Failure of Adaptation to Multifocal Lenses: Longitudinal Evidence and Implications on Falling

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Abstract

Objectives: Measure longitudinal vision and gait adaptations of multifocal lens wearers.
Design: Participants were tested with a modified Dynamic Gait Index (DGI-m) and for contrast sensitivity (CS) and depth perception (DP) at 2 weeks, 3 months and 6 months. A within-subject repeated measures analysis with *a priori* contrasts was used. Subjective response (SR) reports on comfort level while performing the DGI-m were also analyzed.
Setting: A rehabilitation facility in a Midwestern city.
Participants: 28 participants who were first time multifocal lens users. Age ranged from 40-59; 22 were female.
Main Outcome Measures: Performance scores on the DGI-m, DP and CS tasks, and SR reports.
Results: All measures exhibited statistically significant differences, except CS comparing performance with old single lenses and new multifocal lenses at 1st visit (DGI-m, p=.026; DP, p=.004; SR, p=.003; CS, p=.092). Scores for DP and SR remained significantly different for the 3 subsequent visits using the new multifocal lenses compared to the old single lenses. While differences in scores for the DGI-m and CS were not statistically significant, the means for each visit were lower with multifocal lenses than with single lenses.

Background

Falling is a major health issue, especially as people age. Millions of injuries and thousands of deaths each year are due to falls (National Center for Injury Prevention and Control [NCIPC], 2010). Approx. $19 billion in health care dollars is spent each year on fall related injuries (CDC, 2009). Many causes (intrinsic & extrinsic) of falls have been identified and studied (Stevens, 2005). The importance of good visual information while ambulating is known, but has been somewhat neglected in falls prevention research and practice. Corrective lenses, esp. bifocals & progressives are an important component of good vision, esp. for older adults (Ivers, Cumming, & Mitchell, 1998). Multifocal lenses have been shown to cause decreases in visual performance areas that are important for ambulation (Lord, Dayhew, & Howland, 2002). Lord & Dayhew (2001) found that bifocals caused decreased depth perception and contrast sensitivity, and increased falls by a 2:1 ratio in an older (mean age=75) population. These multifocal lens glasses may potentially be a major variable that has been missing from research.

Goals & Research Questions

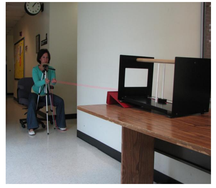
- Determine the effects of new multifocal lenses on a middle-aged population on gait and visual performance.
- Replicate results of Lord et al. (2002) study, which used an older population:
  - Do multifocal lenses cause decreased visual performance (as measured by depth perception and distant edge contrast sensitivity)?
  - Do multifocal lenses cause impaired gait performance?
  - Does multifocal lens use increase the risk rate for falls in a middle-aged population?
- Do decreases in performance last *over time* (6-month period) after first using multifocal lens glasses?

Methods

Instruments and Measurement

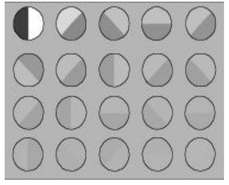
1. Depth Perception
was measured using the Howard-Dohlman Depth Perception Apparatus. Users try to align two 0.8 cm rods, one of which is fixed, and one that can be moved, at a distance of 3 meters by pulling a string. Scores are measured in millimeters, and can be positive or negative, with a score of zero indicating optimal performance. For analysis, absolute scores were used.

Figure 1: Person using the Howard-Dohlman Depth Perception Apparatus.



2. Distant Edge Contrast Sensitivity
was measured using an Enlarged version of the Melbourne Edge Test (MET), specially created by Stephen Lord for his 2001 study of the effects of bifocals on visual and gait performance relating to falls. The Enlarged MET consists of octagonal plates, which are divided into two sections that consist of different shades of gray. These two areas differ in the amount of contrast. The edge separating the two sections can be horizontal, vertical, or either of the 2 diagonals. The participant is directed to identify the orientation of the edge. There are 28 levels, and participants begin testing on level 12. The contrast is reduced in each subsequent plates. When the participant misses 2 consecutive plates edge orientations, their score is the number of the last correctly identified plate.

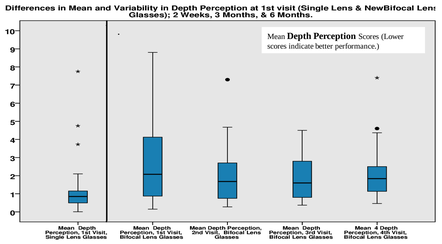
Figure 2: Example of contrast sensitivity plates used in the MET.



3. Modified version of the Dynamic Gait Index (DGI-m).
This is a tool which measures functional gait. The original DGI used 8 tasks, scored from 0-3. Our modified version contains 10 tasks and was scored from 0-5 in an attempt to limit ceiling effects that occurred in a previous study. The DGI-m consists of a 20 ft long path, with tasks that include turning and tilting of the head, walking over or around obstacles, and negotiating steps. Participants are rated by an expert observer on a scale of 0 (completely unable to perform the task) to 5 (normal gait, no problems with the task). Participants completed each task twice in succession.

4. Subjective Response Questionnaire.
Participants were asked to respond to the tasks of the DGI-m based on their discomfort level while performing the tasks at each trail. The scale ranged from 1 (complete comfort) to 5 (very queasy). There were 8 subjective response questions. Participants were also asked to report any falls that occurred during the duration of the study.

