al.*, 1992; Szlyk *et al.*, 1997; Carta *et al.*, 1998; Geruschat *et al.*, 1998; Kuyk *et al.*, 1998), there is no accepted method. Furthermore, our previous research showed that many of these methods had a lower correlation with mobility performance than the 'Anatomical Total Visual Field Score' (Haymes *et al.*, 1996). In this study, we have attempted to improve our previous scoring method by using finer gradations.

Measurement of ADL performance

The MLVAI (Haymes *et al.*, 2001) is a desk-based clinical assessment of ADL performance with demonstrated validity and high reliability (Cronbach's α coefficient of internal reliability = 0.96, intraclass correlation coefficient of reliability = 0.95). It comprises 25 standardised items in two parts: part (a) 16 observed items on instrumental ADLs (for example, reading newsprint and recognising faces) and part (b) nine

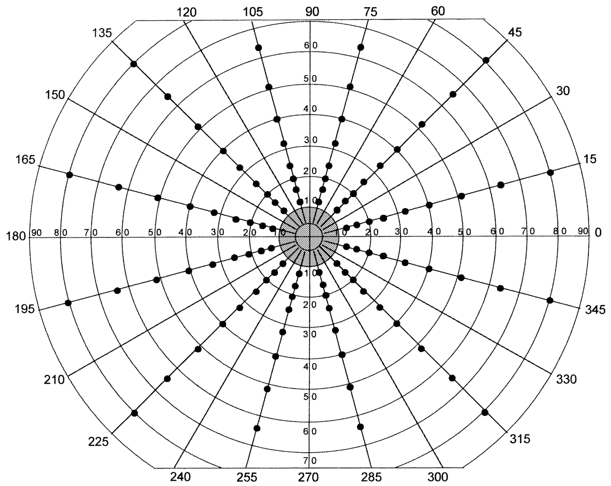

Figure 1. The 'Anatomical Visual Field Score'. The visual field was divided into two parts: the central area, from fixation to an eccentricity of 10° and the peripheral area beyond an eccentricity of 10°. This was based on retinal anatomy (Wyszecki and Stiles, 1982) and the representation of the visual field in the primary visual cortex. Fifty per cent of scoring points were allocated to the central visual field and 50% to the peripheral visual field, as the central 10° projects to approximately 50% of the primary visual cortex in primates (Mason and Kandel, 1991). As the density of retinal ganglion cells decreases logarithmically with eccentricity and is directly proportional to the area of visual cortex per degree of visual field (Rovamo and Virsu, 1979; Wässle *et al.*, 1990), points were allocated along each meridian at eccentricities that followed a logarithmic progression. In the peripheral visual field, there are nine points along each meridian at eccentricities of 80, 64, 51, 40, 32, 25, 20, 16 and 12°; except for the four meridians closest to the vertical where there is no point at an eccentricity of 80°. The points seen in the peripheral visual field are tallied and added to the points seen in the central visual field, which is shaded for clarity in this figure. Within the central 10° there are nine points along each meridian at eccentricities of 10, 8, 6, 5, 4, 3, 2.5, 2 and 1.5°. The 'Anatomical Visual Field Score' is scored out of a possible 212 points.

questionnaire items on basic self-care ADLs (for example, preparing meals and grooming). A questionnaire format was used for the items on basic ADLs for practical reasons only. During the development of the measure, every effort was made to keep part (b) as objective as possible and consistent with part (a), by using the same scale for each and the same adjectives to describe each rating level. In part (a) the test administrator is required to observe the subject's performance and assign a rating based on ability, independence, efficiency and speed of performance. In part (b) the subject is asked to report and rate their performance of basic ADLs using the same specific criteria. This differs from other self-report low vision questionnaires in that other questionnaires require subjects to rate the level of difficulty involved in performing a task, the degree of the problem or feelings about vision loss. Each item of the MLVAI is rated on a five-level descriptive scale from 0 to 4. The total score is derived by summing the rating for each item. Thus, the maximum possible total score is 100. The MLVAI takes approximately 20 min and can be viewed at http://www.optometry.unimelb.edu.au/dept/99research/SAHLV/SAHLV.html.

