Author/s:
Razavi, H;Baglin, E;Sharangan, P;Caruso, E;Tindill, N;Griffin, S;Guymer, R

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Razavi Hessom (Orcid ID: 0000-0002-2232-8731)

Original Article – Clinical Science

Gaming to improve vision: 21st century self-monitoring for patients with age-related macular degeneration

Hessom Razavi FRANZCO,[1,2] Elizabeth Baglin BOrth,[1,2] Pyrawy Sharangan BOrth,[1,2] Emily Caruso BOrth,[1,2] Nicole Tindill BBus,[1,2] Susan Griffin[1] and Robyn Guymer FRANZCO[1,2]

1. Centre for Eye Research Australia, Royal Victorian Eye and Ear Hospital, Australia
2. Ophthalmology, University of Melbourne, Department of Surgery, Australia

Correspondence: Dr Hessom Razavi, Lions Eye Institute, 2 Verdun St, Nedlands, WA 6009, Australia.

email: hessomrazavi@lei.org.au

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ABSTRACT

Importance: Improved vision self-monitoring tools are required for people at risk of neovascular complications from age related macular degeneration (AMD).

Background: to report the self-monitoring habits of participants with intermediate AMD using the Amsler grid chart, and the use of personal electronic devices and gameplay in this over 50 year old cohort.

Design: single-centre descriptive study carried out at the Centre for Eye Research (CERA), Melbourne, Australia.

Participants: 140 participants over 50 years of age, with a diagnosis of intermediate AMD and best-corrected visual acuity (BCVA) of ≥6/12 in each eye.

Methods: structured questionnaire survey of participants who were enrolled in natural history of AMD studies at CERA.

Main outcome measures: frequency of vision self-monitoring using of the Amsler grid chart, and frequency of general use of personal electronic devices and gameplay.

Results: Of 140 participants with mean age of 70.5 years, 83.6% used an Amsler grid chart, but only 39.3% used it once per week. Most participants (91.4%) used one or more personal electronic devices. Of these, over half (54.7%) played games on them, among whom 39% played games once a day. Of participants aged 50-69 years, 92% (95%CI 85.1-98.9) were willing to play a game to monitor their vision, compared to 78% (95%CI 69.0-87.0) of those aged 70 years and older ($p<0.05$).

Conclusions and relevance: a large proportion of AMD patients already use personal electronic devices. Gamification techniques are likely to increase compliance with self-monitoring, leading to earlier detection in the next generation of patients with neovascular AMD.

Keywords: age-related macular degeneration; self-monitoring; medical devices.

INTRODUCTION

The advent of intravitreal anti-vascular endothelial growth factor (anti-VEGF) therapies has dramatically improved visual outcomes for patients with neovascular age-related macular degeneration (nAMD)[1]. However, the long-term visual outcome in these patients is not uniformly excellent, and is strongly determined by their visual acuity (VA) at the time of their first presentation for treatment[2-4]. Early detection of nAMD activity is therefore a public health priority, in order to optimize long-term vision for these patients.

Early detection of nAMD relies on patients, who have been identified as being at-risk of progression to advance AMD, to self-monitor their vision at home. These at-risk patients are readily identifiable by signs of early or intermediate AMD, often years before any vision threatening complications occur. Additional and growing knowledge of particular subgroups at greatest risk, such as those who continue to smoke or who have reticular pseudodrusen, allows clinicians to further emphasize the importance of self monitoring vision to particular groups of AMD patients[5,6]. The onset of nAMD may precede visual symptoms, particularly in first-affected eyes, which are compensated for by good VA in the second eye. Since 1945, the recommendation for patient self-monitoring has consisted of the Amsler grid chart[7]. However, the Amsler has limitations in terms of subjectivity, poor compliance and low sensitivity[8]. Even when the Amsler is used, it has been shown to detect less than 30% of patients who subsequently develop choroidal neovascularization[9].

In an attempt to improve the monitoring of AMD, a host of technologies are emerging[8]. These include the use of preferential hyperacuity perimetry in devices such as the ForeseeHome device[10], or hyperacuity shape discrimination on a mobile hand held device such as a smart phone, using the MyVisionTrack application[11] , When compared with the Amsler grid, perimetry demonstrated a sensitivity of 72.5% versus 52.4%, respectively, for the detection of nAMD[10] . High patient compliance (84.7%) with daily hyperacuity testing on a smartphone device was also reported[11]. It is also possible to have remote surveillance of individual results and a system of automated alerts to both the patient and the treating ophthalmologist, in the event of a decline in the patient's visual performance. Schmier et al[12] concluded that effective telemonitoring could provide better visual outcomes and substantial cost savings for patients and the health system.

