



Queensland University of Technology
Brisbane Australia

This may be the author's version of a work that was submitted/accepted for publication in the following source:

Wood, Joanne, Lacherez, Philippe, Black, Alexander, Cole, Michael, Boon, Mei, & Kerr, Graham

(2009)

Postural stability and gait among older adults with age-related maculopathy.

Investigative Ophthalmology and Visual Science, 50(1), pp. 482-487.

This file was downloaded from: <https://eprints.qut.edu.au/18890/>

© Consult author(s) regarding copyright matters

This work is covered by copyright. Unless the document is being made available under a Creative Commons Licence, you must assume that re-use is limited to personal use and that permission from the copyright owner must be obtained for all other uses. If the document is available under a Creative Commons License (or other specified license) then refer to the Licence for details of permitted re-use. It is a condition of access that users recognise and abide by the legal requirements associated with these rights. If you believe that this work infringes copyright please provide details by email to qut.copyright@qut.edu.au

Notice: *Please note that this document may not be the Version of Record (i.e. published version) of the work. Author manuscript versions (as Submitted for peer review or as Accepted for publication after peer review) can be identified by an absence of publisher branding and/or typeset appearance. If there is any doubt, please refer to the published source.*

<https://doi.org/10.1167/iovs.08-1942>

Postural Stability and Gait among Older Adults with Age-related Maculopathy

Joanne M Wood PhD,^{1,2} Philippe F Lacherez BSc(Hons),^{1,2} Alex A Black BAppSc(Hons),^{1,2} Michael H Cole BSc(Hons),^{2,3} Mei Ying Boon PhD,^{1,2} Graham K Kerr PhD^{2,3}

¹School of Optometry, Queensland University of Technology, Brisbane, Australia

²Institute of Health and Biomedical Innovation, Queensland University of Technology, Brisbane, Australia

³School of Human Movement Studies, Queensland University of Technology, Brisbane, Australia

The authors have no proprietary or commercial interest in the products used in this investigation.

Word count: 3192 (excluding Title page, Abstract, Tables and Figure captions)

Corresponding author: Prof Joanne M Wood, PhD, School of Optometry, QUT, Kelvin Grove, Brisbane Q 4059, Australia.

Email: j.wood@qut.edu.au

Purpose: To assess the postural stability and gait characteristics of adults with Age-Related Maculopathy (ARM) and to identify the visual factors associated with postural stability and gait in this clinical population.

Methods: Participants included 80 individuals with a range of severity of ARM (mean age = 77.2 years). Binocular visual function measures included visual acuity, contrast sensitivity and merged binocular visual fields. Postural stability was assessed on both a firm and a foam surface using centre of pressure measures derived from a force platform. Forty three of the participants underwent a three-dimensional motion analysis to quantify a number of gait characteristics, including walking velocity, proportion of time spent with both feet in contact with the ground (double support time), stride length and step width.

Results: After adjusting for age, gender, self-reported physical function, and cataract severity, all of the vision measures were significantly associated with postural stability on the foam surface, with contrast sensitivity being the strongest correlate. In the analysis of the gait measures, only contrast sensitivity was significantly associated with walking velocity, step width or stride length, while contrast sensitivity and visual field loss were both significantly associated with double support time.

Conclusions: Impaired contrast sensitivity was associated with postural instability, slower walking velocity, increased step width and reduced stride length. Impairments in either contrast sensitivity or visual fields were associated with increased double support time. This suggests that loss of contrast sensitivity and visual fields in ARM patients can lead to balance and mobility problems.

Keywords: Age-related maculopathy, balance, gait, visual function

INTRODUCTION

Effectively navigating through a complex environment requires successful integration of both sensory and motor functions. Loss of visual function may pose significant challenges to an individual in terms of such integration. Among those with low vision, important visual cues for effective locomotion may be degraded, such that individuals require more time or effort to navigate safely through their environment. While the mobility problems of individuals with age-related macular degeneration (ARM) have been well documented,¹⁻⁵ much less is known about the mechanisms underlying these problems. In the present study we assessed the balance and gait characteristics of individuals with ARM and sought to identify the visual factors associated with these characteristics in this population.