Standardised instructions were given for every MLVAI item. All of the observed items were performed at 25 cm using habitual spectacles, except for recognising faces and telling the time using a wall clock, which are performed at 1 m. The use of low vision devices was not allowed. This was performed to determine disability as defined by the World Health Organization (1980): the subject's lack of ability to perform the activity *in the manner considered normal for human being*. The test was administered under standard illumination conditions of 240 lux, as recommended in the Australian Standard (1990) for moderately difficult indoor tasks.

Procedure

Testing took place in an ophthalmic consulting room at the Kooyong Low Vision Clinic. The clinical vision measures and MLVAI were administered over two sessions. Distance visual acuity was measured during both sessions to ensure there had been no sudden vision loss. The median duration between the two sessions was 2 weeks, with the interquartile range being between 1.5 and 3 weeks.

Analysis

The data were double entered into a Microsoft Excel spreadsheet (Microsoft Corportation, Seattle, WA, USA, version 6.0) and analysed using Minitab® for Windows (Minitab Inc., State College, PA, USA, version 12.0) statistical software. The data collected were used to determine the correlation between the vision impairment measures and the MLVAI. Non-parametric Spearman correlation coefficients are reported, as the distribution of several of the variables measured was not strictly Normal and the MLVAI scale was ordinal. To develop a predictive model of vision disability, the data set was analysed using multiple regression analysis.

Results

The 120 vision impaired subjects recruited for the main study were aged between 20 and 89 years and 74 were female. The mean age was 70 (S.D. 16) years. The majority of subjects, 79 out of 120, lived with another person and were significantly younger than those who lived alone (unpaired *t*-test: mean difference = 11 years, $t_{0.975} = 4.25$, df = 117, $p < 0.001$). Half of the subjects, had a vocational diploma or tertiary degree and 54 subjects were in the highest two categories of the

Table 1. Causes of vision impairment*

Primary cause of vision impairment	No. of subjects (%)
Age-related macular degeneration (AMD)	68 (57)
Retinitis pigmentosa/retinal dystrophy	15 (12.5)
Macular dystrophy	9 (7.5)
Optic atrophy	6 (5)
Diabetic retinopathy	4 (3)
Glaucoma	3 (2.5)
Myopic degeneration	3 (2.5)
Retinal vein occlusion	2 (1.5)
Congenital cataract	2 (1.5)
Other diagnoses (e.g. albinism, cataract, congenital nystagmus, keratoconus)	8 (7)

*Note that 16 of the 120 subjects had secondary diagnoses.

Australian Standard Classification of Occupations (Australian Bureau of Statistics, 1994), i.e. they were current or retired 'managers' or 'professionals'.

The causes of vision impairment are given in *Table 1*. The means and standard deviations of the clinical vision measures and the MLVAI score are given in *Table 2*. In addition to summing the ratings for each test item, which is an ordinal level of measurement, we calculated a person vision ability score from the MLVAI using item response theory, specifically Rasch analysis (BIGSTEPS: MESA Press, Chicago, IL, USA, version 2.82). The person vision ability score, in 'logits' (logarithm of the odds ratio), is an interval level of measurement. A detailed description of item response theory is given by Hambleton *et al*. (1991), and Massof (1998) provides a description of the specific application of Rasch analysis to a vision disability measure. The mean and range of the person vision ability score for the MLVAI is given at the bottom of *Table 2*. A positive ability logit indicates higher ability and a negative ability logit indicates less ability.

Relationship between demographics, vision measures and Melbourne Low Vision ADL Index

A two-tailed Mann–Whitney test was used to analyse the relationship between the discrete demographic variables (gender and living arrangement) and MLVAI total score. There was no statistically significant difference in MLVAI total score between females and males (difference between median scores = −2.0, W statistic = 4411.5, $p = 0.73$ adjusted for ties), nor between those who did not live alone and those who did live alone (difference between median scores = 4.0, W statistic = 4956.0, $p = 0.33$ adjusted for ties).

The relationships between the continuous demographics, vision measures and the MLVAI were determined by examining plots of the data and the correlation coefficients. Years of vision impairment were not correlated with MLVAI. The strongest correlation coefficients are given in *Table 3*. Given the multiple correlations performed, a Bonferroni adjustment would result in a significant p-value of 0.00032 rather than 0.05. This is an overly stringent value (Browner and Newman, 1987) and instead it should be noted that approximately 8 (168×0.05) of the 'significant' correlations may have been because of chance at the 5% level.

