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Orientation and mobility in age-related macular degeneration

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Abstract This study investigated the orientation and mobility (O&M) performance of subjects with age-related macular degeneration (ARMD). Mobility performance, assessed as walking speed, percentage preferred walking speed (PPWS), and number of contacts with obstacles, was measured on 21 subjects with ARMD and 11 age-matched controls using a 79-meter indoor mobility course. Orientation was assessed by asking subjects to perform two tasks. Similar trends were found for results using walking speed and PPWS, except that age had a significant effect on walking speed. No significant difference in mobility performance was found between ARMD and control subjects. Reduced illumination resulted in worse mobility performance by both subject groups.

Key words Orientation; mobility; age-related macular degeneration

Introduction Although age-related macular degeneration (ARMD) is one of the main causes of severe vision loss in western countries,[1,2] limited research has been done on the relationship between ARMD and mobility. Brown et al.[3] used a computer-controlled system to analyze subject position and time on various indoor mobility courses under different luminance levels. They found that at low luminances, but not at high luminances, subjects with ARMD had significantly poorer mobility performance compared to control subjects. A limitation of the Brown et al. study was that the mobility course did not contain obstacles. Object avoidance is a part of safe mobility and is used in navigation. The ability to avoid obstacles on a mobility course may better reveal subjects' orientation and mobility (O&M) performance than walking a clear path.

Wilcox and Burdet[4] asked subjects to walk twice along an indoor path free of any obstacles. Mobility was scored in terms of time taken to complete the course and the number of errors (i.e. walking outside

the path boundary). They found no significant difference between ARMD and control subjects on either measure. Brown et al.[3] and Haymes et al.[5] suggested that differences in mobility may be best elicited by more complex courses. Zahn and von Dollen[6] found that the walking speed of a subject wearing simulated central vision loss was slower than that of subjects with normal vision. A limitation of that study was that vision impairment was simulated monocularly and little detail was given about the mobility course.
The purpose of the present study was to investigate the performance of subjects with ARMD navigating an indoor course containing many obstacles.

Methods

SUBJECTS Thirty-two adult subjects participated in the study: 21 subjects with ARMD and 11 age-matched control subjects with normal vision. ARMD subjects were recruited from the clinical records of the Queensland University of Technology (QUT) Vision Rehabilitation Centre in the School of Optometry. Subjects had a confirmed diagnosis of ARMD from an optometrist or ophthalmologist, but were not screened with respect to orientation and mobility experience or previous training. The mean age of the ARMD subjects was 80±5 years (range: 66-87 years). Distance visual acuities ranged from 0.18 logMAR ($6/9.5^{+1}$) to 1.44 logMAR ($6/150^{-2}$).

The control subjects, recruited from either the clinic records of the QUT Optometry Clinic or through a database of 'control subjects' from an earlier unrelated study, had a mean age of 77±7 years (range: 66-86 years). There was no significant difference in the age distribution of the two groups (Wilcoxon-Mann-Whitney $z=-1.21$, $p=0.226$). The mean age of the control group was slightly lower than that of the ARMD group because of the set criteria of corrected binocular visual acuity of 0.10 logMAR (6/7.5) or better, normal contrast sensitivity, and full visual fields. The mean binocular high contrast VA of the control subjects was 0.02±0.06 logMAR.

Apart from ARMD, all subjects had no other ocular, physical, or cognitive disorder that significantly affected their mobility, vision performance, or their ability to follow instructions.

MOBILITY ASSESSMENT Subjects wore their habitual prescription and used no mobility devices in the assessment of mobility performance.

Preferred walking speed Each subject's preferred walking speed (PWS) was measured as the time taken to walk a 20-m, straight, unobstructed, level corridor.[7] Subjects were instructed to walk at their normal, comfortable pace along the corridor. This was measured four times prior to the commencement of the mobility course trials. As subjects walked more slowly on the first trial than on the subsequent three trials, PWS was defined as the mean speed (m/s) of the last three trials.

Mobility course An indoor mobility course, weaving through a series of six connecting rooms, was constructed at the QUT Centre for Eye Research laboratories. Total path length was 79 m, with a width of 1.2 m. Path boundaries were outlined using high-reflectance, plastic bubble wrap, folded to give a width and height of approximately 5 cm. The path was both 'windy' as well as straight. It included a step, a ramp, and an 'open area' approximately 2.4 m wide bordered by large plastic sheets to simulate a pathway between two walls. Within the path boundary was an array of 100 obstacles of varying sizes and heights. These were randomly scattered along the path and there was one 'obstacle-free' section, 2.4 m wide and 3.4 m long.

The illumination of the course was constant and in the photopic range (approximately 300-500 lux) except in one room where only a 60-watt globe was positioned in the middle of an otherwise darkened room. The average illuminance in this room was 52 lux. The lamp was directed at the doorway so that it acted as a glare source when subjects opened the door.