Older adults with ARM demonstrate greater magnitudes of sway when postural stability is measured under conditions of reduced somatosensory feedback compared to age-matched controls.^{1,6} This suggests that individuals with ARM are more likely to fall during times of somatosensory disruption (such as walking on carpeted flooring),¹ given that decreased postural stability is associated with an increased propensity for falling.^{7,8} Reduced contrast sensitivity has been shown to be the strongest visual predictor of increased postural sway in independent community-dwelling older adults,⁹ and in a smaller sample of adults with ARM.¹

The walking and mobility characteristics of adults with ARM have largely been measured during navigation through specially designed “mobility courses”, where performance is usually expressed as time to complete the course and/or ability to avoid obstacles. On these courses, the performance of adults with ARM has been found to be worse than that of age-matched control participants under low,¹⁰ but not under high levels of illumination.^{4,10,11} In studies which have considered the range of performance within ARM subjects, variations in mobility performance were associated with reductions in visual fields and contrast sensitivity,^{4,5} or the level of ARM (as defined by fundus appearance).¹² To date only two studies have measured the specific gait characteristics of individuals with ARM and have demonstrated that adults with ARM walk more slowly and cautiously (shorter stride length and longer time for stride and stance) than age-matched controls.^{2,3} These differences were more

apparent when walking on different surface types, although they were not related to the ambient level of illumination.^{2,3} These studies did not, however, examine the specific aspects of visual function that were associated with these gait adaptations.

Collectively, these studies have shown that individuals with ARM have problems with various aspects of mobility and balance compared to those with normal vision. Our study aimed to extend upon this by identifying which measures of visual function are associated with these balance and gait difficulties. The postural stability and gait characteristics of older adults with ARM were assessed using gold standard measures of postural stability¹³ and three-dimensional motion analysis,¹⁴ while standardised, validated measures of visual acuity, contrast sensitivity, and visual fields were included as visual function measures.

METHODS

Participants

Eighty community-dwelling individuals with retinal changes consistent with a diagnosis of ARM were recruited to participate in the study. Participants were either recruited from the School of Optometry Clinic at Queensland University of Technology, via the electoral roll, or from Brisbane-based members of the Macular Degeneration Foundation (Sydney, Australia).

Participants were required to have no significant ocular or visual pathway disease leading to visual field loss, other than ARM. Participants were excluded from the study if they were unable to walk unaided, had a history of Parkinson's disease, diabetes or peripheral neuropathy, or showed signs of dementia (Mini Mental State Examination score <24 out of 30).¹⁵ The research followed the tenets of the Declaration of Helsinki, and informed consent was obtained prior to participant assessment. The research was approved by the Queensland University of Technology Human Research Ethics Committee.

Vision Assessment

All participants underwent an eye examination, including assessment of the presence and severity of lens opacification, using the slit lamp-based Lens Opacities Classification System (LOCSIII).¹⁶ For the purpose of analysis the highest LOCS score (either nuclear, posterior subcapsular or cortical) in the eye with the better visual acuity was used as the level of cataract severity. The severity of ARM was graded independently from fundus slide photographs of each participant according to the AREDS classification scheme.¹⁷ The average of the AREDS grades for the two eyes was used in the analysis, as it places greater weight on participants with equal degeneration in both eyes, representing more severe impairment.

Binocular high contrast visual acuity was measured with participants' habitual distance refractive correction using a Bailey-Lovie high contrast letter chart at a working distance of 3.2 metres and an average luminance of 195 cd/m². Participants were instructed to guess letters, even when they were unsure, until a full line of letters was incorrectly read. Visual acuity was scored as the total number of letters read correctly, converted to logMAR units. Contrast sensitivity was measured binocularly using the paper version of the Melbourne Edge Test,¹⁸ at a working distance of 40 cm and an average luminance of 65.5 cd/m², with an appropriate near correction. Participants were asked to identify the orientation of the edge within each circular patch until two consecutive incorrect responses were made and the lowest contrast edge correctly identified recorded as the participant's contrast sensitivity in dB. Visual fields were assessed using the Humphrey Field Analyzer (Model HFA-II 750, Carl Zeiss Meditec Inc., Dublin, CA, USA). Monocular 24-2 SITA-Standard threshold tests were performed by an experienced optometrist. A binocular mean deviation (MD) score was derived by merging the right and left fields to create a binocular visual field, based on the more sensitive of the two eyes at each visual field location.¹⁹