Age was the only demographic variable with a statistically significant correlation with the total MLVAI score ($r_s = 0.39$, $p < 0.001$), whereas all of the vision measures had a moderate to high and statistically significant correlation with MLVAI total score ($r_s = 0.56$ to -0.86, $p < 0.001$). The highest correlation coefficient obtained was for near word acuity ($r_s = -0.86$, $p < 0.001$). Plots of the clinical vision measures that correlated most highly with MLVAI total score are shown in *Figure 2*. Vision measures were better correlated with part (a) scores (observed instrumental ADL items) than with part (b) scores (question items on basic

Table 2. Distribution of clinical vision impairment measures and Melbourne Low Vision ADL Index (MLVAI) Score

Vision measure	Mean	S.D.	Range
Distance visual acuity (log MAR)	0.92 (6/48-1) (20/160)	0.47	0.02–1.84 (6/6-1–6/300-2) (20/20–20/1000)
Near word acuity (log MAR)	1.1 (N24 at 25 cm) (3.2 M)	0.5	0.3–2.2 (N4–N320 at 25 cm) (0.5–40 M)
Melbourne Edge Test (dB)	11.6	4.4	3.0–20.0
Pelli–Robson Chart (log CS)	1.02	0.43	0.00–1.85
Anatomical Total Visual Field Score (score out of 212)	130.3	49.6	12.0–208.0
MLVAI total score (out of 100)	64.4	19.3	26.0–100.0
MLVAI part (a) score (out of 64)	36.3	15.9	7.0–64.0
MLVAI part (b) score (out of 36)	28.1	4.2	17.0–36.0
MLVAI person vision ability total score (logits)	0.99	1.68	−1.48–6.62
MLVAI person vision ability part (a) score (logits)	0.58	2.05	−2.69–6.25
MLVAI person vision ability part (b) score (logits)	3.03	1.96	−0.52–7.34

Table 3. Spearman correlation coefficients for clinical vision impairment measures and Melbourne Low Vision ADL Index*

Melbourne Low Vision ADL Index		r_s					
Item no.	**Item description**	**Age**	**Distance visual acuity**	**Near word acuity**	**Melbourne Edge Test**	**Pelli–Robson Chart**	**Anatomical Total Visual Field Score**
Total score		−0.39	−0.78	−0.86	0.80	0.69	0.56
a2	Cheque	−0.30	−0.63	−0.72	0.67	0.61	0.43
a3	Accounting	−0.39	−0.77	−0.83	0.75	0.63	0.44
a4	Wrist watch	−0.27	−0.73	−0.76	0.64	0.53	0.40
a5	Telephone	−0.47	−0.50	−0.57	0.56	0.44	0.33
a6	Telephone book	−0.23	−0.70	−0.75	0.64	0.51	0.40
a7	Newspaper print	−0.19	−0.76	−0.79	0.61	0.54	0.42
a8	Medicine label	−0.20	−0.76	−0.81	0.69	0.57	0.41
a9	Digital clock	−0.35	−0.46	−0.55	0.54	0.47	0.39
a10	Face recognition	−0.18	−0.61	−0.68	0.67	0.64	0.51
a11	Typed letter	−0.28	−0.78	−0.87	0.71	0.64	0.48
a12	Needle threading	−0.28	−0.60	−0.73	0.61	0.55	0.40
a13	News headlines	−0.31	−0.62	−0.72	0.62	0.54	0.47
a14	Pouring	−0.25	−0.54	−0.57	0.60	0.56	0.39
a15	Wall clock	−0.21	−0.60	−0.64	0.56	0.62	0.43
a16	Packet labels	−0.38	−0.73	−0.76	0.69	0.64	0.45
a17	Coin identification	−0.49	−0.57	−0.59	0.63	0.54	0.42
Part (a)	Observed items	−0.38	−0.81	−0.90	0.80	0.71	0.53
b1	Shopping	−0.25	−0.58	−0.61	0.61	0.52	0.46
b2	Meal preparation	−0.33	−0.38	−0.48	0.50	0.36	0.30
b3	Housework	−0.36	−0.36	−0.34	0.39	0.29	0.40
b4	Medication	−0.18†	−0.38	−0.44	0.47	0.35	0.31
b5	Eating	−0.22	−0.29	−0.42	0.49	0.41	0.35
b6	Dressing	−0.14†	−0.18	−0.28	0.34	0.27	0.33
b7	Grooming	−0.13†	−0.14†	−0.23	0.19	0.20	0.21
b8	Mobility	−0.01†	−0.36	−0.37	0.45	0.43	0.54
b9	Bathing	−0.37	−0.16†	−0.19	0.20	0.17†	0.18†
Part (b)	Question items	−0.33	−0.47	−0.55	0.59	0.49	0.49

*Except for those marked with †, all correlation coefficients were $p < 0.05$.