Orientation tasks Orientation performance was assessed by requiring subjects to perform two tasks at different stages along the mobility route. At the start of the course, the subject was given a packet. The subject was asked to place the packet on a specific bench labeled Table 1. The second task required the subject to identify a table with three shopping items and a plastic bag, place the items into the bag, carry the bag for a short distance, and place it on a sign-posted table near the end of the mobility route. Each incorrectly performed task incurred an error score.

Mobility performance The mobility performance of all subjects was measured once at two different experimental sessions. The sessions were held between one and three weeks apart except for two control subjects, where there was an eight-month lapse between measurements. Examination of their mobility performance revealed no significant changes between visits.

At the commencement of each mobility trial, subjects were instructed to walk through the mobility course, stay within the boundary, and avoid contact with the obstacles. Subjects were instructed to walk normally. From the path design, the course was divided into four stages. Walking speed and PPWS were recorded for each of the four stages of the mobility course, as well as for the whole course (Table 1).

Mobility performance was measured using walking speed, percent preferred walking speed (PPWS), and number of errors. Walking speed was the distance traversed (m) divided by the time it took for each subject to complete that section of the course (s).

PPWS was the ratio of a subject's walking speed on the course to their PWS, expressed as a percentage.[8] The number of errors made on each trial

TABLE 1. The stages of the mobility course.

Stage	*Path features*	*Distance (m)*
a	From start of course up to and including Task 1	31.17
b	From completion of Task 1 to start of 'glare' room	24.00
g	From start of 'glare' room to end of 'glare' room	6.13
c	From end of 'glare' room to finish of mobility course (including Task 2)	17.63
Total	The entire path length from start to finish	78.93

was recorded as the sum of the total number of obstacles contacted on the course plus the number of errors incurred from incorrectly performed tasks.

Results

PREFERRED WALKING SPEED (PWS) No significant difference in PWS was found between ARMD and control groups (repeated measures ANOVA, $F_{1, 29}$=0.90, p=0.35), but age was a significant co-variate (t_{31}=–2.33, p=0.03). A significant correlation was found between age and PWS for the combined ARMD and control groups (Spearman r=-0.35, p=0.049 for trial 2).

WALKING SPEED ON MOBILITY COURSE No significant difference in absolute walking speed on the course was found between ARMD and control subjects (repeated measures ANOVA, $F_{1, 29}$=3.80, p=0.06). Age was again a significant co-variate with walking speed (t_{31}=-2.33, p=0.03). Using the combined ARMD and control data, age correlated significantly with mean walking speed, averaged over the entire mobility course (Spearman r=-0.39, p=0.038 for trial 2). All other trends for walking speed were identical to those obtained using PPWS (detailed below).

PPWS Combining ARMD and control data, there were no significant correlations between age and mean PPWS (averaged over the entire mobility course) on either mobility trial (Spearman r=-0.23, p=0.212 and r=-0.16, p=0.376 for trials 1 and 2, respectively). Furthermore, age was not a significant co-variate with PPWS (repeated measures ANOVA, t_{31}=-0.48, p=0.63). Therefore, because PPWS controls for intra- and inter-subject variations in age, stride length, height, and natural speed, differences between groups and between different conditions (e.g. stages) were examined using PPWS.

No significant difference in PPWS (averaged over the entire mobility course and for all individual stages) was found between the ARMD and control groups (repeated measures ANOVA, $F_{1, 29}$=3.23, p=0.08). However, significant differences in PPWS at different stages of the mobility course were found ($F_{3, 90}$=152, p<0.001). In general, PPWS of the ARMD group in stage g (the glare room) and stage c (the following room) were lower than PPWS in the two earlier stages (Duncan's multiple range test p<0.05).

PPWS improved significantly from trial 1 to trial 2 (repeated measures ANOVA, $F_{1, 30}$=9.4, p=0.005) for both subjects groups. On trial 2, the ARMD group was significantly faster on stages a and b (by 11% and 15%, respectively; t_{20}<-2.58, p<0.018), but not on stages g and c (t_{20}<-0.25, p>0.263).

ERRORS There was no significant difference in the total number of contacts made with obstacles on either mobility trial between the ARMD and control subjects (chi-square test for relatedness, $\chi^2_{6, 1}$=0.344, p=0.637 and $\chi^2_{6, 1}$=0.44, p=0.098, respectively). Subjects with ARMD made significantly more errors in trial 1 than in trial 2 (Wilcoxon matched-pairs signed rank test, z=-2.23, p=0.03). Very few errors were made during either of the 'orientation' tasks. On trial 1, 10 ARMD and two control subjects made errors with either orientation task. On trial 2, only seven ARMD and two control subjects made errors associated with either task.

