2013 Fry Lecture: Blurred vision, spectacle correction and falls in older adults

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Abstract

This paper reviews the literature on how blurred vision contributes to falls, gait and postural control and discusses how these are influenced by spectacle correction. Falls are common and represent a very serious health risk for older people. They are not random events as studies have shown that falls are linked to a range of intrinsic and extrinsic risk factors. Vision provides a significant input to postural control in addition to providing information about the size and position of hazards and obstacles in the travel pathway and allows us to safely negotiate steps and stairs. Many studies have shown that reduced vision is a significant risk factor for falls. However, randomized controlled trials of optometric interventions and cataract surgery have not shown the expected reduction in falls rate, which may be due to magnification changes (and thus vestibulo-ocular reflex gain) in those participants who have large changes in refractive correction. Epidemiological studies have also shown that PAL and bifocal wearers are twice as likely to fall as non-multifocal wearers, lab based studies have shown safer adaptive gait with single vision glasses than PAL or bifocals and a randomized controlled trial has shown that an additional pair of distance vision single vision glasses for outdoor use can reduce falls rate. Clinical recommendations to help optometrists prevent their frail, older patients from falling are suggested.

Keywords: blurred vision, spectacle correction, falls, gait, postural control

This review of how vision is linked with postural control, gait and falls in older adults, builds on earlier reviews [1-5] and concentrates on the role of refractive correction.

Consequences of falls

Falls are the major cause of accidental death and non-fatal injuries in elderly US adults.[6] About 21,700 older US adults died from fall-related injuries in 2010 and

2.3 million non-fatal injuries among older adults were treated in emergency departments with more than 660,000 hospitalized, at a direct cost of about $30 billion.[6] Fall-related injuries include lacerations, hip and other fractures. Furthermore, even non-injurious falls have significant consequences as they can lead to a fear of falling which, in turn, results in a self-imposed restriction of functional activity such as curtailing shopping or house cleaning. This can have an avalanche effect as the activity restrictions can lead to decreased mobility and independence, social isolation, deteriorating health and depression, which all mean that the person is more likely to fall again.[5]

Falls are common and not accidents

Falls are common with at least a third of community-dwelling, healthy adults aged 65 years and over falling once a year or more, [2,5] increasing to about 60% in those aged 90 years and over. Indeed, these falls rate data are likely underestimates (due to poor memory recall [7]) as they were obtained from retrospectively questioning older people about falls in the previous year. Falls in older adults are not random, chance events or 'accidents', but typically multifactorial and linked to 'geriatric syndromes' with risk factors that include increasing age, female gender, lower-limb disabilities, impaired muscle strength, hypotension, stroke, arthritis, diabetes, cognitive impairment, Parkinson's disease, visual impairment, sedative use, polypharmacy (taking more than four prescription medications per day) and a history of falls.[8-9] The more risk factors you have, the more likely you are to fall. For example, Tinetti and colleagues[8] found an approximately linear relationship between falls and risk factors ranging from an 8% falls rate with none to 78% with four or more risk factors.

The most common cause of fall-related injuries in older adults are trips, slips and stumbles (57% of 1.69 million fall injuries in older US adults between 2001 and 2003), with 27% being due to loss of balance, dizziness, fainting or a seizure.[10] In addition, steps, stairs and curbs are the most common environmental hazard associated with a fall in older people with visual impairment (30% of all hazard-related falls, which constituted 57% of all falls).[11] Injuries are particularly associated with descending stairs, with associated injuries being about three times more frequent than stair ascent injuries.[12] As Templer dramatically phrased it: 'To fall down stairs is not only to fall off a cliff, but to fall on rocks below, for the nosing of steps presents a succession of sharp edges'.[13]