Postural Sway Assessment

Postural sway was assessed using standardised techniques which have been employed in previous studies of balance,^{1,6,20} on two different surfaces (firm and foam), with eyes open and with participants wearing their habitual walking spectacle correction. For the firm surface condition, participants were positioned in the centre of an AccuSway force platform (Advanced Mechanical Technology Inc., Watertown, MA,

USA) and asked to stand as still as possible for a period of 30 seconds. For the foam surface trials, the participants stood on a medium-density 15 cm thick block of foam with a surface area of 50 cm², which was positioned over the surface of the force platform. This condition reduced the somatosensory input to balance control. For both conditions, the participants were instructed to place their feet 10 cm apart while gazing directly ahead at a cross subtending 1.43 degrees in width which was mounted on a wall. To ensure the participants' safety, a member of the research team stood nearby to help steady the participants if they became unbalanced. During each 30 second trial, centre of pressure data were collected by the force platform at a sampling rate of 50 Hz and provided information on the anterior-posterior and medio-lateral sway of the individual. The extent of postural sway was represented by the overall length of the centre of pressure path for the firm and the foam surface. Several common measures derived from the centre of pressure data were compared (anterior-posterior and medio-lateral extent and RMS amplitude, elliptical area and rectangular area). Of these measures, path length had the best predictive validity, in that this measure had more robust correlations with the vision measures at the bivariate level, and these bivariate relationships better met the assumptions of multiple regression in having evenly distributed, or homoscedastic, residuals. Path length has also shown to be been a strong predictor of postural instability and falls in previous prospective studies.²¹ Due to equipment problems, only data from 77 participants were available for analysis.

Gait Assessment

Forty-three participants (those who were recruited via the Optometry clinic or Macular Degeneration Foundation) also completed a gait assessment while wearing their habitual walking spectacle correction. Each participant was asked to walk at a self-selected and comfortable pace along a firm walkway measuring 12 metres (6 trials) at an average illumination of 468 lx. To remove any influence of shoe design on gait characteristics, the participants performed the trials in a barefooted condition, which is in accordance with methods used in previous clinical gait assessments.^{22,23} Twenty eight spherical markers were positioned on the body in accordance with the Helen Hayes marker set,²⁴ which was modified to include the upper body. Markers were attached to the trunk (sacrum, sternum and C7 spinous process), arms (lateral border of the acromion, olecranon process of the humerus, radial and ulnar styloids),

and head (supra-auricular point and the top of the head). During the walking trials, the motion of these markers was tracked at a rate of 50Hz using a six-camera three-dimensional motion analysis system (Peak Motus 2000; Vicon, Oxford, UK). The three-dimensional position of the markers was used to calculate stride length, double support time (percent time spent with both feet in contact with the ground), step width (distance between right and left heels during double support) and walking velocity (stride length divided by stride period)²⁵ as shown in see Figure 1. The selection of these variables was based on the knowledge that older individuals often seek to reduce stride length and walking velocity and increase double support time in an attempt to minimise postural instability.²⁶

Figure 1 about here

Questionnaire

A measure of physical function was derived from the SF-36 physical function scale. This self-reported measure was used to provide an index of the general physical functioning and health of the participants and has been shown to be an effective and valid health care measure in older community-based populations.²⁷

Statistical Analyses

We examined the association of the vision measures with the postural sway and gait outcome measures. Characteristics considered likely to be associated with visual impairment, postural sway and gait characteristics were included as potential confounders (age, gender, physical function, and cataract severity). To assess the relative contributions of each vision variable to each of the postural sway and gait outcome measures, while maximising the ratio of cases to variables, a series of stepwise regression analyses were performed using a forward selection procedure. The forward selection technique is appropriate in instances where the goal is to derive a minimal set of predictor variables that maximise prediction of a given criterion.²⁸ First, partial correlations were examined for each independent variable/dependent variable pair controlling for the covariate set. Then, multivariate regressions were performed in which entry to the model was controlled by whether the inclusion of the variable in the model significantly improved model performance.