Discussion There was no significant difference between ARMD and control subjects for mobility performance assessed using PPWS. This is in agreement with previous research into vision and mobility in ARMD on simpler mobility courses. Brown et al.[3] and Wilcox and Burdett[4] found no significant differences in mobility between subjects with ARMD and normal vision when measured under high illuminance conditions. Furthermore, Kuyk et al.[9,10] found that their 'acuity loss' groups (comprised of approximately 60% and 80% ARMD subjects in their two studies) walked more quickly and made fewer errors than either the 'field restriction' or 'combination loss' groups (no normal vision group was included). This was true under photopic, mesopic, and scotopic light conditions.

As expected, PPWS during stage g (reduced illumination plus glare) was significantly lower for both ARMD and control subjects in comparison to the other three stages. Subjects with ARMD[3,9,10] have been found to walk more slowly at lower illuminance levels. The effect of reduced illuminance on people with ARMD has been attributed to an altered dark-adaptation function.[11,12] Whether the reduced PPWS in stage c, compared to stages a and b, can be attributed to problems associated with re-adaptation to a photopic luminance after leaving the dimly lit stage g is not clear. The other factor that may have contributed to a lowered PPWS in stage c was the time spent performing task 2.

Familiarity (practice) with the course appeared to have an important role in the orientation and mobility performance of both the ARMD and control subjects. This was illustrated by significant increases in walking speed and PPWS in stages a and b and averaged over the entire course, on trial 2. The effects of low illumination and glare on mobility in stage g negated any improvement due to familiarity. Similarly, mobility in stage c did not improve significantly on the second trial, probably due to the time involved with task 2. Familiarity also reduced the number of errors found on trial 2. The low numbers of errors made by ARMD subjects, despite the obstacle-rich course, suggests that errors, either scored as the number of contacts made with obstacles or errors associated with orientation tasks, is not a good indicator of mobility performance for subjects with ARMD, because errors were an infrequent event.

In agreement with Haymes et al.,[5] we found PPWS to be a better measure of mobility performance than walking speed. Age was a significant co-variate and correlated significantly with only PWS and walking speed. It appears that PPWS controls for age. For this reason and since PPWS appears to control for inter-subject variation in such factors as stride length and fitness level, it may be a preferred measure of mobility performance over absolute walking speed and errors.

In conclusion, this study confirms the results of other studies and clinical opinion that subjects with ARMD do not have any more difficulty with mobility than do subjects of the same age with normal vision, except under conditions of reduced illuminance.

References

1 Evans J, Wormald R. Is the incidence of registrable age-related macular degeneration increasing? Br J Ophthalmol 1996;80:9-14.

2 Yuzawa M, Tamakoshi A, Kawamura T, Ohno Y, Uyama M, Honda T. Report on the nationwide epidemiological survey of exudative age-related macular degeneration in

Japan. Int Ophthalmol 1997;21:1-3.
3 Brown B, Brabyn L, Welch L, Haegerstrom-Portnoy G, Colenbrander A. Contribution of vision variables to mobility in age-related maculopathy patients. Am J Optom Physiol Opt 1986;63(9):733-739.
4 Wilcox DT, Burdett R. Contrast sensitivity function and mobility in elderly patients with macular degeneration. J Am Optom Assoc 1989;60(7):504-507.
5 Haymes S, Guest D, Heyes A, Johnston A. Mobility of people with retinitis pigmentosa as a function of vision and psychological variables. Optom Vision Sci 1996;73(10):621-637.
6 Zahn JR, von Dollen K. Simulation of the environment of the visually impaired: central vision loss versus peripheral vision loss. J Vision Rehabil 1990;4(3):45-51.
7 Black A, Lovie-Kitchin JE, Woods RL, Arnold N, Byrnes J, Murrish J. Mobility performance with retinitis pigmentosa. Clin Exp Optom 1996;80(1):1-12.
8 Clark-Carter DD, Heyes AD, Howarth CI. The efficiency and walking speed of visually impaired people. Ergonomics 1986;29(6):779-789.
9 Kuyk T, Elliott JL, Biehl J, Fuhr PS. Environmental variables and mobility performance in adults with low vision. J Am Optom Assoc 1996;67(7):403-409.
10 Kuyk T, Elliott JL, Fuhr PS. Visual correlates of obstacle avoidance in adults with low vision. Optom Vision Sci 1998;75(3):174-182.
11 Brown B, Lovie-Kitchin J. Dark adaptation and the acuity/luminance response in senile macular degeneration (SMD). Am J Optom Physiol Opt 1983;60(8):615-650.
12 Holopigian K, Seiple W, Greenstein V, Kim D, Carr RE. Relative effects of aging and age-related macular degeneration on peripheral visual function. Optom Vision Sci 1997;74(3):152-159.