Home monitoring technologies for AMD require elderly patients to utilise personal electronic devises and customised software.   This patient cohort grew up in the era before widespread digital technology. Their ability to navigate this technology for ophthalmic purposes has not been well established. We sought to investigate the self-reported vision monitoring frequency using the Amsler grid chart and the general use of personal electronic devices and gameplay, in patients with intermediate AMD.

METHODS

This was a single-centre descriptive study consisting of a structured questionnaire survey of participants who were enrolled in natural history of AMD studies at the Centre for Eye Research Australia (CERA). We enrolled male and female participants aged 50-95 years. Inclusion criteria included a BCVA of ≥ 6/12 in both eyes, the presence of at least one large drusen (≥125um) in each eye, with or without bilateral macular pigmentary disturbance, in keeping with the accepted classification of intermediate AMD[13]. Late stage AMD in either eye was an exclusion criterion. All participants knew that they had AMD and were at risk of vision loss, as they were actively involved in longitudinal AMD natural history projects. There was no screening of participants prior to enrolment, with regard to their use of personal electronic devices. Participants were asked their current personal vision self monitoring regimen using the Amsler grid, based upon what ever prior advice they had been given.

All participants were surveyed in person or by telephone, using a structured interview questionnaire about their vision self-monitoring habits and current use of personal electronic devices. Participants could nominate all personal electronic devices that they used regularly, and list more than one reason for use of their devices. Survey data were manually entered into REDCap (Research Electronic Data Capture), which is a secure, web-based application designed to support data capture and statistical analysis for research studies (REDcap, Vanderbilt, USA). Statistical analysis was carried out with SPSS version 24.0 (IBM Corp, Armonk, New York, USA)..Ethics approval was obtained from the Human Research and Ethics Committee at the Royal Victorian Eye and Ear Hospital. The research described adhered to the tenets of the Declaration of Helsinki.

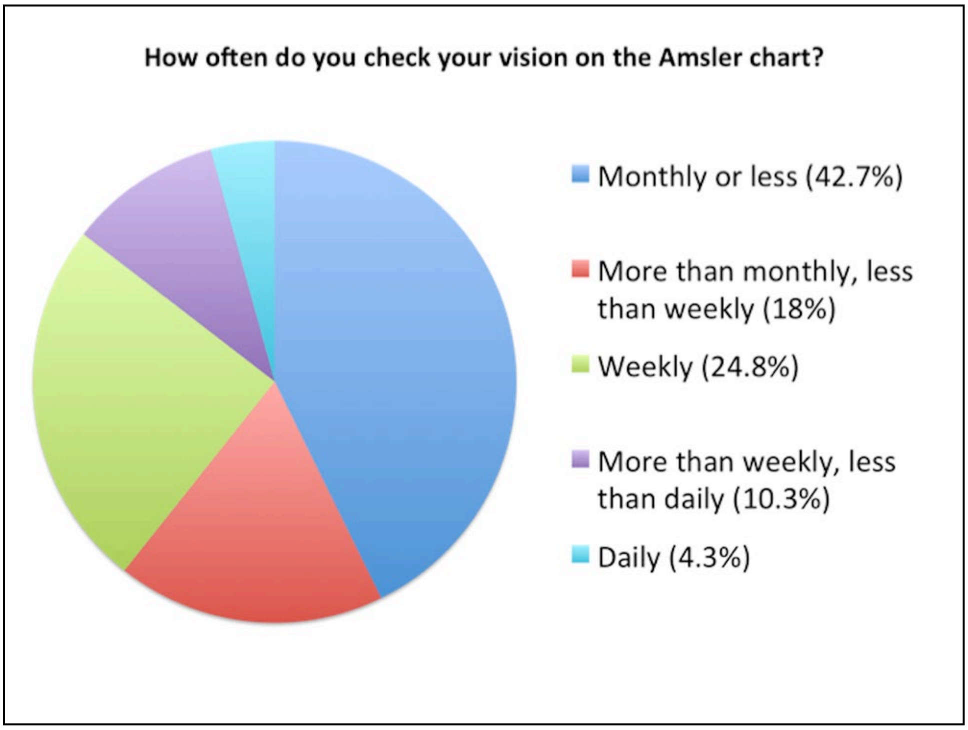
RESULTS

A total of 140 consecutive participants were included in this study. The mean age was 70.5 years, and 80% of participants (n=112) were female. Most participants (n=109, 77.9%) understood that they were supposed to self-monitor their vision. One hundred and seventeen participants (83.6%) used a paper Amsler grid chart to do so. (Table 1). Of these, 88% (n=103) checked one eye at a time. Only 39.3% (n=46) used the Amsler at least once per week (Figure 1). Of the participants that did not use an Amsler chart, half (n=12, 52.2%) used another technique for monitoring their vision.