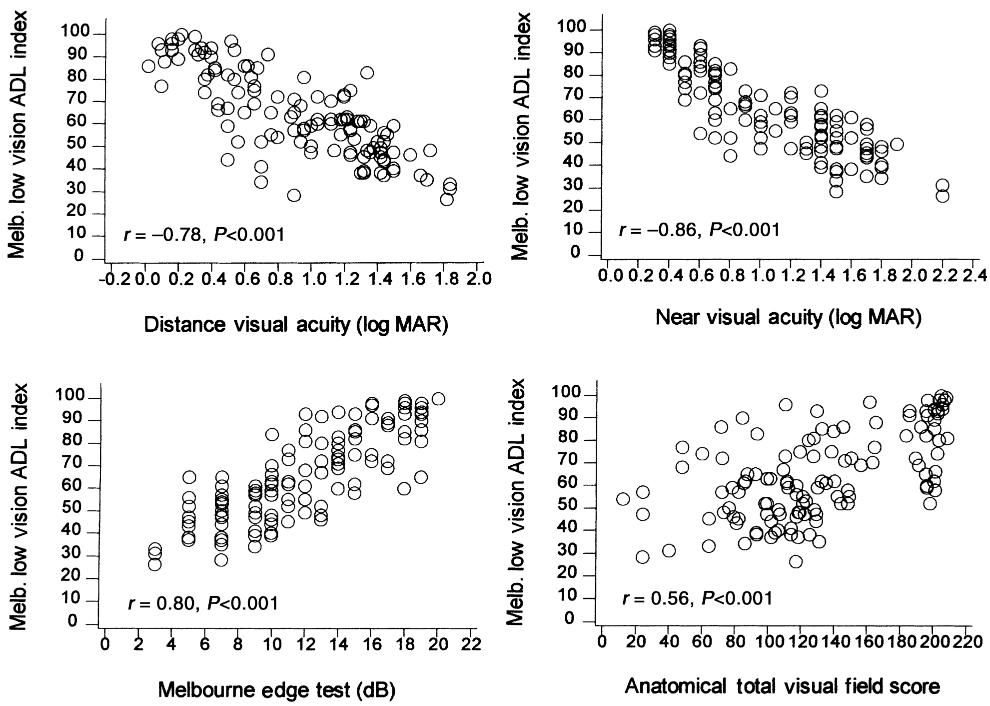

Figure 2. Plots of the relationship between four clinical measures of vision impairment and Melbourne Low Vision ADL Index total score.

ADLs). The correlation coefficients for part (a) scores ranged from $r_s = 0.53$ to -0.90 ($p < 0.001$), whereas for part (b) scores they ranged from $r_s = -0.47$ to 0.59 ($p < 0.001$). For part (a), the highest correlation coefficient obtained was for near visual acuity. For part (b), the highest correlation coefficient obtained was for Melbourne Edge Test contrast sensitivity. All correlation coefficients obtained using the MLVAI person vision ability score were comparable with those reported using the MLVAI raw score.

Regression analysis

The independent variables age, distance visual acuity, near word acuity, Melbourne Edge Test contrast sensitivity, Pelli–Robson contrast sensitivity and the Anatomical Total Visual Field Score were entered into the regression analysis to predict the total MLVAI score. Best subsets regression analysis was first used to select the best model for further analysis. The best model for predicting total MLVAI incorporated the variables age, distance visual acuity, near word acuity, Melbourne Edge Test contrast and the Anatomical Total Visual Field Score (adjusted R^2 82.3). However, the model with the same independent variables, except for distance visual acuity, was almost identical (adjusted R^2 82.2), and more convenient from a clinical perspective because it incorporated one less variable. A similar adjusted R^2 value of 74.7 was obtained using the person vision ability score. Thus, the latter predictive model incorporating age, near word acuity, Melbourne Edge Test contrast and the Anatomical Visual Field was analysed in greater detail.