The link between vision and falls 1: Postural control during standing

Postural (or balance) control is the ability to keep the body's center of mass above the base of support (typically 50% of the area under and between the feet) as even when attempting to stand still, the body sways slightly in response to respiration for example (Figure 1). Inputs from the visual, vestibular and somatosensory systems are integrated centrally and instructions sent to the motor system to maintain balance. The vestibular system monitors motion and spatial orientation, with the semi-circular canals of the inner ear monitoring rotational head movements and the utricle and saccule monitoring linear head movements and the acceleration of gravity.[14] The somatosensory system receives sensory input from receptors throughout the body that indicate the position and movement of the feet, legs, arms, body and head. For example, mechanoreceptors provide pressure information from the surface of the feet, proprioceptive information from the ankles monitor the body's sway movement and information from the neck indicates the way that the head is turned and/or tilted.[14] Two aspects of visual input likely play a role in both standing balance and postural stability during more dynamic tasks such as walking: optical flow provides information about antero-posterior body sway as evidenced by moving room experiments that artificially manipulated optical flow[15] and information from eye movements likely provides information about lateral body sway. Movement of the focused retinal image is less likely to be involved in detecting lateral body sway as the movement would be automatically corrected by the vestibulo-ocular reflex, although information from motion parallax of out-of-focus objects may also aid lateral postural stability.[15] Although the peripheral visual system is important in the assessment of optical flow and thus postural control, it may not be dominant or functionally specialized compared to central vision as has been suggested, as their effects are similar when equated in size.[15,16] Not surprisingly, vision plays a bigger role in postural control when input from the somatosensory and/or vestibular systems are disrupted.[17,18] Given the importance of both central and peripheral vision plus eye movements to visual control of balance, it is not surprising that standing postural control has been shown to be poorer with dioptric blur, cataract and age-related macular degeneration; with reduced visual field and glaucoma and with a variety of eye movement disorders.[17-22]

The link between vision and falls 2: Locomotion and stair negotiation

Vision is also used to adapt gait to enable safe travel though the environment, avoiding obstacles and negotiating steps and stairs. Global assessments of locomotion can be provided by measurements of time taken and the number of 'hits' as subjects complete an obstacle course, but more detailed assessments of gait can be provided by 3-D movement analysis systems (see Figure 2 and supplementary video-clip), often used in combination with force platforms. Typically vision is used to scan the travel pathway for obstacles and changes in terrain, with greater amounts of visual sampling used as the task becomes more challenging.[22] This is a feed-forward or planning system and is typically used to scan 1-2 steps ahead[3,23] with the information being kept in short-term visual memory. In addition, an online 'fine tuning' of gait is provided by expproprioception (position of the lower limbs relative to the environment) information from the peripheral visual system[3,24] and particularly the lower peripheral visual field.[3,25]

Vision is known to play a major role in successful stair negotiation [12,13] and the initial visual scan checks for objects on the stairs, the regularity of step size and shape, other people, possibly choices of route and the position and height of the first step.[13] Looking at the first step is very important in successful negotiation of stair descent and ascent[26] and fixations are aimed at step tread edges, particularly in stair descent.[27] When the lead foot is first placed on the step tread and the trail foot remains on the floor, somatosensory information about the position of the feet provides additional information about the size of the step. Additional information about step height is also provided by the size of the drop in height from the position of maximum foot elevation in the swing phase of the gait cycle and its final position on the step tread. Further somatosensory information about the antero-posterior position of the step edge will be provided by the extent of overhang of the forefoot in step descent and heel in step ascent. Negotiating stairs is tiring work, particularly for older people,[12] so that energy conservation strategies are used which leads to typically low foot clearances when it is safe to do so. When descending stairs, foot clearances become progressively smaller,[28,29] presumably as the combined information from occasional central vision fixations (fixation of every step is not required[27]), peripheral vision expproprioceptive and somatosensory information provides increasingly accurate assessments of the step riser and tread dimensions[12] These sensory inputs regarding successive step dimensions might also confirm that the initial visual assessment that all steps in a flight are the same size so that it is safe to progressively decrease foot clearance.