Table 1: Participant responses to selected binary interview questions

Questions	Responses 'Yes' n (%)	Responses 'No' n (%)
Amsler grid chart		
Did you know that you are supposed to monitor your vision when you have early stages of AMD?	109 (77.9)	31 (22.1)
Do you monitor your vision with an Amsler grid chart?	117 (83.6)	23 (16.4)
Using the Amsler chart, do you monitor your vision by checking one eye at a time, by closing or covering the other eye?	103 (88.0)	14 (12.0)
If you don't use the Amsler chart, do you check your vision any other way, e.g. checking straight lines on doorframes?	12 (52.2)	11 (47.8)
Personal electronic devices		
Do you use a personal electronic device for general use?	128 (91.4)	12 (8.6)
If you use a personal electronic device, do you play games on it?	70 (54.7)	58 (45.3)
If you play games, are they interactive with other competitors?	18 (25.7)	52 (74.3)
Do you think you would play a game on a personal electronic device if it helped to monitor your vision?	117 (83.6)	23 (16.4)

Figure 1: Participants' reported frequency of use of the paper Amsler grid chart



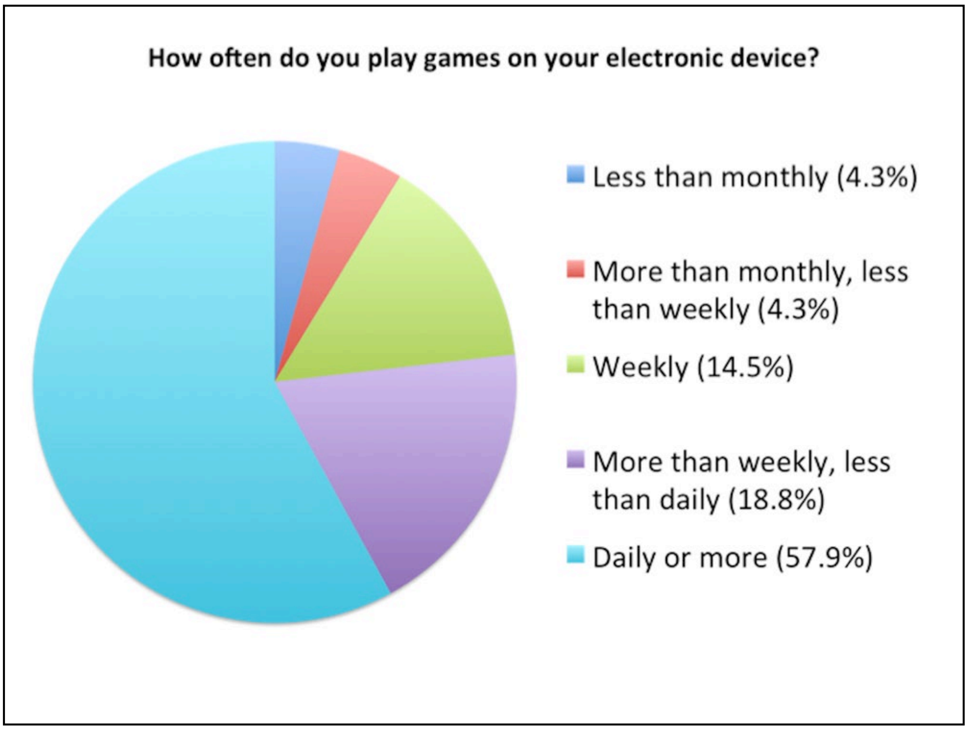
Most participants used one or more personal electronic devices (n=128, 91.4%; Tables 1 and 2). Computers (75%) and smart phones (64%), were used most commonly, followed by iPads or other tablets (50%). Of participants that used any device, over half (n=70, 54.7%) played games on them, amongst whom 57.9% (n=40) played games at least once per day (Figure 2).

Table 2: Participant responses to selected questionnaire items

Questions	Responses n, (%)
How often do you check your vision on the Amsler?	
Less than once per month	24 (20.5)
Once a month	26 (22.2)
Less than weekly but more than monthly	21 (17.9)
Once a week	29 (24.8)
More than once a week	7 (6.0)
Less than once a day but more than once a week	5 (4.3)
Once a day	5 (4.3)
More than once a day	0
Which electronic devices do you use regularly?	
Computer	105 (75.0)
iPad (or equivalent)	72 (51.4)
Smartphone	90 (64.3)
EReader	12 (8.6)
Other	1 (0.7)
None	12 (8.6)

