MODIFYING THE DYNAMIC GAIT INDEX FOR IMPROVED DISCRIMINATION OF MULTIFOCAL EYEGLASS CONDITIONS

Dennis B. Tomashek, M.S., Kurt E. Beschorner, Ph.D., Roger O. Smith, Ph.D., Autumn Milanowski, B.S.
Rehabilitation Research Design & Disability Center, University of Wisconsin-Milwaukee
Department of Industrial & Manufacturing Engineering, University of Wisconsin-Milwaukee

ABSTRACT

The objective of this project is to create and test a modified version of the Dynamic Gait Index (DGI) to improve discrimination of functional gait between performance with and without multifocal lens glasses. Previous studies have modified the DGI to increase the ability of the measure to make it a more sensitive assessment for younger adults with no expected gait or balance pathology by modifying the scoring scale, adding tasks, and creating a portable, standardized DGI, the "DGI-m'. While the DGI-m was proven to be somewhat more sensitive, it remained dependent on trained and experienced observers. This project aimed to refine the functional gait measurement of multifocal lens wearers by adding a task and applying more quantifiable measures of gait performance. We employ motion capture analysis, wireless electromyography (EMG), and force plate technologies to more sensitively measure performance as participants negotiated various height steps and ramps via measurement of kinematics, muscle activity, and ground reaction forces, respectively. The researchers expect that this re-modified DGI (DGI-m2) with the new tasks, and using the advanced measures will more clearly observe differences in performance for young adults either wearing or not wearing multifocal lens glasses (MfLs). This will significantly improve the research capacity of studying the effects of multifocal eyeglass use.

BACKGROUND

A major factor that has been linked to both gait and falls is vision. Vision has been cited as an important component for safe ambulation (Marigold & Patla, 20080. The most common visual impairment is presbyopia, a condition of natural aging in which the lens of the eye loses flexibility, making it unable to accommodate for near distance viewing (AOA.org, 2006-2009). While not curable, a common solution to this problem is the prescription of multifocal lens glasses (MfLs), which can include lined bifocals, trifocals, and unlined progressive glasses. MfLs contain an upper region for distance viewing, and a lower “add” region for near viewing. While this is convenient, it also causes blurred vision while walking. Lord & Dayhew (2002) established MfLs as a potent factor in increased fall rates. These findings were reinforced by Haran, et al., in 2010, showing an 8% increase in falls for older adults wearing MfLs. Other researchers since then have continued to accumulate evidence on the negative effects of MfLs on gait and negotiating steps (Elliott & Chapman, 2009).

The DGI is a well established tool for assessing gait, balance and fall risk in older adults (Herman, Inbar-Borovsky, Brozgol, Giladi, & Hausdorff, 2009). It has also been shown to be reliable for other populations, such as those with stroke (Jonsdottir & Cattaneo, 2007). However, a study conducted in 2006 (Joerger, Smith, & Tomashek, in preparation) found that the original DGI reached ceiling limits when comparing young (18-22 years old) participants wearing bifocal lens glasses compared to single lens glasses?. A follow-up study, (Brayton, Smith, & Tomashek, in preparation), modified the DGI by increasing the scoring from a 4- point to a 5-point scale. However, two groups, first time bifocal wearers and a control (non-wearer) group again encountered ceiling effects. A third bifocal study (Smith, Tomashek & Stalberger, in preparation), modified the DGI further in to the DGI-m. In addition to increasing the scoring range, the DGI-m included:

1. Two new tasks.

1. A step-over task with a long, diagonal obstacle.
2. A step-up/step-down platform.

2. Overlaid the DGI walkway and all obstacles with a checkered-pattern Amsler grid.
3. Introduced a visual distraction task for certain DGI tasks.

These modifications produced significant results that discriminated between single lens and multifocal lens use. The mean for single lens glasses performance was 47.07 (out of a possible 50), and for the initial performance with MfLs, the mean was 45.07 ($t=2.821$, $p=.009$, $n=28$). This difference persisted over 6 months, though at non-significant levels 45.64 ($t=1.788$, $p=.085$) (Stalberger, et al.).

THE DGI-M2 PROJECT

The current project is being conducted to gather pilot data to identify measures during ramp and stair walking that are sensitive to MfL glasses. This project is essential to accomplishing our long term goal, which is to develop and test interventions that reduce the number of falling accidents in older adults wearing bifocal/multifocal lens glasses. Our main goal of this project is to develop a task that requires subjects to adapt to floor level changes, which we expect to be difficult while wearing multifocal lens glasses. To accomplish this, the researchers have developed modified the DGI in five ways:

1) Addition of a step/ramp task.

2) Addition of motion capture analysis.

3) Addition of EMG analysis

4) A more continuous task.

5) The use of force plates.