Vision becomes increasingly more important at the top (when ascending) or bottom (when descending) of the stairs when a transition to a floor surface is required.[12] Fall-related accidents in older adults are three times more likely to occur during stair descent compared to stair ascent,[12,13] with a higher incidence occurring on either the top three or bottom three stairs when vision is increasingly relied upon.[12,13] Reduced foot/heel clearances, greater clearance variability over the stair-edge and misjudgements in foot placement when descending surface level changes or flights of stairs are factors that are reported to increase the falls risk.[28,29]

Reduced vision and gait

With central vision loss, typically minimal changes are seen with simple walking tasks but caution-based strategies are used when task difficulty is increased and there is a greater chance of falling.[30] Locating the first step edge position may be particularly problematic for older adults when the lighting levels are low and/or the stair covering is patterned and/or if their vision is blurred at that intermediate distance.[12,13,29,31] In addition to good contrast sensitivity and visual acuity, good stereoacuity may also be important to accurately determine the first step edge position. For example, improvements in stereoacuity due to cataract surgery have been found to be correlated with the change in lead-limb toe clearance when negotiating an obstacle.[32]

With adaptive gait, a variety of caution-based strategies are used when vision is blurred. For example, with simulated cataract when stepping up, subjects used a threefold safety-driven adaptation.[31] First, to increase dynamic stability they ensured that the horizontal position of their center of mass was kept close to the center of the base of support (i.e. support limb); second, they increased toe clearance while swinging their lead limb forward to reduce the risk of tripping; and finally, they also slowed their forward movement, which increases the likelihood of recovering balance if a trip occurs.[31] However, these adaptations have a downside. Because the gait is slowed and foot lifted higher, the stepper is in single-limb support (only one leg is on a surface, the other is swinging up or down over a step edge) for longer[31] and single-limb support is the most dangerous part of the stepping process. Indeed, single-limb support stability in the medial–lateral direction has been shown to be considerably reduced with blurred vision, especially when stepping down and particularly from a high step.[33] This may help explain why sideways falls on stairs occur in older adults, particularly with higher step heights. When stepping down (with simulated cataract), subjects were more cautious and attempted to 'feel' their way to the floor rather than 'drop' on to it. This may have been an adaptation to increase the somatosensory information from the lower limb to make up for the unreliable or incomplete visual information.[33]

Epidemiological studies: Visual impairment and falls

Although most epidemiological studies have shown that visual impairment (typically defined as binocular visual acuity worse than 6/12 or 6/18) is a significant and independent risk factor for falls with an odds ratio of about 2.5, not all studies report a link between poor vision and falls.[34] This likely highlights the limitations of epidemiological data regarding vision and falls, rather than suggesting that visual impairment is a relatively minor risk factor for falls. One limitation is that the participants' vision may be different between when it was measured in the study (at the beginning of a prospective study that monitors whether people fall in the following year and at the end of a retrospective study that attempts to determine whether people fell in the previous year) from that when the fall actually occurred. For example, vision measurements would likely be made with spectacles if usually worn, but if these spectacles were updated after vision measurement in a prospective study or after a fall in a retrospective study, this is not usually captured in the data collection. In addition, there is often no determination of whether the subjects were wearing spectacles at the time of their fall and it has been shown in accident research (and is well known to optometrists) that people do not always wear their spectacles when they should and can even wear reading glasses when walking about.[35] In addition, most studies have measured visual impairment based on visual acuity only, when other aspects of vision might show a better link with falls (such as visual field assessments,[36,37] contrast sensitivity and stereoacuity [4,37]) and/or changes in visual acuity/function may be more associated with falls than the actual level of visual acuity.[38] In summary, the majority of the current epidemiological evidence likely underestimates the link between poor vision and falls and more well designed studies are required. These should include measurements of contrast sensitivity, stereoacuity (measured at distance?) and binocular visual fields as well as visual acuity (measured using logMAR charts) and participants should be asked to report if and when they acquire new spectacles or receive other ophthalmic treatment, the type of spectacles worn and whether they were wearing spectacles at the time of any falls.

Emergency clinic studies

Emergency clinic studies may provide a better indication of the importance of poor vision with falls as the level of vision is typically measured soon after the fall. Clinical audit studies have reported that many older adults who attended emergency clinics because of a fall or who had undergone hip fracture surgery [39] had visual impairment (46%[39], 59%[40], 76%[41]), with binocular visual acuity worse than 20/40 [40] or 20/60.[39,41] Importantly, they also reported that a large percentage of this poor vision (79%[41], 66%[39]) was correctable by cataract surgery or updated spectacles.