RESULTS

Demographic characteristics, visual function, postural stability and gait data for the participants are given in Table 1, while Table 2 presents the range of AREDS classifications for participants in the sample.

[Tables 1 and 2 about here](#)

The mean age of the participants was 77.2 years with a range from 59 to 95 years of age. There were more women than men in the sample (36 males, 44 females), which is typical of those with ARM.²⁹ There was wide range of severity of ARM within our participants, according to their AREDS score and the level of their binocular visual acuity, contrast sensitivity and visual field loss. The subset of participants who took part in the gait assessments ($n = 43$) were younger on average (mean age = 75.8 years, $SD = 7.2$), and overall had poorer visual function (mean visual acuity = 0.39 logMAR, $SD = 0.47$) than those who did not. All participants undertook the balance and gait assessments wearing their habitual walking spectacle correction which included 32% wearing bifocals, 23% progressive lenses, 4% trifocals, 5% single correction, and 36% no correction. No differences were found for any of the sway or gait outcome measures according to the type of habitual walking spectacle correction worn.

The postural stability and gait characteristics of our sample of individuals with ARM also demonstrated a wide range of performance levels across the group. The effect of disrupting the information from the somatosensory system by standing on the foam was highly significant, where the length of the centre of pressure path on the foam surface was longer than that on the firm ($t(76) = -14.05$, $P < .001$).

Table 3 shows the partial correlations between the vision measures and the performance measures of postural sway and gait including walking velocity, stride length, step width and double support time. Covariates were age, gender, physical function, and cataract severity. Table 4 shows the multivariate linear regression models for each outcome measure.

[Table 3 about here](#)

Contrast sensitivity, visual acuity and visual field loss were all significantly associated with postural stability on the foam surface at the bivariate level. Figure 2A shows the relationship between contrast sensitivity and postural sway on foam. For each measure, reductions in visual function were associated with greater postural instability, after controlling for the covariate set. In the multivariate model (Table 4) the only vision measure that was significant was contrast sensitivity, indicating that the other vision variables did not significantly add to the prediction of postural sway on the foam surface after contrast sensitivity was taken into account. None of the vision variables were correlated with sway on the firm surface.

Table 4 and Figure 2 about here

At the bivariate level, contrast sensitivity was significantly associated with all four of the gait measures after controlling for the covariate set, while visual field loss was only significantly associated with double support time and the AREDS score was associated with walking velocity and stride length. Poorer scores in these vision measures were associated with shorter stride length and wider step width, slower walking velocity and longer double support time (illustrated for contrast sensitivity and walking velocity in Figure 2B). Visual acuity was not significantly associated with any of the gait measures. In the multivariate model only contrast sensitivity was significantly associated with these gait characteristics. The other vision measures did not significantly add to the prediction of these outcome measures after reductions in contrast sensitivity were taken into account (Table 4).

For those bivariate analyses where visual field loss was significantly associated with the sway and gait outcome measures, we also explored the question of whether visual field loss in the upper or lower hemifield was more strongly associated with these outcome measures, again controlling for the same covariates. Greater inferior field loss was found to be the better predictor of increased sway (inferior, $r = -0.324$, superior, $r = -0.212$), while greater superior field loss was the better predictor of increased double support time (inferior, $r = -0.186$, superior, $r = -0.414$).

DISCUSSION

Our study demonstrated that increasing visual impairment due to ARM was significantly associated with postural instability and gait problems measured within a controlled laboratory environment. Poorer visual function was associated with greater postural instability and gait adaptations including shorter steps, wider stance, slower walking speed and more time spent with both feet on the ground. Of the visual functions examined, contrast sensitivity was the strongest individual predictor of each outcome, while visual fields were related to only some of the gait parameters. It is likely that these associations may be even stronger in the real world environment which is far more visually challenging, and in a frailer population.