How often do you play games on your electronic device?	
Less than once per month	3 (4.3)
Less than once per week, more than once per month	3 (4.3)
Once a week	10 (14.5)
More than once a week	9 (13.0)
Less than once a day but more than once a week	4 (5.8)
Once a day	27 (39.1)
More than once a day	13 (18.8)
Why do you play games on your electronic device?	
For fun	55(78.6)
Because you think it helps the brain	34 (48.6)
Because you think it helps your eyes	7 (10.0)
Other	16 (22.9)

Figure 2: Reported frequency of gameplay on personal electronic devices, in participants who reported using any device



Reported reasons for gameplay included fun (n=55, 78.6%), participants believing that it helped their cognitive function (n=34, 48.6%), or because it helped their visual function (n=7, 10%; Figure 2). One hundred and seventeen participants (83.6%) said that they would play a game on a device if it helped to monitor their vision.

A sub-analysis of participants aged 50-69 years (n=59) compared to those aged 70 years and above (n=81) found that 97% (95%CI 92.6-100) and 89% (95%CI, 82.2-95.8) used any electronic device, respectively ($p=0.078$). The proportions that would play games to monitor their vision was 92% (95%CI 85.1-98.9) and 78% (95%CI 69.0-87.0), respectively, in these two age groups ($p<0.05$, two-tailed Z-test).

DISCUSSION

In this study of patients with intermediate AMD, most participants (78%) were aware of the need to self-monitor their vision, and almost 84% reported using an Amsler chart, Among participants who used the Amsler chart, the majority (88%) reported using the correct technique of testing one eye at a time, but only 39% did so at the recommended frequency of at least once a week. The vast majority (91%) of this older cohort reported using personal electronic devices such as computers, smartphones and iPads. Most participants (84%) expressed an interest in playing games to monitor their vision; this was significantly higher among participants aged under 70 years, compared to those aged 70 years and older (92% and 78%, respectively, $p<0.05$). To our knowledge, this is the first report on the readiness of patients with intermediate AMD to use personal electronic devices, and gameplay in particular, in order to self-monitor their macular function.

The ability to treat nAMD at the earliest possible time point, before there is irreversible structural damage to the retina, enables the best visual outcomes. We are also entering an era of potential treatment for geographic atrophy, where the symptoms of disease progression are more subtle. This will necessitate regular, long-term macular surveillance, possibly with functional tests that monitor sensitivity in addition to distortion. Making use of psychophysical data to inform new electronic testing platforms may prove more agile in detecting these early changes, as exemplified by Wu et al[14] with the recently reported Psypad App.

In the HOME study by Chew et al[10], which used a quantified electronic metamorphopsia test on a portable device, frequent self-monitoring resulted in the best visual outcomes. Daily compliance with the device was shown to provide a better visual acuity at the time of CNV detection, when compared to standard monitoring with the Amsler grid (94% versus 62% of patients with BCVA of ≥ 20/40, respectively). However, there was a 20% screen failure rate, whereby participants with pre-existing visual field defects could not use the technology. A further 20% of patients stopped monitoring at various times points in the study for other reasons.

In order to increase patient compliance with self-monitoring, embedding a validated psychophysical test into a downloadable application on a personal electronic device appears to be a strategy worth pursuing. Such applications could provide an engaging test with the ability to compete, interact and track progress, with the potential use of gamification techniques. The ability to provide remote tele-surveillance closes this loop, by ensuring that pre-determined reductions in visual performance result in alerts being sent to both the patient and their eye care clinician. Engagement with industry stakeholders could help to determine funding schemes for the cost-effective delivery of these systems. To a limited extent, this is already occurring in the USA, with the FDA approval of the ForeseeHome program, and recent Medicare coverage for its use. In Australia, recent changes to the Medicare Benefits Schedule for teleophthlamology may provide similar opportunities[15]. Our findings suggest that the next generation of patients with early stages of AMD, who are currently under 70 years of age, are even more able and willing to use electronic games to monitor their visual function.

The strengths of this study include a large sample size of participants, all of whom had intermediate AMD. By virtue of their involvement in existing research, participants may have been more motivated to self-monitor, as well as more educated and familiar with electronic devices, compared to AMD patients in the general community. This may limit the applicability of our results to the wider community. Real-world compliance with weekly Amsler self-monitoring, and real-world use of personal electronic devices may be lower than the 39% and 91%, respectively, of participants in this study.

A large proportion of AMD patients already own and regularly use personal electronic devices for general use and a surprising number engage in daily game playing on their devices. Using these new technologies for the benefit of eye health is a logical next step. Further research is needed to investigate whether gamification of a validated visual task, for use on a tablet or smartphone, is likely to increase patient compliance with self-monitoring at home, leading to earlier detection and better long-term visual outcomes for patients with advanced AMD.

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