Prevalence of correctable reduced vision

Correctable poor vision is common in the US, particularly in older people. In the Projecto VER study, 15% of 1812 Mexican-American adults over 60 had habitual visual acuity worse than 20/40, with prevalences of 10% between 60-69, 17% between 70-79 and 34% in those aged 80+.[42] They report that 73% of the reduced vision in their whole sample (they do not report this for different age groups) was correctable to better than 20/40 with their subjective refraction results.[42] In the NHANES study, 11% of 2853 American adults over 60 years of age had habitual visual acuity of 20/50 or worse and about 60% of these could be improved to 20/40 or better using an autorefractor prescription.[43] This suggests that there are many older people with outdated glasses or no glasses at all who may benefit from wearing glasses with updated prescriptions.[43] The prevalence of poor vision was higher in persons who were of black, Hispanic, or other ethnicity or who were poor, less educated, or lacked private health insurance.[43] This suggests that health care access and resources are important barriers to consider in addressing the need for refractive correction. Poor vision due to cataract can also be found in older US adults. The Salisbury Eye Study found that 2.7% of older African Americans and 1% of White Americans had best corrected (subjective refinement of an autorefractor result) visual acuity worse than 20/40 due to cataract.[44]

Optometric interventions on falls rate

The research evidence described above indicates that falls are common in older people, they can have substantial effects on morbidity and mortality and they are increased in older people with visual impairment. In addition, correctable poor vision is relatively common in older people. The answer seems obvious: provide updated spectacles and cataract surgery to older people at risk of falling and falls rates will reduce, and several randomized controlled trials (RCTs; these are considered the gold standard for evidence-based medicine / optometry) have been reported that tested this hypothesis. Although one multi-intervention RCT found a reduced falls rate, the individual effect of optometric interventions was not reported.[45] However, in the multi-intervention RCT by Day and colleagues, ophthalmic intervention showed no effect on its own and only a modest 11% reduction in falls rate when combined with exercises. [45] The evidence from studies of the effect of cataract surgery on falls rate is similarly limited. McGwin and colleagues reported no difference in falls rate between patients who had undergone cataract surgery (*n* = 122) and a control group of patients with cataract who did not have surgery (*n* = 92), although this was not an RCT and may be open to bias.[46] Harwood and colleagues had approximately 150 participants in each arm of their RCT of first-eye cataract surgery and found a similar falls rate in the intervention and control groups (49% vs. 45%) during the year after surgery.[47] However, they also reported small reductions in recurrent falls (i.e. two or more; 18% vs. 25%) and number of fractures (3% vs. 8%) with cataract surgery.[47] Foss et al. recruited about 120 participants to each arm of a second-eye cataract surgery RCT and reported no difference in falls (40% vs. 34%), recurrent falls (18% in each group) or fractures (4% vs. 2%) post surgery.[48]

The findings of cataract surgery and injury/hip fracture data from hospital records also present conflicting results. Analysis of over 28,000 Western Australian hospital data from patients over 60 who had received bilateral cataract surgery found that the risk of an injurious fall that required hospitalization increased by 114% (risk ratio: 2.14, 95% confidence interval: 1.82 to 2.51) between first- and second-eye cataract surgery compared with the two years before first-eye surgery and by 34% in the 2 years after second-eye cataract surgery compared with the 2 years before first-eye surgery (risk ratio: 1.34, 95% CI, 1.16–1.55).[49] However, analysis of over 1 million US Medicare data from patients 65 years and older (after adjustment using logistic regression modeling as the subjects undergoing cataract surgery were older than those that did not for example) suggested that cataract surgery reduced the risk of hip fracture by 16% (adjusted odds ratio: 0.84; 95% CI, 0.81-0.87). [50]

Limitations in optometric intervention RCTs

Two limitations of optometric intervention RCTs that could prevent improvements in falls rate being found include non-representative study participants and the influence of ethical issues. A representative sample of participants would include both those patients who regularly seek optometric care and those who do not, but the former are more likely to be easily contactable and agree to participate in a clinical trial and may be over-represented in RCTs.