Using standard multiple regression, the regression equation was:

$$\text{MLVAI total score} = 74.1 - 0.1\ (\text{age}) - 22.2\ (\text{NVA}) + 1.0\ (\text{MET}) + 0.1\ (\text{VF}),$$

where the MLVAI is the Melbourne Low Vision ADL Index raw total score, age (years), NVA is near word acuity (logMAR), MET is Melbourne Edge Test score (dB), and VF is the Anatomical Total Visual Field Score. The results of the regression analysis for this model are given in *Table 4*.

The coefficients in the regression equation were significantly different from 0.0 ($p \leq 0.02$) and the variance inflation factor for each predictor variable was favourably low. Plots of the residuals were favourable, showing a Normal distribution (Ryan–Joiner test $r = 0.99$, $p < 0.05$), linearity and homoscedasticity, that is, the variability of the residuals was approximately the same at all predicted values. However, there was one subject who did not fit the model well (standardised residual > 3 S.D. from the mean), for reasons that are not clear. Eliminating the data for this subject produced an adjusted R^2 of 84.6 for the predictive model with age, near word acuity, Melbourne Edge Test and Anatomical Total Visual Field Score.

As the correlation coefficients obtained for MLVAI part (a) score were higher than those obtained for part

Table 4. Results of regression analyses

Predictor	Coefficient	S.D.	*t*-Statistic	*p*
MLVAI total score				
Constant	74.1	6.5	11.3	<0.01
Age	−0.1	0.1	−2.5	0.02
Near word acuity	−22.2	2.3	−9.6	<0.01
Melbourne Edge Test	1.0	0.3	3.6	<0.01
Anatomical Total Visual Field score	0.1	0.0	4.4	<0.01
$S = 8.1$	$R^2 = 82.8\%$		Adjusted $R^2 = 82.2\%$	
MLVAI part (a) score				
Constant	42.9	4.2	10.2	<0.01
Near word acuity	−20.9	1.8	−11.5	<0.01
Melbourne Edge Test	0.9	0.2	4.04	<0.01
Anatomical Total Visual Field Score	0.04	0.01	2.9	<0.01
$S = 6.4$	$R^2 = 83.9\%$		Adjusted $R^2 = 83.5\%$	
MLVAI part (b) score				
Constant	23.6	1.9	12.0	<0.01
Age	−0.06	0.02	−2.7	<0.01
Melbourne Edge Test	0.4	0.1	3.9	<0.01
Anatomical Total Visual Field score	0.03	0.0	4.4	<0.01
$S = 3.5$	$R^2 = 46.1\%$		Adjusted $R^2 = 44.7\%$	

(b) score (*Table 3*), additional regression analyses were performed to determine the best predictors of MLVAI part (a) score and part (b) score separately (*Table 4*). The best model for predicting MLVAI part (a) score incorporated the variables near word acuity, Melbourne Edge Test contrast and the Anatomical Total Visual Field Score (adjusted R^2 83.5). The best model for predicting MLVAI part (b) score incorporated the variables age, Melbourne Edge Test contrast and the Anatomical Total Visual Field Score (adjusted R^2 44.7). Similar adjusted R^2 values were obtained for these models using the person vision ability measure for part (a) and for part (b), rather than the raw score (adjusted R^2 77.3 and 44.5, respectively).

Discussion

Although the sample included a high proportion of subjects with age-related macular degeneration (AMD), which is characteristic of the low vision population in economically developed western countries, the proportions of other ocular diseases were not accurately represented in this sample. The proportions of subjects with retinitis pigmentosa and macular dystrophy were over-represented, whereas the proportions of subjects with diabetic retinopathy and glaucoma were under-represented (Wolffsohn and Cochrane, 1999).

With regard to combined performance of instrumental and basic ADLs, age was the only demographic variable with a statistically significant correlation, albeit low to moderate, whereas all of the vision measures (visual acuity, contrast sensitivity and visual field score) had a moderate to high and statistically significant correlation with the MLVAI total score. The clinical vision measures with the best correlation were near word acuity and Melbourne Edge Test contrast sensitivity. In general, visual acuity and contrast sensitivity measures were better correlated with items on the MLVAI than were visual field measures. The only exception was for the mobility item, where the correlation with visual field was higher. Our findings on the correlation between vision impairment and performance of activities of daily living, compared with those of other studies are summarised in *Table 5*.