The DGI-m2 Ramp/Step

The ramp/step apparatus consists of two constructions, each of which has a ramp connected to a step. One step/ramp has 3” step with a ramp pitched at 1” rise per foot of run, and the second step/ramp has a 6” step with a ramp pitched at 2” rise per foot of run. A total of 5 ramp/step conditions will be tested: 1) level walking; 2) step up/ramp down (3”); 3) ramp up/step down (3”); 4) step up/ramp down (6”) and 5) ramp up/step down (6”). Participants are harnessed for safety during this task, and motion capture, EMG, and force plate data is also gathered at this time. Subjects perform a standard DGI task between each ramp/step task. The tasks are performed in a loop to maximize fluidity of their movement from task to task. Participants wear clear, non-prescription glasses for half of the trials, and a pair of non-lined progressive lens glasses that are clear on the top and have an add region of +2.75 diopters. The order of glasses will be randomized. A total of 3 of each of the ramp/step conditions will be performed and 6 normal walking trials for each glasses condition. The trial order will be randomized within each glasses condition.

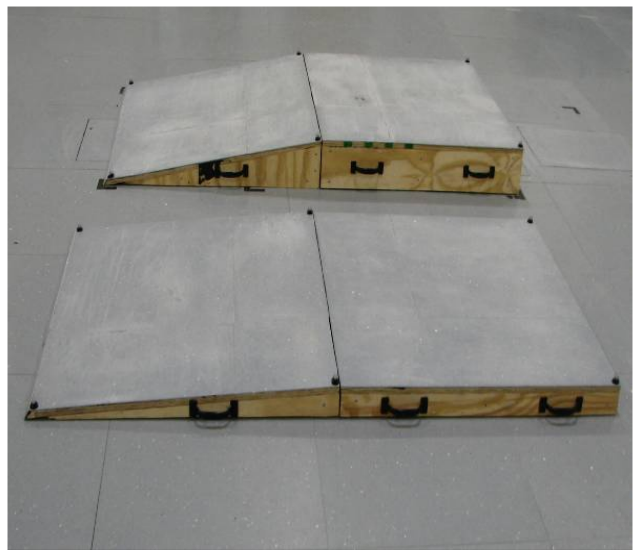


Figure 1. Image of the 6” and 3” ramp/steps created for the DGI-m.

Participants

20 young (18-25 years old) participants will be recruited from the UWM campus. Participants are required to have normal or corrected to normal (at least 20/30) vision, but must have contact lenses if corrected. Currently, two subjects have already participated in this study. This protocol was reviewed and approved by the University of Wisconsin-Milwaukee Institutional Review Board.

DATA ANALYSIS

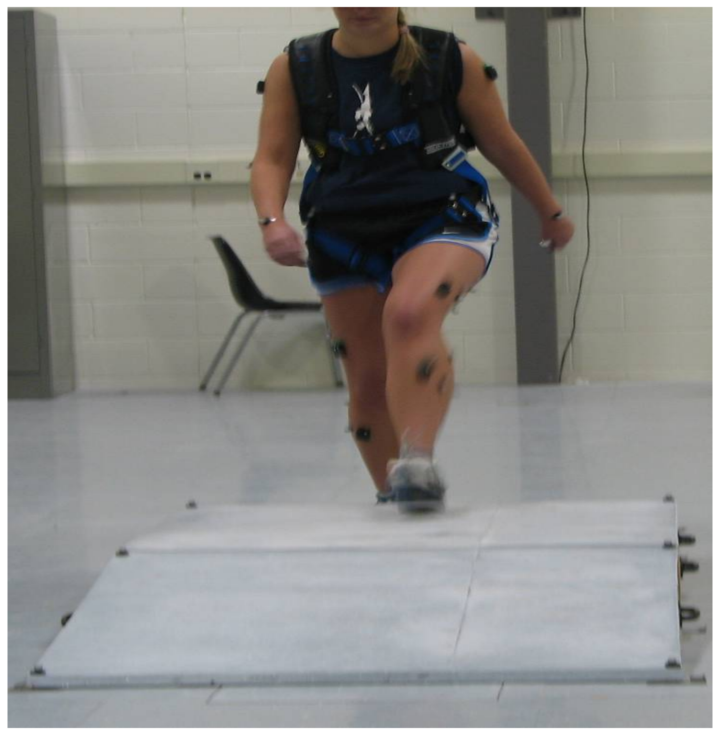
A within-subjects repeated measures analysis will compare individual's performance with and without MfLs.

Kinematic, muscle and kinetic activity will be measured and analyze to identify measures that are sensitive to MfLs. In particular, we aim to determine if differences exist between MfL and single lens for measures that are linked to tripping risk. In addition, we aim to determine if higher levels of muscle activity are observed in the MfL condition compared to single lens condition to determine due to protective co-contraction or due to corrective postural responses from postural imbalance caused by the MfL glasses.

Tripping risk will be primarily measured using toe clearance during stair and ramp ambulation. The minimum toe clearance during step up and step down will be calculated as the minimum distance between a marker placed at the toe of the subject and the edge of the step. The mean and standard deviation of toe clearance will be compared between MfL and single lens conditions, step height condition and their interaction. Toe clearance during stepping up and stepping down will be treated separately. Toe clearance will also be measured during ramp ascent and descent as the minimum toe height between 30% of swing phase and 70% of swing phase. Walking up the ramp and walking down the ramp will be treated separately. We hypothesize that toe clearance will increase when wearing MfL as subjects adapt a safer walking style but that the standard deviation will also increase as subject's ability to perceive the location of their foot relative to the ground adversely affects their ability to control toe clearance. We will also examine the maximum normal force during stair descent. We expect that subjects wearing MfL glasses will have higher peak normal forces than single lens wearers as their ability to determine the height of the step is impeded.