For example, in Close et al.'s multi-intervention RCT, only 27 of 152 participants (18%) required referral to their optometrist [40] and in Day and colleagues RCT, of the 547 randomly selected to receive an ophthalmic care intervention, a mere 26 participants (5%) had some form of treatment that they wouldn't otherwise have had, with 20 obtaining new spectacles and six having some form of surgery.[45] In addition, ethical considerations mean that control group participants in optometric intervention RCTs cannot be told to avoid optometric services and they are typically asked to keep to their 'usual care'. Ethical considerations also mean that all study participants must be informed of the aims of a study ("This study is intended to determine whether updating spectacles leads to a reduction in falls rate…"), so that some participants in control groups could be tempted to obtain additional ophthalmic care beyond 'the usual', having been alerted to their potential benefits by study participation.[45] For example, in the multi-intervention RCT by Day et al.[45], there was no change in visual acuity in the intervention group, yet visual acuity marginally improved in the control group! It seems that the extent that control groups in RCTs restrict themselves to their 'usual care' depends on how easy it is to obtain the potential benefits of any intervention and obtaining optometric care is relatively easy.[45] It is little wonder that the Day et al study found no effect on falls rate of ophthalmic interventions on their own. However, these considerations do not explain the overall lack of an effect of cataract surgery on falls rate, which may be better explained by the results of an optometric intervention study discussed below.

RCT shows an increase in falls with new glasses

The optometric intervention RCT by Cummings and colleagues included about 300 participants aged 70+ and living in the community in each arm of a RCT with an intervention of an optometric examination, treatment and referral and a control group who were left to their usual care.[51] Of the intervention group, 92 received new spectacles, 24 were referred for a home visit by an occupational therapist, 17 were referred for suspect glaucoma and 15 for cataract surgery. This seems a much more reasonable number of interventions than those provided in the previously described multi-intervention RCTs. Very surprisingly, falls occurred *more often* in the year follow-up period in the intervention group than in the control group (65% vs. 50% falls rate, 758 vs. 516 total falls, $p < 0.001$) and there was a trend towards more fractures in the intervention group (31 vs. 18, $p=0.06$). One limitation that the authors suggested could be significant was that the control group may have been less motivated and reported falls less accurately,[51] but the falls rate of 50% in the control group is similar to the rate in the year before the study (55%) and similar to the expected falls rate for this age group. The authors reported that, the control group appeared to obtain optometric care beyond 'the usual' and there was no difference in visual acuity in the two groups at the 12-month follow-up visit.[51] However, although this could explain a lack of difference between intervention and control groups, it does not explain an increase in falls in the intervention group.

What might change with new spectacles?

New spectacles generally provide improved visual acuity in older patients, and this should improve falls rate given the link between poor vision and falls discussed earlier. Perhaps other changes that can accompany new spectacles, such as changes in magnification, optical centers and lens type (e.g., PAL rather than single vision, PAL design change) and position of bifocal/PALs could adversely affect falls risk. Although postural stability could be reduced by incorrect optical center positioning leading to induced heterophoria (particularly vertical[21]), all the spectacles would have been checked prior to fitting and significant induced vertical heterophoria is very unlikely. There was also minimal change of lens type (from single vision to PAL for example) in the Cummings study (although changes in PAL design or bifocal type may have occurred but were not reported) and the authors suggested two main possible reasons for their findings[51]: The first was that the intervention participants, because of improved confidence due to better vision, may have increased their outdoor activities and put themselves at greater risk of falling. However, there was no evidence to support this. The second was that some of the subjects received large changes in spectacle prescription and older frail people may have greater difficulty adapting to such changes and be at increased risk of falling during this adaptation period. This was supported by the finding that 74% of the intervention group who had major changes in refraction fell at least once, compared with 53% (i.e. at the pre-intervention and control group level of falls rate) of those who had minor changes. A major change in refraction was defined as ≥ ± 0.75DS or DC, axis changes of ≥10° up to 0.75DC and ≥5° for 0.75DC+, any prism change or an introduced anisometropia of ≥0.75DS.