With regard to the performance of part (a) observed instrumental ADLs compared with part (b) questionnaire items on basic ADLs, our results show a clear difference in the correlation of these two types of activities with vision measures. To a certain extent this might be because of the difference in method of assessment (observation vs questionnaire). It may also be the result of the visual complexity of the items. Clinical vision measures had a higher correlation with performance of complex instrumental ADL items such as, reading, writing and using the telephone, than with basic ADL items such as, eating and dressing. For part (a) observed instrumental ADL items, the best single correlate was near word acuity whereas for part (b) questionnaire items on basic ADLs the best single correlate was Melbourne Edge Test contrast sensitivity.

The correlation between age and ADL performance obtained in this study is consistent with the findings of all but two of the studies that investigated demographic variables (Vlahakis, 1993; Steinberg *et al.*, 1994; Turco *et al.*, 1994; Mangione *et al.*, 1999; Klein *et al.*, 2001). It is also supported by a study on the perception of real world targets by Owsley and Sloane (1987). Hazel *et al.* (2000) and Wolffsohn and Cochrane (2000) did not find a significant correlation with age and quality of life questionnaires. The reasons are not clear.

Of the two visual acuity measures, we obtained a higher correlation for near word acuity than distance visual acuity. It should be noted that this was not only the case for the text-based items of the MLVAI, but was also the case for many of the non-text-based items, such as writing a cheque, face recognition, needle threading, pouring and coin identification. This agrees with the findings of two other studies (Turco *et al.*, 1994; Carta *et al.*, 1998). However, Hazel *et al.* (2000) and Wolffsohn and Cochrane (2000) found little difference. The reasons are unclear. It would not seem to be the result of the difference in the proportion of distance and near vision items that made up each measure, as one of the scales used by Hazel *et al.* (2000) used a similarly high proportion of near reading-related items. However, regardless of the proportion of distance and near vision items, all of these studies except Turco *et al.* (1994) showed significant correlations for both distance and near visual acuity. This is not surprising, as distance and near visual acuity are highly correlated. The reason Turco *et al.* (1994) failed to find a significant correlation for distance visual acuity may be explained by their categorisation of distance visual acuity into four broad groups that did not cover equal intervals of visual acuity. Of the other studies that investigated distance visual acuity, but not near visual acuity, most found a statistically significant moderate to high correlation for distance visual acuity (Elliott *et al.*, 1990; Ross *et al.*, 1991; Mangione *et al.*, 1992, 1999, 2001; Steinberg *et al.*, 1994; Parrish *et al.*, 1997; Szlyk *et al.*, 1997; Boisjoly *et al.*, 1998; Carta *et al.*, 1998; Hart *et al.*, 1999; Hazel *et al.*, 2000; McClure *et al.*, 2000; Wolffsohn and Cochrane, 2000). Although Vlahakis (1993) found a moderate correlation coefficient for distance visual acuity similar to the other studies, the *p*-value was greater than 0.05, and very likely because the sample size was small.

The significant correlation with contrast sensitivity measures found in this study also agrees with the findings of other studies (Elliott *et al.*, 1990; Ross *et al.*,

Table 5. Summary of main studies on relationship between vision impairment and ADL performance*