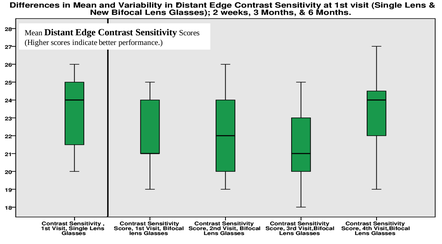
Results from the longitudinal study of adaptation to new multifocal lens glasses



Within-subjects Repeated Measures Regression: Comparing Single Lens Depth Perception performance to Multifocal Lens Depth Perception performance during initial visit, & at 2 weeks, 3 months, and 6 months.

Visit 1, Single Lens Glasses		Visit 1, Multifocal Lens Glasses		Visit 2, 2 Weeks Multifocal Lens Glasses		Visit 3, 3 Months Multifocal Lens Glasses		Visit 4, 6 Months Multifocal Lens Glasses	
Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
1.24	1.65	2.83**	2.55	2.36**	2.47	1.91	1.33	2.19*	1.63

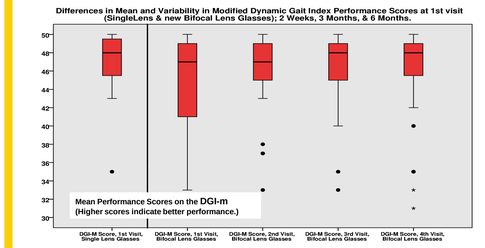
* Significantly different from visit 1, Single Lens Trials, p≤.05.
** Significantly different from visit 1, Single Lens Trials, p≤.01.



Within-subjects Repeated Measures Regression: Comparing Single Lens Contrast Sensitivity performance to Multifocal Lens Contrast Sensitivity performance during initial visit, & at 2 weeks, 3 months, and 6 months.

Visit 1, Single Lens Glasses		Visit 1, Multifocal Lens Glasses		Visit 2, 2 Weeks Multifocal Lens Glasses		Visit 3, 3 Months Multifocal Lens Glasses		Visit 4, 6 Months Multifocal Lens Glasses	
Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
23.11	1.88	22.15*	2.02	22.37	2.13	21.37**	1.94	22.19*	2.00

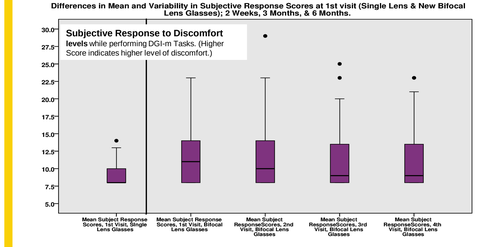
* Significantly different from visit 1, Single Lens Trials, p≤.05.
** Significantly different from visit 1, Single Lens Trials, p≤.01.



Within-subjects Repeated Measures Regression: Comparing Single Lens DGI-m performance to Multifocal Lens DGI-m performance during initial visit, & at 2 weeks, 3 months, and 6 months.

Visit 1, Single Lens Glasses		Visit 1, Multifocal Lens Glasses		Visit 2, 2 Weeks Multifocal Lens Glasses		Visit 3, 3 Months Multifocal Lens Glasses		Visit 4, 6 Months Multifocal Lens Glasses	
Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
46.96	3.31	45.00**	5.19	45.81	4.57	45.89	4.30	45.48	5.61

* Significantly different from visit 1, Single Lens Trials, p≤.05.



Within-subjects Repeated Measures Regression: Comparing Single Subjective Response Scores to Multifocal Lens Subjective Response Scores during initial visit, & at 2 weeks, 3 months, and 6 months.

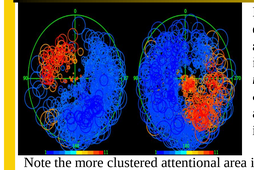
Visit 1, Single Lens Glasses		Visit 1, Multifocal Lens Glasses		Visit 2, 2 Weeks Multifocal Lens Glasses		Visit 3, 3 Months Multifocal Lens Glasses		Visit 4, 6 Months Multifocal Lens Glasses	
Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
9.22	1.93	11.65**	4.33	12.24**	5.52	11.54**	5.05	11.19*	4.57

* Significantly different from visit 1, Single Lens Trials, p≤.05.
** Significantly different from visit 1, Single Lens Trials, p≤.01.

Conclusions

Participants exhibited immediate effects of switching from single lens glasses to multifocal lens glasses. Significant decrements were observed in both visual and physical performance. Variability also greatly increased. At 2 weeks, functional gait approached the pre-multifocal lens glasses performance levels, but visual performance was still decreased. At 3 months and 6 months, visual performance was still significantly decreased, while gait performance stabilized, but never completely returned to pre-multifocal lens levels. Variability remained high for all multifocal lens trials.
Of significant interest, the subjective response scores relating to discomfort levels remained high, even after 6 months, as did the variability in these scores. This may be an indication that some participants were not successfully adapting to their new multifocal lenses, but were capable of compensating somewhat when performing the gait tasks. Interestingly, of the 28 participants, 3 reported having falls during the 6 month study period, and these 3 participants had highly elevated discomfort level scores compared to the others.

Future Research Directions



Images of an fMRI brain scan of an experienced progressive lens wearer attending to targets at 11 o'clock (left image) and 5 o'clock (right image) while *not wearing their multifocal glasses*. Red & orange indicate highly correlated activity relative to baseline attention. Blue indicates inhibited attention.

Note the more clustered attentional area in the upper region vs. the more spread area in the lower, as well as the cleaner separation between the attentional area and inhibited area in the upper region. *Could this be an indication of a change in neural behavior caused by wearing multifocal lens glasses*?

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Acknowledgements

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