Spectacle magnification

Changes in refractive correction and lens form can provide magnification changes. Hyperopia and myopia will lead to slight increases and decreases in magnification respectively and objects will consequently appear closer or further away than they really are. This may not seem to be of much importance until everyday actions such as stepping over curbs or obstacles or walking upstairs that require a very precise judgment of the step/curb position are considered.[52] These magnification effects also change the vestibulo-ocular reflex gain,[53] which links the vestibular system with the extraocular muscles and produces the rapid compensatory eye movements needed to maintain stable vision of an object of interest as the head moves. With changed magnification due to spectacles, the eyes have to move faster or slower than previously to match head movement speed and this new relationship has to be relearned.[52,54] Prior to this occurring, the world 'swims' as some patients report.[54] Different spherical refractive correction changes in the two eyes cause aniseikonia and more complex adaptation. Changes in astigmatism can cause even more problems because different amounts of magnification occur along two meridians, so that objects look distorted.[55] Symptoms can include walls, doors and floors sloping before adaptation,[54] due to a recalibration between disparity and the perceived slant.[55] The magnification effects of spherical and astigmatic spectacle lens changes can have significant effects on adaptive gait on steps and stairs, which could compromise safety.[52,56] For example, with negative lens changes a single step appeared further away and smaller and appropriate gait changes were made: the trail foot position before the step was placed significantly closer to the actual step than the control condition and lead vertical toe clearance over the step edge was reduced. The single step looked closer and bigger with positive lenses and the trail foot position before the step was placed significantly further away from the actual step than the control condition and lead vertical toe clearance was increased. Not only do magnification effects appear to drive adaptive gait changes, but they override any safety adaptations due to blurred vision.[52,56] Astigmatic magnification had the greatest effects on adaptive gait when cylinders were oblique as they caused steps to be perceived as sloping parallelograms, causing gait changes in the anterior and posterior, vertical and lateral directions.[56] One participant missed the step completely with induced oblique astigmatism due to a large lateral foot movement. Compare this with induced astigmatism with axes at 90°, providing magnification in the horizontal meridian only, which caused no change in stepping pattern.[56]

Bifocals, progressive addition lenses (PALs), gait and falls

A change from a distance single vision lens to a PAL or bifocal does not just provide major convenience to the patient. It significantly affects their peripheral vision, providing distortion throughout the peripheral visual field in a PAL and a blurred and magnified view of the lower visual field beyond their near working distance in both PALs and bifocals. This will affect the peripheral optic flow information used for postural control (particularly in PALs) and make it difficult to judge the position of obstacles in the lower visual field, including obstacles and step and stair edges and/or foot placements relative to such environmental obstacles.[25] Bifocal wearers may also perceive significant image jump at the top of the reading add, depending on the bifocal type. All these negative 'side-effects' of PALs and bifocals are greatest when the add is highest, as are typically worn by the oldest presbyopes (i.e. those patients with the greatest risk of falling). Many clinicians advise first-time bifocal and PAL wearers to "tuck their chin in" if wearing the glasses when ascending and descending stairs so that they view the stairs through the distance vision part of their glasses. Although flexing the neck in this way can disrupt the input from the vestibular system regarding postural control,[57] this seems a useful strategy as postural stability in PAL / bifocal lens wearers was found to be better in a 'head flexed-gaze down' compared with a 'head neutral-gaze down' position.[58]

First-time PAL wearers typically use safety gait changes of slowing down and increasing foot clearance over step edges.[59] After adaptation to the glasses, these safety changes are reduced or disappear and well adapted bifocal/PAL wearers do not show an increased foot or toe clearance over step edges.[60] In addition, long-term bifocal/PAL wearers did not 'tuck their chin in' to view the steps through their distance portion of the lens in any of these studies.[60] However, they do report more variable toe clearance of the step edge and more variable foot placement before the step [60] and 'dropping' on to the floor during step descent rather than a more controlled step down.[61] The lack of an increase in toe clearance plus increased variability meant that subjects hit the step edge or obstacle more often when wearing bifocal/PALs than distance single-vision lenses,[60,62] particularly when walking with their attention divided.[62]