Study	Subjects, *n*	Assessment	*r*: Distance acuity	*r*: Contrast sensitivity	*r*: Visual field	*r*: Other	R^2 multiple correlation (%)
Elliott *et al.* (1990)	33 Cataract	Self-report questionnaire	0.41	−0.60 (Pelli–Robson Chart)	–	0.61 (glare)	–
Ross *et al.* (1991)	144 Various	Observed assessment	0.56	−0.46 (mean CSF)	0.31 (rating)	–	57
Mangione *et al.* (1992)	334 Cataract	ADVS self-report questionnaire	−0.39	–	–	–	–
Vlahakis (1993)	19 AMD	Observed assessment	−0.37†	0.50 (Melbourne Edge Test)	–	–	–
Steinberg *et al.* (1994)	766 Cataract	VF-14 self-report questionnaire	0.27	–	–	–	42
Turco *et al.* (1994)	94 Various	Four observed tasks	−0.19†	−0.40 (peak Vistech)	–	−0.50 (near acuity)	35
Parrish *et al.* (1997)	147 Glaucoma	VF-14 self-report questionnaire	−0.59	–	−0.38 (Esterman)	–	–
Szlyk *et al.* (1997)	167 RP	Self-report questionnaire	Significant	–	Significant	Significant (ERG)	59
Carta *et al.* (1998)	120 Various	Self-report questionnaire	0.45	0.55 (Pelli–Robson Chart)	0.38 (rating)	0.55 (near acuity) −0.07† (glare)	49
Boisjoly *et al.* (1998)	134 Cornea	VF-14 self-report questionnaire	−0.53	–	–	–	–
Mangione *et al.* (1999)	201 AMD	ADVS self-report questionnaire	−0.47	–	–	–	40
Cole *et al.* (2000)	244 Optic neuritis	NEI-VFQ self-report questionnaire	<−0.30	<0.22 (Pelli–Robson Chart)	<0.23 (Humphrey mean deviation)	–	–
Hazel *et al.* (2000)	28 Central field loss	Reading scale self-report questionnaire	0.86	−0.66 (Pelli–Robson Chart) 0.88 (low contrast visual acuity)	–	0.85 (near acuity) −0.77 (reading speed)	83
		VCM 1 self-report questionnaire	0.76	−0.66 (Pelli–Robson Chart) 0.79 (low contrast va)	–	0.77 (near acuity) −0.81 (reading speed)	65
Wolffsohn and Cochrane (2000)	150 Various	LVQOL self-report questionnaire	0.47	−0.43 (Melbourne Edge Test)	–	0.47 (near acuity)	32
Klein *et al.* (2001)	602 Diabetic retinopathy	NEI-VFQ 51 self-report questionnaire	0.46	–	–	–	–
Mangione *et al.* (2001)	597 Various	NEI-VFQ 25 self-report questionnaire	0.72	–	–	–	–
This study	120 Various	Melbourne Low Vision ADL Index observed and questionnaire items	−0.78	0.80 (Melbourne Edge Test) 0.69 (Pelli–Robson Chart)	0.56 (anatomical)	−0.86 (near acuity)	82

*Except for those marked with †, all correlation coefficients were $p < 0.05$. ADVS, Activities of Daily Vision Scale; NEI-VFQ, The National Eye Institute Visual Function Questionnaire; LVQOL, Low Vision Quality-of-Life Questionnaire; CSF, contrast sensitivity function; ERG, electroretinogram; VF-14, visual function index.

1991; Vlahakis, 1993; Turco *et al*., 1994; Cole *et al*., 2000; Hazel *et al*., 2000; McClure *et al*., 2000; Wolfsohnn and Cochrane, 2000). With the exception of Cole *et al*. (2000), all studies indicate a moderate to high correlation. The likely reason for the finding by Cole *et al*. (2000) is that, although the subjects had optic neuritis, they had good vision at the time of testing. Of the two 'peak' contrast sensitivity measures we investigated, the Melbourne Edge Test had a higher correlation with ADL performance than the Pelli–Robson Chart. The Melbourne Edge Test was able to distinguish between subjects better than the Pelli–Robson Chart at the lower end of the contrast sensitivity scale, particularly for the many subjects in this study with central vision impairment. Whereas the Melbourne Edge Test is a simple edge detection task, the Pelli–Robson Chart is a letter recognition task. For a group of letters near the threshold level for detection on the Pelli–Robson Chart, many subjects reported that they were able to see something, but not recognise what was on the chart.

Of all the clinical vision impairment measures investigated in this study, visual field had the weakest correlation with overall ADL performance. This is consistent with other studies that investigated visual field (Ross *et al*., 1991; Parrish *et al*., 1997; Szlyk *et al*., 1997; Carta *et al*., 1998) regardless of the nature of the vision impairment studied and the different methods used to score the visual field. The result is reasonable given that, with the obvious exception of mobility, relatively few ADLs involve peripheral vision, which is best measured by the area of the visual field.