Our study found that contrast sensitivity was the only visual function measure significantly associated with sway on a foam surface, when the visual function measures were combined in a multivariate model. This is consistent with the findings of Elliott and co-workers¹ who reported a significant association between contrast sensitivity and postural sway in the foam condition in adults with ARM, but little association between postural sway and central visual field measures. Our findings are also in accord with balance studies from general older populations, where reduced contrast sensitivity was the strongest independent visual predictor of postural sway.⁹ The finding that visual function was predictive of postural stability on the foam and not the firm surface was not unexpected given that the contribution of vision to postural stability increases under conditions of reduced somatosensory input.⁹

Furthermore, we found that contrast sensitivity was the only visual function measure significantly associated with the gait adaptations in the multivariate models. The gait adaptations associated with reduced contrast sensitivity included shorter strides, wider steps, slower walking speed and more time spent with both feet on the ground. These characteristics have been postulated to be representative of a more conservative walking pattern and are thought to occur due to an increased degree of caution being adopted by a particular individual.^{26,30,31} While our study is the first to investigate the visual predictors of gait adaptations in ARM, Spaulding et al.² demonstrated that those with ARM, as compared to controls, also adopted more cautious gait patterns when walking in challenging environments.

The finding that contrast sensitivity is the best predictor of gait adaptations complements previous mobility research involving relatively complex obstacle courses.^{4,5} These studies suggest that the most important predictors of mobility performance in ARM patients were impaired contrast sensitivity and visual fields. It is likely that the contribution of visual field loss in safe navigation through these complex mobility courses is greater than that found in this study due to the inclusion of peripheral obstacles and increased path complexity. Importantly, the findings in the current study do indicate that visual field loss was significantly associated with increased double support time in the bivariate analyses, suggesting that a combination of visual field and contrast sensitivity may play an important role in determining the gait adaptations among older adults with ARM. Previous research has suggested that falls may occur more frequently in those individuals with inferior field loss.³² However, while our findings suggest that greater inferior field loss was more strongly associated with increased postural sway, greater superior field loss was more strongly associated with increased double support time.

This study has important strengths in that we have used well established and standardized measures of postural stability, gait and visual function. Our measure of postural stability based on force platform data and the three-dimensional motion analysis are considered to be gold-standard measures of balance¹³ and gait.¹⁴ There are, however, a number of limitations that should be addressed in further research. Firstly, although the sample size used in these analyses is larger than many others in this field, the large degrees of freedom for the effects (the number of predictors and covariates in the model) reduce the power of some analyses. Further research using larger samples would strengthen the conclusions made. It would also be useful to investigate the relationship between changing visual function and gait longitudinally within an ARM sample, rather than cross-sectionally. Further research is also needed to examine whether these changes found in our laboratory-based study are also mirrored during real-world navigation in both novel and familiar environments.

In summary, this study demonstrated that visual impairment among older adults with varying levels of ARM affects postural stability and gait characteristics. Impaired contrast sensitivity was associated with postural instability, slower walking velocity, increased step width and reduced stride length, while impairments in either contrast

sensitivity or visual field sensitivity were associated with increased double support time. These findings suggest that eye care providers should be aware that increasing loss of contrast sensitivity and visual fields in their patients with ARM may lead to difficulties in balance and mobility.

ACKNOWLEDGMENTS

Funding support was received from the NHMRC Prevention of Injuries in Older People Partnership in Injury grant. The Macular Degeneration Foundation (Sydney, Australia) is thanked for their assistance in recruiting participants to this study, as are all of the participants who gave so generously of their time. The authors would also like to thank Roger Martin, Melissa Newton, Matthew Roodveldt, Jocelyn Stewart, Oren Tirosh and Paul Turner for assistance in various stages of the laboratory-based data collection.