In a 1-year prospective epidemiological study (*n* = 156, mean age 77 years, the study included a determination of which spectacles were worn at the time of the fall), Lord and colleagues reported that their 87 regular bifocal/PAL wearers were more than twice as likely to fall (odds ratio 2.29, 95% confidence interval 1.06–4.92) as non-bifocal/PAL wearers after adjusting for age and other known risk factors for falling.[63] Bifocal/PAL wearers were also more likely to fall because of a trip, when outside their homes or on stairs. Accident data have also suggested that bifocal and PAL wear increases the risk of trips, 'underfoot' accidents and falls.[35] The epidemiological and lab-based evidence certainly indicates that older patients at high risk of falling should not be switched from single vision glasses to PAL or bifocals if they have never worn them before. What about long-term wearers of bifocals or PALs who become high-risk (by having a fall, diagnosed as diabetic, having a stroke, taking more medications etc.): should they be switched to single vision glasses? Haran et al. recruited approximately 300 participants of mean age of about 80 years to each arm of their RCT of an additional distance single-vision pair of spectacles to long-term bifocal/PAL wearers against a control group who continued to use their bifocal/PAL spectacles for all tasks.[63] The intervention group were advised to wear the distance single-vision glasses when walking outside the home, other than when selecting items at the supermarket. Participants were provided with a glasses cord and/or a spectacle case to help with the swapping of glasses and were given verbal and written advice regarding when to wear the new glasses and why wearing the new glasses was important in terms of safety. Overall, there was no difference in falls rate (~58%) between the two groups. However, preplanned subgroup analysis [65] between active and non-active participants (using a cut-off of the median score of 15 on the Adelaide activities profile questionnaire) found a decreased falls rate for active participants in the intervention group (52%) compared to the control group (60%). In the active participants, outdoor falls and injurious falls were also less in the intervention group (42% versus 51% and 38% versus 47%).[89] For the less active participants, outdoor falls were greater in the intervention group compared to controls (51% versus 36%), although overall falls and injurious falls were similar. A limitation of the study and the report is that the participants in the intervention arm of the study were encouraged to accept transition lenses as their additional distance glasses or lenses with less than a 30% tint or a graduated tint "to reduce outdoor glare". The report does not indicate how many of the intervention group received such tints, although one sentence in the discussion suggests that they all did.[64] In addition, there is no indication of how many of the participants in each group had tinted bifocal/PAL lenses. If we assume that all intervention participants accepted tinted lenses, this raises the question of whether the smaller outdoor falls rate was due to wearing distance single-vision spectacles outdoors rather than bifocal/PALs or due to wearing tinted lenses rather than clear, or a combination of the two. There is no mention of an intention to promote tinted lenses for the intervention group in the report that described the methodology for the study [65] and it is possible that they were used as a recruitment tool for the study, given that recruitment was very difficult.[64]

In all, 357 people declined participation in the Haran study after initially expressing an interest in taking part and one of the reasons was that they thought that switching between two pairs of glasses needed too much effort.[64] Only 41% of participants reported satisfactory adherence to wearing the additional glasses for the majority of the study (10–12 months), with 32% reporting giving up within the first 3 months. Note that this is with free spectacles/prescription sunglasses. Unlike other RCTs of optometric interventions mentioned earlier, very few of the control group (2 of 301, 0.7%) were tempted to try the intervention in the follow-up period and these figures reflect the difficulty in persuading happy, long-term bifocal/PAL wearers to swap into single-vision spectacles when outside their home.

To date, falls and gait studies suggest little difference between bifocal and PAL lenses. In the epidemiological and RCT studies, the majority of participants wore bifocals (87%[63], 60%[64]) and no comparisons between lens types were made. Most lab-based studies have presented data from similar numbers of wearers of bifocal and PAL spectacles and indicated no difference in adaptive gait changes between spectacle types,[60,62] although Timmis et al. found less adaptive gait changes with PALs when stepping down compared to bifocal lenses and further research is required in this area.[61]

Recommendations for optometrists

To be able to better manage patients in optometric practice to help prevent falls, clinicians first need to be able to identify patients who are at high risk of falling. Risk factors include older age (75+), female gender, a history of falls, living alone, decreased muscle strength, Parkinson's, stroke, arthritis, diabetes, Meniere's disease, dementia, taking sedatives, antidepressants and polypharmacy (taking more than four prescription medications per day).[1-5] The more risk factors patients have, the more likely they are to fall.[8] This may need an adaptation to the case history, including routinely asking elderly patients whether they have a prior history of falls, determining when glasses are actually worn (do elderly patients always wear their distance glasses when walking outside the home?) and asking bifocal/PAL wearers whether they have any problems with steps and stairs and whether they take off their bifocal/PALs when negotiating stairs? [5]