The best predictive model of combined part (a) instrumental and part (b) basic ADL performance incorporated the variables age, near word acuity, Melbourne Edge Test contrast and the Anatomical Total Visual Field Score. In this study, these predictor variables explained 82% of the variance in overall ADL performance. However, when analysed separately, the best predictive model of part (a) observed instrumental ADL performance was different to the best predictive model of part (b) questionnaire items on basic ADL performance. The best predictive model of part (a) observed instrumental ADL performance incorporated the variables near word acuity, Melbourne Edge Test contrast and the Anatomical Total Visual Field Score. Together, these variables explained 84% of the variance in *instrumental* ADL performance. Although we found the best predictive model of *basic* ADL performance incorporated two of the same variables, Melbourne Edge Test contrast and the Anatomical Total Visual Field score, near word acuity was not included. Instead, age was included as a predictor variable in the best model for basic ADL performance. However, this model explained only 45% of the variance in basic ADL performance. As mentioned, such a result may in part be because of the fact that basic ADL performance was investigated using a self-report questionnaire, which may be less reliable than the observed performance strategy used to investigate instrumental ADL performance. Nevertheless, these results suggest that basic ADL performance involves important factors other than vision, one of those being age.

In comparison with all other studies except one, the amount of variance in ADL performance explained in this study is high (*Table 5*). With the exception of Hazel *et al*. (2000), other studies have explained no more than 59% of the variance in overall ADL performance using vision and demographic predictors (Ross *et al*., 1991; Steinberg *et al*., 1994; Turco *et al*., 1994; Szlyk *et al*., 1997; Carta *et al*., 1998). Clearly, other studies have similar results with each other: moderate correlations between vision measures and ADL performance, in spite of investigating different groups of subjects using widely different measures. We suggest that the high correlations we obtained were in part because of the high reliability of the ADL performance measure used. The reliability and validity of the MLVAI is higher than any of the measures used in the studies that report correlation coefficients and multiple regression analyses. Another reason for the difference in results may be because most of the measures used in other studies were entirely self-report questionnaires. It is important to emphasise that many of these questionnaires examine different characteristics of ADL performance compared with the MLVAI. Many contain items not only related to ADL performance but to social and psychological issues. These are not likely to correlate with vision measures as highly as the MLVAI, which aims to measure performance as objectively as possible and does not aim to tap social and psychological issues relating to vision impairment. Indeed, Szlyk *et al*. (2001) showed that, although self-reported and observed performances are significantly correlated, the correlation is moderate. Also, in contrast with the MLVAI, many of the self-report questionnaires assess the patient perspective by asking subjects to rate 'difficulty'. Questions phrased in this open manner are more likely to be influenced by psychological factors than the MLVAI and this may also contribute to the difference in results between studies.

One might also suggest that the high correlations obtained in this study, in comparison with other studies, were because of the wide range of vision impairment investigated. However, in seven of the studies reported in *Table 5* (Ross *et al*., 1991; Steinberg *et al*., 1994; Parrish *et al*., 1997; Szlyk *et al*., 1997; Boisjoly *et al*., 1998; Wolffsohn and Cochrane, 2000; Mangione *et al*., 2001), the range was similarly wide and yet the correlations obtained were weaker than those obtained in this study. The one exception was the study by Hazel *et al*. (2000) who, as mentioned, also obtained high correlations.

Like this study, Hazel *et al.* (2000) investigated a group with a wide range of vision impairment and the functional measure used, a 15-item reading scale, contained a high proportion of reading related items. Indeed, it has been suggested that a reason for the high correlations in this study is the high proportion of reading related items in the MLVAI (10 out of 25 items). However, the high proportion of reading related items does reflect the problems reported by people with vision impairment (Genensky *et al.*, 1979; Branch *et al.*, 1989) and the content of the MLVAI was based on this evidence.

Furthermore, in two other studies (Vlahakis, 1993; Turco *et al.*, 1994) the proportion of reading items was similar to the MLVAI, and yet the correlations obtained were again weaker than those obtained in this study.

This study indicates that clinical vision measures, other than high contrast visual acuity, are good predictors of overall ADL performance as measured by the MLVAI. However, vision measures are better predictors of instrumental ADL performance than basic ADL performance. Although, clinical vision measures may explain most of the variance in capacity to perform instrumental ADLs, other factors are likely to be involved in capacity to perform basic ADLs. Age is one of those factors and psychological variables, such as confidence and personality traits, may also be important. This requires further investigation. Also, requiring further investigation is the relationship between what people *can* do as measured by the MLVAI and what people *actually* do in their own environment.

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