REFERENCES

1. Elliott DB, Patla AE, Flanagan JG, Spaulding SJ, Rietdyk S, et al. The Waterloo Vision and Mobility Study: Postural control strategies in subjects with ARM. *Ophthalmic & Physiological Optics* 1995;15:553-559.
2. Spaulding SJ, Patla AE, Elliott DB, Flanagan J, Rietdyk S, Brown KS. Waterloo Vision and Mobility Study: Gait adaptations to altered surfaces in individuals with age-related maculopathy. *Optometry & Vision Science* 1994;71:770-777.
3. Spaulding SJ, Patla AE, Flanagan J, Elliott DB, Rietdyk S, Brown KS. Waterloo Vision and Mobility Study: Normal gait characteristics during dark and light adaptation in individuals with age-related maculopathy. *Gait & Posture* 1995;3:227-235.
4. Hassan SE, Lovie-Kitchin JE, Woods RL. Vision and mobility performance of subjects with age-related macular degeneration. *Optometry & Vision Science* 2002;79:697-707.
5. Kuyk T, Elliott JL. Visual factors and mobility in persons with age-related macular degeneration. *Journal of Rehabilitation Research & Development* 1999;36:303-312.
6. Turano KA, Dagnelie G, Herdman SJ. Visual stabilization of posture in persons with central visual field loss. *Investigative Ophthalmology & Visual Science* 1996;37:1483-1491.
7. Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. *New England Journal of Medicine* 1988;319:1701-1707.
8. Turano KA, Rubin G, Herdman S, Chee E, Fried L. Visual stabilization of posture in the elderly: Fallers vs. nonfallers. *Optometry & Vision Science* 1994;71:761-769.
9. Lord SR, Menz, HB. Visual contributions to postural stability in older adults *Gerontology* 2000;46:306-310.
10. Brown B, Brabyn L, Welch L, Haegerstrom-Portnoy G, Colenbrander A. Contribution of vision variables on mobility in age-related maculopathy patients. *American Journal of Optometry & Physiological Optics* 1986;63:733-739.
11. Wilcox DT, Burdett, R. Contrast sensitivity function and mobility in elderly patients with macular degeneration. *Journal of the American Optometric Association* 1989;60:504-507.
12. Klein R, Klein BEK, Knudtson MD. Frailty and age-related macular degeneration: The Beaver Dam Eye Study. *American Journal of Ophthalmology* 2005;140:129-131.
13. Vuillerme N, Chenu O, Pinsault N, Boisgontier M, Demongeot J, Payan Y. Inter-individual variability in sensory weighting of a plantar pressure-based, tongue-placed tactile biofeedback for controlling posture. *Neuroscience Letters* 2007;421:173-177.
14. McLean SG, Walker K, Ford KR, Myer GD, Hewett TE, van den Bogert AJ. Evaluation of a two dimensional analysis method as a screening and evaluation tool for anterior cruciate ligament injury. *British Journal of Sports Medicine* 2005;39:355-362.

15. Heun R, Papassotiropoulos A, Jennssen F. The validity of psychometric instruments for detection of dementia in the elderly general population. *International Journal of Geriatric Psychiatry* 1998;13:368-380.
16. Chylack LT, Jr., Wolfe JK, Singer DM, Leske MC, Bullimore MA, et al. The Lens Opacities Classification System III. The Longitudinal Study of Cataract Study Group. *Archives of Ophthalmology* 1993;111:831-836.
17. The Age-Related Eye Disease Research Group. The Age-Related Eye Disease Study (AREDS) system for classifying age-related macular degeneration from stereoscopic color fundus photographs: AREDS Report No. 6. *American Journal of Ophthalmology* 2001;132:668-681.
18. Verbaken JH, Johnston AW. Population norms for edge contrast sensitivity. *American Journal of Optometry & Physiological Optics* 1986;63:724-732.
19. Nelson-Quigg JM, Cello K, Johnson CA. Predicting binocular visual field sensitivity from monocular visual field results. *Investigative Ophthalmology & Visual Science* 2000;41:2212-2221.
20. Lord SR, Menz HB, Tiedemann A. A physiological profile approach to falls risk assessment and prevention. *Physical Therapy* 2003;83:237-252.
21. Lord SR, Clark RD, Webster IW. Postural stability and associated physiological factors in a population of aged persons. *Journal of Gerontology* 1991;46:M69-76.
22. Lord SR, Lloyd DG, Li SK. Sensori-motor function, gait patterns and falls in community-dwelling women. *Age & Ageing* 1996;25:292-299.
23. Chan GNY, Smith AW, Kirtley C, Tsang WWN. Changes in knee moments with contralateral versus ipsilateral cane usage in females with knee osteoarthritis. *Clinical Biomechanics* 2005;20:396-404.
24. Kadaba MP, Ramakrishnan HK, Wootten ME. Measurement of lower extremity kinematics during level walking. *Journal of Orthopaedic Research* 1990;8:383-392.
25. Perry J. *Gait analysis: Normal and pathological function*. Thorofare, NJ: Slack Incorporated; 1992.
26. Woollacott MH, Tang PF. Balance control during walking in the older adult: Research and its implication. *Physical Therapy* 1997;77:646-660.
27. Chia EM, Rochtchina E, Wang JJ, Mitchell, P. Utility and validity of the self-administered SF-36: findings from an older population. *Ann Acad Med Singapore* 2006;35:461-467.
28. Tabachnick BG, Fidell LS. *Using Multivariate Statistics*. 5th ed. Boston: Allyn and Bacon; 2007.
29. van Newkirk MR, Nanjan MB, Wang JJ, Mitchell P, Taylor HR, McCarty CA. The prevalence of age-related maculopathy: The visual impairment project. *Ophthalmology* 2000;107:1593-1600.
30. Maki BE. Gait changes in older adults: Predictors of falls or indicators of fear? *Journal of the American Geriatrics Society* 1997;45:313-320.
31. Sudarsky L. Geriatrics: Gait disorders in the elderly. *New England Journal of Medicine* 1990;32:1441-1446.
32. Coleman AL, Cummings SR, Yu F, Kodjebacheva G, Ensrud KE, et al. Binocular visual-field loss increases the risk of future falls in older white women. *Journal of the American Geriatrics Society* 2007;55:357-364.