To help prevent falls, changes to refractive corrections in older people should be conservative[51] with maximum changes of approximately 0.75D and minimal changes in cylinder axes, particularly if oblique.[51,54] Indeed, if a patient reports no problems with their vision, but simply requests a new frame, "if it ain't broke don't fix it" is an appropriate clinical maxim and the refractive correction is best not changed.[66] Similarly, it may be better to keep lens form, PAL design, bifocal type etc the same in any new glasses unless there are significant reasons for change. Although experienced optometrists in the UK have reported that they 'partially prescribe' in response to a questionnaire containing a selection of clinical vignettes, less experienced optometrists more commonly prescribe the full subjective refraction result.[66] This suggests a need for further education and training in this area of clinical practice. Patients should also be warned of magnification changes with new spectacles: myopic shifts will make objects, including steps and stairs, look smaller and further away; hyperopic shifts will make steps and stairs look bigger and closer; and astigmatic changes will make stairs and steps slope. [52]

Information from eye movements provides important information about lateral body sway [15] and correct positioning of optical centers is necessary to avoid inducing heterophoria, particularly vertical. Small amounts of vertical heterophoria have been linked with poor postural control and this can be corrected with appropriate prism.[21]

PALs or bifocals should never be prescribed to patients who are used to wearing single-vision glasses and who could be categorized as at high-risk for falls. PALs, bifocals and monovision correction are hugely convenient and patients are loath to change to standard single vision glasses.[64] However, appropriate advice should be provided to long-term wearers if and when they can be categorized as at high risk for falls: Be wary of using a monovision approach because of the loss of stereoacuity;[5] long-term wearers of bifocal/PALs with minimal ametropia may be advised that they would be less likely to fall if they removed their glasses when walking outside their home; long-term wearers of bifocal/PALs with significant ametropia who take part in frequent outdoor activities should use distance single-vision glasses when outside their home (other than when driving or shopping) and prescription single-vision sunglasses may be particularly useful for sunny days and holidays; long-term wearers of bifocal/PALs with significant ametropia who take part in few outdoor activities should continue to wear bifocal/PALs for most activities.[64] Suggesting that patients 'tuck their chins in' to look through the distance vision part of their PALs or bifocals when negotiating steps and stairs seems useful.

Haran et al. recommended that distance single-vision glasses should be provided for outside use when patients are prescribed their first pair of bifocal/PAL glasses.[64] Presumably, this is so that they can become accustomed to using spectacles in this way as there are no data in their study to support this recommendation. Indeed, a first pair of bifocal/PALs would provide a reading addition of about +1.00DS and provide a very clear view of steps and obstacles on or near the floor and patients would be 40–50 years of age so that the vast majority would be at little risk of falls, so that this recommendation does not seem appropriate and is certainly not evidence-based. An alternative strategy to distance single-vision glasses for outside use in long-term PAL/bifocal wearers may be to instead prescribe a PAL/bifocal with an add of intermediate power that provides less peripheral distortion, less blur beyond the near working distance so that it should provide less risk of falls, and yet allows spot reading (of menus, shopping lists etc) and we are currently investigating the usefulness of this strategy.

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Figure 1. Measurement of postural stability. A force platform is used to determine excursions in the centre of pressure (COP). These excursions reflect movements (sway) in the centre of mass. Courtesy of Dr. John Buckley, University of Bradford.

Figure 2. A subject in the vision and gait lab at the University of Bradford with retro-reflective markers attached to important anatomical landmarks on the patient's skin or clothing. Ten cameras arranged around the lab (not shown) are surrounded by digitally controlled strobes that emit infrared light. From the reflected (non-visible) light returning to the cameras, the Vicon system software reconstructs a three-dimensional location for each marker and a three-dimensional figure walking through the lab.

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