Bilateral EMG activity of the vastus lateralis, tibialis anterior, medial gastroc, medial hamstring and deltoids will be measured to identify the postural responses caused by subtle imbalances due to an misperceptions of the flooring. EMG activity will be full-wave rectified, and low-pass filtered at 10Hz, similar to (Marigold & Patla, 2002). Muscle activity will be normalized to the maximum activity during normal gait. Peak activity during stance and swing for each muscle will be identified for each of the step up/step down/ramp up/ ramp down conditions. Peak activity will be compared against the MfL and single lens conditions for each of the step/ramp conditions separately. Large and sudden increases in muscle activity will be indicative of a postural response.

Other gait parameters will also be analyzed to determine if subjects adopt a more conservative gait pattern. Gait speed and step length as subjects approach the ramp/step will be analyzed during the 2 steps preceding the first step on the ramp up/step up and the last 2



steps before stepping off the ramp down/step down. Joint angle data will be available for analysis in case any changes in gait patterns are observed in the MfL condition.

Video of the testing conditions will be examined and number of stumbles will be identified and counted by a qualified researcher. The total number of stumbles during a testing session between MfL and single lens conditions will be compared.

Figure 2. Participant negotiating DGI-m2 ramp/step. Participant is outfitted with safety harness, wireless EMG detectors, and reflective markers for Motion capture analysis.

EXPECTED OUTCOMES

We expect that the DGI-m2 will be able to discriminate the performance of young non-MfL wearers functional gait performance when wearing MfLs as opposed to single lens glasses.

We expect that there will be significant differences in gait speed, toe clearance, and toe height between performance with and without MfLs, and that the variance for each of these outcomes will be higher while wearing MfLs.

We expect that muscle activity will increase while negotiating the step/ramp when wearing MfLs.

We expect that there will be more contacts with the step/ramp, and more missteps, as measured by the force plates when wearing MfLs.

Importantly, this updated measurement system will serve as a highly sensitive data collection research instrument, but based on its clinical valid DGI predecessor and counterpart, significantly advancing beyond other previous methods used for measuring performance of MfL wearers.

CONCLUSION

Falls are a major health concern for older adults. Eyeglasses which are meant to be assistive could be creating an avoidable rise in the risk rate for falls. It is essential to understand the dynamics of MfLs on gait and stepping performance in order to develop interventions that can be used by clinicians and therapists in the field. If the DGI-m2 developed by the researchers proves to be able to discriminate between performance with and without MfLs, it would provide an easily replicable tool that can be used to assess the risk of falls for individuals who use MfLs. Once proof of concept testing is completed, future research will consist of a longitudinal, cross-sectional study following new MfL wearers and experienced MfL wearers over a 1 year period, to see if individuals performance improves as they adapt.

REFERENCES

[1] D.S. Marigold and A. E. Patla,"Visual information from the lower visual field is important for walking across multi-surface terrain," *Journal of Experimental Brain Research,* vol. 188, pp. 23-31, 2008.

[2] Presbyopia. (n.d.). 2006-2009 from *American Optometric Association* website: AOA.org.

[3] S.R. Lord, J. Dayhew, and A. Howland, "Multifocal Glasses impair edge contrast sensitivity and depth perception and increase the risk of falls in older people." *Journal of the American Geriatrics Society* vol. 50, pp.1760-1766, 2002.

[4] M. Haran, et al., "Effect on falls of providing single lens distance vision glasses to multifocal glasses wearers: VISIBLE randomised controlled trial." *British Medical Journal,* vol. 340, 2010.

[5] D.B. Elliott and G. Chapman, "Adaptive gait changes due to spectacle magnification and dioptric blur in older people," *Investigative Ophthalmology & Visual Science*, 2009.

[6] J. Jonsdottir, D. Cattaneo, “Reliability and validity of the Dynamic Gait Index in persons with chronic stroke.” Archives of Physical Medicine and Rehabilitation, Vol 88, pp.1410-1415, 2007.

[6] T. Joerger, R. Smith, & D. Tomashek, “Work not yet published” Submitted to *Assistive Technology*, 2010.

[7] A.Brayton, R. Smith, & D. Tomashek, “Work not yet published”, *submitted to Physical & Occupational Therapy in Geriatrics*, 2011.

[8] R. Smith, D. Tomashek, & K. Stalberger, “Work not yet published”, *submitted to Journal of the American Geriatrics Society, 2011.*

[9] D. Marigold & A. Patla, “Strategies for dynamic stability during locomotion on a slippery surface: Effects of prior experience and knowledge” *Journal of Neurophysiology*, Vol. SS, No. 1, pp. 339-353, 2002.