Table 1. Group mean, standard deviation and range for vision, postural sway and gait measures

	Mean (sd)	Range
Age (years)	77.18 (6.89)	59 - 95
Binocular visual acuity (logMAR)	0.31 (0.42)	-0.14 - 1.38
Binocular contrast sensitivity (dB)	16.43 (4.57)	5 - 24
Binocular field mean deviation (dB)	-2.8 (4.44)	-21.89 - 3.46
AREDS score (average of both eyes)	2.37(1.12)	1 - 4
Postural sway firm (cm)	36.92 (12.06)	18.17 - 87.39
Postural sway foam (cm)	52.04 (22.99)	24.94 - 155.3
Walking velocity (m/s)	1.08 (0.25)	0.66 - 1.73
Double support (%)	24.85 (4.83)	15.53 - 38.83
Step width (m)	0.18 (0.06)	0.07 - 0.3
Stride length (m)	1.14 (0.19)	0.73 - 1.5

Table 2. AREDS classification for participants in this sample

AREDS Score	Number of participants (percent)	
	Best Eye	Worst Eye
0 -1 (early)	22 (27.5 %)	12 (15 %)
2 (early to mid-stage)	21 (26.3 %)	14 (17.5 %)
3 (mid-stage to advanced)	14 (17.5 %)	16 (20 %)
4 (advanced)	18 (6.3 %)	33 (41.3 %)
Missing	5 (6.3 %)	5 (6.3 %)
	80 (100%)	80 (100%)

Table 3. Partial correlations between vision measures (independent variables) and sway and gait variables (dependent variables) controlling for age, gender, physical function, and cataract severity

	Sway Firm	Sway Foam	Walking Velocity	Stride Length	Step Width	Double Support Time
Binocular Contrast Sensitivity	-0.04	-0.33**	0.40*	0.35*	-0.36*	-0.34*
Binocular Visual Acuity	0.08	0.29*	-0.19	-0.12	0.28	0.13
Binocular Visual Field	-0.01	-0.28*	0.24	0.20	-0.31	-0.32*
AREDS Score	0.00	0.13	-0.32*	-0.33*	0.28	0.27

*p<.05, **p<.01

Table 4. Stepwise multiple regression analyses using vision measures as predictors, age, gender, physical function and cataract severity as covariates, with the dependent variables of postural sway on a foam surface, walking velocity, stride length, step width and double support time. Variables included in the final model are shown at the top of the table. Variables not included in the final model are presented below together with their respective Beta-to-enter values

Sway foam			Walking velocity			Stride length			Step Width			Double support time		
Variables included	Beta	P		Beta	P		Beta	P		Beta	P		Beta	P
Age	0.44	<.01	Age	-0.39	0.01	Age	-0.30	0.04	CS	-0.45	<.01	CS	0.39	0.01
CS	-0.27	0.01	CS	0.37	0.01	CS	0.35	0.02				Age	-0.32	0.03
						Gender	-0.28	0.03						
Variables not included														
Gender	0.08	0.42	Gender	-0.05	0.71	PF	0.17	0.21	Age	0.22	0.16	Gender	0.13	0.29
PF	0.19	0.05	PF	0.19	0.14	Cataract	0.02	0.89	Gender	-0.15	0.30	PF	-0.25	0.06
Cataract	-0.15	0.13	Cataract	-0.03	0.82	Fields	-0.02	0.92	PF	0.04	0.77	Cataract	0.03	0.85
Fields	-0.04	0.77	Fields	0.00	0.82	VA	0.32	0.16	Cataract	-0.01	0.97	Fields	-0.19	0.30
VA	0.13	0.44	VA	0.30	0.19	AREDS score	-0.05	0.84	Fields	-0.15	0.44	VA	-0.31	0.19
AREDS score	-0.20	0.17	AREDS score	0.10	0.65				VA	-0.12	0.65	AREDS score	-0.12	0.63
									AREDS score	-0.03	0.90			

PF: Physical Function
 VA: Visual Acuity
 CS: Contrast Sensitivity

Figure 1. The events measured in the gait cycle. Double support is defined as the time during which both feet are in contact with the ground. The black leg is the left.

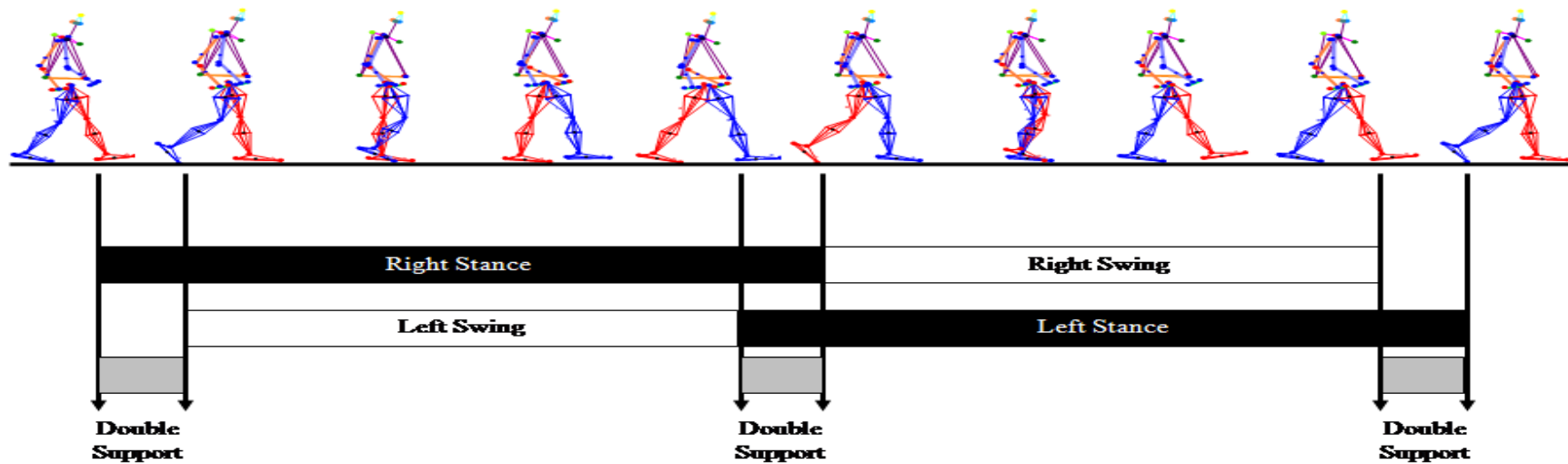


Figure 2. Relationship between contrast sensitivity (Melbourne Edge Test), path length for sway on a foam surface (A), and walking velocity (B)

